

MULTILIN 869

Comprehensive Motor Protection and Management for Medium and Large Motors

The Multilin™ 869 relay is a member of the Multilin 8 Series protective relay platform and has been designed for the protection, control and management of medium and large induction and synchronous motors.

The Multilin 869 provides advanced functionality for various types of applications such as high-speed protection, extensively customizable programmable logic, advanced motor monitoring and diagnostics, and flexible configuration capabilities.

The Multilin 869 is now available with an integrated synchronous motor protection module for protection and control of synchronous motors.

Advanced communications in the 8 Series platform allows easy integration into process and electrical control systems for smoother asset monitoring and control.

Key Benefits

- Comprehensive motor protection for medium and large induction and synchronous motors
- User-configurable Single Line Drawing on color display for local control, system status, and metering
- Advanced motor diagnostics with comprehensive fault and disturbance recording
- Integrated arc flash detection using light sensors supervised by overcurrent to reduce incident energy and equipment damage
- Advanced cyber security including features such as AAA, Radius, RBAC, and Syslog helps enable NERC® CIP requirements
- Draw-out design simplifies testing and increases process uptime
- Supports the latest in communication protocols and networking technology, enabling seamless system integration and interoperability
- Optional Wi-Fi connectivity minimizes system configuration and facilitates safe relay programming and diagnostic retrieval

Applications

- Wide range of motor applications for oil & gas, mining & metals, cement, and wastewater
- Comprehensive protection and management of medium to large motors; two-speed, VFD-driven, cyclic loading and synchronous motors
- Specific and advanced features for high inertia loads and reduced-voltage starting motors
- Stator and rotor protection of medium to large synchronous motors
- Synchronous motor DC field excitation application control
- Advanced predictive motor diagnostics and motor health visualization



Innovative Technology & Design

- Advanced motor protection, control and diagnostics capabilities
- Proactive motor health diagnostics with Electrical Signal Analysis for electrical, mechanical and thermal monitoring
- Patented environmental monitoring and diagnostics
- Advanced, flexible and embedded communications: IEC® 61850 Ed2, IEC 62439/PRP, Modbus® RTU & TCP/IP, DNP3.0, IEC 60870-5-104
- Single setup and configuration across the 8 Series platform
- Elimination of electrolytic capacitors
- Field swappable power supply
- Enhanced relay draw-out construction

Exceptional Quality & Reliability

- IPC A-610-E Class 3 manufacturing standards
- Highest reliability standards for electronics testing
- Environmental Stress Screening and full functional testing
- Rated for IP54 (front) applications
- Harsh Environment Coating

Uncompromising Service & Support

- Covered under GE Vernova's 10 year warranty plan
- Designed, tested and assembled by GE Vernova



GE VERNOVA

Multilin 869 Overview

The Multilin 869 Motor Protection System is a protection device designed for the management, protection and control of medium to large horsepower motors. The 869 provides comprehensive protection and control of various types of motors with different loads they run.

Protection & Control

As part of the 8 Series family, the Multilin 869 provides superior protection and control. The 869 offers comprehensive protection and control solutions for medium and large motors for various applications. It contains a full range of selectively enabled, self contained protection and control elements.

Recent enhancements include the following:

Starting Control

- Start sequence control
- Reluctance torque synchronization
- Incomplete start sequence
- Stabilizing feature
- Auto loading and unloading feature

Squirrel Cage Rotor Thermal Protection (separate from the main thermal model)

- Time vs speed curve based
- Reduced voltage starting feature

Enhanced Thermal Protection with Speed Biasing

Enhanced power factor protection

- Ride-through feature - directly trips motor
- Resynchronization feature - allows motor to re-synchronize instead of tripping

Power Factor Based Regulation

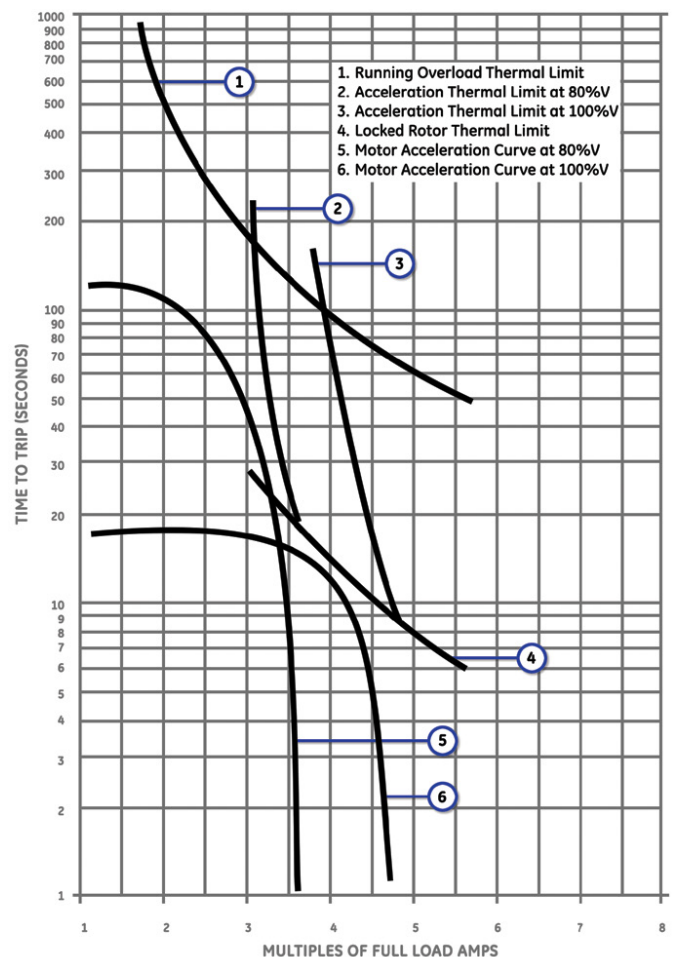
Motor Thermal Model

Many motor failures are directly or indirectly related to, or caused by, extensive heating of the different motor parts involved in electromechanical operation. Proven through several generations of GE Vernova's Multilin motor relays, an enhanced thermal model is used in the 869 relay with seven major features:

Motor thermal limit curves - NEMA® standard, voltage dependent and customized motor curves

- IEC 60255-8 thermal overload curves
- Smoothing filter for cyclic loads
- Current unbalance biasing
- Independent running and stopped exponential cooling curves
- Optional RTD biasing of the thermal model to adapt to real-time temperature measurements
- Compensation for hot/cold motor condition

The flexibility of the Multilin 869 thermal models allows for proper set up and performance for applications, including high inertia and cyclic loads.



Multilin 869 – Advanced Thermal Model High inertia overload curves sample, 8500HP, 13.2kV, Reactor coolant Pump

Thermal Model with Speed Biasing

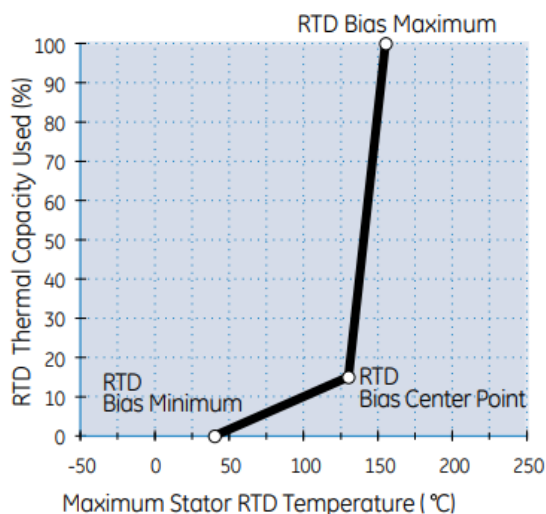
This feature acts as an additional check of the amortisseur, or squirrel cage winding rotor heating. This feature uses estimated speed-dependent thermal capacity used (actual value " and compares this value to the Thermal Capacity Used calculated by the current-based and RTD Bias (when Enabled) methods. The larger of the three values is used from that point onward.

RTD Biasing

The Multilin 869 supports up to 13 programmable RTD inputs that can be configured for an Alarm or Trip. The RTD voting option gives additional reliability to ignore any RTD failures.

The RTDs can be assigned to a group for monitoring the stator, bearing and ambient temperatures.

The Thermal Model is also biased by the RTD's temperature feedback. This feature allows the relay to protect the motor against unusual high ambient temperatures or abnormal heating due to overvoltage or damaged bearings. The RTD biasing feature can correct for this temperature rising by forcing the TCU register up to the value appropriate to the temperature of the hottest stator RTD.



RTD bias curve

High-Inertia Load Applications

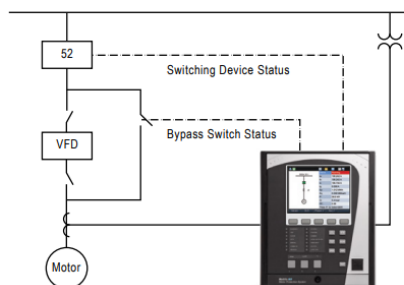
The voltage dependent overload curve feature in Thermal Model is tailored to protect motors which are used in high inertia load applications. Voltage is continually monitored when the motor is started and during acceleration. The thermal limit curve is then adjusted accordingly. This enables the Multilin 869 to distinguish between a locked rotor condition, an accelerating condition and a running condition.

VFD-Driven Motor Applications

The Multilin 869 provides protection for motors fed through VFDs (Variable Frequency Drives). A wide range of the frequency tracking (3-72Hz) allows the 869 to track the motor frequency and adjust its sampling rate to accurately measure phasors. An advanced algorithm allows switchable current and voltage tracking in case VFD is bypassed.

Thermal protection also considers the extra heating generated by the higher harmonics due to VFD to achieve the accurate response to the actual motor heating. RMS currents fed to the various motor protection elements are further processed through the averaging filter to eliminate oscillations in current signals to ensure the security.

Additionally, users may indicate a starting VFD frequency that helps the device to track the motor frequency faster and therefore accurately measures the phasor quantities, which, otherwise, could cause delayed or false protection operation of the protection.



Multilin 869 – VFD Driven Motor Protection with or without bypass switch

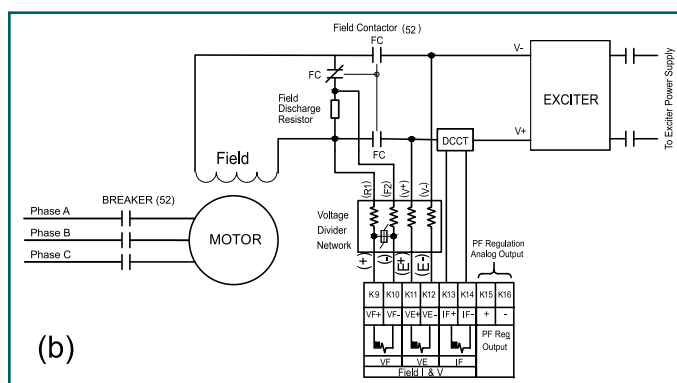
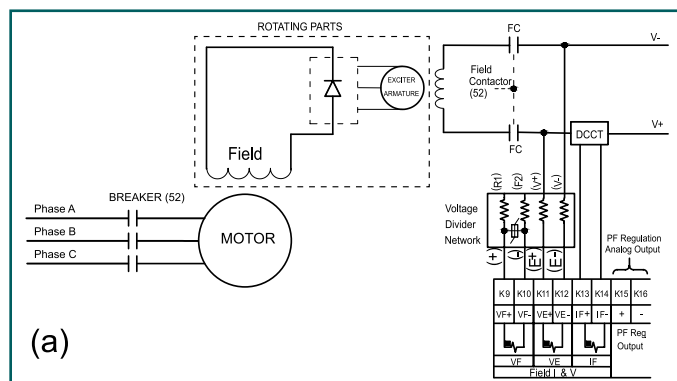
Cyclic Load Motor Applications

Input currents of a motor driving cyclic load can vary between very low to above the maximum allowable current during a load cycle. Variation in current magnitude results in motor heating and cooling depending on the heat and cooling time constants. Thermal overload protection response is made adaptive to the cyclic load based on the cooling time constants.

In addition, to provide more accurate overload thermal model response to cyclic load, the input currents to the thermal model are averaged over the settable duty cycle interval. With a reciprocating load application, the number of cycles to average can be determined from current waveform capture using the Oscillography/Datalogger features in the 869 motor protection relay.

Synchronous Motor Applications

The 869 is equipped to protect and control synchronous machines without the need for external hardware. All protection functions essential to the synchronous motor during asynchronous operation while starting up, during normal and overload operations and under fault conditions are available. In addition to stator protection and control, the relay 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. With its well established and matured Thermal Model, it prevents overheating of both stator and rotor windings during both synchronous and asynchronous operation. During asynchronous operation or startup, the thermal model with VD (voltage dependent) function provides protection against excessive heating in the damper winding due to stalled or locked rotor conditions.



Multilin 869 Synchronous Rotor wiring diagram (a) Brushless
(b) Brush-type

SM Field Overcurrent/ Undercurrent

The 869 relay provides monitoring of overcurrent and loss of DC field excitation input to the rotor of a synchronous motor. These elements respond to DC current input from the direct current transducer.

SM Field Overtemperature

The 869 relay provides protection of the rotor winding against overheating by exploiting the direct proportionality between temperature and resistance. This element responds to rotor resistance to detect rotor temperature. When magnitude of the field resistance or temperature exceeds the Pickup level for the time specified by the Pickup Delay setting.

SM Field Overvoltage/ Undervoltage

Excitation system output voltage to the rotor is monitored using these elements, corresponding to DC Field voltage measured across the field winding or exciter terminals. DC voltage is brought to the relay terminals through the voltage divider network, provided with the relay.

SM PF Regulation

Power Factor (PF) regulation is useful in applications where motors are subjected to high-level transient impact loads (such as chipper drives). The PF regulator senses the power factor dip occurring when the motor is loaded and signals the silicon-controlled rectifier (SCR) Exciter to respond with a boosted output. As a result, the pull-out torque of the synchronous motor is increased for the duration of the transient load. After the load subsides, the regulator senses an excessive leading power factor and signals the SCR to reduce its output. This automatic boosting of field current to avoid pull-out is called field forcing. The Power Factor regulator thus provides automatic boosting when field forcing is required and economical low field operation when the motor is idling.

Another application of the power factor regulator is to control power factor swings resulting from various levels of loading so as not to cause fluctuations in the plant system voltage.

SM Start Sequence Control

The 869 Start Sequence Control function provides:

- Controlled application of a DC field to the rotor winding for both brush-type and brushless synchronous motors.
The start sequence function is comprised of three field application control methodologies:
 - Slip-frequency based for brush-type motor applications.
 - Timer-based for both brushless and brush-type motor applications.
 - Reluctance-torque based synchronization for brush-type motor applications.
- Incomplete start sequence protection to trip/alarm if the starting sequence is not completed within a set time.
- Load application relay functionality enabling motor loading following the DC field application and unloading following a trip and/or loss of synchronization (pole slipping).
- Start sequence control when the motor enters re-synchronization mode.

Reduced Voltage Starting

Many induction and synchronous motor starting applications

involve either reduced voltage (starting reactor or autotransformer) or part winding starting methods. The 869 can control the transition of a reduced voltage starter from reduced to full voltage. Based on "Current Only", "Current and Timer", or "Current or Timer" (whichever comes first).

Reactive Power

In a synchronous motor application, the reactive power element can be used to detect an 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 the 869 is applied to a synchronous machine, it is not desirable to trip or alarm due to the power factor until the field has been applied. Therefore, the power factor 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 occurs indicating a Lead or Lag condition. The power factor alarm can be used to detect loss of excitation and out of step.

Stator Differential

Differential protection is considered as the first line of protection for internal phase-to-phase or phase-to-ground faults for medium and large motors to provide sensitive and fast clearing protection against winding faults including turn-to-turn faults. The Multilin 869 provides two flavors of the stator current differential protection:

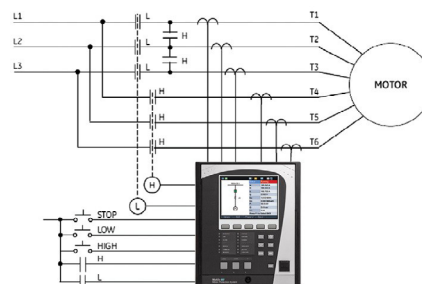
- Traditional dual-slope percent differential protection enhanced with CT saturation detection and directional checks for both AC and DC saturation provides exceptional security without sacrificing sensitivity
- Core-balanced differential protection enhanced with biasing during motor starting to inhibit differential protection when inrush currents may upset differential protection

All differential values are available in metering and oscillography allowing easy testing and troubleshooting.

Two-Speed Thermal Model

The two-speed motor protection feature provides protection for motors that can operate at two different speeds, with a detailed algorithm integrating the heating at each speed into a single thermal model.

The Multilin 869 automatically determines which settings should be active at any given time by considering the transition from speed one to speed two within a specific period of time. All required logic and time delays are provided to ensure a safe speed transition.



Underpower Protection

The Underpower element in the 869 is based on the three-phase real power (kW) measured from the phase currents and voltages. Underpower may be used to detect loss of load conditions. For more sensitive detection of load loss or pump cavitation, or detecting process related issues.

Current Unbalance

Unbalance current, also known as negative sequence current or I_2 , results in disproportionate rotor heating.

The current unbalance protection feature can detect when the motor's thermal capacity is exhausted and alarm and /or trip before the motor has heated substantially. For the 869 relay, unbalance is defined as the ratio of negative-sequence to positive-sequence current.

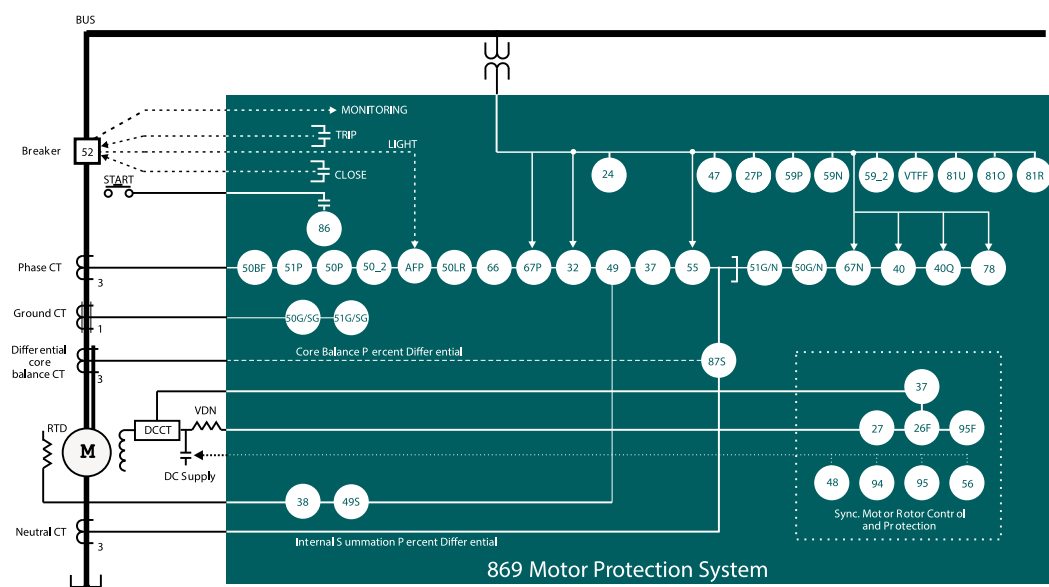
Voltage and Frequency Protection

The voltage and frequency protection functions detect abnormal system conditions such as over/under voltage, over/under frequency and/or phase reversal that are potentially hazardous to the motor.

Undercurrent Protection

The undercurrent protection element provides the ability to trip the motor due to external conditions causing the load being driven by the motor to drop below a pre-set level. This function is used to protect pumps from loss of suction, fans from loss of airflow due to a closed damper or a conveyor system due to a broken belt.

Functional Block Diagram



ANSI DEVICE	DESCRIPTION
12/14	Over Speed Protection/ Under Speed Protection
24	Volts per Hertz
26F	Sync. Motor Field Overtemperature
27F	Sync. Motor Field Undervoltage
27P	Phase Undervoltage
32	Directional Power
37	Undercurrent
37F	Sync. Motor Field Undercurrent
37P	Underpower
38	Bearing RTD Temperature
40	Loss of Excitation
41	Loss of Excitation
40Q	DC Field Breaker/Contactor
46	Current Unbalance
47	Phase Reversal
48	Incomplete Sequence
49	Thermal Model
49S	Stator RTD Temperature

ANSI DEVICE	DESCRIPTION
50BF	Breaker Failure
50G	Ground Instantaneous Overcurrent
50SG	Sensitive Ground Instantaneous Overcurrent
50SG/G	Ground Fault
50LR	Mechanical Jam
50N	Neutral Instantaneous Overcurrent
50P	Phase Instantaneous Overcurrent
50_2	Negative Sequence Instantaneous Overcurrent
51G	Ground Time Overcurrent
51SG	Sensitive Ground Time Overcurrent
51N	Neutral Time Overcurrent
51P	Phase Time Overcurrent
52	AC Circuit Breaker
55	Power Factor
56	Sync. Motor Start Sequence Control
59F	Sync. Motor Field Overvoltage
59N	Neutral Overvoltage

ANSI DEVICE	DESCRIPTION
59P	Phase Overvoltage
59X	Auxiliary Overvoltage
59_2	Negative Sequence Overvoltage
66	Maximum Starting Rate
67N	Neutral Directional Element
67P	Phase Directional Element
76F	Sync. Motor Field Overcurrent
78	Out-of-Step Protection
81O	Overfrequency
81U	Underfrequency
81R	Frequency Rate of Change
86	Start Inhibit
87S	Stator Differential
90F	Sync. Motor Power Factor Regulation
95	Reluctance Torque Sync/Resync.
96	Autoloading Relay
AFP	Arc Flash Protection
VTFF	Voltage Transformer Fuse Failure

Table 1-1: ANSI Device Numbers and Functions

Acceleration Time	FlexLogic Equations	Reduced Voltage Starting
Analog Input	Flex States	RTD Temperature
Analog Output	IEC 61850 Communications	Setpoint Groups (6)
Breaker Arcing Current (I2t)	Mechanical Jam	Short Circuit
Broken Rotor Bar	Metering: current, voltage, power, PF, energy, frequency, harmonics, THD	Stator Inter-Turn Fault
Switching Device Control	Modbus User Map	Time of Day Timer
Breaker Control	Motor Health Report	Trip Bus (6)
Breaker Health	Motor Learned Data	Transient Recorder
(Oscillography)		
Data Logger	Motor Start Records	Trip and Close Coil Monitoring
Demand	Motor Start Statistics	User-programmable LEDs
Digital Counters	Non-volatile Latches	User-programmable
Pushbuttons		
Event Recorder	OPC-UA Communications	Virtual Inputs (32)
Fault Report	Output Relays	Virtual Outputs (32)
Fast underfrequency	Overload Alarm	Voltage Disturbance
FlexElements	Power Quality	

Table 1-2: Other Device Functions

Motor Start Supervision

Motor start supervision consists of the following features: Time-Between-Starts, Start-per-Hour, Restart Time and Start Inhibit. These elements are intended to guard the motor against excessive starting duty, which is normally defined by the motor manufacturer in addition to the thermal damage curves. The Emergency Restart enables the user to reset the Motor start supervisions in case of process needs.

The start inhibit function prevents the starting of a motor when the motor is too hot and does not have a sufficient amount of thermal capacity available to allow a start without being tripped offline. In case of emergency, the thermal capacity used and motor start supervision timers can be reset to allow a hot motor to start.

Volts/Hz

To take care of over excitation that may result in saturation of the magnetic core or over heating due to stray flux.

In the 869, the per-unit volts-per-hertz (V/Hz) value is calculated using the maximum of the three-phase voltage inputs or the auxiliary voltage.

Mechanical Jam and Acceleration Time

These two elements are used to prevent motor damage during abnormal operational conditions such as excessively long acceleration time or stalled rotors. The mechanical jam element senses increased loading associated with process or load related faults such as an overloaded conveyor.

The Multilin 869 protects the motor from overheating in cases of abnormal loading during motor starts. The motor can be tripped if the motor does not reach a running condition within the programmable motor acceleration time.

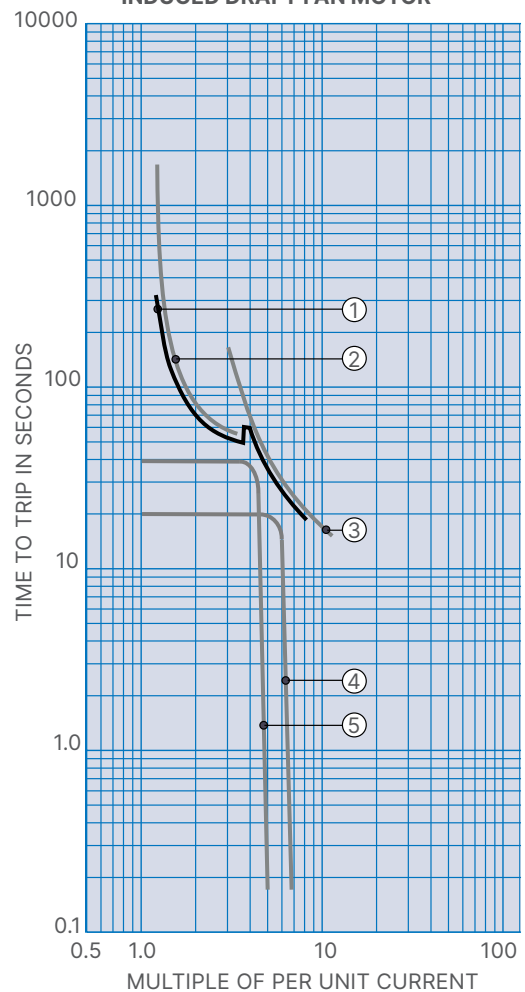
Adaptive Protection

The Multilin 869 offers effective, reliable management of motors. With dynamic, sensitive settings, the 869 provides secure and dependable protection. With six setting groups, the 869 provides the sensitive settings range and groups required to ensure no compromise is made to meet changing system conditions. These setting groups can be enabled automatically or manually via digital inputs, virtual inputs or remote communications to address system needs, ensuring greater system reliability and efficiency.

FlexCurves

For applications that require greater flexibility, FlexCurves™ can be used to define custom curve shapes. These curves can be used to protect motors with different rotor and stator damage curves, allowing complete protection over the total motor capacity.

**TYPICAL CUSTOM CURVE - 6500HP, 13800 VOLT
INDUCED DRAFT FAN MOTOR**



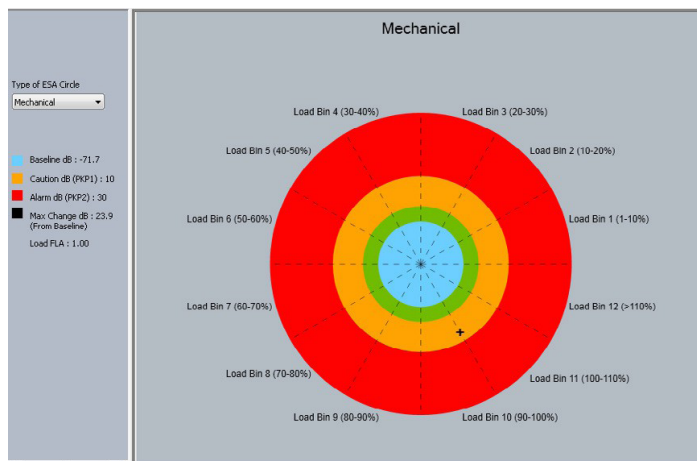
1. PROGRAMMED FLEXCURVE
2. RUNNING SAFETIME (STATOR LIMIT)
3. ACCELERATION SAFETIME (ROTOR LIMIT)
4. MOTOR CURRENT @ 100% VOLTAGE
5. MOTOR CURRENT @ 80% VOLTAGE

Typical FlexCurve overload curve.

Monitoring & Diagnostics

The Multilin 869 includes high accuracy metering and recording for all AC signals. Voltage, current, and power metering are built into the relay as a standard feature. Current and voltage parameters are available as total RMS magnitude, and as fundamental frequency magnitude and angle.

Please refer to the 8 Series brochure for more information related to Communication, metering & monitoring.



Electrical Abnormalities

If undetected, insulation failure can evolve into phase or ground faults, causing equipment damage or loss and significant unplanned downtime. The 869's advanced motor monitoring and trending capabilities provides identification of critical electrical conditions including:

- Stator inter-turn insulation
- Phase-phase insulation
- Stator ground failure
- Loss of load/process
- Unbalance current
- Power factor
- Under/Over frequency

Thermal Abnormalities

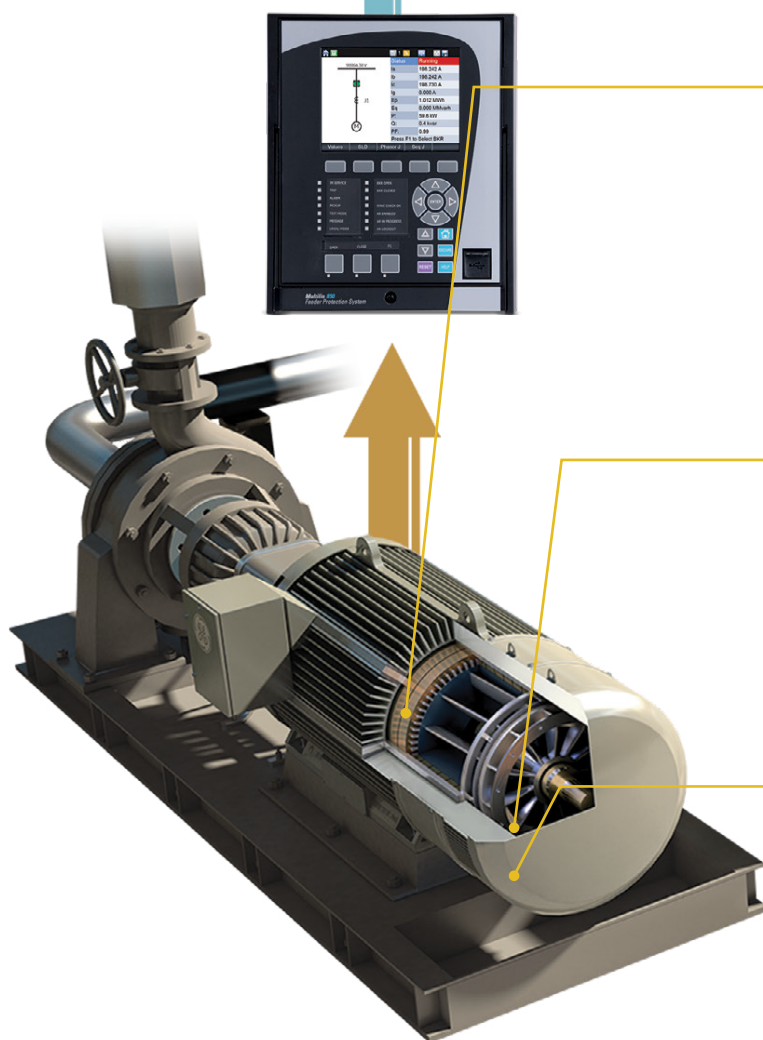
The 869 continuously and proactively monitors the motor for Thermal Capacity Used (TCU) to provide early warning of thermal stresses including:

- Extreme starting conditions
- Ambient Temperature
- Forced cooling stops
- Harmonics
- Single phasing
- Unbalance current
- Increase load
- Locked rotor

Mechanical Abnormalities

Without the need for additional sensors or probes the 869 utilizes Electrical Signature Analysis (ESA) / Motor Current Signature Analysis (MCSA) to identify mechanical abnormalities in the motor including:

- Broken Rotor Bar
- Bearing Failure
- Mechanical Jam
- Static & Dynamic Eccentricity
- Foundation Looseness
- Misalignments



Integrated Motor Monitoring & Diagnostics

Motor failures and faults can have a significant impact on a process, resulting in loss of revenue and material. Predictive maintenance and situational awareness to the motors operating condition can help reduce unplanned downtime and energy consumption - maximizing motor output and life.

The Multilin 869 offers an integrated, cost effective monitoring and diagnostics features that leverage existing relay data without the need for additional devices, sensors, wiring or training.

Motor monitoring & diagnostic features include Stator turn to turn fault, Broken rotor bar detection, Roller bearing faults, foundation looseness, eccentricity, and misalignments. Using advanced Motor Current Signature Analysis (MCSA), the 869 continuously analyzes the motor current signature and based on preset algorithms will determine when an electrical, thermal or mechanical fault / failure condition exists in the motor.

By providing early indication of potential electrical, thermal or mechanical failures, serious system issues can be avoided, such as reduced starting torque, overloads, torque and speed oscillation and bearing wear.

With fully programmable alarms, the Electrical Signature Analysis or Motor Current Signature Analysis provides advanced warning and early detection of impending electrical, thermal or mechanical issues, enabling maintenance personnel to schedule for predictive maintenance of the motor thereby preventing catastrophic motor failures to maximize motor life, repair costs, and system uptime.

Voltage Disturbance

The Voltage disturbance function of Voltage Swell and Voltage Sag, as described in IEEE 1159-2009.

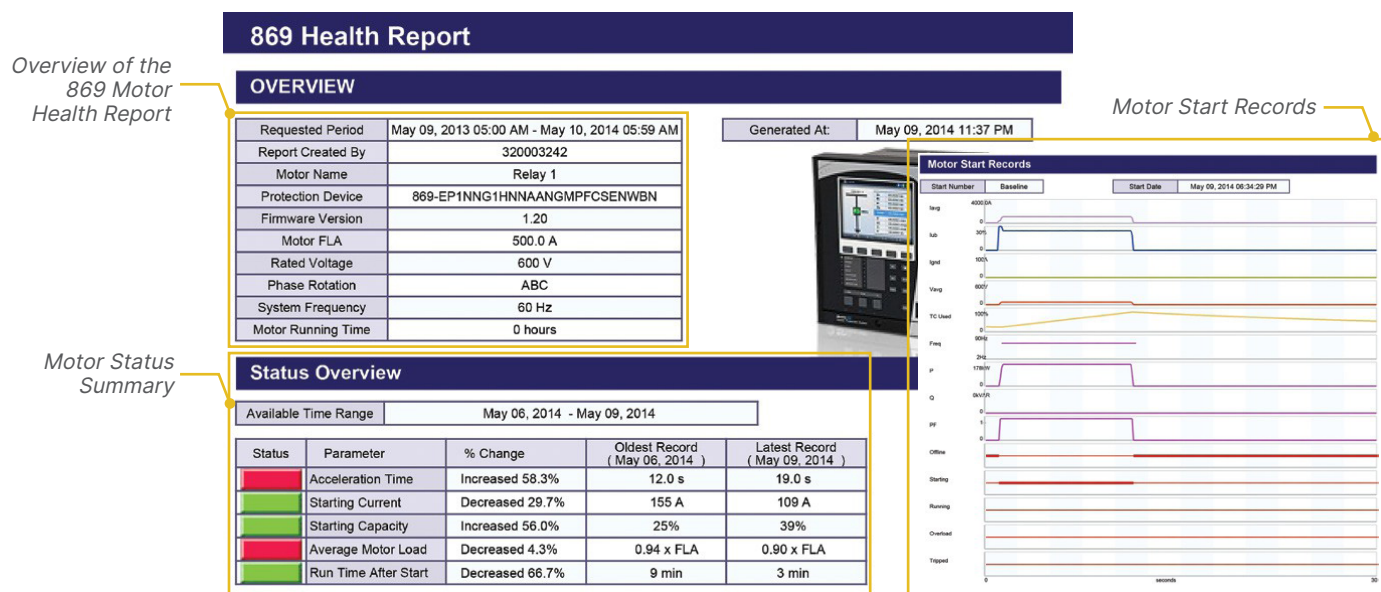
When the voltage on any phase drops below this level a voltage sag condition occurs. Voltage sags are usually associated with system faults but can also be caused by switching heavy loads or starting large motors. Short duration voltage sag may cause process disruptions.

Voltage swells are usually associated with system fault conditions, but they are much less common than voltage sags. An SLG fault on the system can cause a swell to occur, resulting in a temporary voltage rise on the healthy phases. Swells can also be caused by switching off a large load, load shedding, or switching on a large capacitor bank. Voltage swell may cause failure of the components depending upon the magnitude and frequency of occurrence.

Over speed

Any of the input contacts can be used to read the pulses from the input source to determine the speed of the motor. The source of the pulses can be an inductive proximity probe or Hall Effect gear tooth sensor. Two modes of speed: under speed and over speed can be defined.

Multilin 869 Motor Health Report



Proactive Motor Management System

The Multilin 869 delivers a patented approach of integrating advanced monitoring and diagnostic capabilities. Without the cos sensors, the powerful 869 delivers electrical, thermal, and mechanical failure mode detection for electric motors. With early detection and warning asset managers and operators are able to take proactive maintenance steps, reducing costs associated with unplanned downtime and expensive device repair or replacement.

When coupled with the 869's comprehensive protection & control functions, the 869 delivers a continuous, online, and holistic approach to motor management. Starting from detection of an anomaly or degradation of a motor component, to alarming of the condition, to recording and logging the signals and evolving changes, the 869 provides comprehensive condition-based monitoring and visualization.

Advanced Motor Health Report

The 869 motor health report provides a quick snapshot of the motor operating and diagnostic information in an easy way to allow users to make decisions about health of the motor. Based on the graphical representation and trend values of the motor historical data gathered by the 869, users can quickly identify process issues and maintenance requirements before damage occurs and costly repairs are required.

The motor health report quickly provides a motor operation summary with detailed information in seven categories.

- **Device Overview:** gives general information on the motor, including requested period, user name, device name, order code, firmware version, motor and system settings, and motor total running time.
- **Status Overview:** summarizes the historical learned data and gives an evaluation of the status of the motor, including the oldest and latest values of acceleration time, starting current, start thermal capacity used, average motor load, and average running time.
- **Trip Summary:** presents a summary of the events that have tripped the motor.
- **Motor Operating History:** counts the amount of events in terms of Motor Starting/Running, Manual Stop Commands, Trip Commands, Lockouts, Alarm Conditions, and Emergency Restarts.
- **Motor Starting Learned Data:** collects the learned data, including acceleration time, starting current, start thermal capacity used, average motor load, and average running time.
- **Motor Start Records:** displays the start data, including average of three phase RMS currents, current unbalance, ground current, average of threephase RMS voltages, thermal capacity used, frequency and motor status.
- **Motor Stopping/Tripping:** gives details on the events that are specifically related to the stopping and tripping of the motor.

Cyber Security

869 cyber security enables the device to deliver full cyber security features that help operators to comply with NERC CIP guidelines and regulations.

- AAA Server Support (Radius/LDAP)
- Role Based Access Control (RBAC)
- Event Recorder (Syslog for SEM)



Cyber Security with Radius Authentication

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

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