Advanced Motor Management

"GE Multilin. . . The recognized leader in motor protection and control with the most complete line of motor protection solutions in the industry"

imagination at work

Modern Industrial Facility Requirements for Motor Protection Systems

- Protection
- Control
- Monitoring
- Metering
- Communication
- Inputs & Outputs
- Ease of Use
- Reliability

Why?

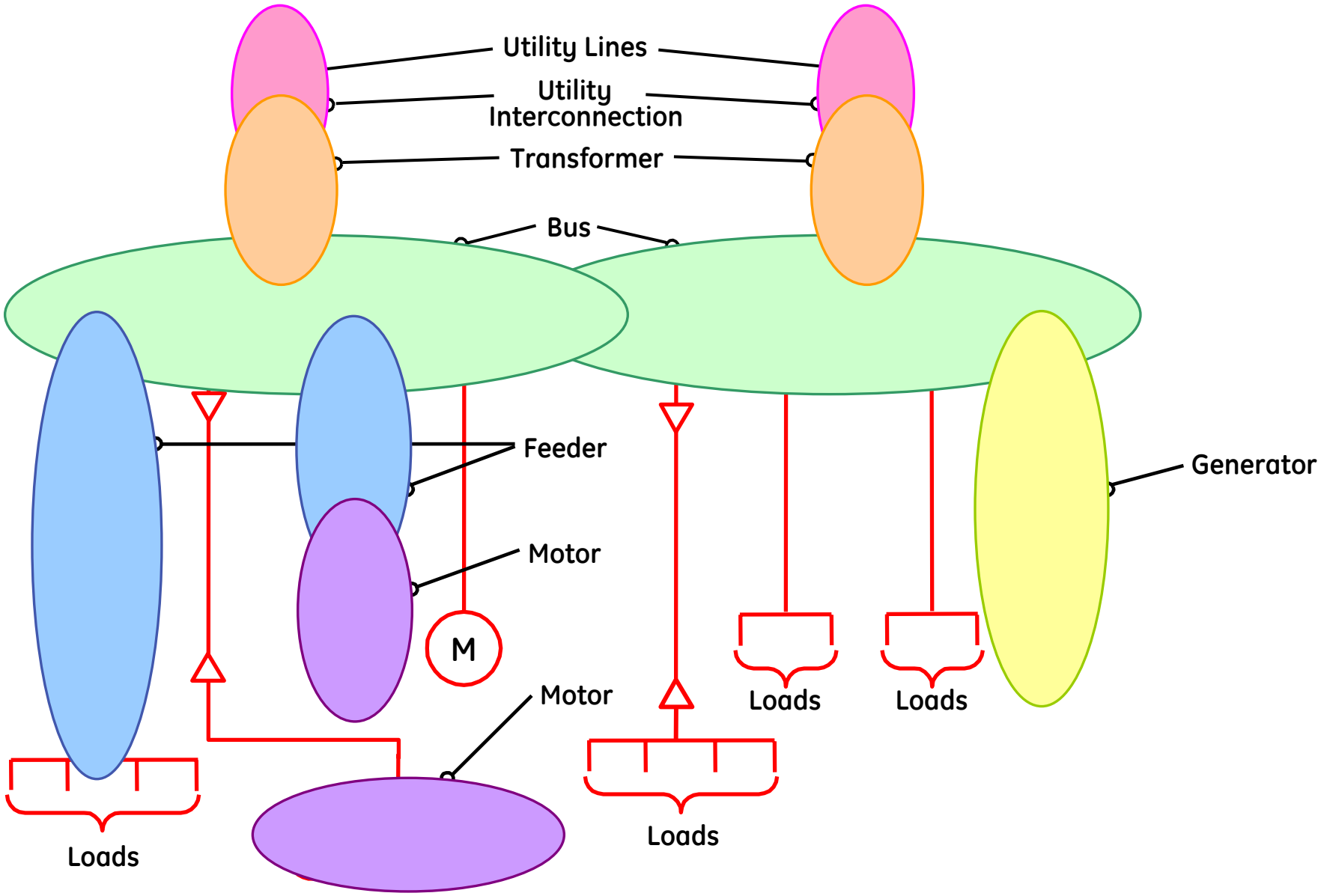
1) Save 1st Cost and Project Cost ($$$)
2) Improve Protection (Asset Preservation & Safety)
3) Improve Tools for Operations (Process Continuity)

Improving Industrial Motor Protection Systems

Explore How GE-Multilin Protection, Control and Software Solutions Can Help:

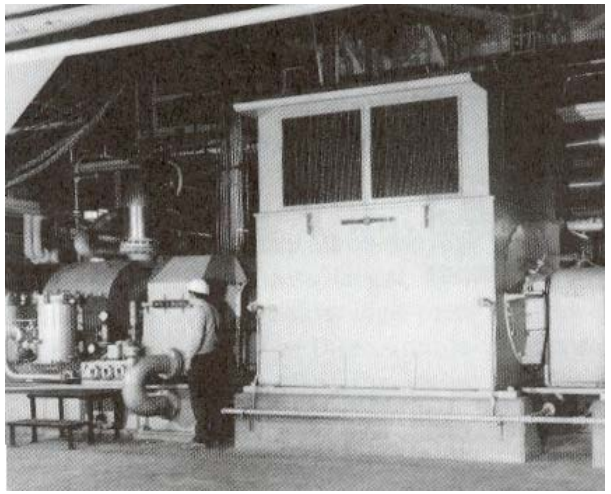
- Improve Safety
- Preserve Infrastructure
- Diagnose Electrical Problems
- Drive JIT/RCM Programs
- Increase Dependability
  - Security, Reliability, Simplicity
- Decrease Maintenance
- Facilitate Standardization
- Hasten Project Execution

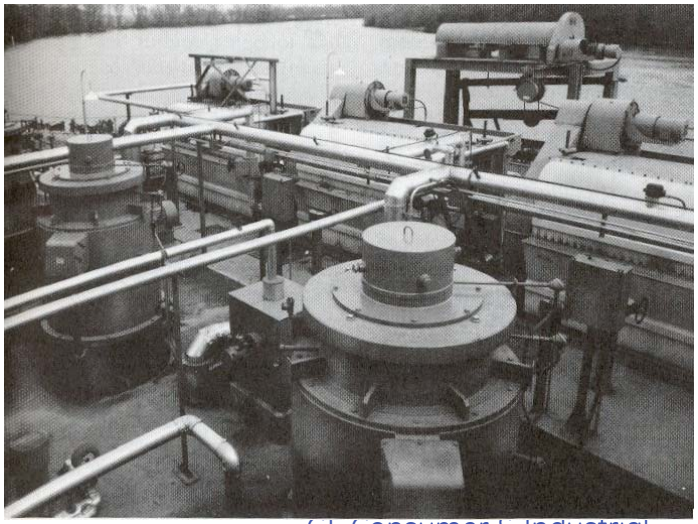
Industrial Electrical Protection Applications



Various Industry Motor Applications

- Fans, Blowers
- Pumps, Compressors
- Grinders, Chippers
- Conveyors, Elevators
- Crushers, Mixers





What Fails?

Per 1985 EPRI & IEEE Surveys

- Bearings (40 - 50%)
- Stator (25 - 35%)
- Rotor (<10%)
- Other Failures

Motor Electrical Protection

- Phase Fault
- Ground Fault
- Abnormal Operating Conditions
  - Voltage
  - Frequency
  - Voltage and current imbalance
  - Load loss
  - Jamming
  - Jogging
- Thermal Overload
  - Process caused
  - High ambient conditions

Short Circuit - Overcurrent Elements

- Phase Overcurrent (50)
  - Used when contactor or breaker is rated for fault interruption
  - Not used for fused starters
- Residual Overcurrent (50N)
  - Sum of phase CT currents, used on solidly grounded motors

Short Circuit - Overcurrent Elements

- Ground Overcurrent (50N)
  - Frequently, ground fault current is limited by transformer neutral resistor, and a separate low-ratio CT is warranted for ground fault protection
    - Detect motor and cable ground faults using window CT with lower ratio for increased sensitivity

Abnormal Operating Conditions

- Load-Loss (37)
  - Protection against pumps running dry, belt/linkage breakage
- Load-Jam or Stall (39)
- Starts/Hour, Time Between Starts (66) (antijogging protection)
- Current Unbalance Element (46)
  - Negative sequence currents rapidly heat stator when running at rated speed

Abnormal Operating Conditions

- Phase Reversal Protection (46 or 47)
- Anti-Backspin Protection

Abnormal Operating Conditions

- Undervoltage
- Overvoltage
- Underpower Element
- Power Factor Element
- Frequency Element

Motor Mechanical - Bearings

- Lubricant issues
  - Grade, contaminants, availability
- Mechanical
  - Excessive radial loading, axial loading
- Rough surfaces
  - Fatigue, cracks, shaft currents
- Vibration
  - Unbalanced phase currents and harmonics

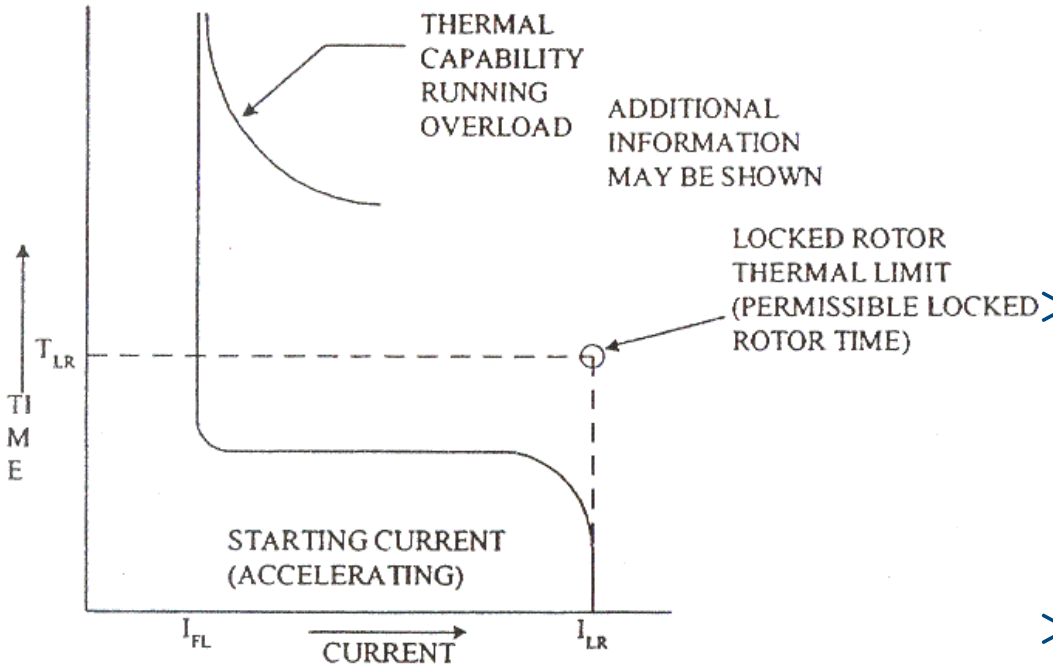
RTD Uses

- Detect Winding Temperature
  - Bias Thermal Model
- Detect Bearing Temperature
  - Detect mechanical issues
- Detect Loss of Cooling Efficiency
  - Cooling system failure
  - High ambient temperature

> Other process variable

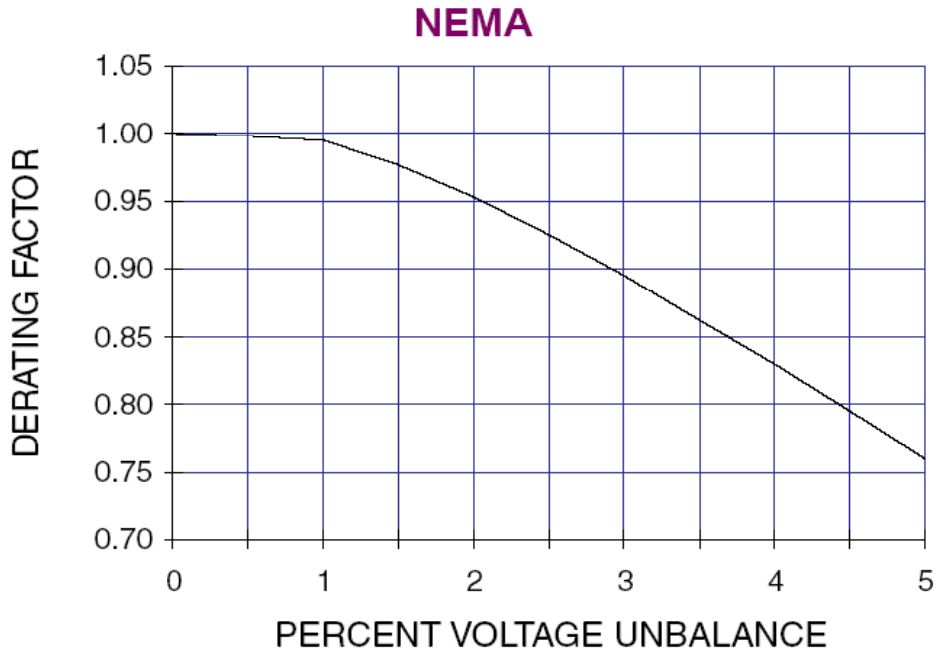
  - Vibration

Thermal Modeling



- Best way to prevent short in motor is to not overheat and degrade the insulation
- Repeated overheating of motor insulation causes cumulative degradation
- Both the stator and the rotor can be overheated

Current Imbalance Derates Thermal Capacity



- Standing negative sequence (current imbalance) causes heating in both the stator and rotor
- Negative sequence current caused by voltage imbalance across load (motor)

Effect of Voltage

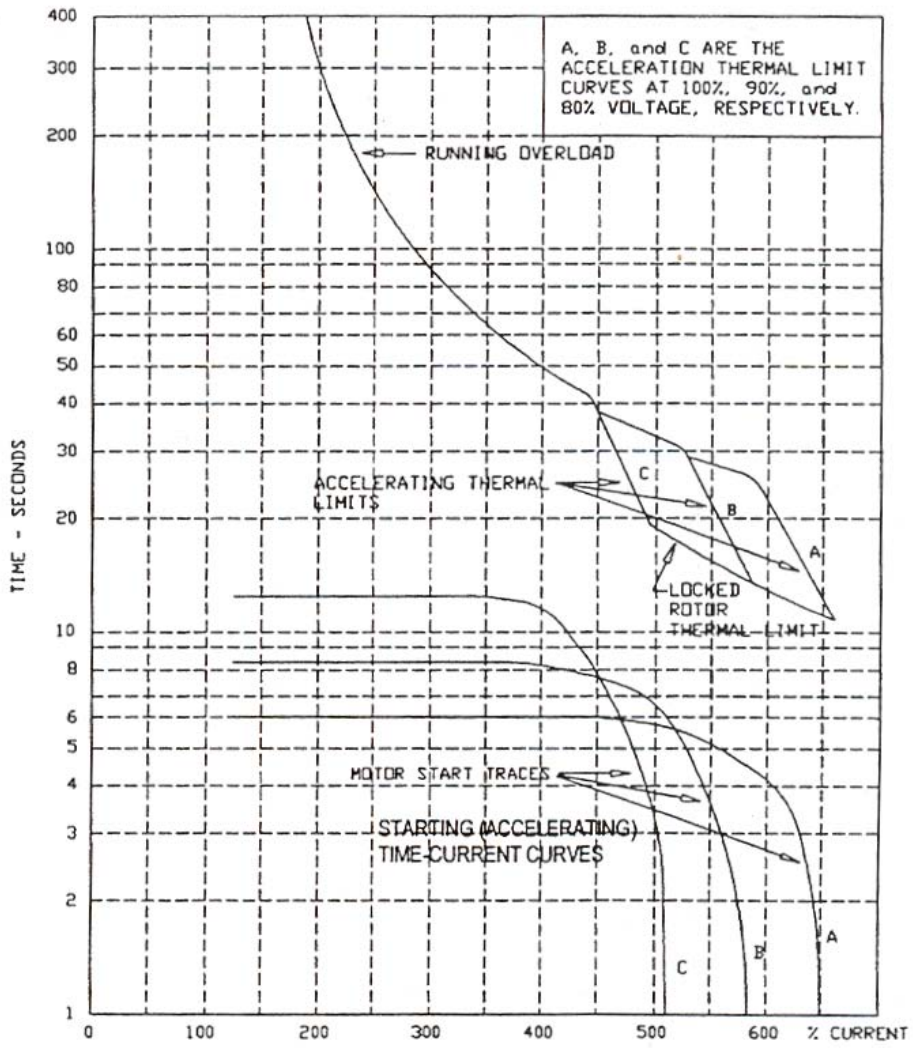


Figure 6 (b)—Typical time-current and thermal limit curves (adapted from IEEE Std 620-1996, Figure 1)

- Starting time sand current are voltage dependent
- Lower voltage causes lower current and lower torque, therefore longer start times

Effect of High Inertia

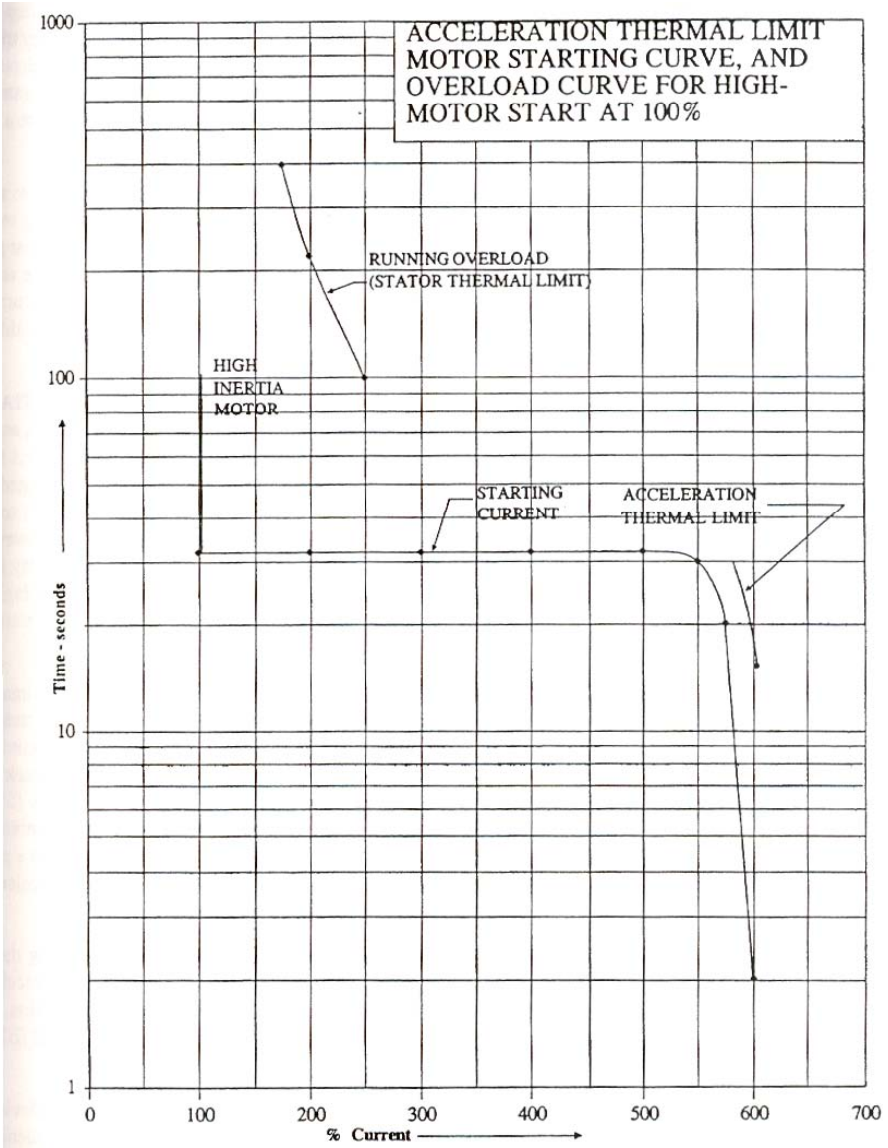
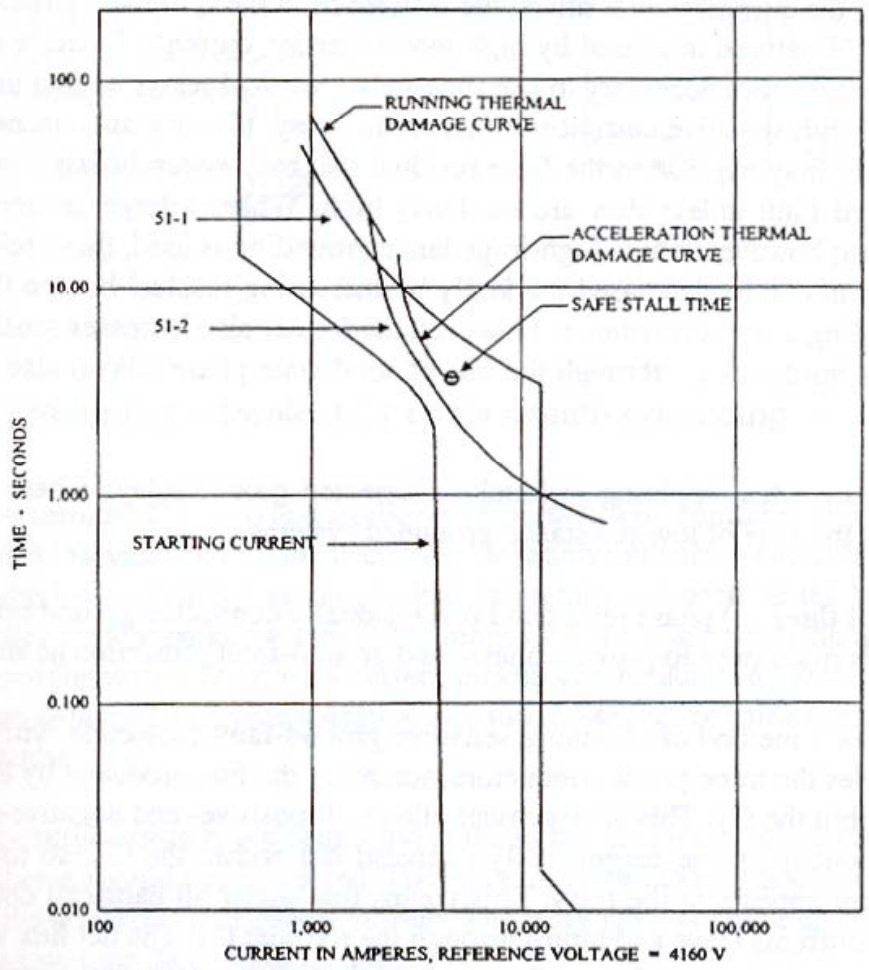


Figure 7—Typical time-current and thermal limit curves for high-inertia motor start

- High inertial starts tend to use a lot of the thermal capacity available in a motor
- Difficult to coordinate with single OC curve

OL Curve Fitting



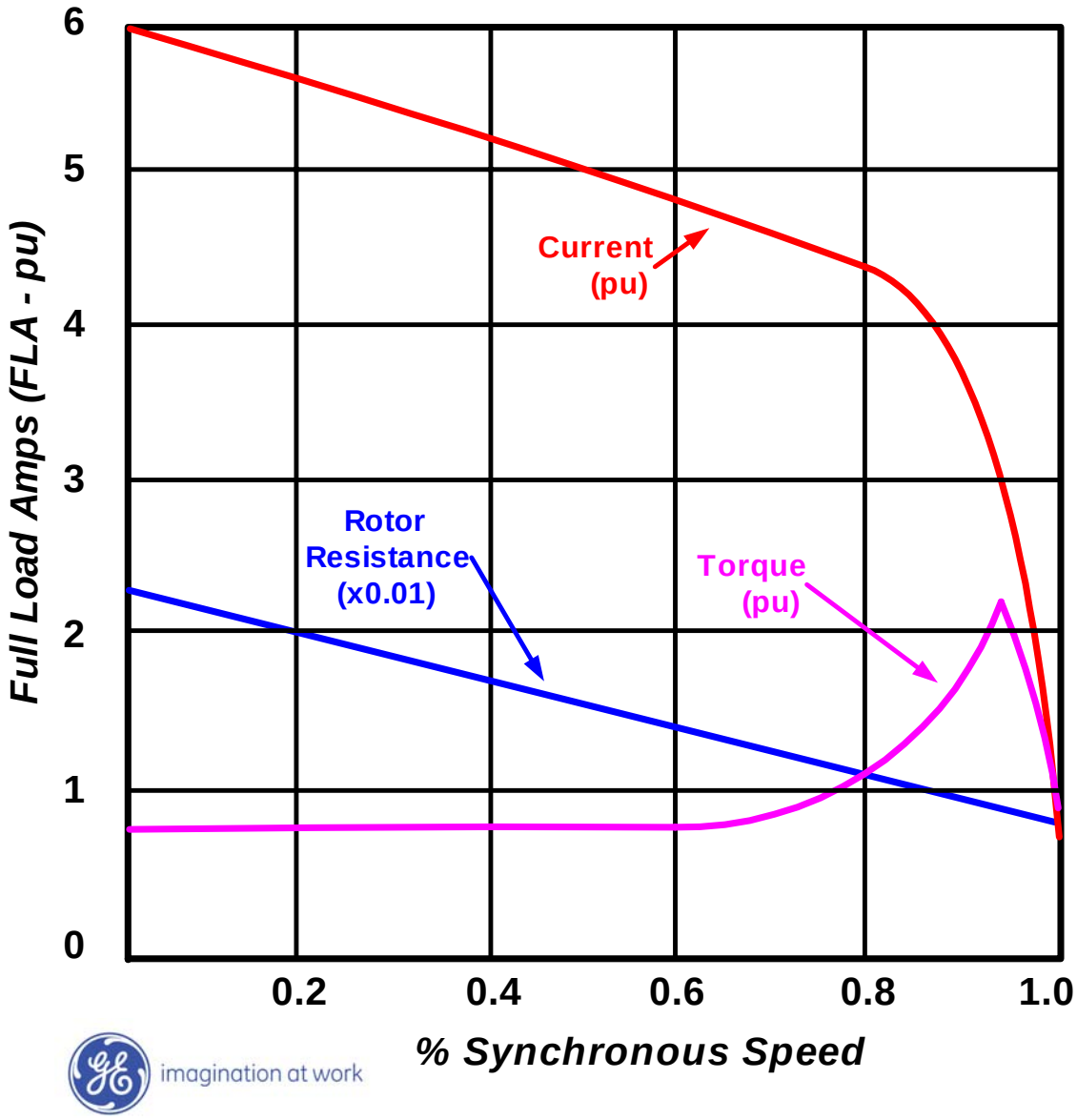
-Thermal damage protection utilizing two overcurrent relays with different pickups and timing characteristics

- Multiple OC curves may be used to attempt difficult coordination, but OC elements do not have thermal memory
- Thermal memory is needed for proper modeling with multiple starts

Rotor Heating on Start Up

The thermal capacity of the rotor cannot be measured directly, but is rather inferred from curves supplied by the motor manufacturing and monitoring of current and recent operating activity

Rotor Resistance & Current



- Rotor Resistance decreases as motor approaches full speed
- The ratio is a 3:1 reduction
- The phenomena is the result of the slip frequency and the skin effect of the current traveling through the rotor bar surface as the frequency increases

Heating Factors

- Positive and negative sequence currents contribute to heating during various operational modes of the motor
  - > Starting: Effect for I_1 and I_2 is 3X the measured current
  - > Running: Effect for I_1 is 1X, and the effect for I_2 is 5X the measured current
- These factors are derived from the rotor resistance and the positive and negative sequence slips
- These factors are taken into account when motor damage curves are developed by the motor manufacturer
  - > Rotor heating is severe at locked rotor conditions
  - > Locked rotor conditions can heat rotor at 108X running!
  - > Stator heating increases due to unbalanced voltage supply to the motor

MOTOR PROTECTION SYSTEM

Complete, integrated protection and management of medium and large motors.

imagination at work

Presentation Overview

- Key Benefits
- Applications
- Protection Features
- Additional & Special Features
- Inputs & Outputs
- Communications
- Reliability
- Connections
- User Interface
- Metering & Monitoring Features
- Event Log
- Reports
- Trending
- Waveform Capture
- Ordering Code
- Summary
- Going Forward

Key Benefits

- **Unique protection features** - Comprehensive motor protection, control and Monitoring
- **Most advanced thermal model** - Including multiple RTD inputs for stator thermal protection
- **Advanced monitoring functions** - vibration, bearing temperature
- **Best in class man machine interface (MMI)** - Large backlit display with 40 characters to view relay information and settings in direct sunlight, full numerical keypad, and setpoint navigation keys.

Key Benefits

- **Minimize replacement time** - Draw-out construction
- **Complete asset monitoring** - Temperature, Analog I/O, full metering including demand & energy
- **Reduce troubleshooting time and maintenance costs** – Event reports, waveform capture, data logger
- **Simplify testing** - Built in simulation features
- **Filed upgradeable** – Through flash memory

Key Benefits

- **Simplify testing** - Built in simulation features
- **Cost effective Access to information** - Via Modbus RTU protocol, through standard RS232 & RS485 serial ports, and optional Modbus RTU over TCP/IP through embedded Ethernet Port to connect to 10MB Ethernet local or wide area networks.
- **Long lasting life** when exposed to chemically corrosive and humid environments with optional conformal coating

Use the 469 to protect Large Induction and Synchronous Motors

- Fans
- Pumps
- Compressors
- Milling
- Crushers
- Grinders
- Conveyers
- Shredders
- Extruders
- Chippers
- De-barkers
- Refiners
- Blowers
- Cranes
- Chillers

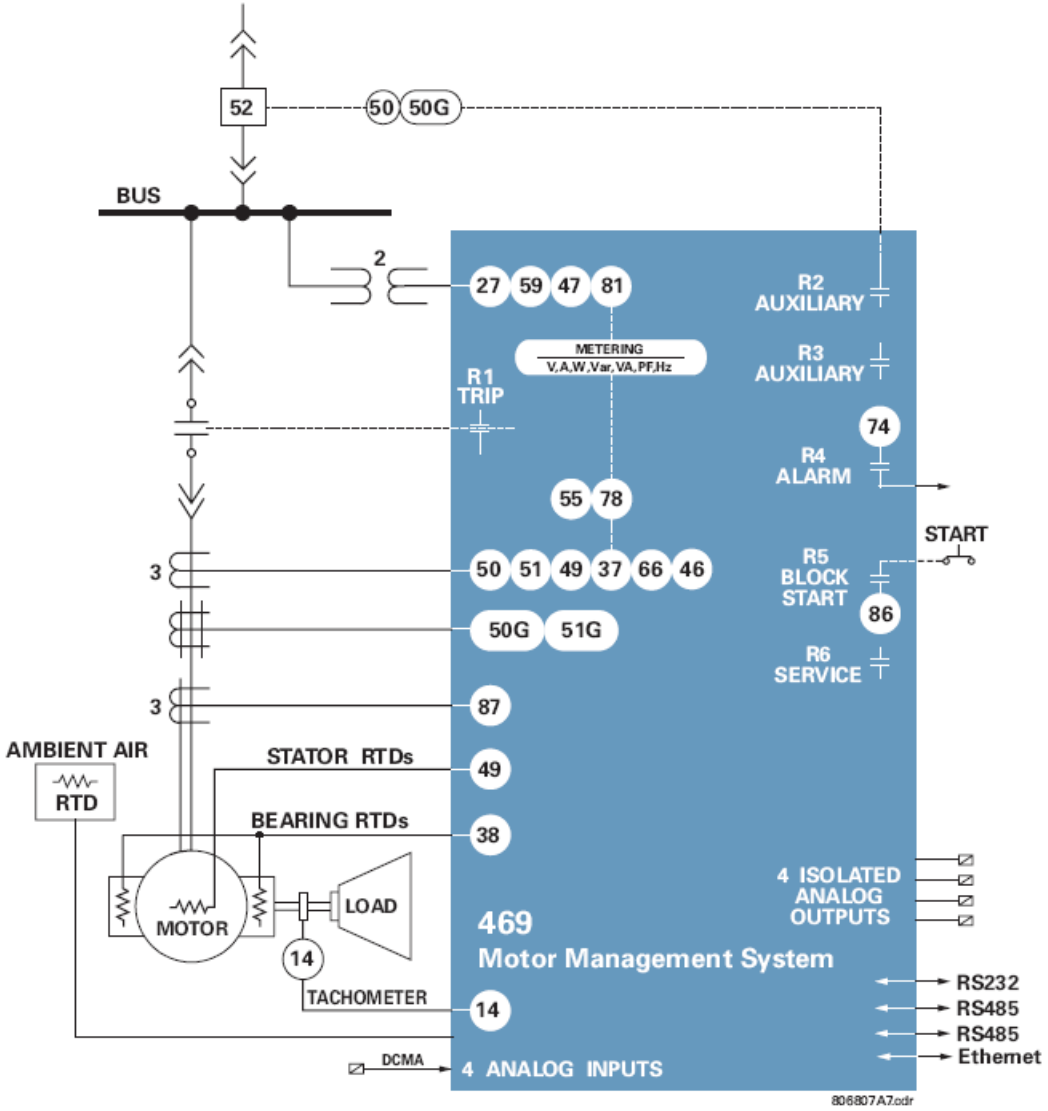
469 – Protection Features

- Thermal modeling of stator and rotor
- RTD (Resistive Thermal Device) and negative sequence feedback
- Overload protection (15 standard curves plus custom “FlexCurve™”)
- Voltage dependent curve for rotor modeling during long acceleration
- Adapts for hot or cold starts
- Power factor with time delays

469 – Protection Features

- Differential
- Under & over, voltage & frequency
- Start protection including:
  - Locked rotor
  - Acceleration timer
  - Starts/hour
  - Time between starts
  - Start inhibit
  - Restart block
- Ground overcurrent
- Short circuit
- Unbalance
- Single phase/phase reversal
- Mechanical jam/rapid trip

469 Application – Function Diagram



DEVICE	PROTECTION
14	Speed switch
19/48	Reduced voltage start and incomplete sequence
27/59	Undervoltage/Overvoltage
32	Reverse power
	Mechanical Jam
	Acceleration time
	Over Torque
37	Undercurrent/Underpower
38	Bearing RTD
46	Current Unbalance
47	Phase Reversal
49	Stator RTD
50	Short circuit backup
50G/51G	Ground overcurrent backup
51	Overload
55	Power factor
66	Starts/hour and time between starts
81	Frequency
86	Overload lockout
87	Differential

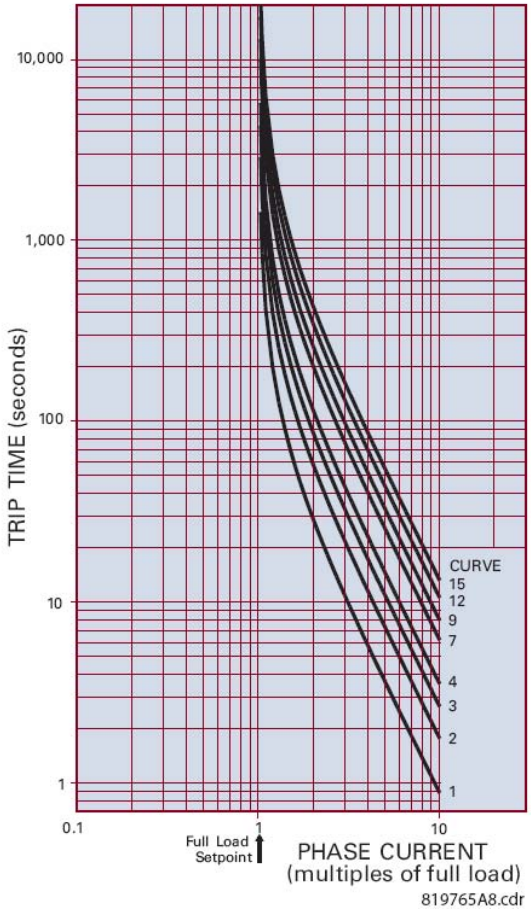
Overload Protection

- Uses nameplate data to create thermal model
  - Starts per hour
  - Hot stall time
  - Cold stall time
- Can learn cooling time with RTD input
- FlexCurve for difficult coordination
- Emergency start override for thermal model

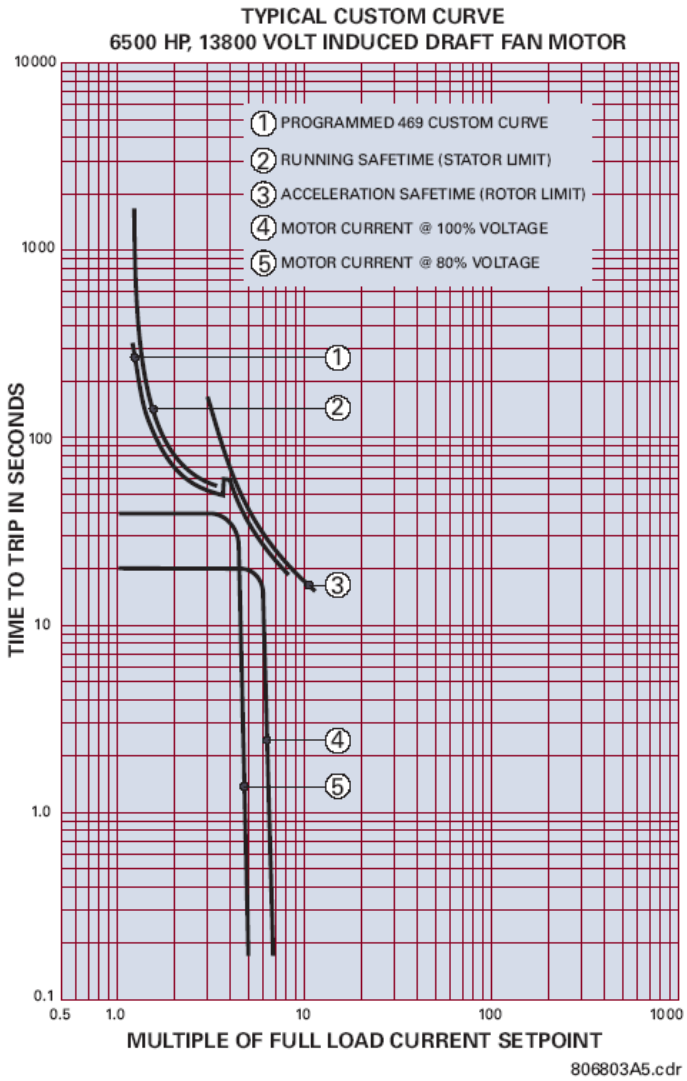
Overload Protection

- 15 Standard Curves
- FlexCurve

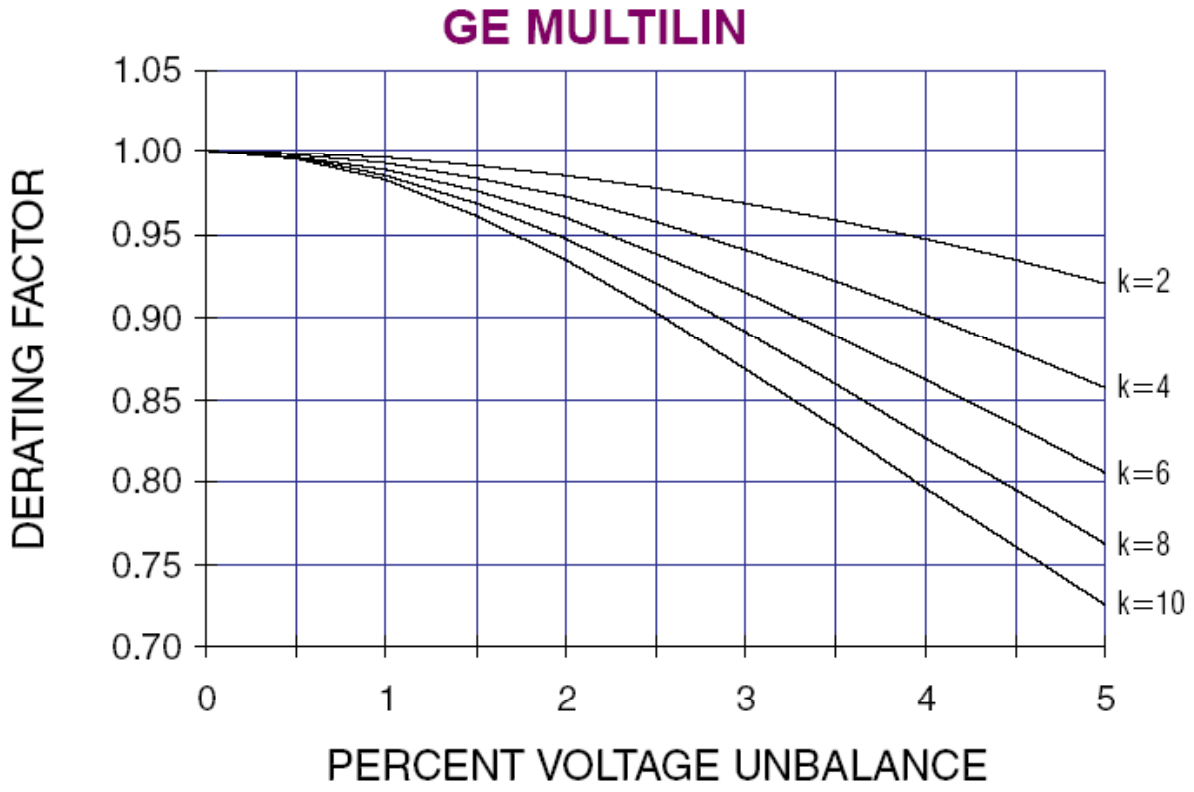
Fifteen standard overload curves.



Typical custom overload curve.



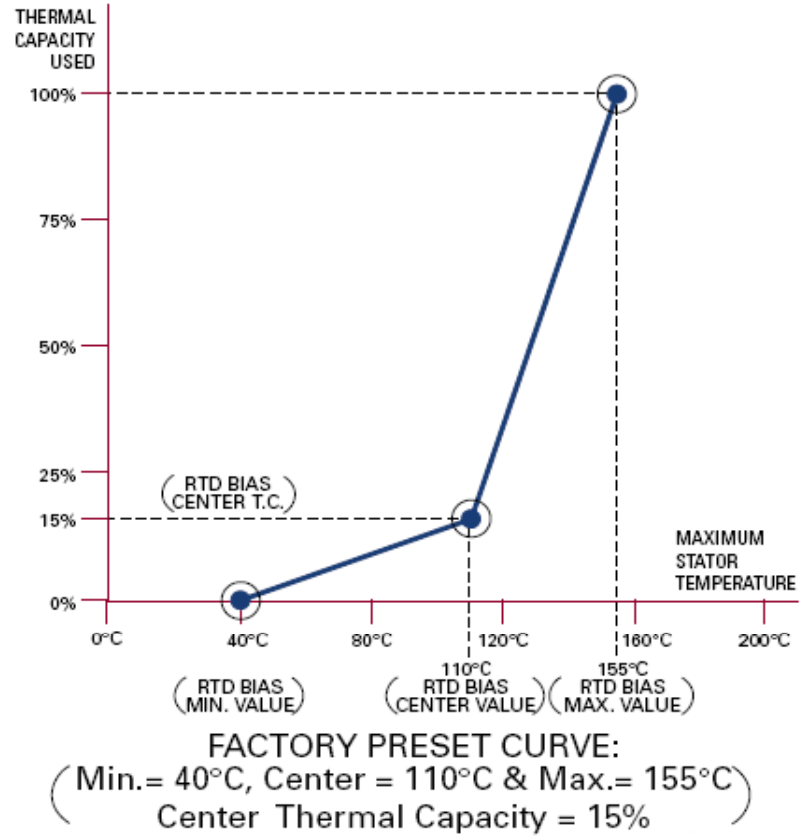
Overload Protection



Negative sequence (current unbalance) biasing for improved protection against rotor damage

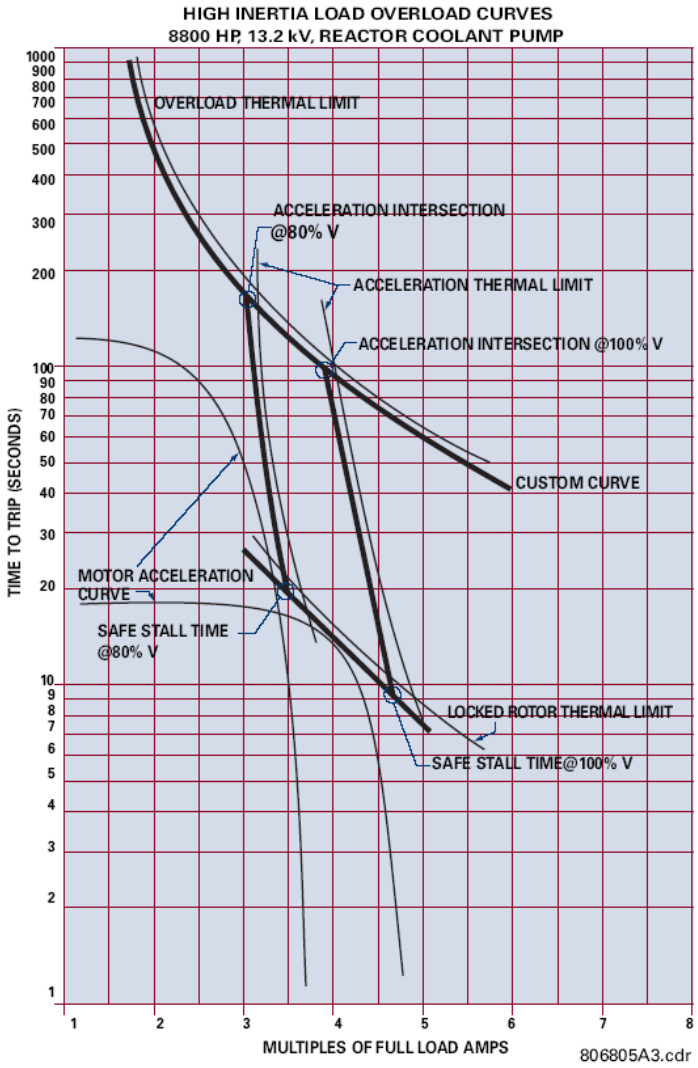
- K = 8 is NEMA derating

Overload Protection



Stator temperature biasing for improved protection against stator damage when stator is hot

Voltage Dependant Thermal Protection



The voltage dependent overload curves are used in high inertia load applications, where motor acceleration time can actually exceed the safe stall time and motor thermal limits.

During motor acceleration, the programmed thermal overload curve is dynamically adjusted with reference to the system voltage level. The selection of the overload curve type and the shape is based on motor thermal limit curves provided by motor vendor.

Additional and Special Features

- Two speed motor protection.
- Load averaging filter for cyclic load applications.
- Reduced voltage starting supervision.
- Variable frequency filter allowing accurate sensing and calculation of the analog values in VFD applications.
- Analog input differential calculation for dual drives applications.
- Speed counter trip and alarm.
- Universal digital counter trip and alarm.
- Pulsing KWh and Kvarh output.
- Trip coil supervision.
- Drawout indicator, Setpoints Access and Test permit inputs.
- Undervoltage auto restart (additional element per special order).
- Experimental broken rotor bar detection system (additional element per special order).

469 – Inputs & Outputs

Inputs

- Universal Power Supply (ac/dc)
- 3 phase CTs & VTs
- Differential currents: 5 or 1 amp
- 4 analog channel inputs
- 9 selectable logic inputs

Outputs

- 5 electromechanical output relays, 10 amp continuous, 30 amp make & carry
- 4 Assignable analog outputs
- 1 fail-safe self-test

Communications

Protocols

- Modbus®RTU over Serial RS232 or RS485 Ports
- Modbus®RTU over TCP/IP via Ethernet Port
- DeviceNet

Man Machine Interface

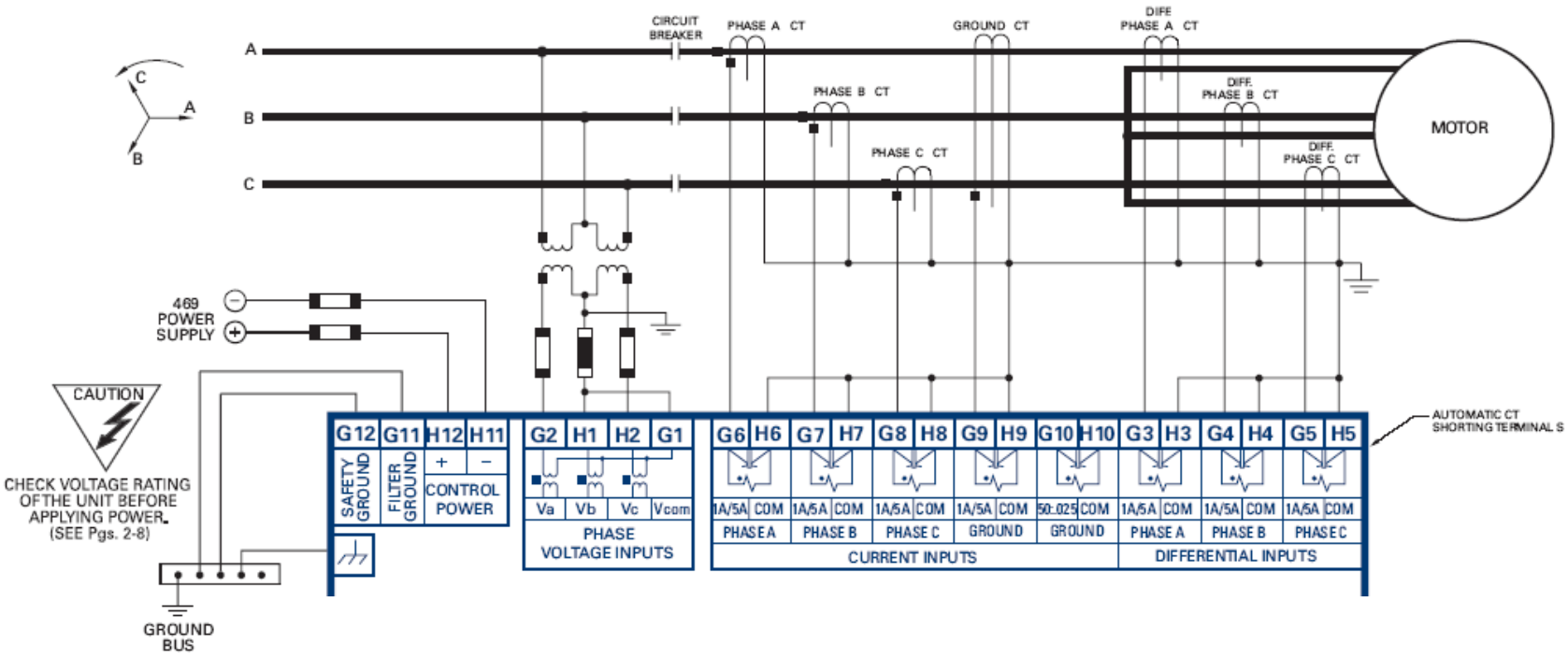
Windows based EnerVista 469 Setup Software allows access to:

- Actual Values
- Setpoints
- Status
- Event records
- Oscillography
- Graphical trending
- Setpoint programming
- Setpoint files
- Download updated firmware to Flash memory

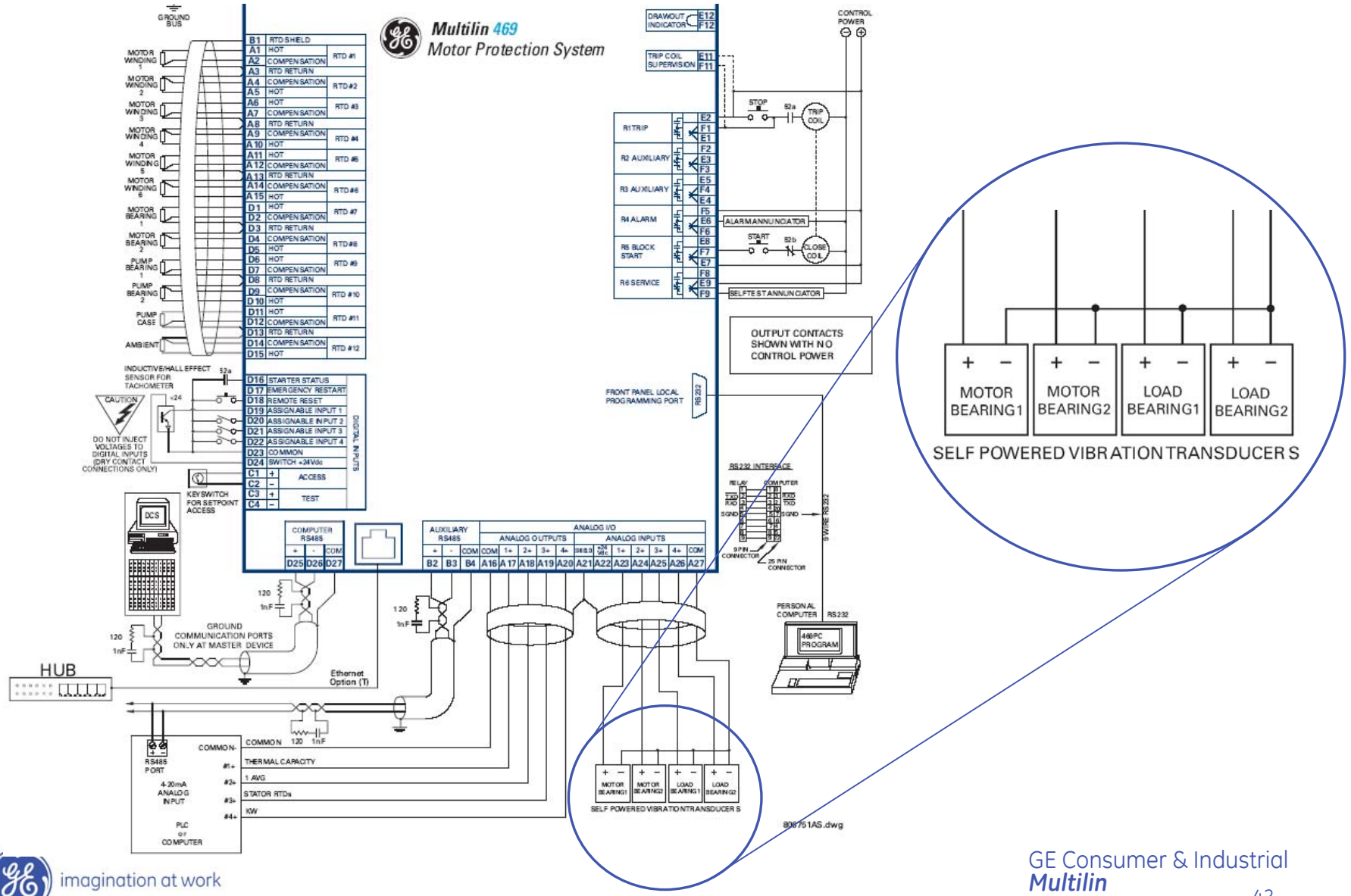
Reliability

- Protected against corrosion when installed in chemically polluted environments through optional conformal coating
- Extensive IEC & ANSI Testing
- Complete Burn-in and testing on Relays
- Self Testing
- Draw out Case (no external hardware)
- Dust Tight Door with Seal Provision
- Heavy Duty Terminals
- ISO 9002 Certified

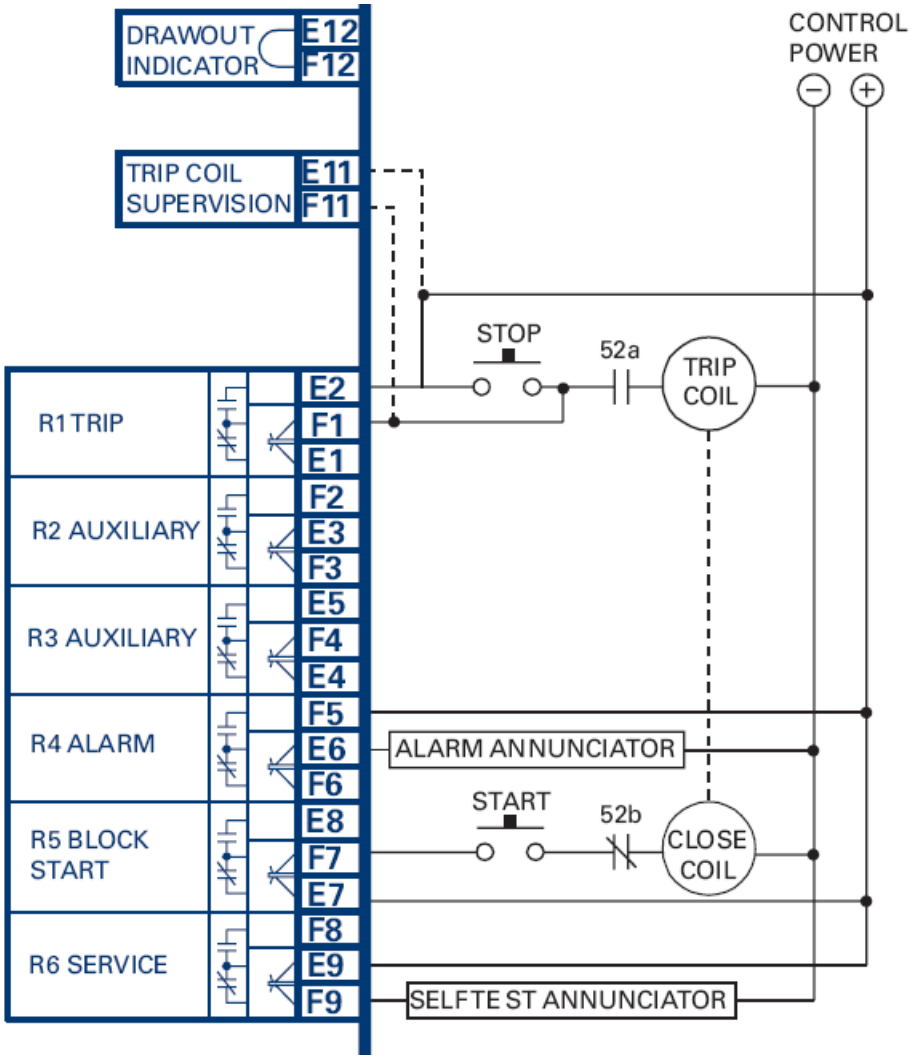
AC Sensing Connections



Power, Output, RTD & Monitoring



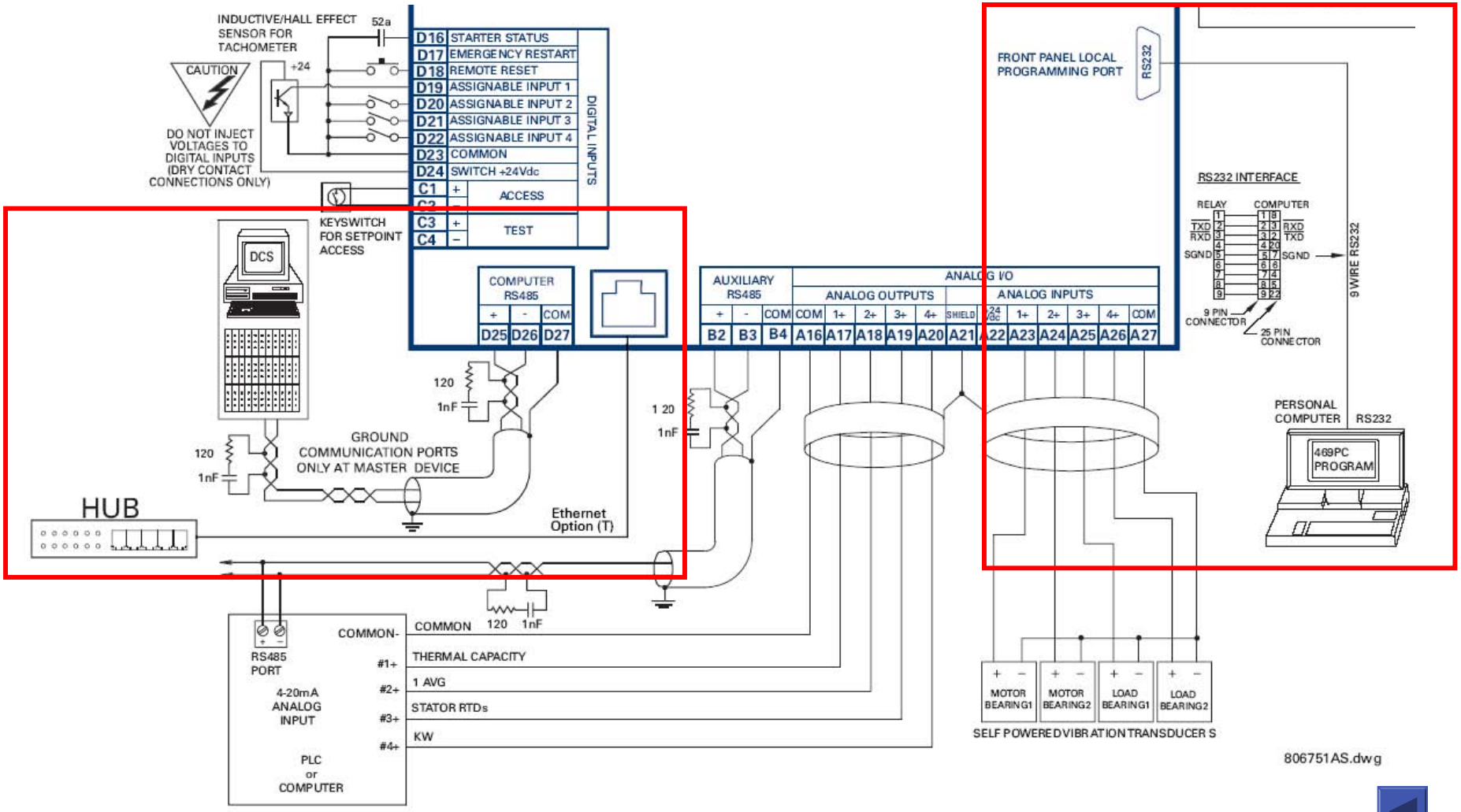
Outputs and Failsafe



OUTPUT CONTACTS SHOWN

WITH NO CONTROL POWER

Communications



User Interface

- EnerVista Setup Software (Windows Based)
- Flash Memory for Future Upgrades or industry modifications
- Fully Programmable keyboard with 40 character display and status indicators
- Fast and easy to use (set up program & manual)
- Draw out construction

User Interface

469 STATUS INDICATORS
- 469 status
- Motor status
- Output relays

NUMERIC KEYPAD
Numeric keys allow for simple entry of setpoint values. Control keys allow simple navigation through setpoint and actual value message structures. Help key provides context sensitive help messages

VALUE KEYS
Value Up, and Value Down keys to change setpoint values

LARGE DISPLAY
Forty character display for viewing setpoints and actual value messages. Diagnostic messages are displayed when there is a trip or alarm condition. Default messages are displayed after a period of inactivity.

CONTROL AND PROGRAMMING KEYS
Menu, Escape, Reset, Enter, Menu Up, and Menu Down keys for complete acess without a computer.

DRAWOUT HANDLE
With provision for a wire lead seal to prevent unauthorized removal

PROGRAM PORT INTERFACE
RS232 for connection to a computer, 9600 baud

469 – Metering & Monitoring Features

- Individual Voltages & Currents
- Real, Reactive & Apparent Power Demand
- Energy
- Running & Maximum Demand Levels
- Power Factor, Speed and Temperatures
- Event Recorder (Last 256 Events)
- Trace Memory (128 Cycle Waveform Capture)
- Breaker Trip Coil Supervision
- Complete Self Checking (Including Drawout Indicator)
- Pressure, Vibration, Speed, and Temperatures via Analog Inputs (4 – 20 mA or 0 – 1 mA)

Monitoring

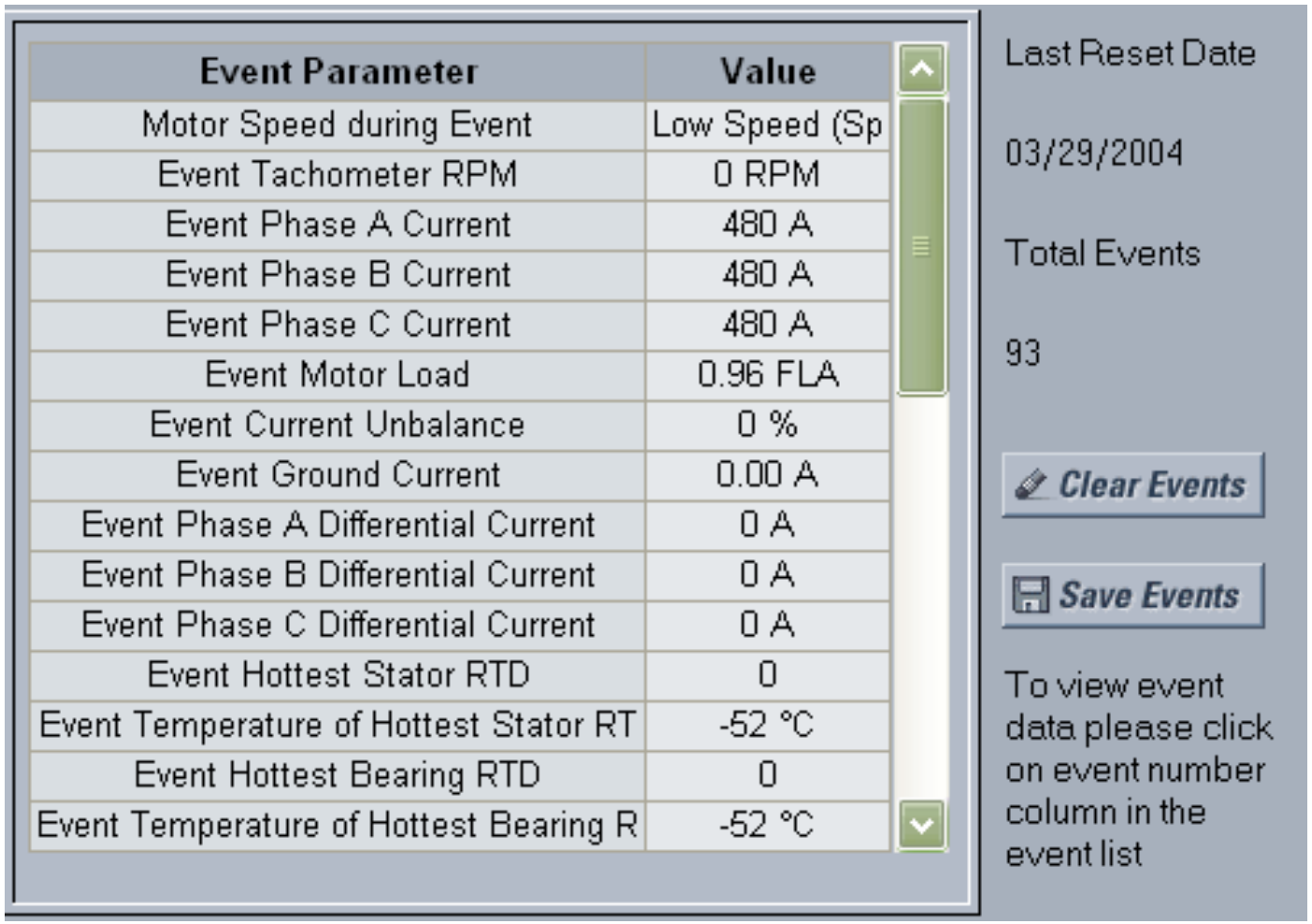
- Event Recorder (256 Events)
  - Allows concise record of fast events
  - Logs important power system parameters at time of event
  - Triggerable by faults, breaker state change, contact/status input change

Event Log

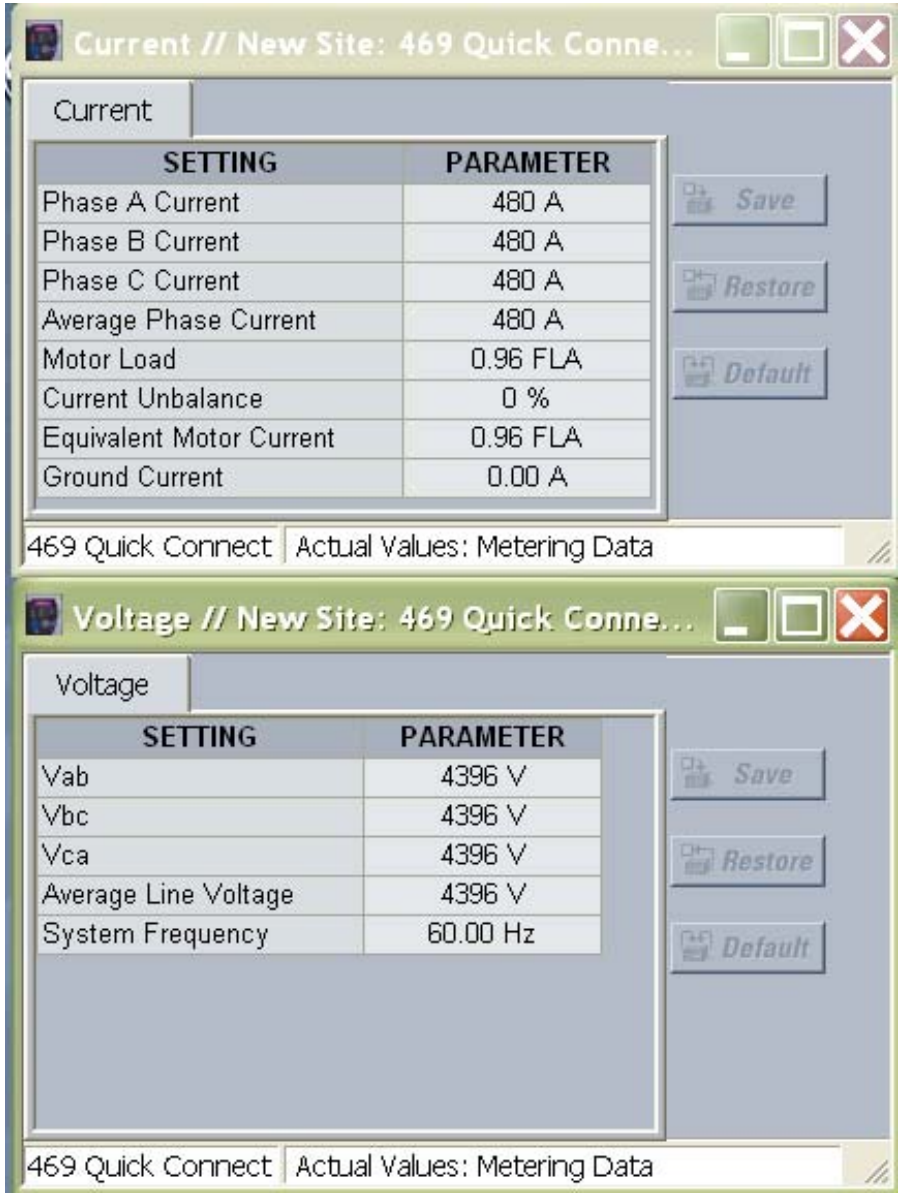
Event	Date	Time	Cause of Event
1	01/17/2005	00:39:39.64	Motor Started
2	01/17/2005	00:39:39.48	Simulation Started
3	01/17/2005	00:35:34.63	Analog I/P 1 Trip
4	01/17/2005	00:34:44.82	Analog I/P 1 Trip
5	01/17/2005	00:33:08.92	Simulation Stopped
6	01/17/2005	00:18:36.5	Motor Started
7	01/17/2005	00:18:35.85	Simulation Started
8	01/17/2005	00:16:54.91	Simulation Stopped
9	01/17/2005	00:16:42.79	Motor Started
10	01/17/2005	00:16:42.71	Simulation Started
11	01/17/2005	00:14:56.9	Analog I/P 1 Trip
12	01/17/2005	00:10:41.67	Analog I/P 1 Trip
13	01/17/2005	00:09:30.86	Analog I/P 1 Trip
14	01/16/2005	22:00:52.92	Cont. Power Applied
15	01/16/2005	21:29:31.18	Control Power Lost

- Select the Event you wish to examine in more detail
- Many power system parameters are recorded in each individual event log

Event Log



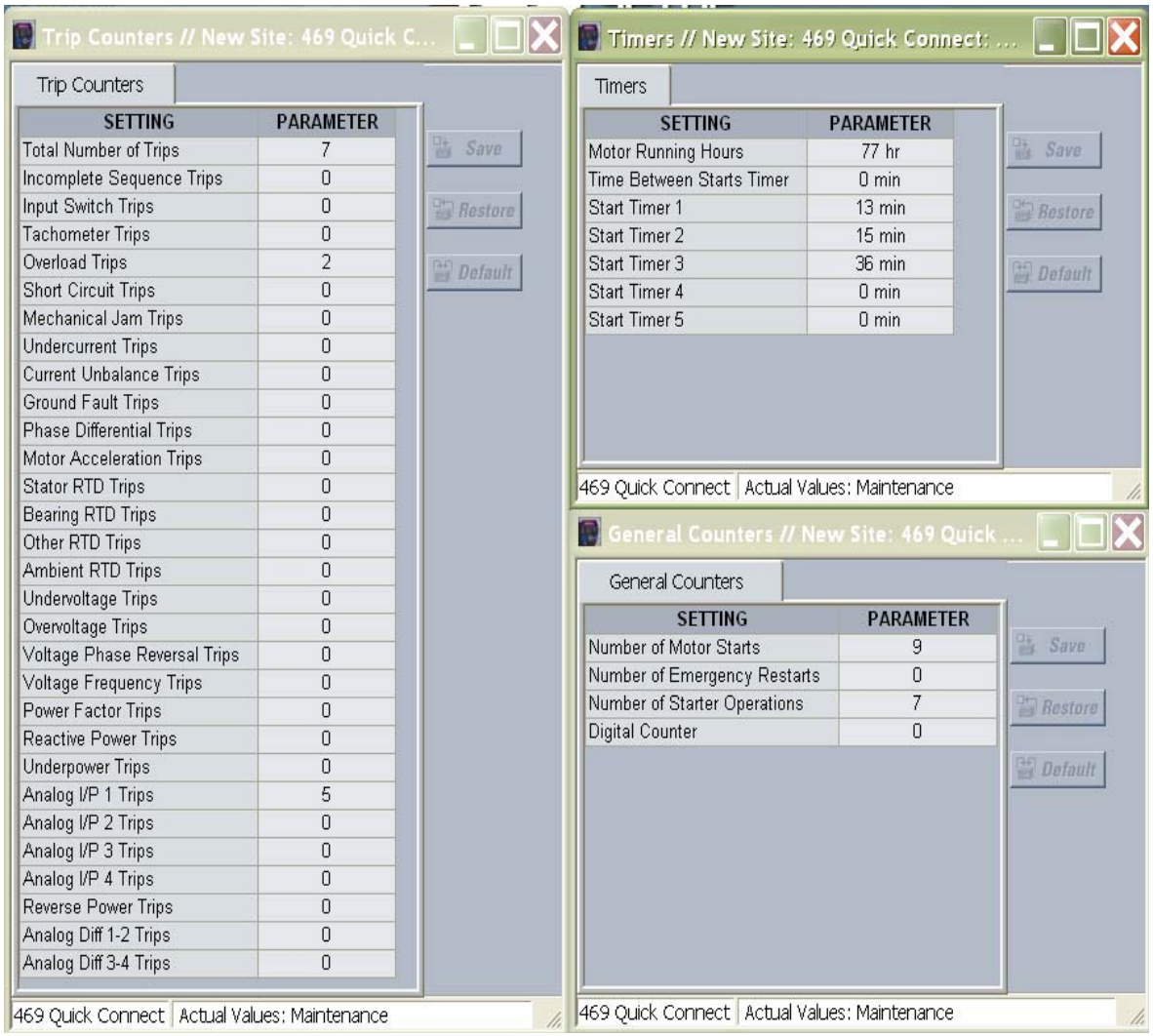
Event Parameter	Value
Motor Speed during Event	Low Speed (Sp
Event Tachometer RPM	0 RPM
Event Phase A Current	480 A
Event Phase B Current	480 A
Event Phase C Current	480 A
Event Motor Load	0.96 FLA
Event Current Unbalance	0 %
Event Ground Current	0.00 A
Event Phase A Differential Current	0 A
Event Phase B Differential Current	0 A
Event Phase C Differential Current	0 A
Event Hottest Stator RTD	0
Event Temperature of Hottest Stator RT	-52 °C
Event Hottest Bearing RTD	0
Event Temperature of Hottest Bearing R	-52 °C



Metering, Monitoring & Reporting

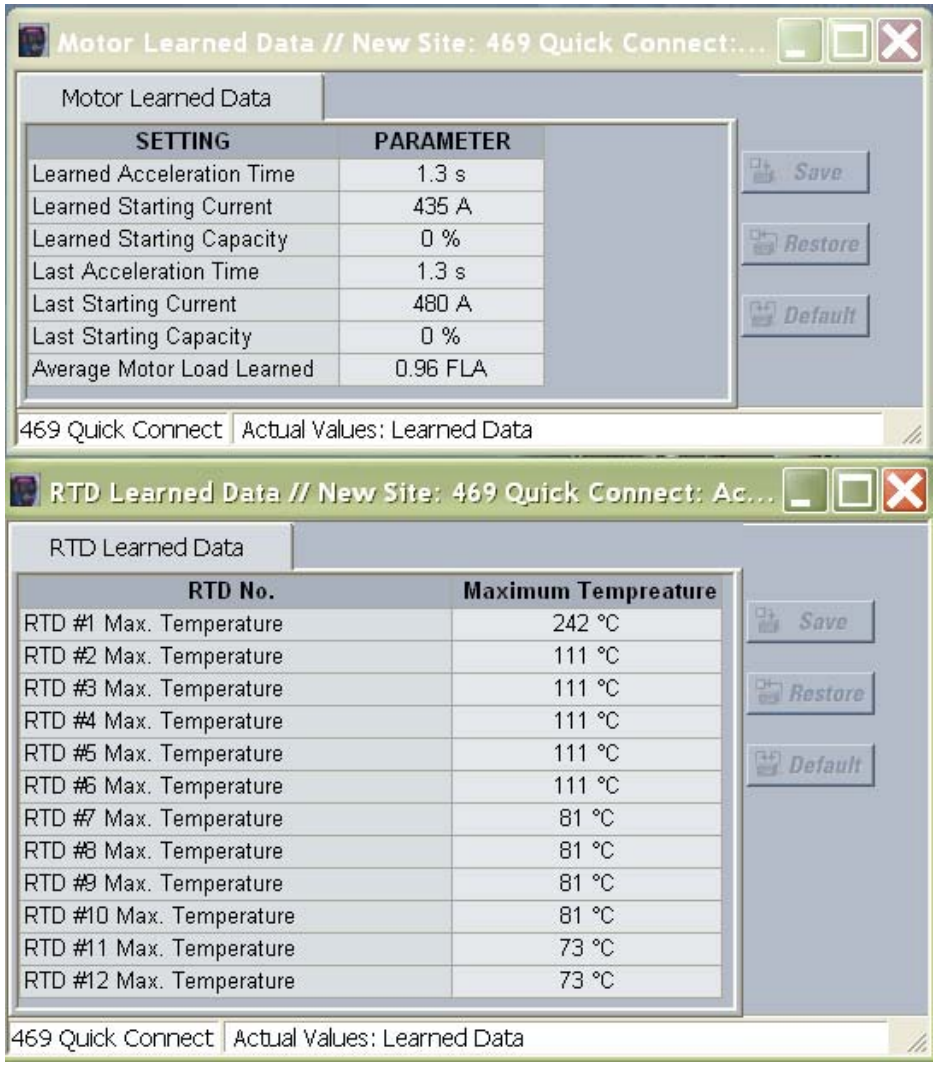
- Running Hours
- # of Trips by Type (summary)
- Time left for trip by overload start (cooling)
- Greasing interval
- Contactor inspection interval
- Pretrip values included in trip report

Reports



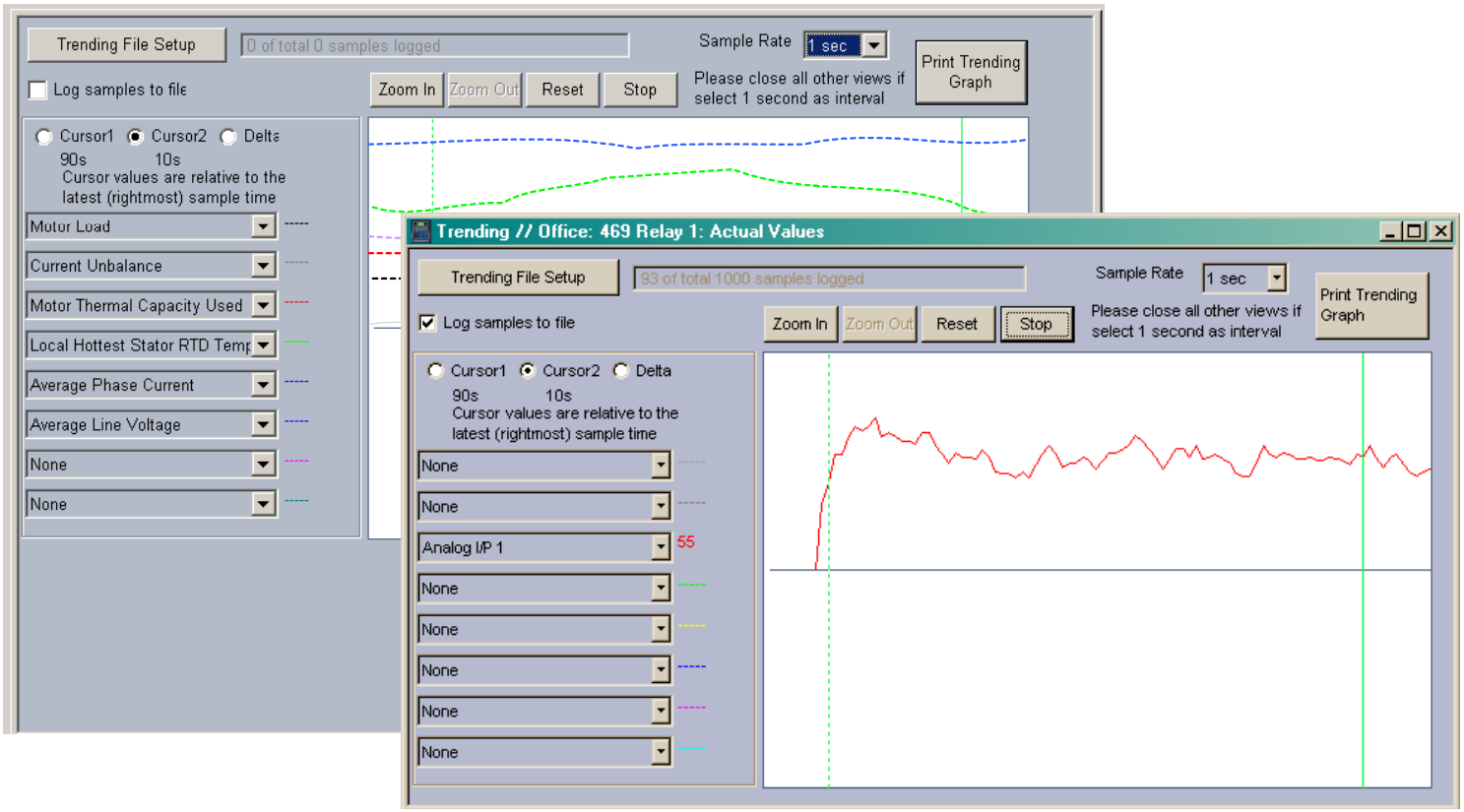
- Trip Counter
- Timers
- General Counters

Learned Data



- Allows you to see average operating values
- Ability to make corrective action to plant electrical system or process based on statistics

Trending

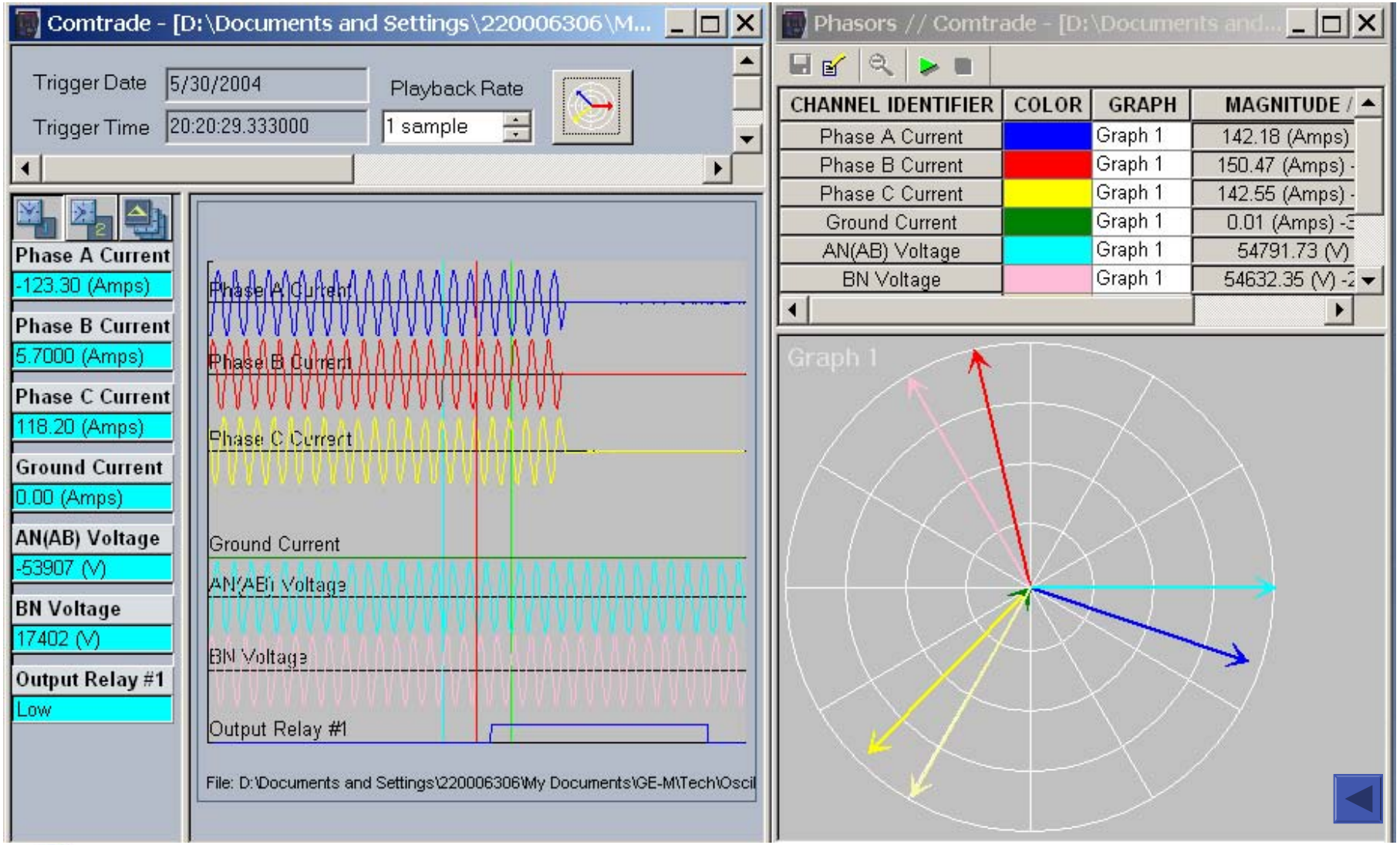


- Set up multiple parameters and time resolution to record starts, running cycles
- See degrading trends develop after alarms are asserted
- Opportunity to fix process or electrical system prior to trip

Monitoring

- Waveform Capture (Up to 128 Cycles)
  - Useful for forensic engineering as well as commissioning
  - Easy identification of fault types, evolving faults, restrikes, arcing, etc.
  - May be triggered by events or manually
  - Time tagging, vector diagrams
  - Automated fault playback is an advanced diagnostic tools

Waveform Capture



Ordering

469	*	*	*	*	*	
469						Basic Unit
	P1					1 A phase CT secondaries
	P5					5 A phase CT secondaries
		LO				DC: 24 - 60 V; AC: 20 - 48 V @ 48 -62 Hz control power
		HI				DC: 90 - 300 V; AC: 70 - 265 V @ 48 -62 Hz control power
			A1			0 - 1 mA analog outputs
			A20			4 - 20 mA analog outputs
				E		Enhanced front panel
				T		Enhanced front panel with Ethernet 10BaseT option
					H	Harsh (Chemical) Environment Conformal Coating

Accessories

EnerVista:	Included with each relay
DEMO:	Metal carry case in which 469 unit may be mounted
19-1 PANEL:	Single cutout 19" panel
19-2 PANEL:	Dual cutout 19" panel
SCI MODULE:	RS232 to RS485 converter box designed for harsh industrial environments
Phase CT:	50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 600, 750, 1000
HGF3, HGF5, HGF8:	For sensitive ground detection on high resistance grounded systems

1 3/8" Collar: For shallow switchgear, reduces the depth of the relay by 1 3/8".

3" Collar: For shallow switchgear, reduces the depth of the relay by 3".

Dual mounting availablewith the 19-2 Panel.IP54 Collar

NOTE: For dimensions see SR Family brochure.

469 Summary

- Comprehensive protection and control for large, medium voltage induction and synchronous motors
- User-friendly visual software for setting, monitoring, metering and single line diagrams
- Drawout construction for easy replacement
- Communications via RS232, RS485 and Ethernet ports
- Suitable for installations in chemically polluted environments

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Going Forward

Create Motor Protection and Control Applications:

- Lessen Maintenance Costs
- Provide an Enhanced Degree of Standardization
- Improves Plant Performance
- Better Security & Reliability, Ease of Maintenance
- Integrates Easily for Retrofit and New Construction
- Provides More & Better Information to More Places
- Energy Management System, DCS, Process PLCs

Going Forward

We Hope This Discussion Will:

- Start Discussions on Applications
- Develop Applications that Provide Value
- Be the Springboard for to Make Your Electrical Processes More Reliable, Secure, Safe and Profitable