SALES 2002 (Pty) Ltd

ProLoc

Protection & Control

ProLoc 2

Motor Protection, Lockout and Control Relay

Training Manual

ProLoc 2 Relay training manual
Version 01A – 00

(NE_PL2 Training manual_MAN_01_13_A-00)

19 March 2013

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Purpose of the document

The purpose of the document is to serve as training manual for the Emis relay, ProLoc 2. The document is designed to be used in a day-long training session and is to be used in conjunction with ProLoc 2 User Manual. The training is divided into 3 sections, as shown below. Each Section should last about 1-2 hours. Short-breaks can be inserted as necessary, in general about 10 minute leg-stretches every 1 hour.

Section A: Protection background

Glossary

Abbreviations

Motor Protection Principles

Section B: The ProLoc 2 Relay

Background of the relay

Functional description of the ProLoc 2 relay

Physical description of the ProLoc 2 relay

Protection and Management features of the ProLoc 2 relay

Section C: Software and demonstration examples

Front-end Software

Demonstration examples

1. ProLoc 2 configured as Protection relay
2. ProLoc 2 configured and programmed as Direct-On-Line starter
3. ProLoc 2 configured and programmed as Forward / Reverse starter

Why was this relay designed?

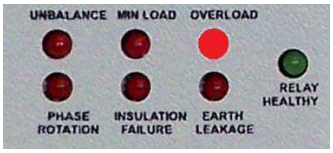
The ProLoc 2 protection and control relay was designed primarily to meet the requirements of the coal mining industry but may naturally be used in similar industries. The client requirements were:

- Comprehensive motor protection features selectable by end user
- Pre-set relay settings for 5 completely different motor settings and logic
- Pre-set relay setting downloaded to relay with limited key strokes on MMI
- Vacuum or Frozen contact protection to back trip MCCB and protect personnel
- Integrated starter logic that prevents unauthorised starting and includes clever starter logic and expanded control logic functions
- Communication with Profibus DP to assist with remote monitoring and control
- Clear descriptive fault indication to assist maintenance and operational staff
- Reliability and accuracy prime requirement to ensure plant operation

Glossary

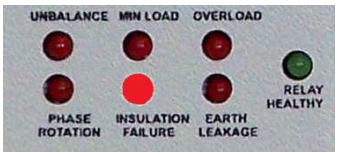
Apparent power consumption	The amount of energy consumed over a period of one hour. It is expressed in kVAh.
Apparent power	Is described as total power used in a system, denoted by $P = \sqrt{3}VI$ VA. (For a motor in delta configuration)
Breaker clearance time	It is the time taken by the breaker to clear the fault by interrupting the supply current to the motor. It can be seen as breaker response time and is useful information for breaker maintenance.
Consecutive starts	The amount of starts allowed during a time interval created by the starts per hour setting. (See also starts per hour)
Core balance current transformer	A current transformer used to detected possible current leakage to earth from one or more of the phases. (Earth leakage detection)
Earth fault	It is a low resistance phase to earth leakage current above 2 amps and a severe form of an earth leakage condition. (See also core balance current transformer)
Motor full load current setting (MLC)	Adjustment of the relay current sensitivity. This is where the actual current level measurement is adjusted to read just below 100% when the motor operates at full load.
Non volatile memory	It is memory that will maintain data even when power is switched off for long periods. (see also volatile memory)
Reactive power	It is the difference between apparent power and real power consumption. (It could be seen as power lost as it is not used for any real work)

Short circuit



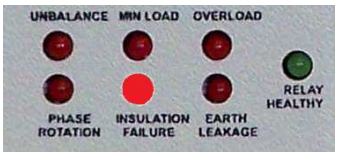
It is a high energy fault current in excess of 10 x Motor Ifl usually caused by a phase to phase short circuit and potentially damaging to equipment

Vacuum loss



It is a condition occurring when any contactor pole remains closed allowing voltage to be present on the motor terminals when a circuit is switched off or a trip signal has been given.

Insulation lockout

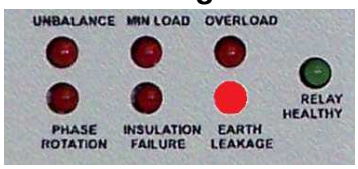


It is a condition occurring when the protection relay does not permit the starting of the motor when is has measured an insulation failure either within the motor windings or the cables feeding the motor.

Frozen contactor

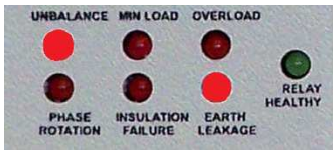
It is a situation that occurs when the main contactor does not open within 2 seconds after being commanded to do so.

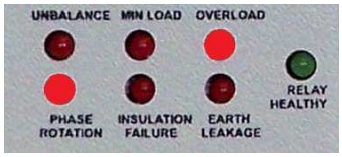
Earth leakage



It is a fault current less than 1500 milli ampere usually as a result of moisture in the motor windings or a degraded cable feeding the motor.

Unauthorized current

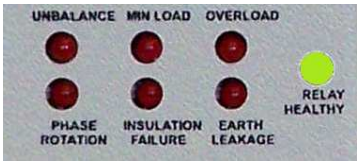


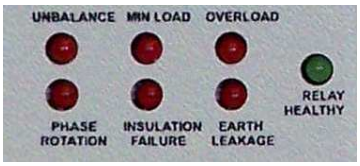


It is a trip condition caused by the sensing of motor current when the protection system is not expecting to “see” any current flow since **no start** command has been issued and may be caused by an external accidental or deliberate start.

Image shows the pattern that will flash in a 1 second interval.

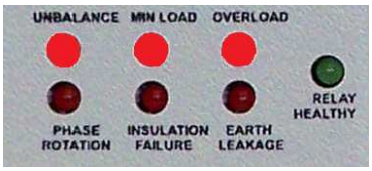
System fault





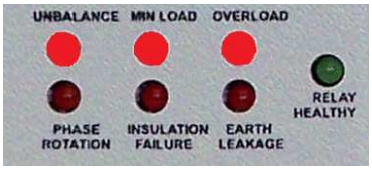
This is a mechanical fault due to plugging out the cable or a loss of communications with the MMI or Profibus communications module loss of Field inputs and control of relay outputs are compromised. Health LED will flash at 1 second interval.

Execution fault



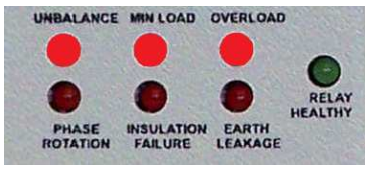
This fault occurs when the request to perform a task has not been completed within the allowed execution time. LED's will run left to right in 1 second interval.

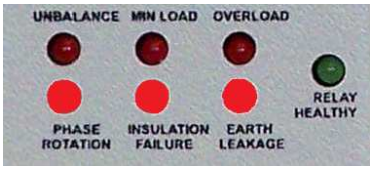
Feedback fault



This condition occurs when the necessary expected feedback [usually current flow] signal does not appear or once having appear drops away and does not recover within a stipulated time interval. LED's will run right to left in 1 second interval.

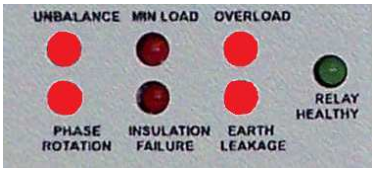
E-stop





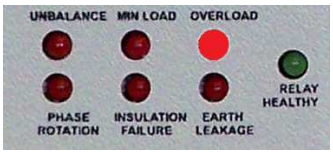
Emergency stop circuit configured as normally closed pushbutton hardwired into the control circuit has been interrupted by someone to stop the drive in a emergency. Image shows the pattern that will flash in a 1 second interval.

External stop



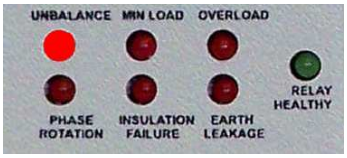
A external field device contact wired directly to trip the ProLoc relay. Typical applications are Pilot wire healthy / trip circuit or any external interlock requiring immediate un-masked masked tripping of ProLoc relay fault recorder in event and fault record time and date stamped another interlock device or switch that prevents the motor from starting but not the emergency stop.

Overcurrent



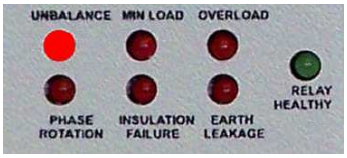
A condition when the motor load current is greater than motor full load current.

Current unbalance



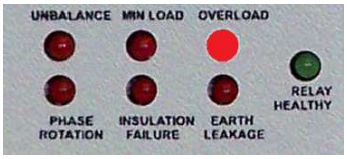
A condition where the measured phase currents are not balanced in magnitude resulting in negative sequence currents which result in motor overheating.

Single phasing



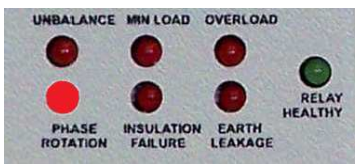
A condition when one phase of the 3-phase supply to the motor is disconnected resulting in severe unbalance and negative sequence current resulting in severe overheating of motor windings with resultant motor burn out and failure.

Run stall



It is a sudden increase in motor load during normal running condition after the motor has accelerated to speed a user selectable threshold is provided to allow for steady and fluctuating loads.

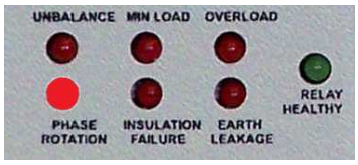
Voltage symmetry



It is a condition occurring when the measured phase to phase voltages are unbalance from one another and will lead to a trip when the user selected permissible deviation is exceeded. Phase rotation LED will flash 1 second ON

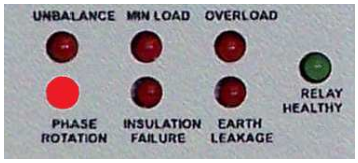
and OFF.

Over voltage



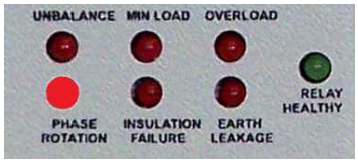
It is a condition where the supply voltage is in excess of the motor rated operational voltage. Phase rotation LED will flash 3 second ON and 1 second OFF.

Under voltage



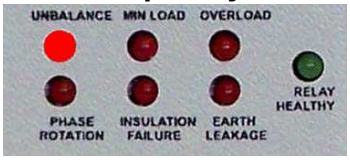
It is a condition that occurs when the supply voltage is below the motor rated operational voltage. Phase rotation LED will flash 1 second ON and 3 second OFF.

Volt phase rotation



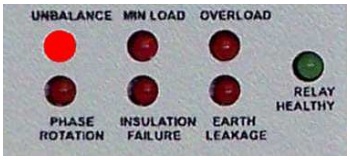
It is an indication that the supply voltage phases are incorrectly connected endangering the proper rotation of the motor.

Over frequency



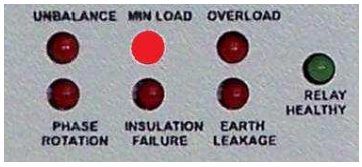
It is an indication that the supply frequency is 10% above the user selected safe value recommended practice. Unbalance LED will flash 3 second ON and 1 second OFF.

Under frequency



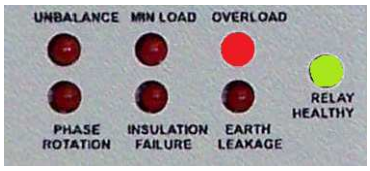
It is an indication that the supply frequency is 10% below the user selected safe value recommended practice. Unbalance LED will flash 1 second ON and 3 second OFF.

Minimum load



An indication that the measured load current is below the specified user selected level.

Start per hour



It is the motor manufacturer's specified safe maximum number of starts that the motor winding insulation can withstand per hour. Overload and healthy LED will flash together at a 1 second interval.

Consecutive starts

It is the motor manufacturer's specified number of direct consecutive starts and stop that can safely tolerate without harming the insulation material of the windings

Abbreviations

CDF	Cyclic Duration Factor
DOL	Direct On Line
IDMT	Inverse Definite Minimum Time
MMI	Man Machine Interface
PLC	Programmable Logic Controller
DCS	Dynamic Control System
MMS	Motor Control Centre

Motor Protection Principles

Having introduced the aspect of protection and control, it maybe worth discussing the protection features required by the motor and to separate these protection features into two categories namely:

1. Basic non negotiable protection features, and
2. Extended protection features offered by the modern motor protection relays.

To further focus the discussion we will attempt to answer, the following questions where applicable. What? Why? When? How? Where?

Basic essential non-negotiable protection features

These features are the minimum essential to protect the motor itself

Thermal Overload full thermal memory
Locked Rotor
Unbalanced current or negative phase sequence current protection
Single phasing

Thermal overload full thermal memory

<u>What</u> must be achieved?

The purpose of the thermal overload protection element is to prevent the motor stator or rotor windings from ever exceeding the safe rated operating temperature of the insulation material used.

<u>Why</u> is it necessary?

The motor can provide 250% rated torque under normal running conditions before the pull out torque point is reach at which point the motor will stall. This means that the motor is capable of driving a load of up to 250% nameplate rating. This will result in the temperature of the motor windings exceeding their rated operating temperature resulting in insulation failure which will progress into a Phase to Phase or a Phase to earth fault at the moment of failure. A useful rule of thumb to see at what temperature the windings will stabilize at above the designed temperature rise is:

Calculate: a 1% overload 2°C temperature rise

This formula can also be used to calculate the C.D.F. (cyclic duration factor) at which a motor operated above the S1 rated load current value by using the calculated temperature rise multiplied by C.D.F. equates to the rated temperature rise specified by the motor manufacturer. A word of caution in using this method is that if the entire repetitive load pattern period exceeds 10 minutes this rule of thumb assumption can result in temperatures during the cyclic loading exceeding the maximum rated insulation rating.

How can one maintain the operating temperature within design limits?

The relationship between the I^2t load current levels flowing in the motor windings has a direct relationship to temperature rise of the motor windings. A thermal memory model based on the stable as well as cyclic load current patterns of the load current, as well as the operational state of the motor standstill or running controls the movement of the selected thermal damage curve between a Hot and Cold curve characteristic. The thermal capacity value must be maintained and restored to the actual value when cycling the auxiliary control power supply to the relay.

Full Thermal memory trip delay curve

IEC 60255-8 :

$$t = \tau \ln \times \left[\frac{(I/Ie)^2 - (Ip/Ie)^2}{(I/Ie)^2 - (Is/Ie)} \right]$$

Where ;

t trip time in seconds

t heating time constant in seconds

I actual load current flowing in motor windings

Ie full load current setting of motor

Ip time averaged load current level prior to present overload condition

Is full load current service factor typical if used is 1.1 or 110%

Locked Rotor

What must be achieved?

The purpose of the locked rotor overload protection element is to prevent the motor stator or rotor windings from ever exceeding the safe rated operating temperature of the insulation material used during the motor starting and accelerating up to operational speed.

Why is it necessary?

The motor load current at start-up on a DOL applications are in the order of 600% to 720% motor full load current rating and are maintained until the motor has accelerated to a rotor speed greater than the pull out torque or breakdown torque value. The load current reduces afterwards to a value below the motor full load current value. The period that the stator and rotor windings can withstand these current levels are referred to as the **safe cold** or **hot stall** times in seconds. This is the maximum period that the motor stator and rotor windings may be subjected to these currents assuming that the rotor remains stationary or as is termed “locked rotor”.

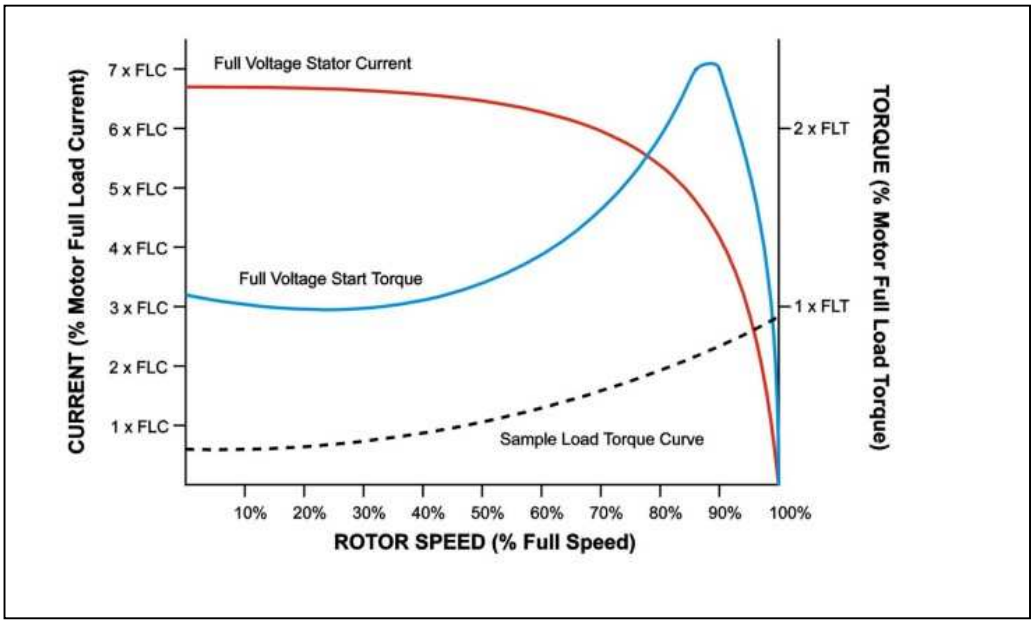


Figure 1: Torque and Current characteristics of an AC motor

The AC rotor resistance of a stationary rotor can be up to 300% the value of the rotor resistance of a motor running at operating speed. This is due to the higher frequency of the rotor current (50 hertz) at standstill versus the frequency of the rotor current at operating speed (2-3 Hertz). At the higher frequency at standstill the rotor current flows on the surface of the conductor a condition referred to as “skin effect”. This phenomena is used by the motor designer with deep bar rotor designs to achieved

high starting torque characteristics, normally achieved with high resistance rotor windings with the low slip characteristic normally associated with low stating torque low rotor resistance winding resulting in lower operating temperatures and cooler running machines.

A very simplistic analogy to describe the operation of the rotor windings even in a standard rotor will be to visualize the rotor winding having a $10mm^2$ conductor during starting and during acceleration the rotor current transferring over to a $30mm^2$ conductor and the "Locked Rotor" current / Time spec is given on the $10mm^2$ conductor.

How is locked rotor detection being done?

1. Vectorial stall rate of change power factor
2. Detection via speed switch or tachometer

If one could detect that the motor is accelerating up to operational speed then we know that the rotor conductor resistance will be decreasing and the I^2T rating of the rotor conductor will be increasing. Methods of detecting that the motor is accelerating to speed are by a tachometer or a speed switch attached to the motor shaft or by the movement of motor power factor during the acceleration period.

The locked rotor trip delay can be extended to cater for conditions in which the motor run up time exceeds the allowable locked rotor trip time. Extreme caution is the password in this application, ensure that the following conditions are met. The tachometer output must be matched to the acceleration profile of the drive. The simplest characteristic would be a linear characteristic monitoring shaft speed against total allowed acceleration time. The basic principle is that the motor speed must always be increasing until the motor has reached operational speed. If a speed switch is used, the shaft speed at which it will close is critical and the higher >20% would be the minimum level. Especially on ID fan application where intake dampers can be opened prematurely and result in the motor failing to accelerate but entering a sub synchronous crawl whilst still drawing the acceleration current.

The safest method to my way of thinking is the" Vectorial Stall" Method, which employs the rate of change of power factor, integrated into the protection relay.

The Thermal trip curve set to the locked rotor time but being extended under control of the vectorial stall element.

Unbalanced current or negative phase sequence current protection

What must be achieved?

The purpose of unbalanced current or negative phase sequence protection is to identify the magnitude of the negative phase sequence component. The thermal capacity level must be modified to cater for the heating effect of the negative phase sequence currents.

Why must protection be provided?

The negative phase sequence current heating component on a running motor will be in the order of 6 to 7,2 times the actual value of the current. Since the negative phase sequence current induced in the rotor will be at twice the line frequency, a condition referred to as skin effect occurs. It results in negative phase sequence current flowing on the surface of the rotor conductors. The result is higher copper losses and localized hot spot heating.

How are the values calculated?

The traditional method of measuring negative phase sequence current is to pass the line current flowing into the load current through a negative phase sequence filter. It only requires the measurement of the I red (0^0) and I blue (240^0) currents. The filter delays the waveform of I red (0^0) value by 60^0 and subtracts the I red and I blue values.

An Alternative method which traces negative phase sequence value to 30% before deviating is to calculate the > deviation from the average value of the three phase current divided by the average x 100 %. for (load currents > Is) and divided by Is for (load current < Is).

A variation that has been noted as well is to calculate the difference between the > and < line current value divided by the average x 100% for (load currents > Is) and divided by Is for (load current < Is).

When is negative phase sequence current of significant levels are detected.

The option to integrate the heating effect into an IDMT curve, which will sum with the thermal overload element to provide thermal protection of the motor windings. An alternative method is to provide a definite time trip once the predetermined Negative phase sequence level is exceeded. Caution is to be exercised if the trip delay time is

extended beyond a reasonable delay typically the safe cold stall time in seconds if not then an IDMT type characteristic must be used and integrated with the thermal overload model.

Single phasing

What must be achieved?

Single phasing protection or phase loss results in a severe condition of unbalanced current or 100% negative phase sequence condition and the motor must be disconnected from the supply within a period of 5 sec maximum.

Why must protection be provided?

The negative phase sequence current heating component on a running motor will be in the order of 6 to 7,2 times the actual value of the current. Since the negative phase sequence current induced in the rotor will be at twice the line frequency a condition referred to as skin effect occurs. It results in negative phase sequence current flowing on the surface of the rotor conductors causing higher copper losses and localized hot spot heating.

How are the values calculated?

The traditional method of measuring negative phase sequence current is to pass the line current flowing into the load current through a negative phase sequence filter which only requires the measurement of the I red (0^0) and I blue (240^0) currents. The filter delays the waveform of I red (0^0) value by 60^0 and subtracts the I red and I blue values.

An Alternative method which traces negative phase sequence value to 30% before deviating is to calculate the > deviation from the average value of the three phase current divided by the average x 100 %.

A variation that has been noted as well is to calculate the difference between the > and< line current value divided by the average x 10

When a single phase condition occurs negative phase sequence current of significant levels are detected.

The option to integrate the heating effect into an IDMT curve, which will sum with the thermal overload element to provide thermal protection of the motor windings

With a trip characteristic of 5 sec for 100% negative phase sequence.

An alternative method is to provide a definite time trip once the predetermined negative phase sequence level for phase loss is exceeded.

Caution is to be exercised if the trip delay time must be less than 5 seconds.

Extended motor protection added value

Running stall / jam detection

Minimum load or under load protection

Under power protection

Earth Leakage

Over voltage

Under voltage

Phase rotation

Starts per hour limitation

Over temperature detection

PTC over temperature detection

RTD over temperature detection

Running stall / jam detection

What is a running stall condition?

Once a motor has accelerated up to operation speed and the load current has reduced below full load current, the operation status of the motor is said to be in service and running at operational speed. The load current is generally below Motor full load level when measured as an RMS value over a 10 min period.

Whilst operation in this state the motor will draw current related to the load applied to the motor shaft, The torque available is roughly 250% of rated torque and this torque

will be used to maintain the motor speed between operational speed and the stall speed which corresponds to the pull out torque point on the speed torque curve,

When will a running stall occur?

Should the motor load increase above the pull out torque value, the motor will stall, the stator load current will increase to locked rotor current levels and the motor will trip after the thermal curve trip delay has elapsed. This is not necessary since the trip delay can be shortened to 1 second.

Can we detect a running stall condition?

If we examine the speed / torque curve of the motor, one can see that once the motor is running at operational speed, the load current level (is >30%) and lower than 350% of motor full load current. Should the current increase above this level, the pull out torque point is exceeded and the motor enters a stall condition during normal motor. The simplest method of implementing a running stall protection is, once the motor is running at operational speed to arm a definite time trip on a set threshold between 110% and 300% of motor full load current.

Where would one use running stall protection?

On almost every application, particularly on compressor and jaw crusher applications, that could be prone to jamming. The equipment used for interrupting the load current limits the trip delay selected. If a contactor is used to interrupt the load current, the minimum trip delay should not be less than 1 second. The reason being that in the event of the motor windings or the cable end box developing a short circuit, the fault current will not be limited to the locked rotor current level but will be at the full system fault level which could vaporize the contactor (Faster is not better if the equipment doing the interrupting is not rated for the task).

Note:

The 1-second trip-grading margin is the trip delay one will get when using at HRC motor fuse at 10 x Fuse rating.

Minimum load or under load protection

What is a minimum load condition?

A load current based minimum load condition is identified as the condition under which the motor load current drawn by a motor under operational conditions is below the minimum safe or normal load current indicating a faulty or abnormal operating condition.

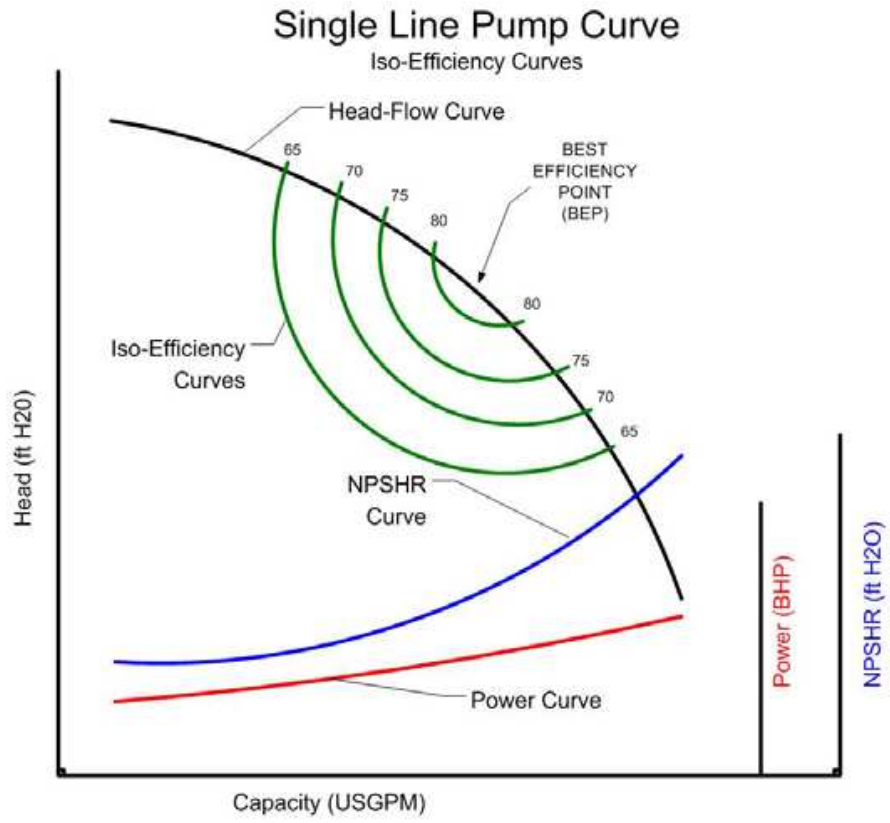


Figure 2: Pump efficiency curves (Source: www.jensenengineeredsystems.com / pump-curves)

<u>When</u> will a minimum load condition occur?

On loss of driven load, Typical examples are loss of suction on a centrifugal pump, snapping of “V belts” on a pulley driven load, shearing of motor shaft or coupling shearing pin to name but a few conditions

<u>How</u> is a minimum load condition detected?

Minimum load is detected by measuring and establishing that the motor load current being drawn by the motor windings (is > 15%) motor full load current but < the preset Minimum load value established by the process healthy condition. Should a Minimum load condition be detected, an alarm condition is generated and after a preset time delay (1 to 100 sec typical) the motor is tripped on minimum load.

Where should minimum load protection be used?

Minimum load protection should be used where the process load, the production line or process would be critical.

Typical examples are;

- A process being controlled by DCS or SCADA which use an auxiliary contact on the contactor via the I/O block is used to indicate a run signal (the contactor is closed the motor must be running?) and this will provide the interlocking to other drives downstream of the effected drive and result in chemical or material spillages since the faulted drive is not clearing the material through its part in the process.
- A centrifugal pump, loss of suction or medium results, in the same medium circulating in the impeller housing raising the temperature of the medium to boiling point damaging the pump seals or if the medium is acidic the corrosivity will double for every 10°C (why does the medium boil. When a p ump is operating it pumps from a low pressure to a high pressure. What happens to a liquid at a low pressure the boiling point decreases now if the same liquid is being spooled around at the suction intake of the centrifugal inlet of the pump it is eventually going to boil.

Under power protection

What is an under power condition?

An under power based minimum load condition is identified as the condition under which the motor load drawn by a motor under operational conditions is below the minimum safe or normal load power factor indicating a faulty or abnormal operating condition

When will an under power load condition occur?

On loss of a driven load, typical examples are: loss of suction on a centrifugal pump, snapping of “V belts” on a pulley driven load, shearing of motor shaft or coupling shearing pin to name but a few conditions.

How is an under power condition detected?

Under power is detected by measuring and establishing that the power factor of the motor load being drawn by the motor windings is < the preset Minimum power factor

value established by the process healthy condition. Should a under power load condition be detected an alarm condition is generated and after a preset time delay (1 to 100 sec typical) the motor is tripped on minimum load.

Where should under power protection be used?

Under power protection should be used where the process load, production line or process would be critical.

Typical examples are:

- When oversized motors are used to resulting in insufficient current differential between a loaded and a unloaded motor in the production process or;
- A process being controlled by DCS or SCADA which use an auxiliary contact on the contactor via the I/O block is used to indicate a run signal (the contactor is closed the motor must be running?) and this will provide the interlocking to other drives downstream of the effected drive and result in chemical or material spillages since the faulted drive is not clearing the material through its part in the process.

Earth Leakage

What is an earth leakage condition?

An earth leakage condition can be identified as a condition under which a current generally not exceeding 1 amp flows to earth in a Health circuit as opposed to earth fault which a current flows to earth in a faulty circuit and is generally > 1 amp

When does an earth leakage occur?

Typically an earth leakage condition occurs when the insulation around the conductors are compromised by contact with human, animal, carbon tracking between the exposed conductor and earth, moisture, or lubricant ingress of windings

The moment the human, animal, carbon tracking or moisture is removed or dried out the insulation of the motor windings are once more ready for service. Thus the definition as earth leakage being in a Healthy insulated circuit.

How is an earth leakage condition detected?

Earth leakage is detected by using a summation or core balance current transformer through which all conductors supplying the protected circuit are passed.

Sensitivities of 0,030 to 1 amp are detected; the balance is maintained by the fact that in a healthy circuit all currents flowing into a circuit are balance against those

currents returning from the circuit, thus resulting in the cancellation of all fluxes generated by the currents flowing in the circuit.

Where should earth leakage protection be used?

Where personal safety is required. In explosive atmosphere conditions or where moisture and carbon can result in leakage current paths to earth.

Over voltage

What is over voltage?

Over voltage in a motor circuit is defined as the maximum voltage level at which the supply phase to phase voltage can operate without the saturation of the stator core laminations resulting in the overheating of the stator windings,

How is over voltage detected?

Over voltage is detected by direct measurement of the main circuit line voltages and should the voltage exceed 115% of rated line voltage, an alarm flag is set and should the condition persist for longer than 10 sec with the motor running, the motor contactor is tripped.

When or where are an over voltage conditions likely to occur?

Over voltage, conditions are not common within the industrial metro areas. It occurs more frequently in outlying areas, feed by rural feeders, farm lines, or underground section feeders. The over voltage condition occurs when the load demand on the feeder is lower than what it normally would be, or if the switching reticulation is altered to alternative feeders during maintenance periods or outages. Bottom line, it can occur at anytime in the rural or single line feeder networks.

Under voltage

What is under voltage condition?

Under voltage in a motor circuit is defined as the minimum voltage level at which the supply phase to phase voltage can operate without significant torque reduction of the motor, resulting in load currents > motor full load, being drawn from the supply resulting in the overheating of the stator windings, (the torque of the motor is

proportional to the square of the voltage the maximum allowed by manufactures is – 10% rated supply).

How is under voltage detected?

Under voltage is detected by direct measurement of the main circuit line voltages and should the voltage drop below 90% of rated line voltage an alarm flag is set. Should the condition persist for longer than 10 sec with the motor running, the motor contactor is tripped.

When or where are an under voltage conditions likely to occur?

Under voltage, conditions are not common within the industrial metro areas. They occur more frequently in outlying areas feed by rural feeders, farm lines, or underground section feeders. The under voltage condition occurs when the load demand on the feeder is greater than what it normally would be, or if the switching reticulation is altered to alternative feeders during maintenance periods or outages. Bottom line it can occur at anytime in the rural or single line feeder networks.

Phase rotation

What is phase rotation protection?

Phase rotation protection will ensure that the incoming supply to the MCC is correct. In the event of the incoming supply phase sequence being altered, the motors on the protected MCC must not be allowed to start, since they will run in the opposite direction to the specified direction (the direction of a three-phase motor is altered by interchanging two phases of the voltage supply).

When will you require phase rotation protection?

In every three phase motor application, since it is critical to ensure that once a motor or plant has been commissioned, that the reversal of the supply to that plant will be correct under any reticulation configuration. In the event of portable equipment the phase rotation protection must be built into the starter panel of the drive since the phase rotation from location to location could be swapped

How is phase rotation detected?

Phase rotation and phase symmetry are generally combine to ensure that the phase voltage sequence will be Vr, Vw, Vb and that the voltage waveforms are displace by 120 degrees. The frequency has to be between 30 hertz and 100 hertz.

Where is voltage phase rotation detected?

It is detected above the main contactor. This enables the detection of phase rotation before the main contactor is closed. IOW ensures that phase sequence is correct before allowing the closing of the main contactor.

Starts per hour limitation

What is a start per hour limitation?

Take the number of starts per hour allowed, divide into 60 min and we have a period specifying the time delay between starts. Example 6 starts per hour Starts per hour means that every (60/6) min = 10 min the drive can be started

When or where would one employ a start per hour limitation?

One may be inclined to think, that it is for thermal protection from the motor manufacturer this will be the spec since they do not know what type of thermal overload or stall protection will been fitted to the drive. It would more sense to fit starts per hour protection in an application where "jogging" or "Inching" of the drive has to be prevented to save switchgear and mechanical drive chain of the machine from operator abuse. On the other hand, if the motor employs a reactor or shared soft start starter that needs to be thermally protected from to frequent starts.

Over temperature detection

What types of over temperature protection are available?

Various types of over temperature sensors are available. It can be divided into two main categories namely:

- Non-linear - PTC sensors (Positive Temperature Coefficient) normally referred to as Thermistors have a S type or switch characteristic normally use to indicate that a specific temperature has be exceeded the device is selected according to the temperature at which the element is to switch or alter the internal resistance on a exponential type switching characteristic. This is the default sensor fitted in LV motor and if the LV overload relay does not have NTC sensors (Negative temperature coefficient) these devices have a more linear type characteristic, which can be linearized to allow accurate temperature measurement.

- Linear Sensors - PT 100 normally referred to as RTD's is the most common and when used in a standard 3 wire configuration or a 4-wire bridge configuration and can be used to measure actual temperature with accuracy with lead resistance compensation. This is the default sensor fitted in MV motors and most MV protection relays have PT 100 inputs

When would one use over temperature detection?

It would be ideal to fit over temperature detectors to every motor but the cost of cabling to connect the sensors in the field is high. A definite application will be when the motor is force cooled by external motorized fan or by circulation of water through water jackets, since the thermal model applied in the overload protection relay will be modeling the predicted motor temperature on the I^2t model assuming that the shaft mounted fan will be operating efficiently and only altering the thermal decay model for "Motor running" standard 2 x Motor heating time constant or "motor cooling" standard 4 x Motor heating time constant.

<u>How</u> and <u>where</u> should temperature sensors be fitted?

Generally, the PT 100 sensors are inserted into the winding slots with the stator winding. This is a very secure and stable location and being in a flat thin wafer type construction will expose a large surface area to the winding.

A point to remember is that the temperature measured in the slot will be up to 20℃ lower than the hot spot temperature measured on the bottom of the stator winding overhang (reflected heat from rotor without having to pass through stator core laminations heat sink.

Locked rotor and stall conditions can not be protected with temperature sensors the thermal overload curve based on I^2t characteristic and full thermal memory will be the first line of defense.

The temperature sensors can be very useful in modifying the thermal memory of the thermal curve and allow actual temperature to establish the available thermal capacity should the thermal model want to restore more capacity than is actually available.

PTC or NTC temperature sensors are bead type construction with leads attached and the entire sensor connection construct insulated with a heat shrink sleeve.

Theses sensors are ideal to fit into the stator-winding overhang and are secured in position with insulation putty with a good temperature coefficient to ensure rapid heat transfer.

Short circuit

What is short circuit protection?

A short circuit condition occurs when the insulation between phase conductors fails and the load current level exceeds the normal locked rotor current levels that the motor would draw during start up.

The Fault level of the motor feeder supply determines the current level during a short circuit and will be as high as 15 x to 50 x the motor full load current value.

When and how can one implement a short circuit protection?

A short circuit fault is a system level fault, which means that it will compromise the stability of the entire network it will result in total power loss to healthy drives and shut down the entire process.

Fundamental in clearing a short circuit fault is grading and use of equipment that can interrupt the high-energy fault.

The main contactor on the motor drive is not suitable since at best a contactor should not try clear a fault current > 10 x contactor rating and upstream a MCCB or fuse should be the first line of defense.

Fuses are not as popular as in past but do provide a ideal solution since they do limit the fault level allowed through to the motor feeder circuit and the motor fuse (rated 200% Motor Ifl) will clear in 1 sec at 15 x motor Ifl and 0,020 sec at 30 x motor Ifl

Using a Motor feeder MCCB is neat clean solution with the ability to be shunt tripped from the protection relay as well as having its own thermal and fast magnetic trips.

The discipline required with maintenance staff is to be disciplined in the inspection of the contact sets and arc chute after clearing a high-energy fault to avoid the possibility of catastrophic failure on clearing the next fault.

The MCCB is a maintenance specific item that can still appear to be functional but is not and will result in a catastrophic failure on next fault clearance, hence my default selection of a fuse in applications that are critical.

Earth Fault

What is an earth fault?

An earth fault condition occurs when the insulation between a phase conductor and earth fails. The fault level of the motor feeder supply determines the current level during an earth fault condition and will be as high as 7 x to 30 x the motor full load current value.

When and how can one implement earth fault protection?

An Earth fault is a system level fault, which means that it will compromise the stability of the entire network it will result in total power loss to healthy drives and shut down the entire process.

Fundamental in clearing an Earth fault condition is grading and use of equipment that can interrupt the high-energy fault.

The main contactor on the motor drive is not suitable since at best a contactor should not try clear a fault current > 10 x contactor rating and upstream a MCCB or fuse should be the first line of defense.

Fuses are not as popular as in past but do provide a ideal solution since they do limit the fault level allowed trough to the motor feeder circuit and the motor fuse (rated 200% Motor Ifl) will clear in 1 sec at 15 x motor Ifl and 0,020 sec at 30 x motor Ifl

Using a Motor feeder MCCB is neat clean solution with the ability to be shunt tripped from the protection relay with sensitive CBCT sensing can provide Earth leakage protection to trip main contactor and once Earth leakage level increases above 1 amp to transfer the trip to MCCB shunt

The discipline required with maintenance staff is to be disciplined in the inspection of the contact sets and arc shuts after clearing a high-energy fault to avoid the possibility of catastrophic failure on clearing the next fault.

The MCCB is a maintenance specific item that can still appear to be functional but is not and will result in a catastrophic failure on next fault clearance, hence my default selection of a fuse in applications that are critical

Background of ProLoc 2 relay

ProLoc 2 name was derived from the purpose of the relay. The relay was designed to be a **Pro**tection relay to **loc**kout any unsafe operation of the motor. The relay was purposely designed for a market identified by Emis (Pty) Ltd, mainly in the mining industry. The relay is designed to cover a range of 1-100 Amps direct measurement with 12 mm conductor range covered with 4 relays namely PL5, PL10, PL50 and PL100. External interposing current transformers can be used to extend the operating range from 100 to 400A.

The ProLoc 2 relay is an ISO9001:2008 compliant local designed and manufactured three phase motor protection relay. The registration covers the Quality Management System for the design, development, manufacture, distribution and repair of electronic motor protection relays.

The ProLoc 2 relay is a micro-controller based precision instrument with protection and control logic (including starters) features. It is designed for the low voltage motor protection market and is available in different current models. The current transformers are internal and integrated into the relay while the core balance current transformer is external. The relay can be used on a Profibus / Modbus network.

The relay is fully configurable with the aid of front-end software or a man machine interface unit (MMI). Event records can also be down loaded via the MMI (iRDA – infra red link) for further analysis. All the settings are password protected. The relay has an on board database where all time and date stamped event and fault records are kept. The event records has only limited access rights (read only) but the fault records are granted full access rights. The front-end is also equipped with a data recorder which could be used to analyze motor performance.

The relay is packed with control features including starter logic. Control logic consists of timers, counters, real time clock, latch etc. Two starter types are selectable namely: Direct On Line and Forward / Reverse. Prestart warning and spin back timers are standard features. The relay and the MMI together provide the full

functionality with four digital field inputs and five relay outputs (potential free change over contacts).

Functional Description of the ProLoc 2 relay

The ProLoc 2 is a micro-controller based relay. The three phase currents, voltages and earth leakage current are detected by current transformers, attenuator circuits and a core balance current transformer respectively. The current and voltage signals are conditioned by appropriate analogue circuits and converted to 0 to 5 volt analogue signals. The analogue signals are digitized to 10 bit resolution.

The micro-controller has non volatile and volatile memory. The non volatile memory contains a boot loader program which is used to upload the operating software program of the relay.

Front-end software is included that runs on MS Windows™. The RS232 port is used as the communication port. The purpose of the front-end is to configure and select the required functionally of a specific application.

The relay will monitor the parameters of the motor for the duration of auxiliary power supply. The auxiliary power supply is selectable (110Vac or 230Vac). When a trip condition occurs, the main trip relay is activated. It will be energized or de-energized (non fail save or fail save respectively) depending on what mode of operation that was selected. A time and date stamped trip record is also generated and saved in non volatile memory for later retrieval. Memory space for 60 trip records is allocated.

When used with the MMI-420, the ProLoc 2 relay communication port will be connected to the MMI-420 communication port. Additionally, there is RJ11 port on the MMI-420 for the dongle, which gives access to modification of settings on slot 2-7, of the Preset Settings on the MMI. All this ports are marked accordingly. Once all the cables and wires have been connected accordingly, on power on, all the lights flash once and the relay is ready to be programmed and put into operation as a standalone relay or a starter.

Physical description of the ProLoc 2 relay and Man Machine Interface (MMI-420)

ProLoc 2 Relay

Figure 3: The picture of the ProLoc 2 relay is shown.

The relay has 2 relay outputs, additional 3 relay outputs and 4 digital inputs and are on the MMI-420. The relay has seven (7) visual LEDs indications for all the faults and a reset button. Some of the LED fault indications are used for multiple purposes and this is explained on the faceplate of the relay itself, under a heading “INDICATION LED FAULT KEY”. For instance, the Overload and relay healthy LEDs will flash (4 Hz) simultaneously if the relay has tripped on **Starts per hour** protection or the Overload & Insulation failure versus Minimum Load and Earth Leakage will flash in a cross if there is **starter fault**.

ProLoc 2 Fault Indication Panel

Flashing LED's are shown as *"F, (ON:OFF)"* were the values in brackets indicates seconds. Example F, (3:1) = 3 seconds on and 1 second off.

Fault description	LED display						
	Relay Healthy	Overload	Minimum Load	Current Unbalance	Phase Rotation	Insulation Failure	Earth Leakage
Over Current		ON					
Thermal Cooling With Auto Reset		F, (1:1)					
Short Circuit		ON					
Minimum Load			ON				
Minimum Load With Auto Reset			F, (1:1)				
Current Unbalance				ON			
Single Phasing				ON			
Phase Rotation					ON		
Run Stall		ON					
Vectorial Stall		ON					
Insulation Failure						ON	
Vacuum failure						ON	
Earth Leakage							ON
Earth Fault							F, (1:1)
Overvoltage					F, (3:1)		
Undervoltage					F, (1:3)		
Voltage Symmetry					F, (1:1)		
Starts Per Hour	F, (1:1)	F, (1:1)					
High Frequency				F, (3:1)			
Low Frequency				F, (1:3)			
Emergency Stop		F, (2:1)	F, (2:1)	F, (2:1)	F, (1:2)	F, (1:2)	F, (1:2)
External Stop		F, (1:1)		F, (1:1)	F, (1:1)		F, (1:1)
System failure	F, (1:2)						
Execution Fault		F, (1:1)	F, (1:1)	F, (1:1)			
Feedback Fault		F, (1:1)	F, (1:1)	F, (1:1)			
Unauthorised Current		F, (2:1)		F, (1:2)	F, (2:1)		F, (1:2)

Table 2: Indication of LED Faults.

Man Machine Interface (MMI)

Figure 4: The picture of ProLoc 2 MMI-420 is shown.

On the control panel there are 6 buttons used to operate the ProLoc 2 MMI-420 as can be seen in figure 4, the functions of which are explained as follows:

Return button (Return) have three functions.

1. Go back to the previous menu structure.
2. Reset a value back to the original value before editing.
3. When the reset button is pressed for more than 4 seconds then the ProLoc 2 MMI-420 will then reset the ProLoc 2 Relay trip condition.

Enter button (Enter) have three functions.

1. Go into another menu structure.
2. Save a value that has been edited.
3. Confirm a command that is asked for the system integrator by the ProLoc 2 MMI-420.

Actual menu button (Actual) is used to access the actual menu structure.
Once inside the menu structure, one can now browse up or down () with the up or down buttons, or scroll left () or right () with the respective buttons.
Setting menu button (Preset) is used to access the setting menu structure.

Up button have two functions.
1. Go up in a menu structure.
2. Increment a value that is being edited.

Down button have two functions.
1. Go down in a menu structure.
2. Decrement a value that is being edited.

Left button have two functions.
1. Go left in a menu structure.
2. Move left in a value that is being edited.

Right button have two functions.
1. Go right in a menu structure.
2. Move right in a value that is being edited.

User manual for ProLoc 2 MMI-420 further explains the MMI-420 menu structure and these will be demonstrated in the Application examples.

Protection and Management features of the ProLoc 2 relay

ProLoc 2 is a high-end protection unit. The key protection features of ProLoc 2 are briefly listed below, and further details on relay protection features are range, type of parameter and any additional characteristics of the protection feature discussed are given on the ProLoc 2 User manual.

Over Current (Overload) Detection
Undercurrent (Minimum load) Detection
Unbalance Phase Currents Detection
Single Phasing (Phase lost) Detection
Run-Stall Detection
Vectorial-Stall Detection
Starts per Hour Control
Short Circuit Detection
Voltage Symmetry Detection
Over Voltage Detection
Under Voltage Detection
High or Low Frequency Detection
Voltage Phase Rotation
Insulation Failure Detection
Vacuum failure detection
Frozen contactor
Breaker Failure (Vacuum loss) Detection
Earth Leakage Detection (IEL < 2A)
Earth Fault Detection (IEL ≥2A)

Various management features are listed here:
Faults Record
Statistical Data Capturing
Trip Fault Recording
Event Recording
Apparent Power and Real Power Measurement

Additionally, there are various categorised memory mapped parameters which can be used for further management of the ProLoc 2 relay and its drive. This data is accessible through the PLC or similar systems.

Table 1: Memory mapped parameters of the ProLoc 2 relay

Relay Parameters	**Alarm Flags**	**Trip Flags**	**Logic Parameters**
Restart	OverCrnt_af	OverCrnt_tf	TmrA_Mon
Zero ('0')	ShortCirc_af	ShortCirc_tf	! TmrA_Mon
One ('1')	RunStall_af	RunStall_tf	TmrA_Bi
InService	I_Unbal_af	I_Unbal_tf	! TmrA_Bi
VoltPresentF	SinglePhase_af	SinglePhase_tf	TmrB_Mon
Starter_OP_1	EarthFault_af	EarthFault_tf	! TmrB_Mon
Starter_OP_2	EarthFault_af	EarthLeak_tf	TmrB_Bi
Starter_OP_3	EarthLeak_af	MinLoad_tf	! TmrB_Bi
Starter_OP_4	MinLoad_af	OverVolt_tf	RTClock
	OverVolt_af	UnderVolt_tf	! RTClock
	UnderVolt_af	VoltSym_tf	LogicFunc_1
	VoltSym_af	HiFreq_tf	! LogicFunc_1
	HiFreq_af	LoFreq_tf	LogicFunc_2
	LoFreq_af	InsuLockOut_tf	! LogicFunc_2
	InsuLockOut_af	VacuumLoss_tf	LogicFunc_3
	VacuumLoss_af	PhaseRot_tf	! LogicFunc_3
		StartsPerHr_tf	TC_AvailLow
		FrozenCntct_tf	StatusReporter
		System_tf	Flasher
		Execution_tf	PwrFacHiWarn
		FeedBack_tf	PwrFacLoWarn
		UnAuthCrnt_tf	Latch
		E_Stop_tf	! Latch

ProLoc 2 Front-end Software

The front-end software is used for configuring the relay. It has various pages, through which relay parameters can be viewed and edited. The front-end has been designed to make it easy to use and configure the relay. A separate ProLoc 2 Front-End Installation Manual is available, where system requirements are detailed.

Installation of the ProLoc 2 Front-end

Installation of the ProLoc 2 Frontend will allow access to the ProLoc Relays actual, settings, faults, events and statistical data.

The frontend will allow changing of the ProLoc 2 Relay settings to user specification and even upgrading the ProLoc 2 Relay to the newest revision released.

Requirements

Minimum requirements for a PC or Laptops:

1.1 Windows operating system: 2000, NT, XP, Vista, 7.
1.2 CPU: Pentium 1 1GHz.
1.3 RAM: 512Mb.
1.4 Hard drive space: 50Mb.
1.5 A communication port (RS232) must be present before opening the Frontend. If a USB to RS232 converter is used, then the USB to RS232 converter must be plugged in before opening the frontend.
1.6 CD drive x2 speed.
1.7 CAB 0101

Installation

After inserting and opening the Emis product CD in windows explorer window, follow the following steps:

1.8 Open the directory “ProLoc\Application”.
1.9 Double click the file “Setup ProLoc xx.exe”. (xx is the revision of the installation file.)

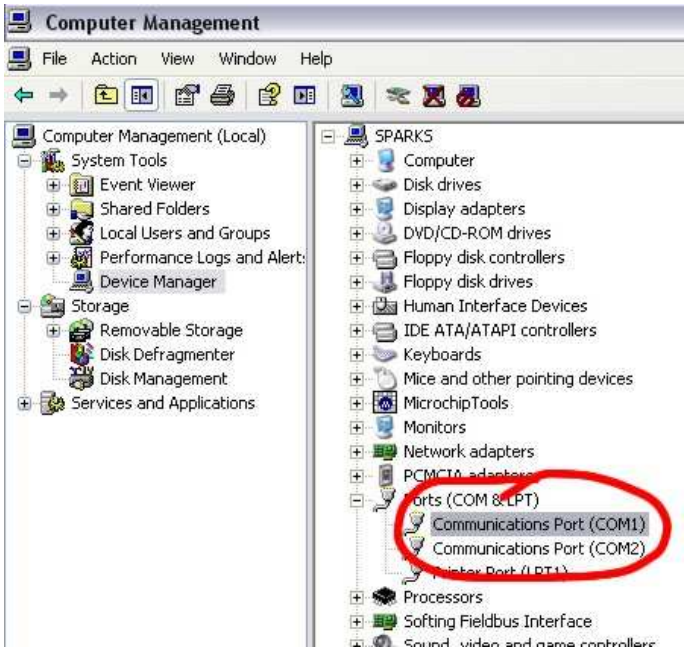
1.10 Follow the instruction on the screen.

Communication port

Make sure that a communication port is available before running the ProLoc Frontend. Looking for a communication port can be done in the following way:

- Right click on “My Computer”.
- Left click on “Manage”.

- Left click on “Device Manager”.
- Expand “Ports” and see if a “(COMX)” is available for use.



Running the frontend

The ProLoc 2 frontend can be found on the startup menu ***Program Files -> Emis -> ProLoc -> ProLoc Frontend***. Then your Front-end showing your Actual screen will open.

Updating ProLoc 2 Relay firmware

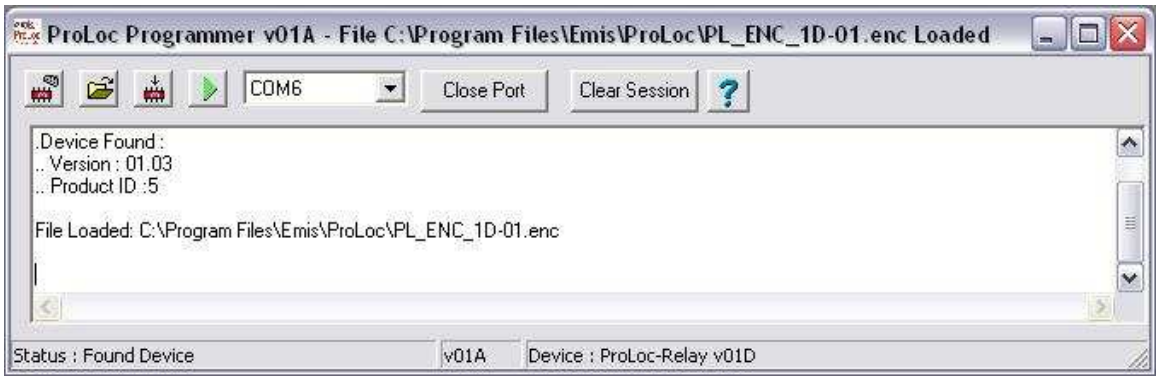
Upgrading of the ProLoc 2 Relay is possible if a newer firmware revision available. Always make sure a copy of the current firmware is available if problems occur with the new update. Updates can be found on the Emis CD under the directory "*ProLoc\ProLoc Revision Updates*"

Ensure that the main circuit is isolated (Trip MCCB). CAB 0101 must be used to update ProLoc relay.

Make sure that the correct comport is selected and that the port is open. If the port is not opened then press the "Open Port" button.

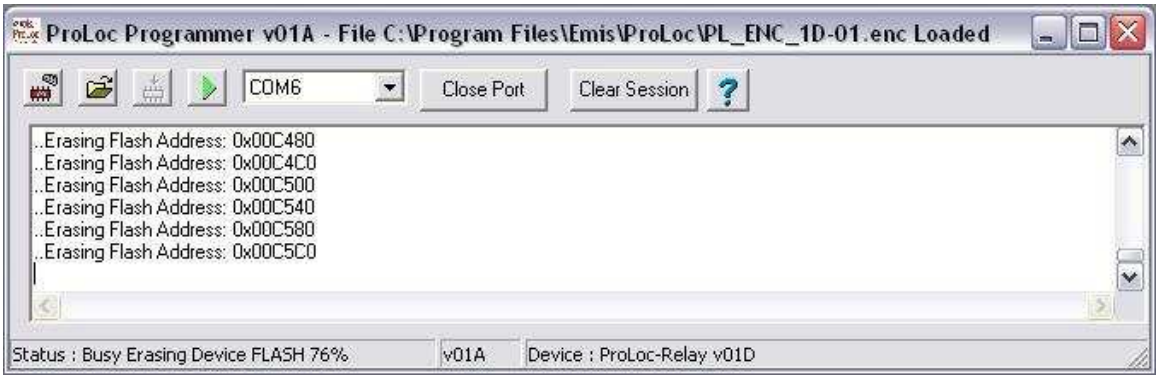
- Press the "find device" button to find the ProLoc 2 Relay. A dialog box will displaying the ProLoc 2 Relay current revision.

- Open up the new encoding file with the “Open file” button.
- If the file was successfully opened that the “Program device” button will be enabled.



- Press the “Program device” button.

U



- After programming is complete press the “Close Port” button and then close the bootloader frontend. This will prevent the frontend to take you back to the bootloader frontend.

Uninstalling the front-end

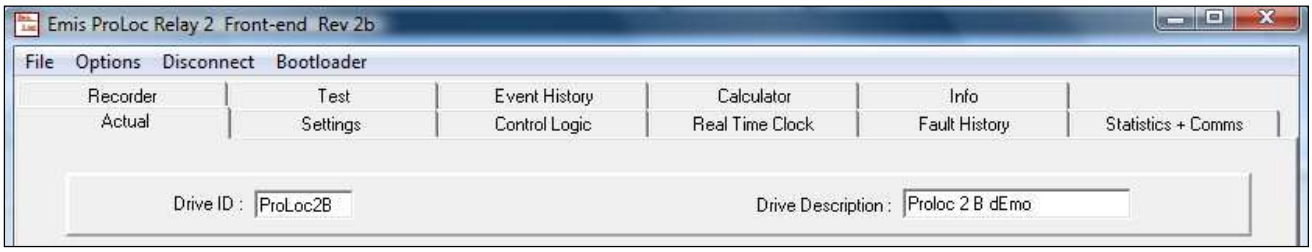
Uninstall is needed to install a new update of a newer frontend. All saved files will not be removed and remains in the directory.

- Uninstall button can be found by ***Program Files -> Emis -> ProLoc II -> Uninstall***.

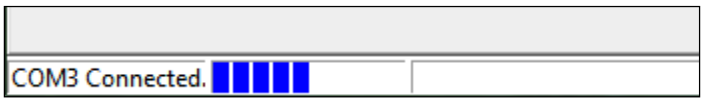
- Press “Yes” and wait for the uninstall to finish.

Connecting the relay and running the Front-end software

Once the relay has been powered, connected to the PC / Laptop and the Front-end installed as explained in the previous section, now it is ready to be programmed. Firstly the communications cables should be connected as explained, and on the main menu, under **Options** menu, choose **COM 3** on the drop down menu as the connection port for the ProLoc 2 relay.



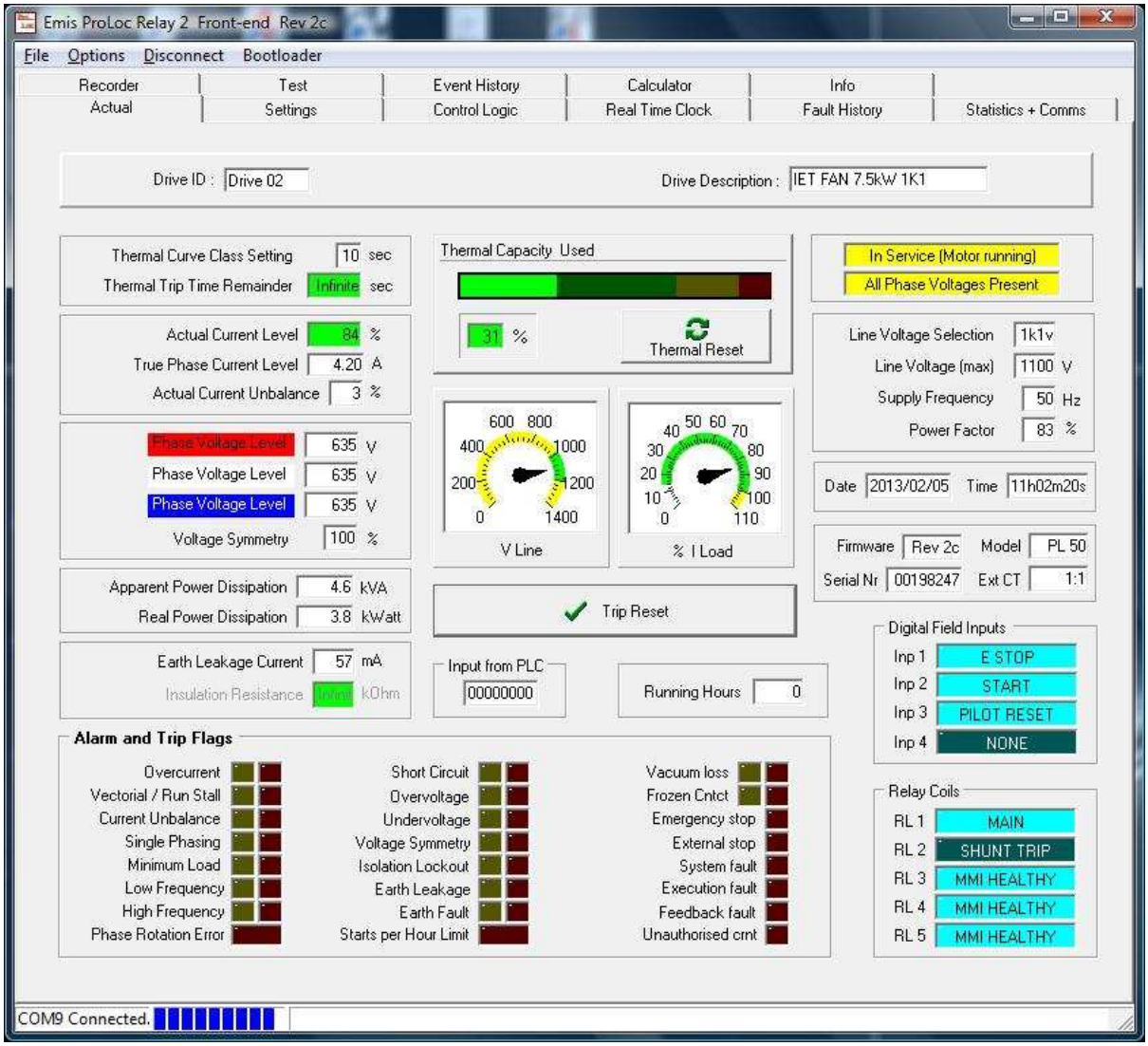
Secondly, on the main menu, under **Connect** menu, connect the ProLoc 2 relay and all your actual values become live. This will be evident with the Drive ID (Drive 02) and Drive Description (JET Fan 7.5kW 1.1kV) being shown as above. Additionally, **COM 3 connected** message with rolling bars will be shown at the base of our page.



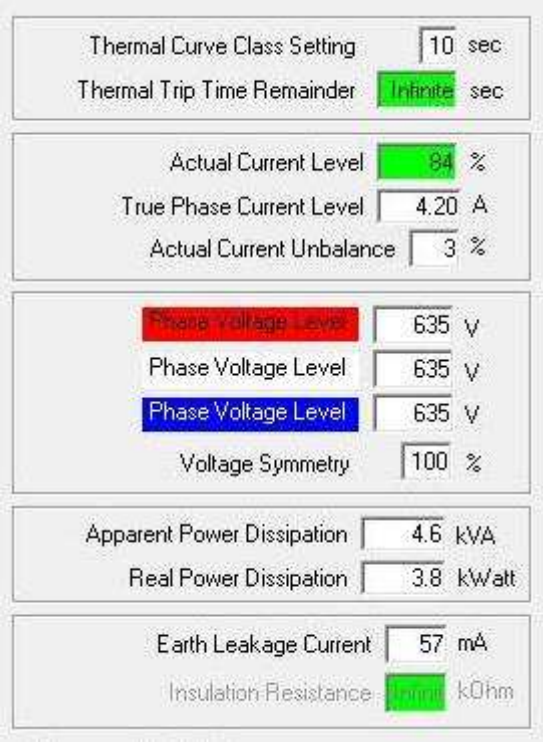
Various self-explanatory pages have been designed to assist with configuration or parameterization of the relay. All pages have an option to **transmit/write settings to relay**, this is important and needs to be done every time changes have been made.

Menu structure

Actual page



This page shows all the actual parameters of a running drive and they will be detailed in the next pages. Additionally, at the bottom of the page, all the alarm and trip flags are shown in green and red respectively for easy of troubleshooting.



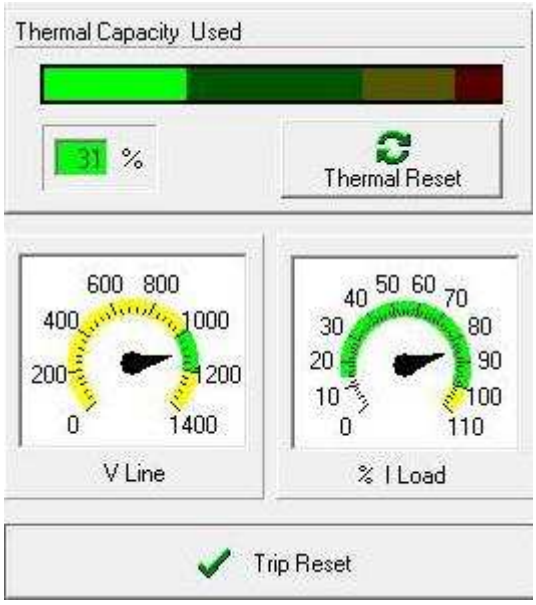
Thermal curve selected and time to pending trip is given.

Actual current and percentage values of the drive are shown.

Colour coded voltage phases are shown, including the voltage symmetry.

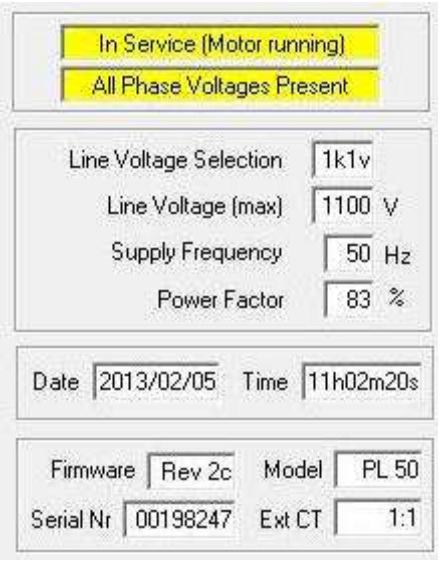
Apparent and Real power consumption of the drive is shown.

Current Earth Leakage and Insulation Resistance values are given.



Visual Thermal Capacity and percentage used are given.

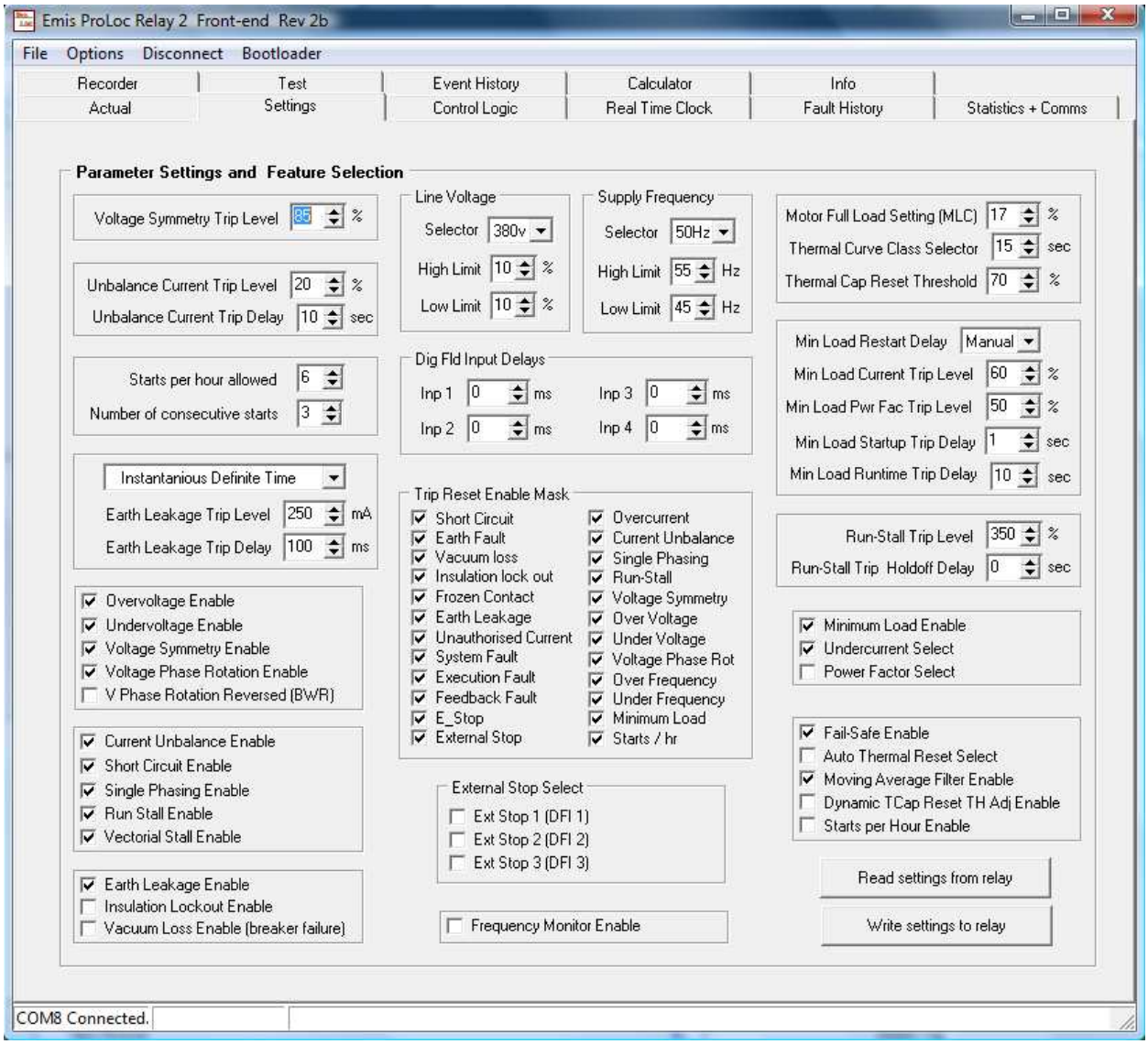
Additionally, the all important Motor Current and Voltage values are shown in a dial. Thermal reset button is also on the actual page.



On the actual page, we have indicators for motor running signal (current detected) and Voltage present on terminals, including additional voltage parameters.

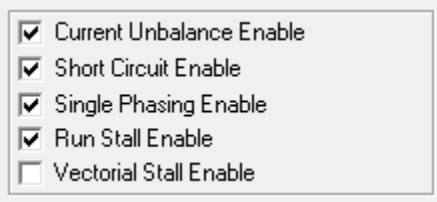
Real Time Clock and relay software and hardware information is shown.

Settings page

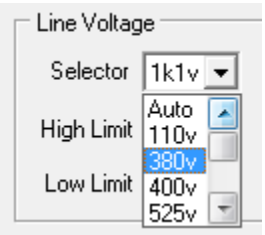


The page shows all the settings required for ProLoc 2 to be used as either a protection relay or a starter. Settings are grouped according to the functions, for easy of configuration and identification. There are various ways in which the settings parameters are effected, such as typing in a parameter, marking or unmarking a parameter, using a “pull down” tag to select predetermined parameters, using “up and down” tags to automatically increment or decrement a parameter. These are all explained in the next page.

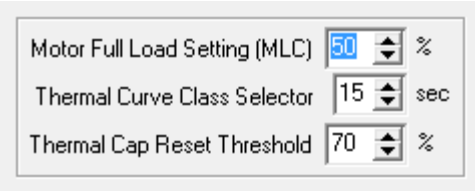
Parameters such as “External Stops” can be configured here to interrupt the ProLoc 2 relay.



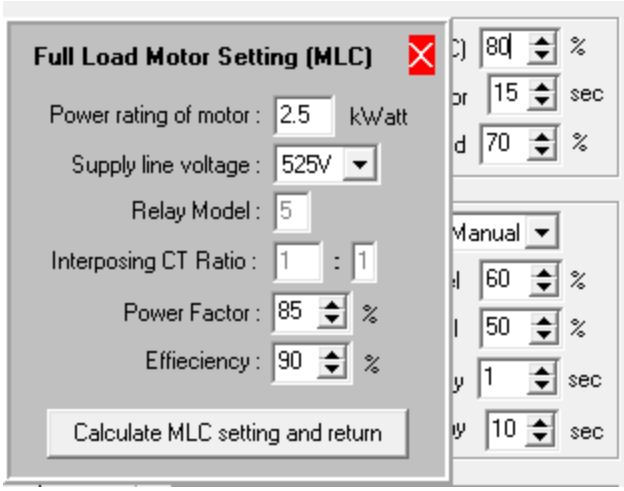
The parameters which are specific to motor current; are enabled by a marking tik, or disabled by unmarking / unchecking the tik as shown on the adjacent picture.



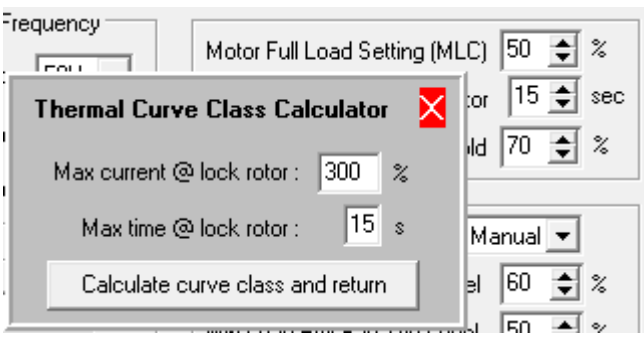
The line voltage selector has pre-populated voltage ranges, which are chosen from the drop-down menu. This is for convenience as most fixed voltage systems are known.



The Motor Full Load parameters, can either be typed in; increased/decreased as required on an “up or down” or calculated with an in-built calculator as shown in the next picture.



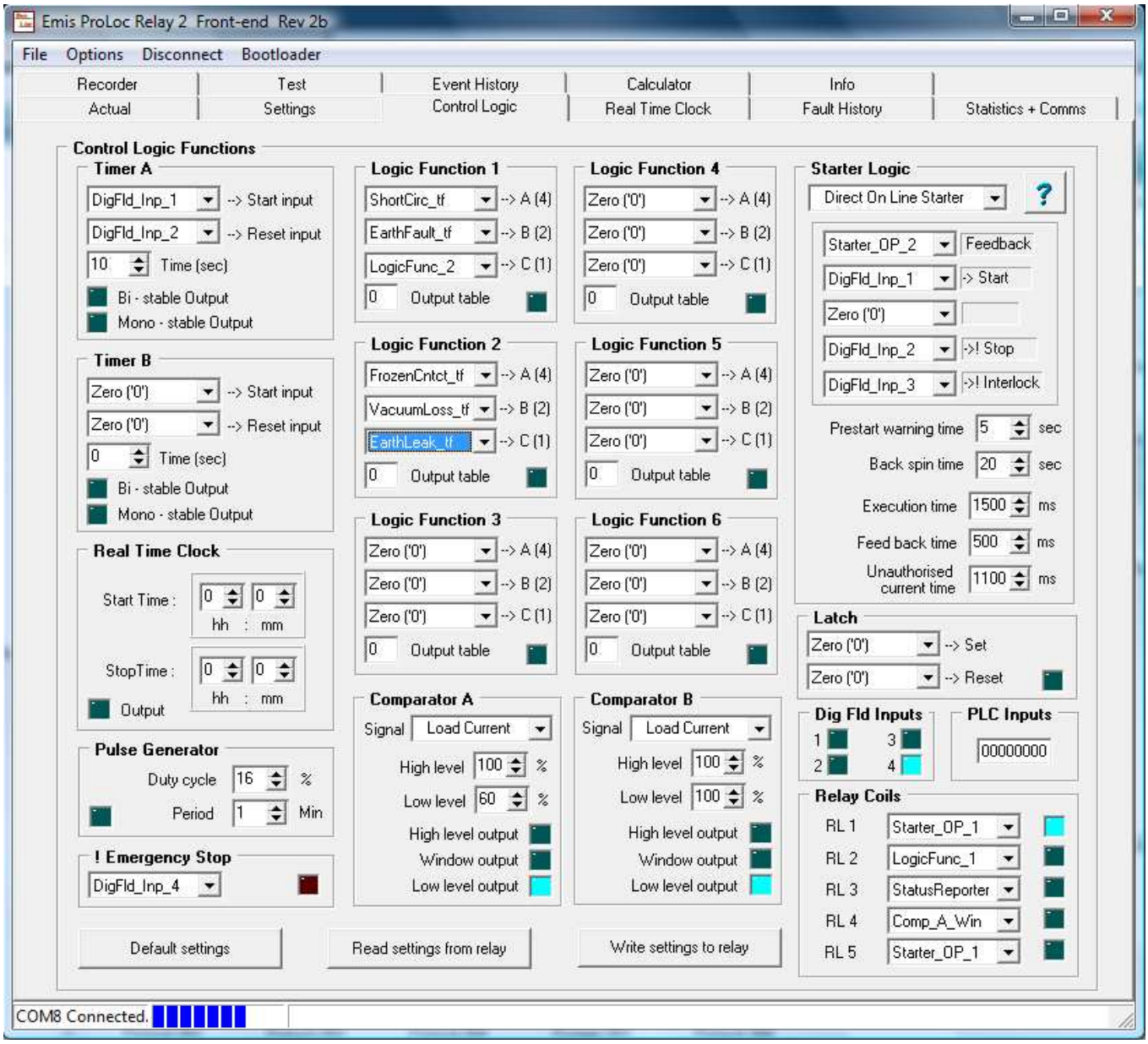
The Full Load Motor setting (MLC) pop-up can be opened by double-clicking the MLC % value. Motor ratings in kW, supply line voltage, Power Factor and efficiency can be specified so that MLC value is automatically calculated for auto-detected relay model.



The Thermal Curve Class Selector for a motor can also be automatically calculated, by using a pop-up

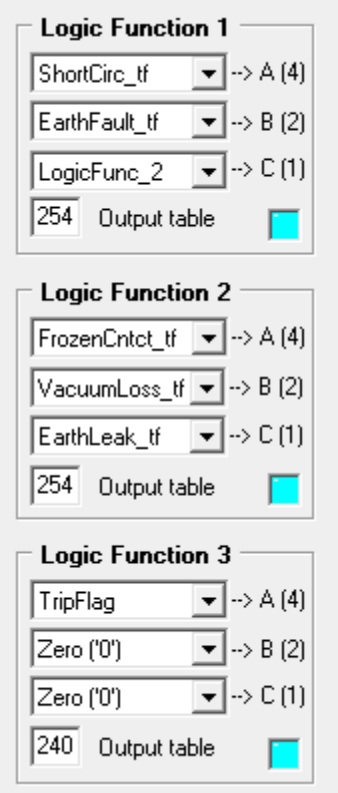
calculator, which requires motor data sheet information on locked rotor current and maximum time for locked rotor.

Control Logic page

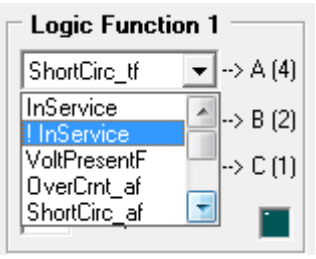


This page shows how to setup logics implemented as part of protection or configured starter. There are light blue or dark green square boxes, which are used to indicate when logic or condition is true or false respectively. Various internal parameters can be used for internal calculations in the Control Logic page. For a full list of this

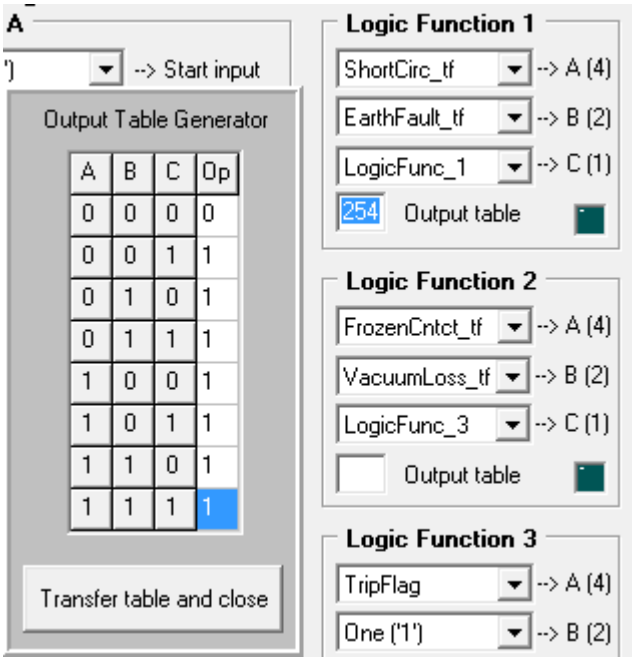
parameters, see page 37, **Table 1:** Memory mapped parameters of the ProLoc 2 relay, in this ProLoc 2 Training Manual. The workings of various logic functions are further explained on the next pages.



There are six (6) logic functions in the ProLoc 2 relay, each with three inputs. The inputs can be digital field inputs or internally calculated parameters, such as flags. This is clearly demonstrated by logic function 1, which uses Short Circuit trip flag, Earth Fault trip flag and output of logic function 2 as inputs.



For this specific Logic Function 1, a Drop down menu has been built-in for all possible parameters which can be used as input (A, B or C) into control logic. This makes it easy as most of potential parameters are calculated during operation. There are 107 possible inputs.



Once in Logic Function 1, you can then build a Truth table for a 3 input (A,B and C) with 1 output (Op). If you double click on highlighted number (254), a truth table pops-up, which can then be configured as an AND, OR, NAND or XOR function. This is easily done by Double clicking the relevant output (Column 'Op'). In the shown example, the configured logic is a 3 input OR gate.

To further expand on the Control Logic Functions, some basic logic theory will be revisited. For simplicity, the theoretical examples show a 2 input.

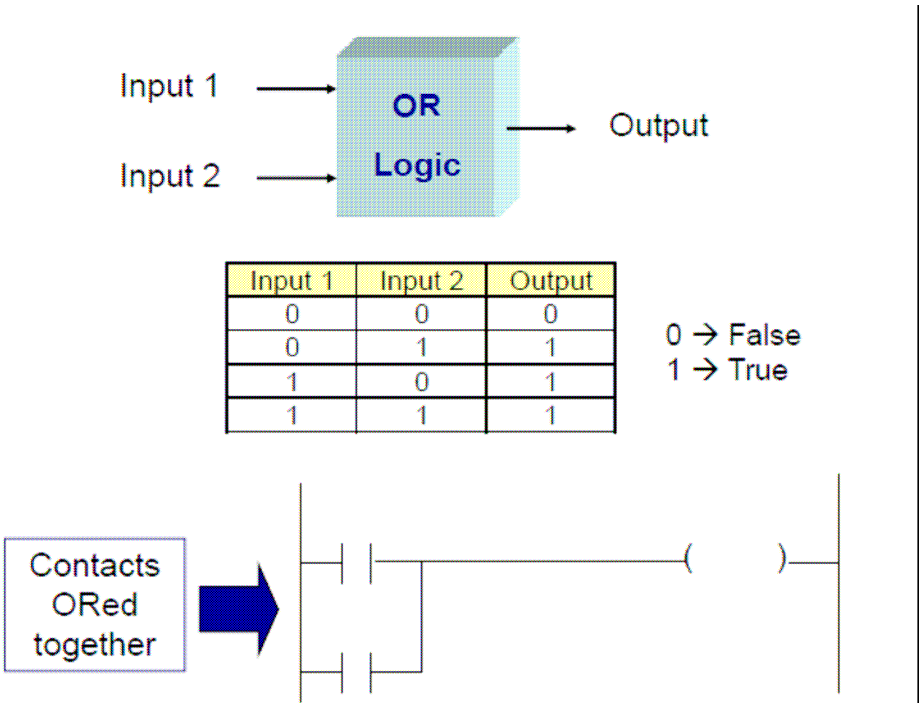


Figure 1a: OR LOGIC showing, Truth table and equivalent Circuit Diagram

(Source: *www2.tech.purdue.edu/.../MET%20382%20**PLC**%20**Fundamentals**%..., Viewed 11/02/2013)*

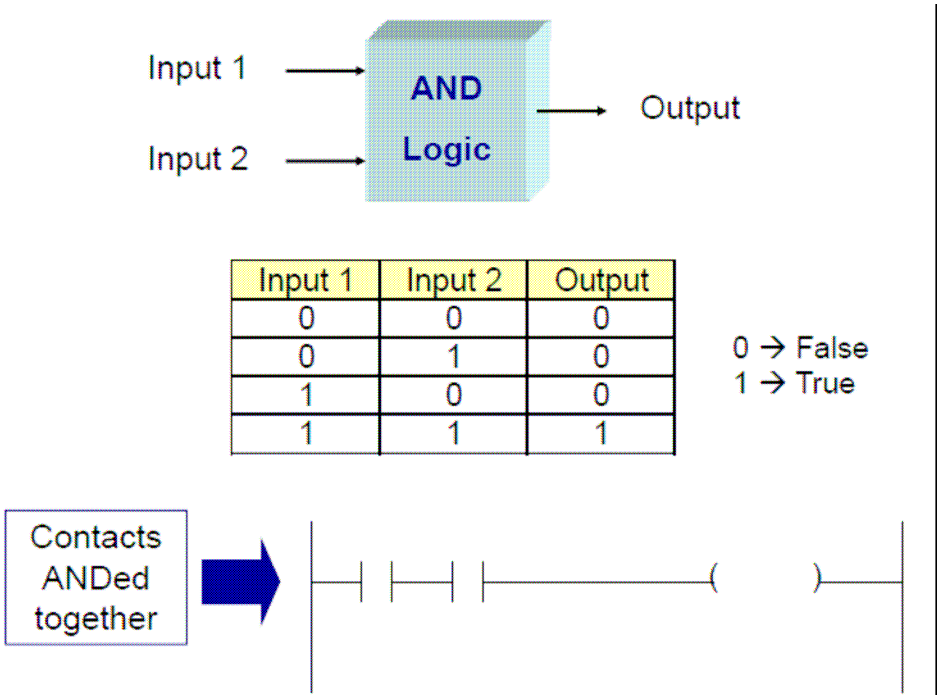


Figure 1b: AND Logic showing, Truth table and equivalent Circuit Diagram

(Source: *www2.tech.purdue.edu/.../MET%20382%20**PLC**%20**Fundamentals**%..., Viewed 11/02/2013)*

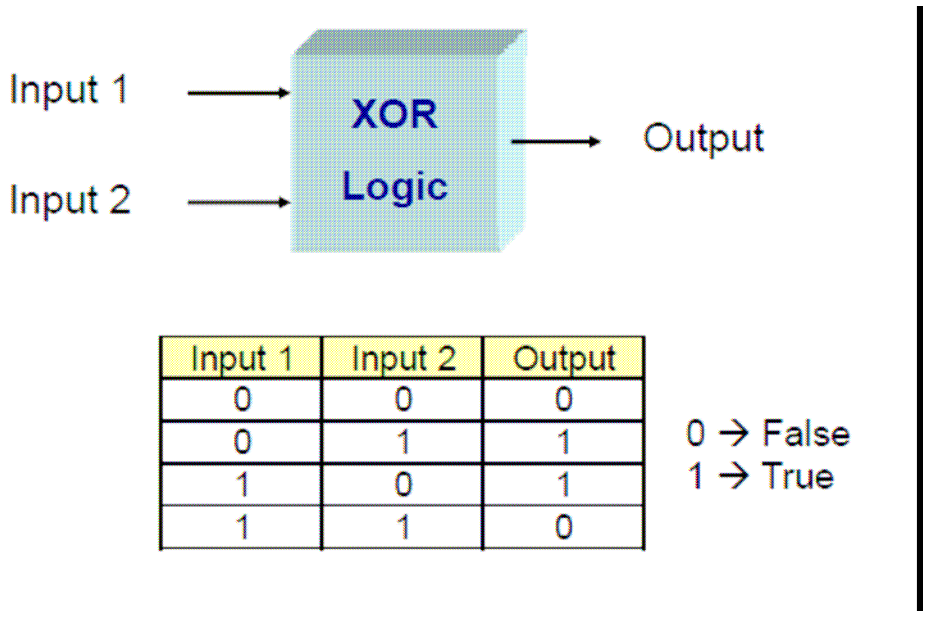
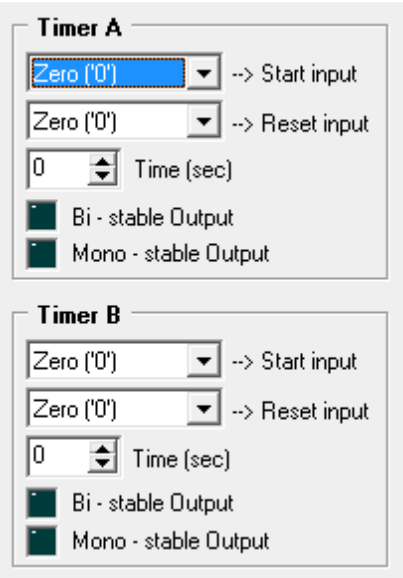
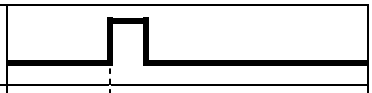
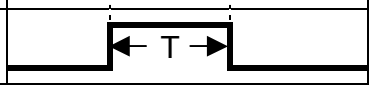


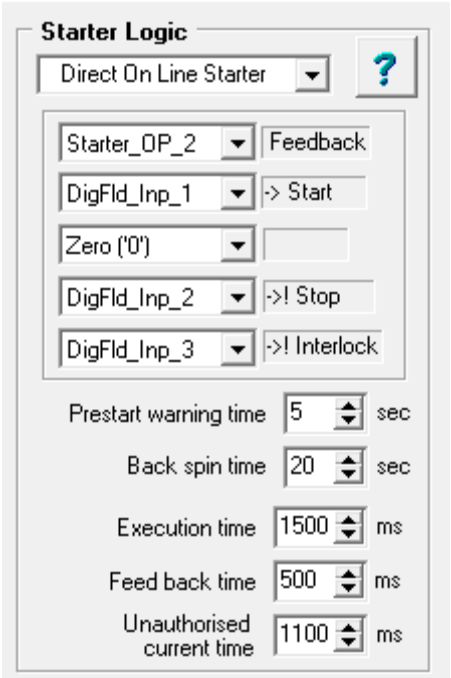
Figure 1c: AND LOGIC showing and associated Truth table.

(Source: *www2.tech.purdue.edu/.../MET%20382%20**PLC**%20**Fundamentals**%..., Viewed 11/02/2013)*

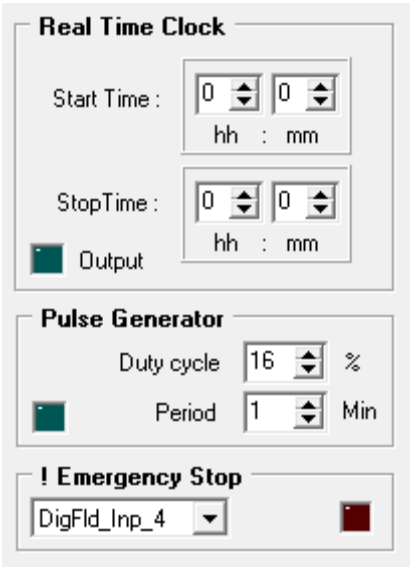


There are two Timers in the ProLoc 2, Timer A and B. The inputs can be digital field inputs, PLC inputs or relay internal calculated parameters. This also have up to 107 inputs.

Start Input	
Reset Input	
Bi – Stable Output	
Mono – Stable Output	

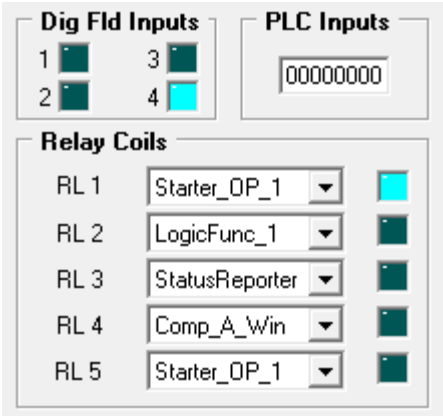


The ProLoc 2 can be configured as Protection relay, Direct On-Line starter or Forward / Reverse starter. All the relevant parameters for each starters are also shown. For example, for Direct Online (DOL) starter parameters such as Pre-start warning time (5 seconds), execution time of the loop (1.5 seconds) and feedback time (0.5 seconds) waiting for contactor feedback is are parameterized as required.

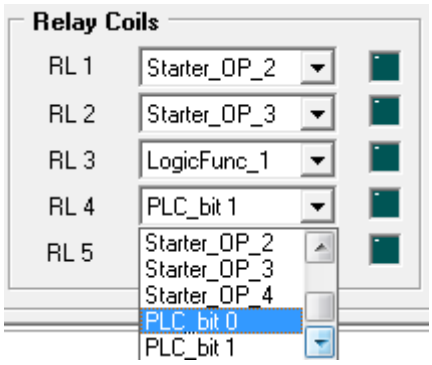


The Real Time Clock can be used in instances where protection or starting needs to be implemented for specific Start times up to Stop time. There is a separate RTC page to program the clock.

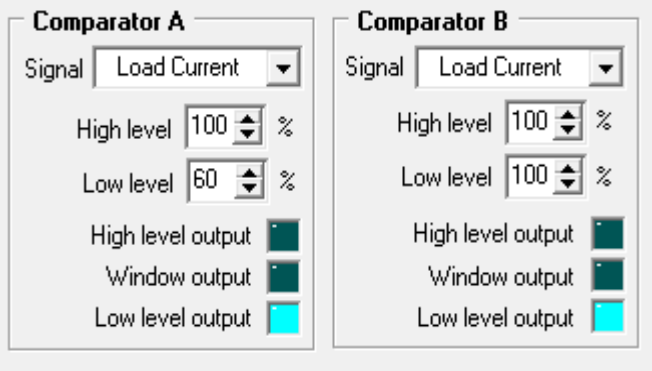
The Emergency Stop, which can be programmed as any input (1-4) is shown here. An exclamation mark(!) shows that the input required comes from a normally close switch. Logic one means that the emergency stop signal is healthy.



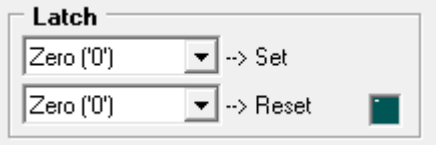
The Digital Field inputs (1-4) statuses into the relay (ON/OFF), the eight binary values of PLC byte input and output relays (1-5) are shown. A reminder is that ProLoc 2 relay has 2 output relays, and relays 3-5 resides in the ProLoc 2 MMI-420



The output into the relays can also be any of multiple parameters which are internally calculated, output of logic functions or starter parameters. This up to 107 possible outputs.

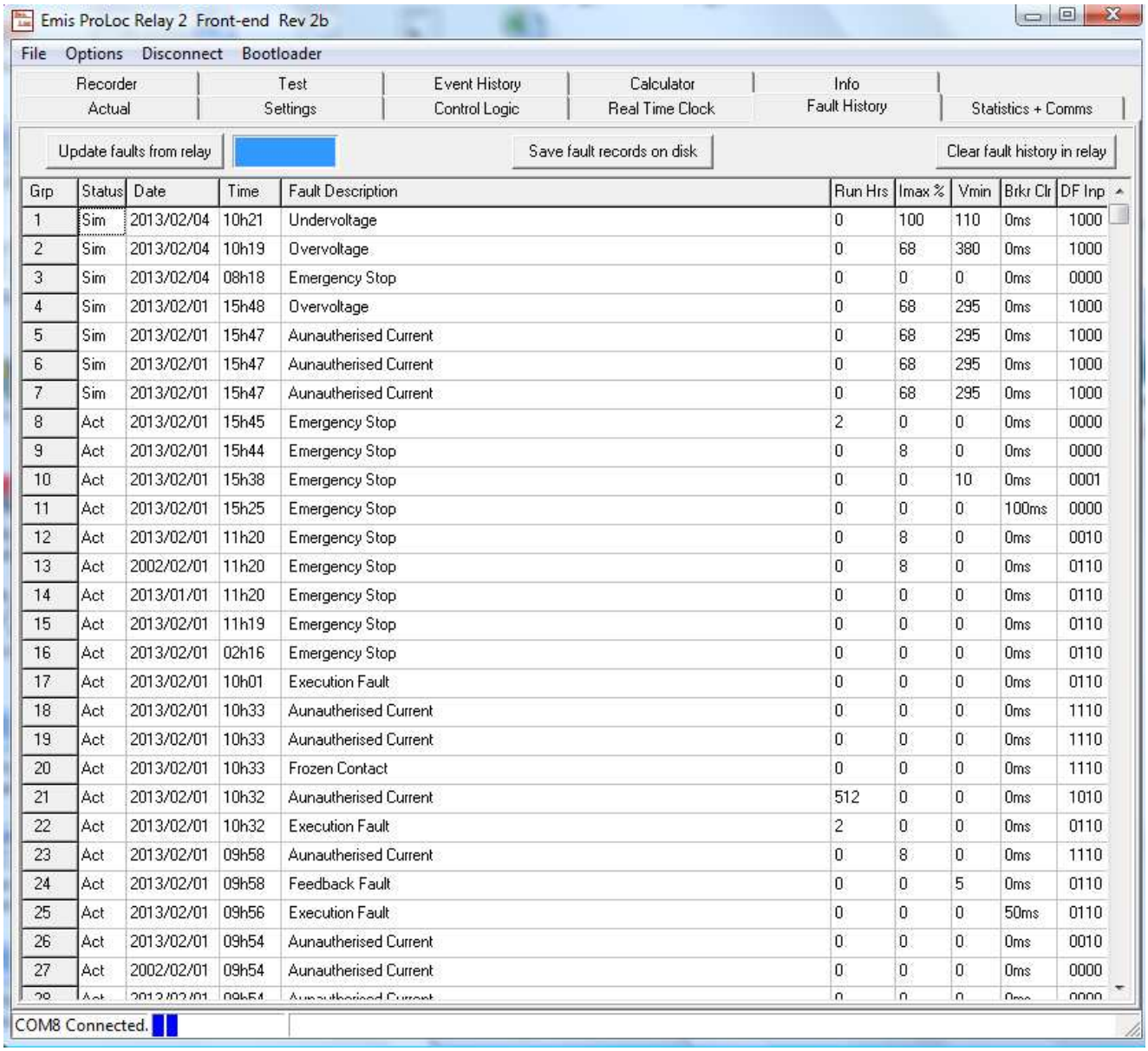


There is Comparators A and B that can be used to generate an output signal, which can be used either as an alarm, trip flag or even as input into a logic function. The values that can be compared here are Load Current, Thermal capacity, Power factor, current unbalance and Voltage symmetry.



A universal latch, with a reset, which can be used for various purposes within the control logics can be configured here.

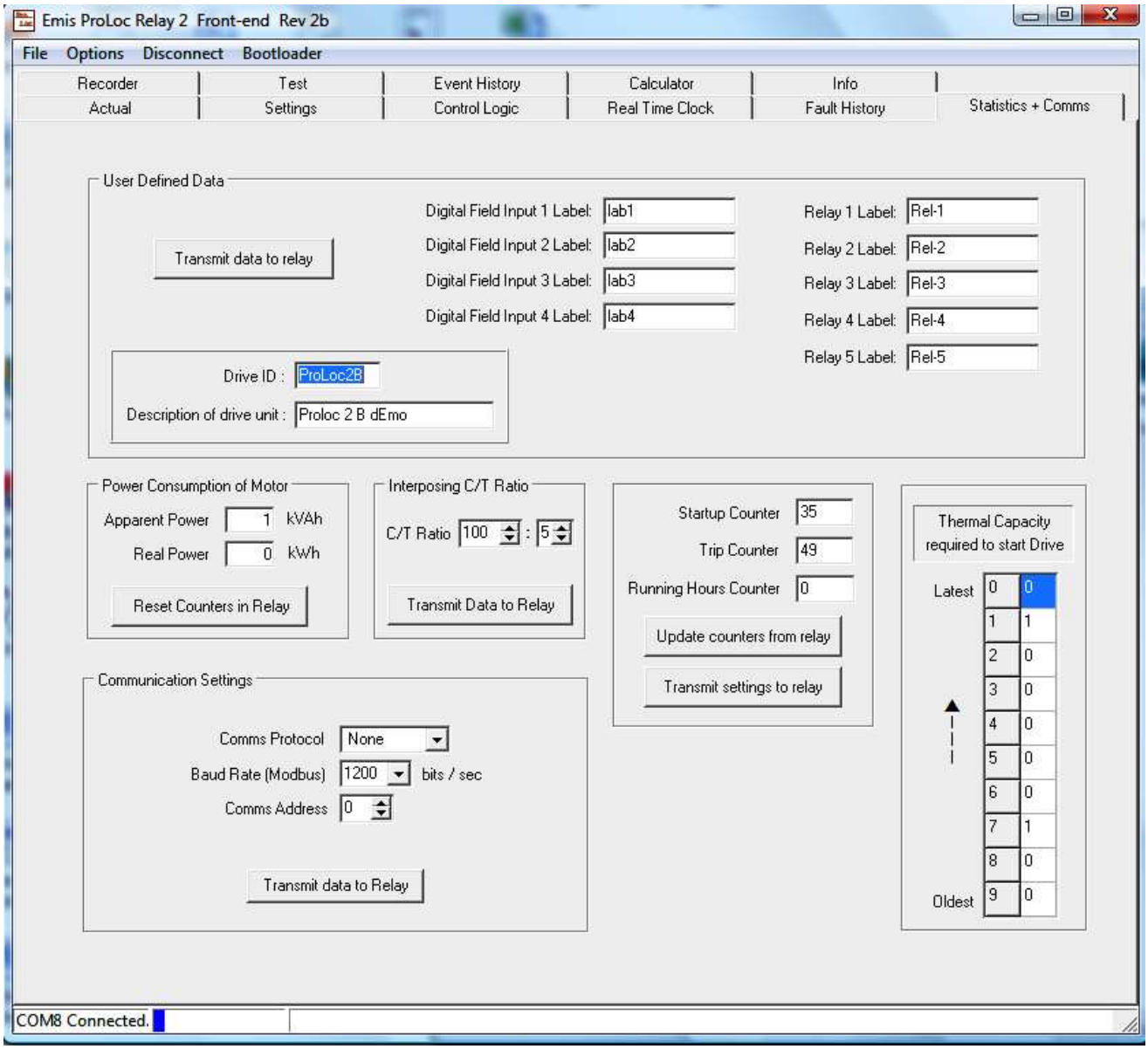
Fault History page



Grp	Status	Date	Time	Fault Description	Run Hrs	Imax %	Vmin	Brkr Clr	DF Inp
1	Sim	2013/02/04	10h21	Undervoltage	0	100	110	0ms	1000
2	Sim	2013/02/04	10h19	Overvoltage	0	68	380	0ms	1000
3	Sim	2013/02/04	08h18	Emergency Stop	0	0	0	0ms	0000
4	Sim	2013/02/01	15h48	Overvoltage	0	68	295	0ms	1000
5	Sim	2013/02/01	15h47	Aunautherised Current	0	68	295	0ms	1000
6	Sim	2013/02/01	15h47	Aunautherised Current	0	68	295	0ms	1000
7	Sim	2013/02/01	15h47	Aunautherised Current	0	68	295	0ms	1000
8	Act	2013/02/01	15h45	Emergency Stop	2	0	0	0ms	0000
9	Act	2013/02/01	15h44	Emergency Stop	0	8	0	0ms	0000
10	Act	2013/02/01	15h38	Emergency Stop	0	0	10	0ms	0001
11	Act	2013/02/01	15h25	Emergency Stop	0	0	0	100ms	0000
12	Act	2013/02/01	11h20	Emergency Stop	0	8	0	0ms	0010
13	Act	2002/02/01	11h20	Emergency Stop	0	8	0	0ms	0110
14	Act	2013/01/01	11h20	Emergency Stop	0	0	0	0ms	0110
15	Act	2013/02/01	11h19	Emergency Stop	0	0	0	0ms	0110
16	Act	2013/02/01	02h16	Emergency Stop	0	0	0	0ms	0110
17	Act	2013/02/01	10h01	Execution Fault	0	0	0	0ms	0110
18	Act	2013/02/01	10h33	Aunautherised Current	0	0	0	0ms	1110
19	Act	2013/02/01	10h33	Aunautherised Current	0	0	0	0ms	1110
20	Act	2013/02/01	10h33	Frozen Contact	0	0	0	0ms	1110
21	Act	2013/02/01	10h32	Aunautherised Current	512	0	0	0ms	1010
22	Act	2013/02/01	10h32	Execution Fault	2	0	0	0ms	0110
23	Act	2013/02/01	09h58	Aunautherised Current	0	8	0	0ms	1110
24	Act	2013/02/01	09h58	Feedback Fault	0	0	5	0ms	0110
25	Act	2013/02/01	09h56	Execution Fault	0	0	0	50ms	0110
26	Act	2013/02/01	09h54	Aunautherised Current	0	0	0	0ms	0010
27	Act	2002/02/01	09h54	Aunautherised Current	0	0	0	0ms	0000

A time stamped fault history, which stores up to 40 incidences, is useful for troubleshooting and auditing purposes. Fault description, Running hours, system Voltage, Motor Current, Breaker Closing duration and state of Digital Field Inputs (DFIs) are shown.

Statistics page

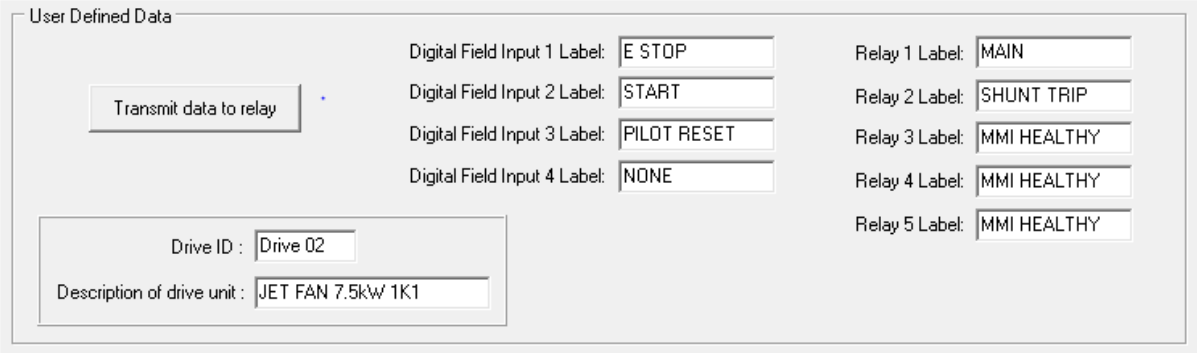


Various useful statistical parameters are shown on this page. Counters giving runtime and starting parameters, power usage and thermal capacity history are housed in this page. Additional on the Statistics page, there is Power consumption data (which can be useful energy management projects and for motor sizing application) and motor running hours, Start-up and trip counters (for maintenance purposes).

There is also a ten line counter for the Thermal Capacity during the last ten start-ups; this is used with **Dynamic Capacity Threshold** function under settings to choose

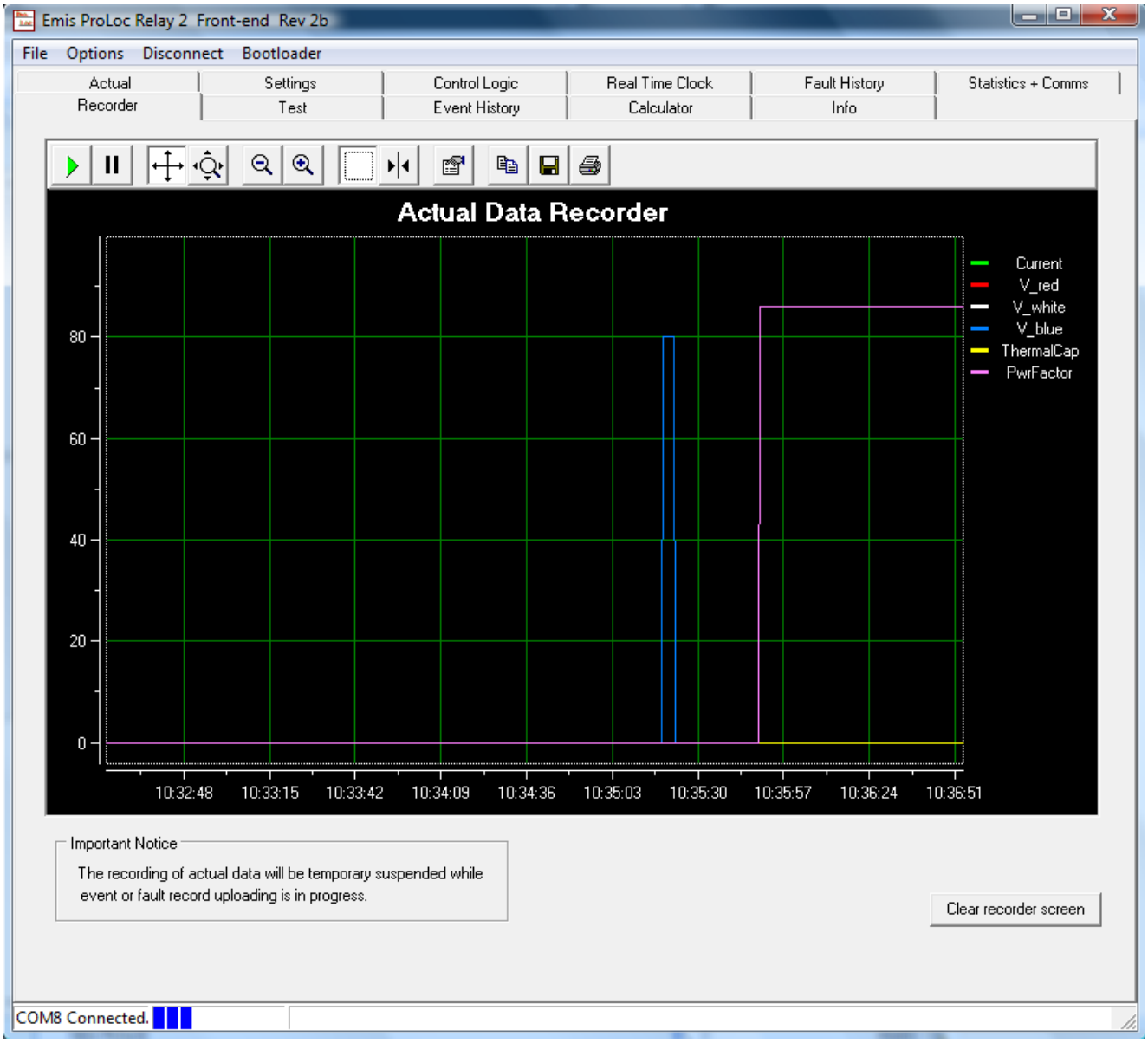
the last best Thermal Capacity Threshold that can be applied to re-start the motor after tripping.

User defined data labels, under Statistics page

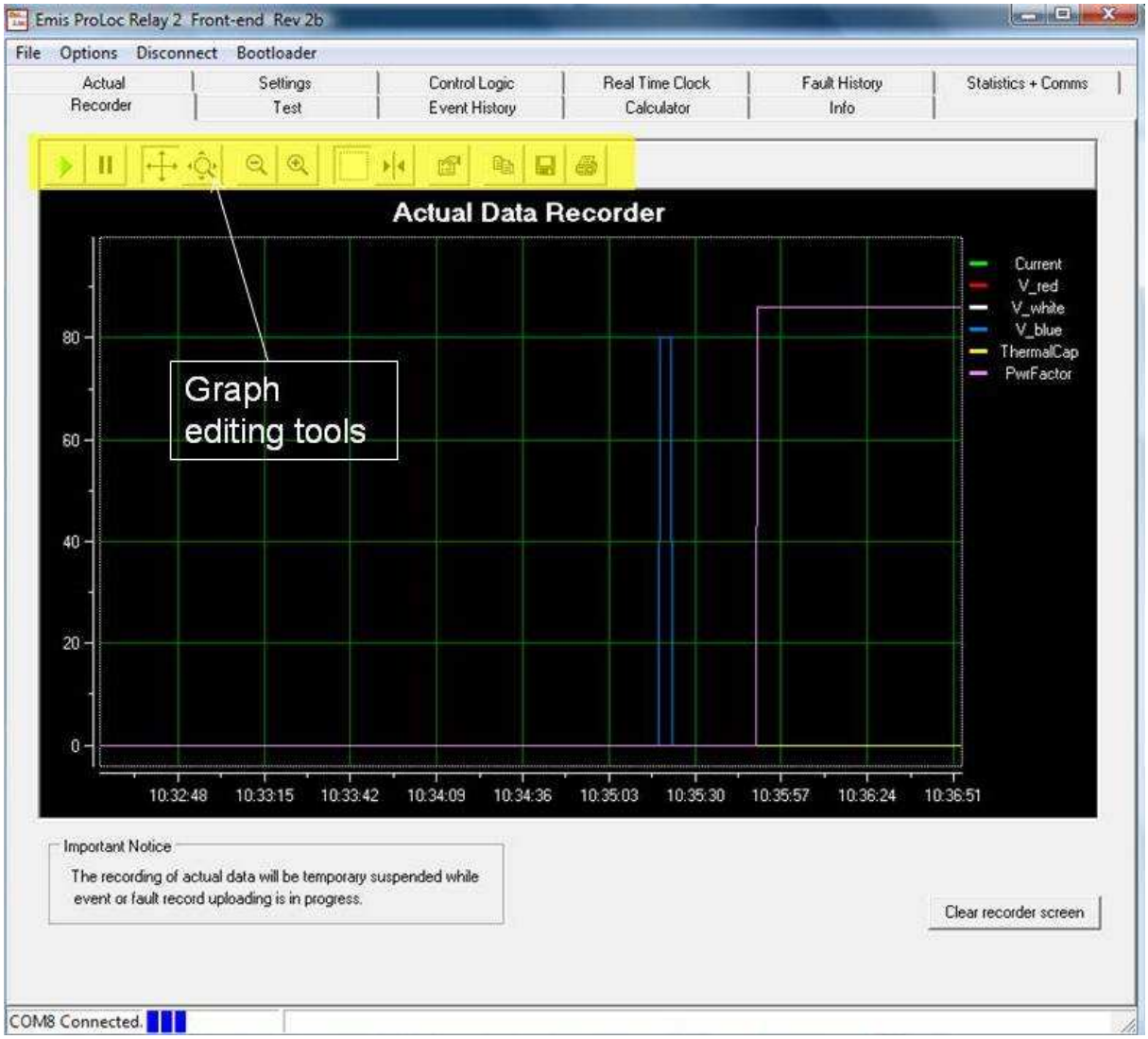


User defined data can be input into the drive too, this information will then be used in fault records and other pages of the parameterization software ProLoc 2 Front-end. As this information can be memory mapped, all the data is accessible and can further be used in Programmable Logic Control (PLC) or higher level control systems.

Recorder page

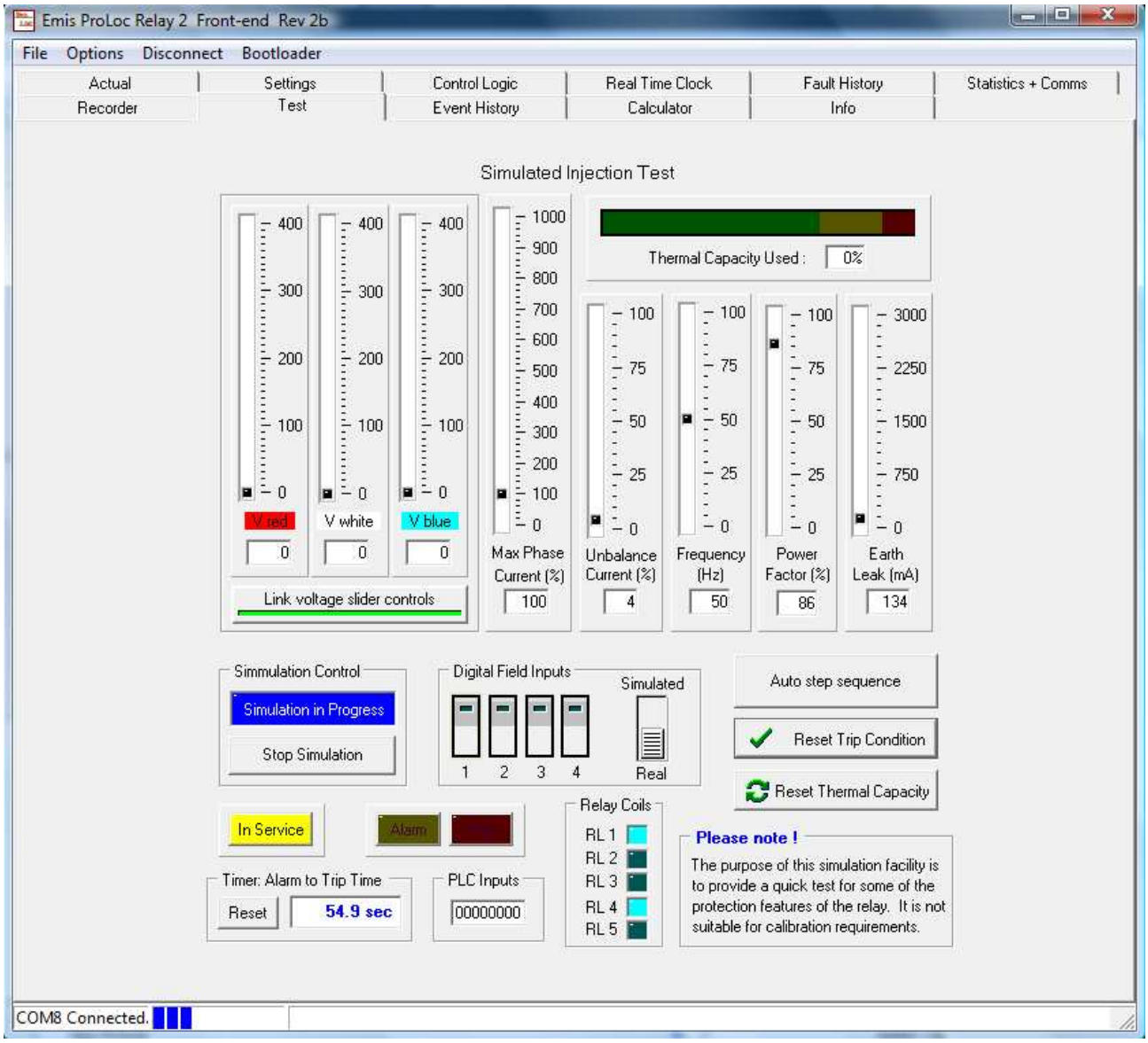


A recorder can be setup to capture various parameters of a ProLoc 2 relay driven motor. Magnitude (%) and time scale parameters of the graph are configurable and the graph can be stored as a picture or metafile. This is a very useful feature for trouble shooting a running drive and for reporting purposes.

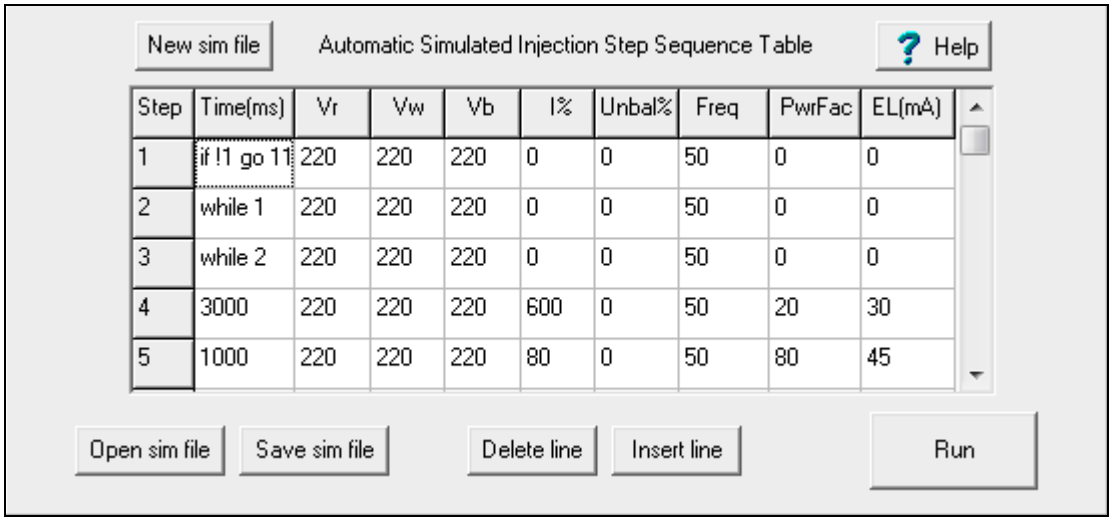


A time scaled recorder can be setup to capture various drive parameters. X and Y parameters of the graph are configurable and the graph can be stored as a picture or metafile. A Cursor to track measured signals is available and one can also zoom in and out of specific parts of the live recording of ProLoc 2 parameters.

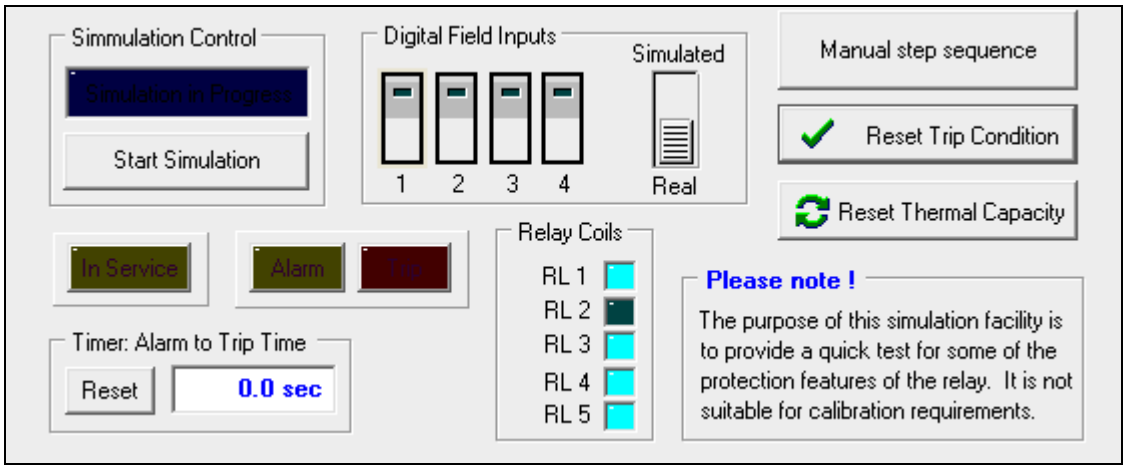
Test page (Simulation)



The Test / Simulation page is used to test various functions of the ProLoc 2 relay. Simulated (on Test page clicked buttons) or Real (physical inputs into relay) signals can be used. Additionally, there are two options for simulations either by Automatic sliding-parameter simulations or self-built simulations in a table format. This feature is also useful for System Integrators during PLC logic checks and cold commissioning.



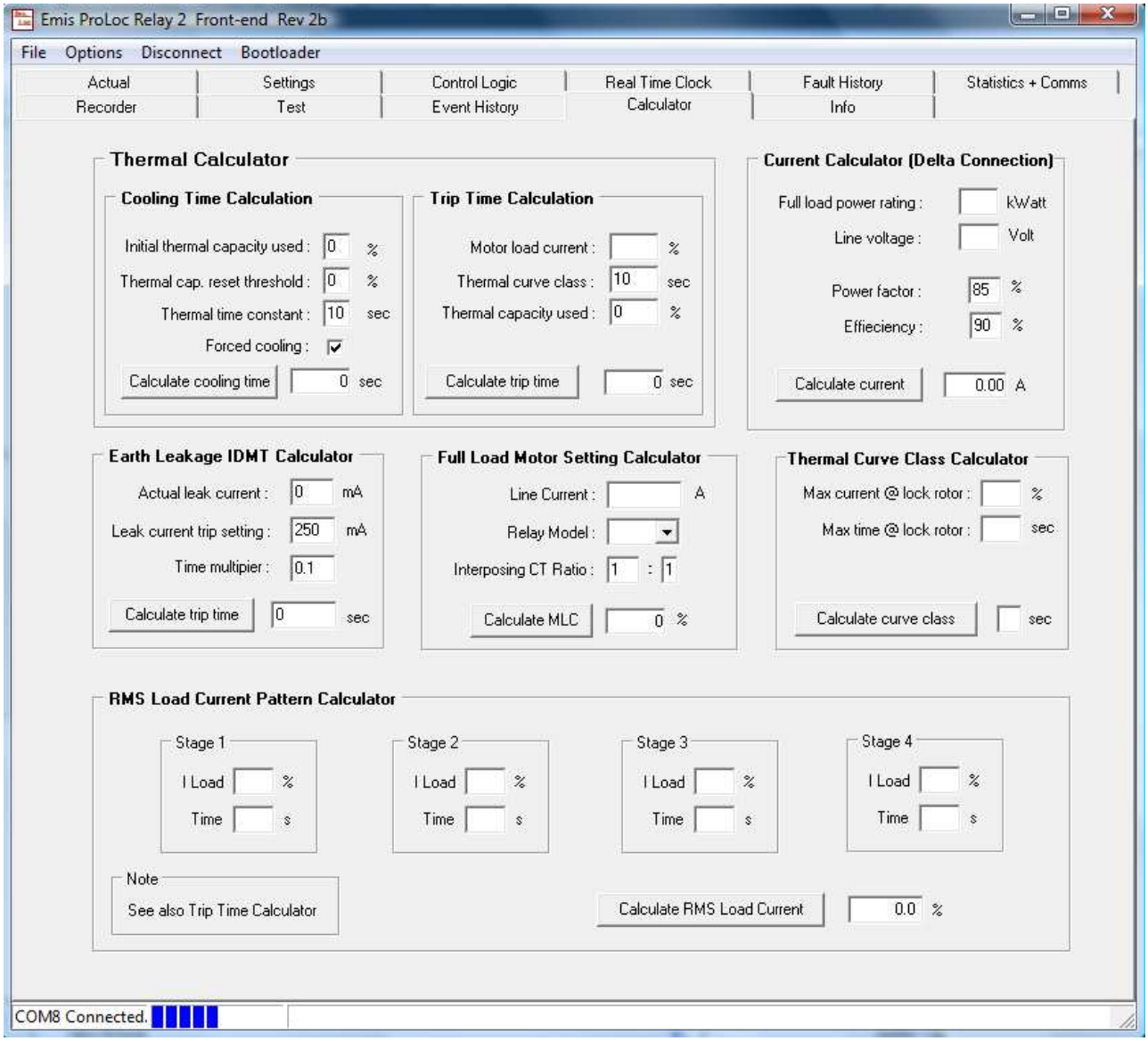
The simulation can be built in the form of statement list and/or motor parameters. Under help, there is all the syntax that can be used to build a **simulation file.** Please note that even if you are not using all the parameters, set them to zero (0) otherwise the simulator will give a form error of “Not integer” when trying to run such a file. Simulation files can be saved in a specified folder and later opened in from a Personal Computer (PC). Menus for the “Save sim file” or “Open sim file” functions are neatly located as shown in the picture above.



The drive simulation is controlled from this lower half of the Test / Simulation page. **Start / Stop simulation** are located on the same button for ease of use. Then Indication for when the simulation is “In Service / Alarmed / Tripped”. When the simulation is run from a created file and has been started, you initiate the simulation by pressing the “Manual step sequence” button. There is also an Automatic Simulation that has all parameters in a sliding controller (Phase voltage in volts, Line

current in percentage, Current unbalance in percentage, Frequency, Power factor and Earth Leakage in milliamps) but effectively works in the same way as manual version. If the simulation is totally ran from Front-End, Simulated is chosen on the Digital Field Inputs and DFI 1 to 4 are used as programmed (under Control Logic) to control the Protection / Starter functions. Else Real on sliding option is chosen for hardwired signals into the ProLoc 2 relay MMI-420 inputs, terminals 11-14 as indicated on ProLoc 2 User Manual.

Calculator page



The Calculator page has various calculators to use when programming the device. For instance, Current calculator will give you the required current for a specified motor, which can then be input in the Settings page.

Other calculators are for Full Load Motor Settings, Thermal Curve Class, Earth Leakage, Cooling Time and Trip Time.

Info page

The info page shows address and contact details of the suppliers for the ProLoc 2 relay, Emis.

Application examples to be demonstrated

1. ***ProLoc 2 configured as Protection relay***

   Configure the ProLoc 2 relay, PL 10, as a Protection relay for a 7.5 kW Jet Fan, on a 1100 Volts system. Configure your high energy faults to backtrip into the MCCB.

2. ***ProLoc 2 configured and programmed as Direct-On-Line starter***

   Configure the ProLoc 2 relay, PL 10, as a Direct Online starter for a 7.5 kW Jet Fan, on a 1100 Volts system. Configure your high energy faults to backtrip into the MCCB. Configure your Start and Stop buttons and Interlocks on Digital field inputs 1-4.

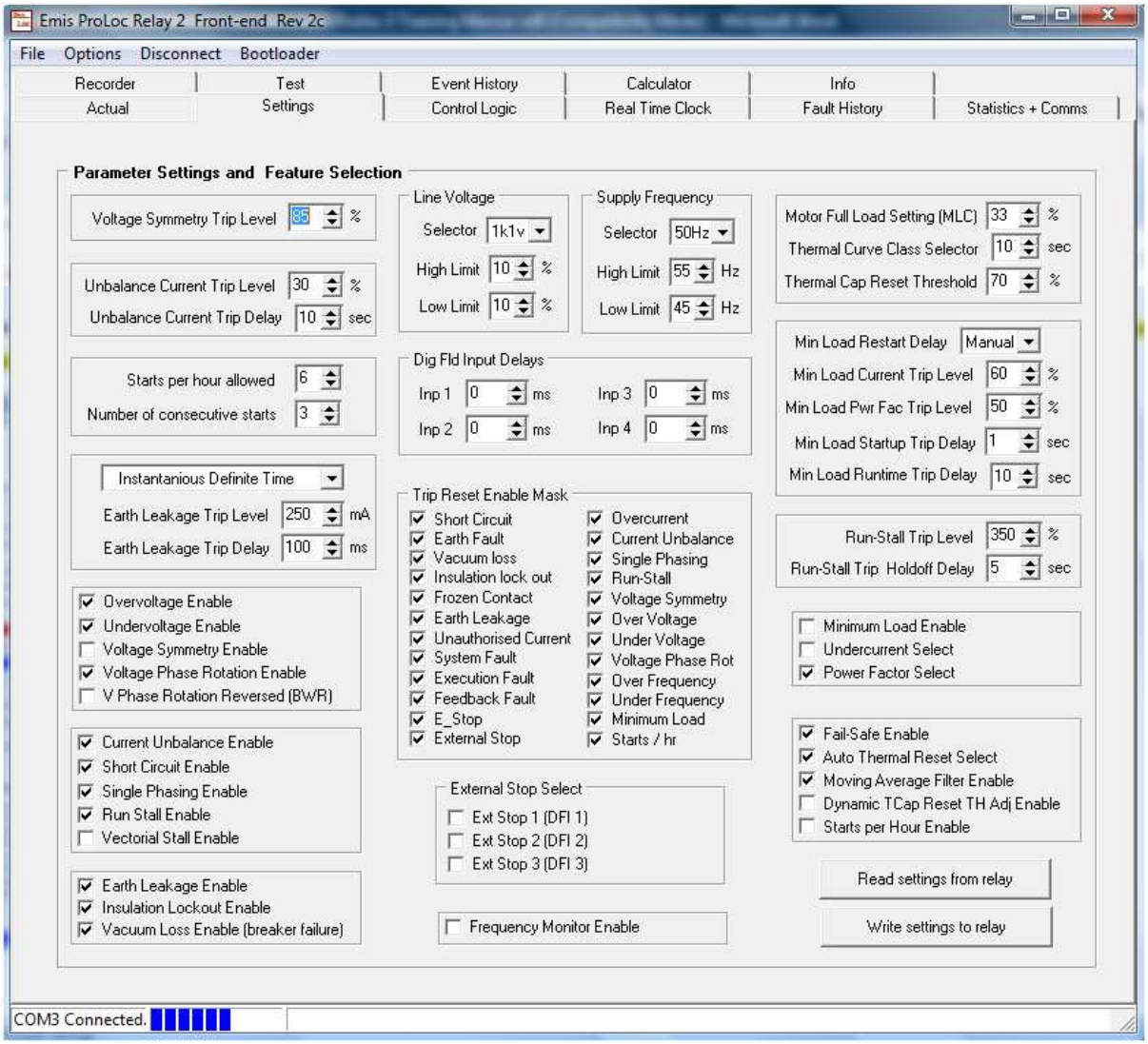
3. ***ProLoc 2 configured and programmed as Forward / Reverse starter***

   Configure the ProLoc 2 relay, as a Forward/Reverse starter for a 55 kW Crane motor, on 1100 Volts system. Configure your high energy faults to back trip into the MCCB. Configure your Forward/Reverse buttons and Interlocks, as many as you need, on Digital field inputs 1-4.

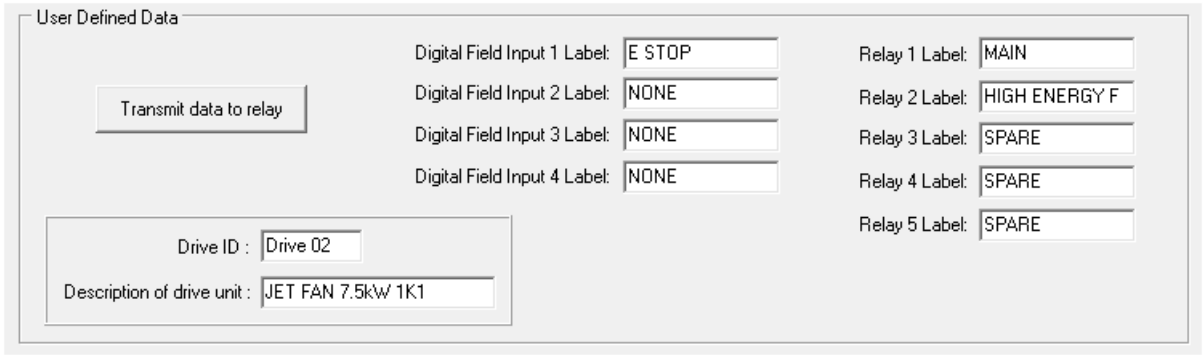
Solutions to application examples

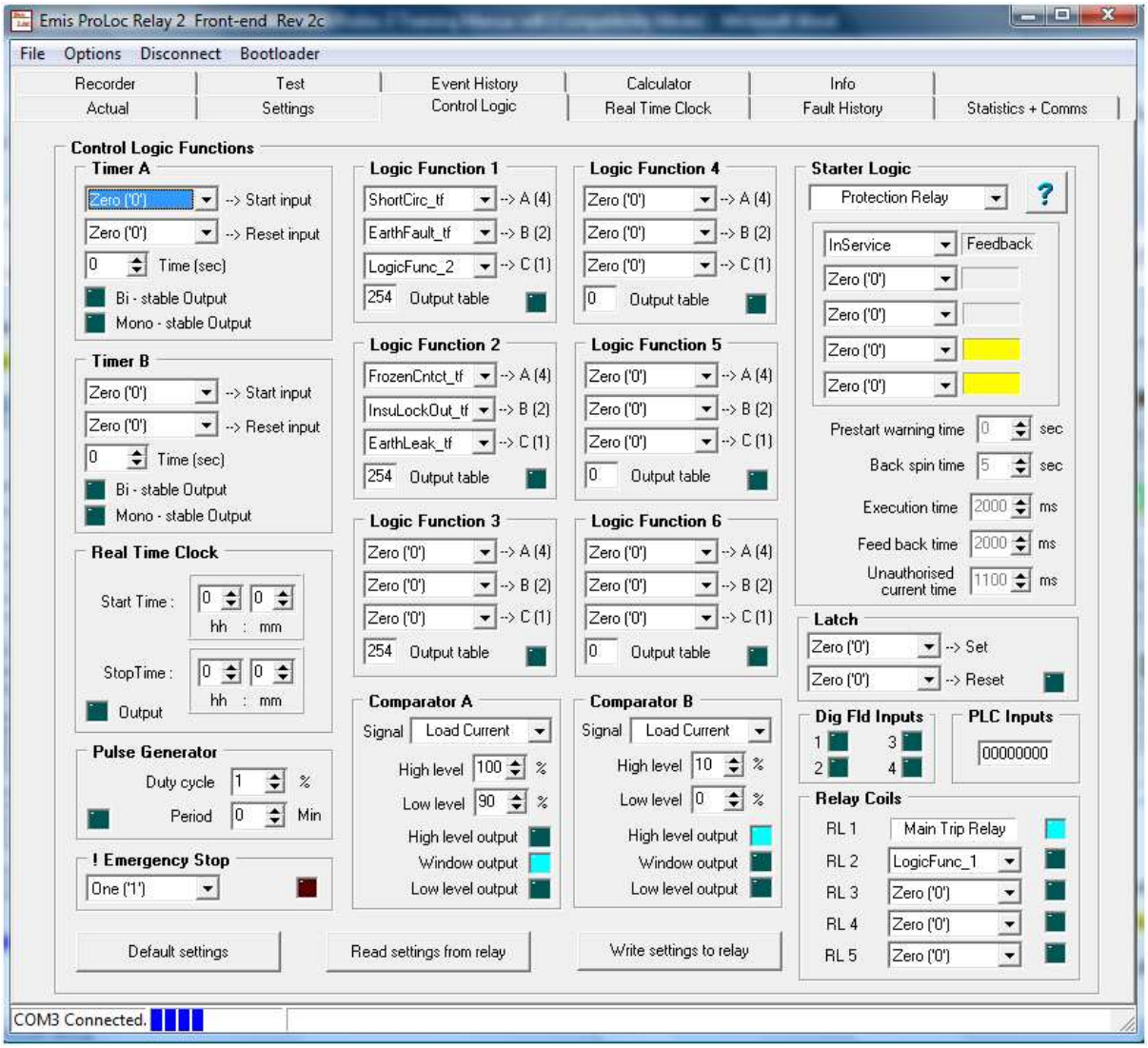
1. ProLoc 2 configured as Protection relay

Typical Settings, Control logic and Actual pages for a ProLoc 2 relay, PL 10, as a Protection relay for a 7.5 kW Jet Fan, on a 1100 Volts system. Configure your high energy faults to backtrip into the MCCB.



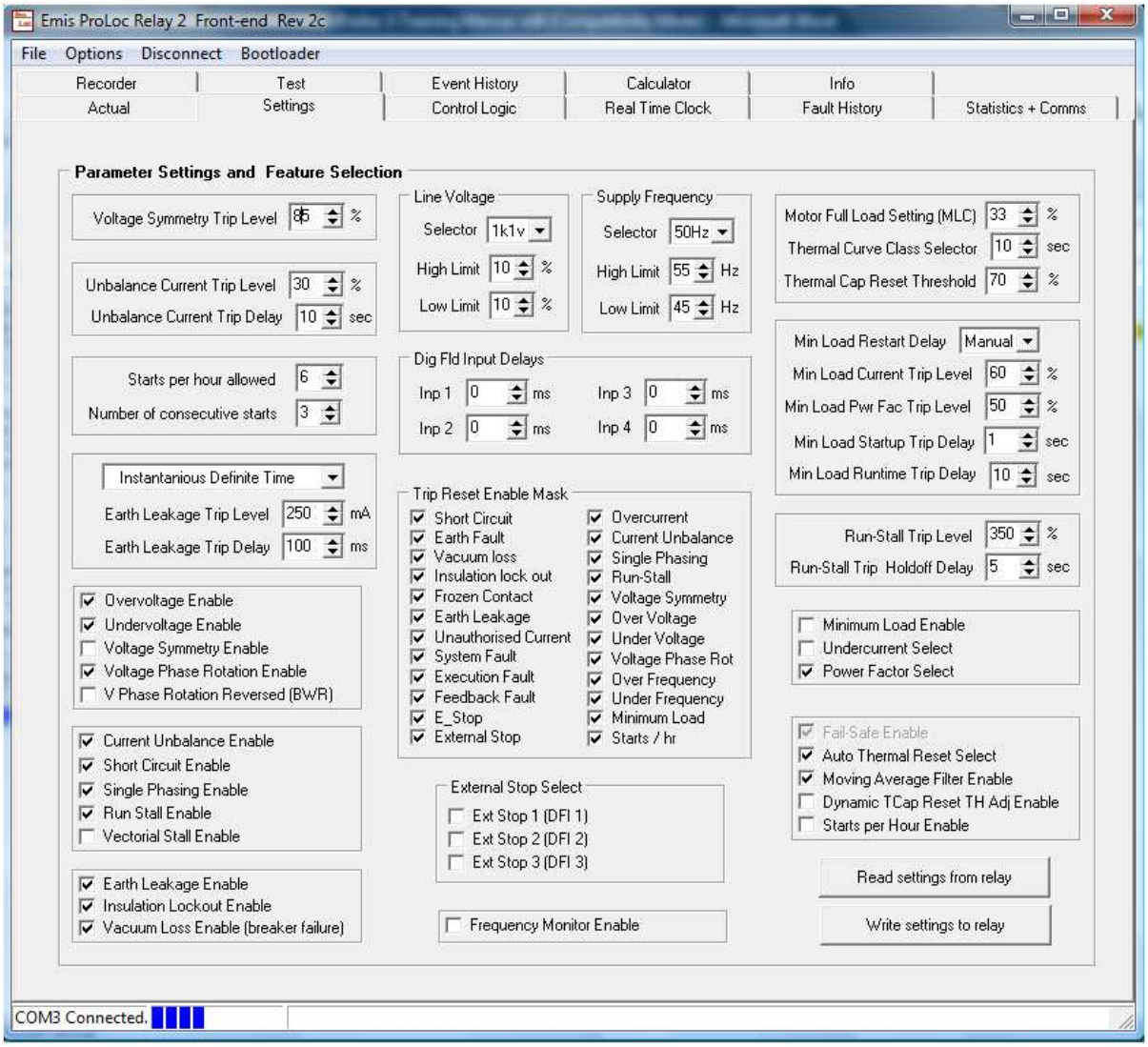
Emis ProLoc Relay 2 Front-end Rev 2c
File Options Disconnect Bootloader
Recorder Test Event History Calculator Info
Actual Settings Control Logic Real Time Clock Fault History Statistics + Comms
Drive ID : Drive 02
Drive Description : JET FAN 7.5kW 1K1
Thermal Curve Class Setting 10 sec
Thermal Trip Time Remainder Infinite sec
Thermal Capacity Used
0 %
Thermal Reset
In Service (Motor running)
All Phase Voltages Present
Actual Current Level 100 %
True Phase Current Level 3.30 A
Actual Current Unbalance 3 %
Line Voltage Selection 1k1v
Line Voltage (max) 1100 V
Supply Frequency 50 Hz
Power Factor 0 %
Phase Voltage Level 635 V
Phase Voltage Level 635 V
Phase Voltage Level 635 V
Voltage Symmetry 100 %
V Line
% I Load
Date 2013/02/05 Time 14h05m48s
Firmware Rev 2c Model PL 10
Serial Nr 00199708 Ext CT 1:1
Apparent Power Dissipation 3.6 kVA
Real Power Dissipation 0.0 kWatt
Trip Reset
Earth Leakage Current 0 mA
Insulation Resistance Infinit kOhm
Input from PLC 00000000
Running Hours 0
Digital Field Inputs
Inp 1 E STOP
Inp 2 NONE
Inp 3 NONE
Inp 4 NONE
Alarm and Trip Flags
Overcurrent
Vectorial / Run Stall
Current Unbalance
Single Phasing
Minimum Load
Low Frequency
High Frequency
Phase Rotation Error
Short Circuit
Overvoltage
Undervoltage
Voltage Symmetry
Isolation Lockout
Earth Leakage
Earth Fault
Starts per Hour Limit
Vacuum loss
Frozen Cntct
Emergency stop
External stop
System fault
Execution fault
Feedback fault
Unauthorised cmt
Relay Coils
RL 1 MAIN
RL 2 HIGH ENERGY F
RL 3 SPARE
RL 4 SPARE
RL 5 SPARE
COM3 Connected.


User Defined Data
Transmit data to relay
Digital Field Input 1 Label: E STOP
Digital Field Input 2 Label: NONE
Digital Field Input 3 Label: NONE
Digital Field Input 4 Label: NONE
Relay 1 Label: MAIN
Relay 2 Label: HIGH ENERGY F
Relay 3 Label: SPARE
Relay 4 Label: SPARE
Relay 5 Label: SPARE
Drive ID : Drive 02
Description of drive unit : JET FAN 7.5kW 1K1

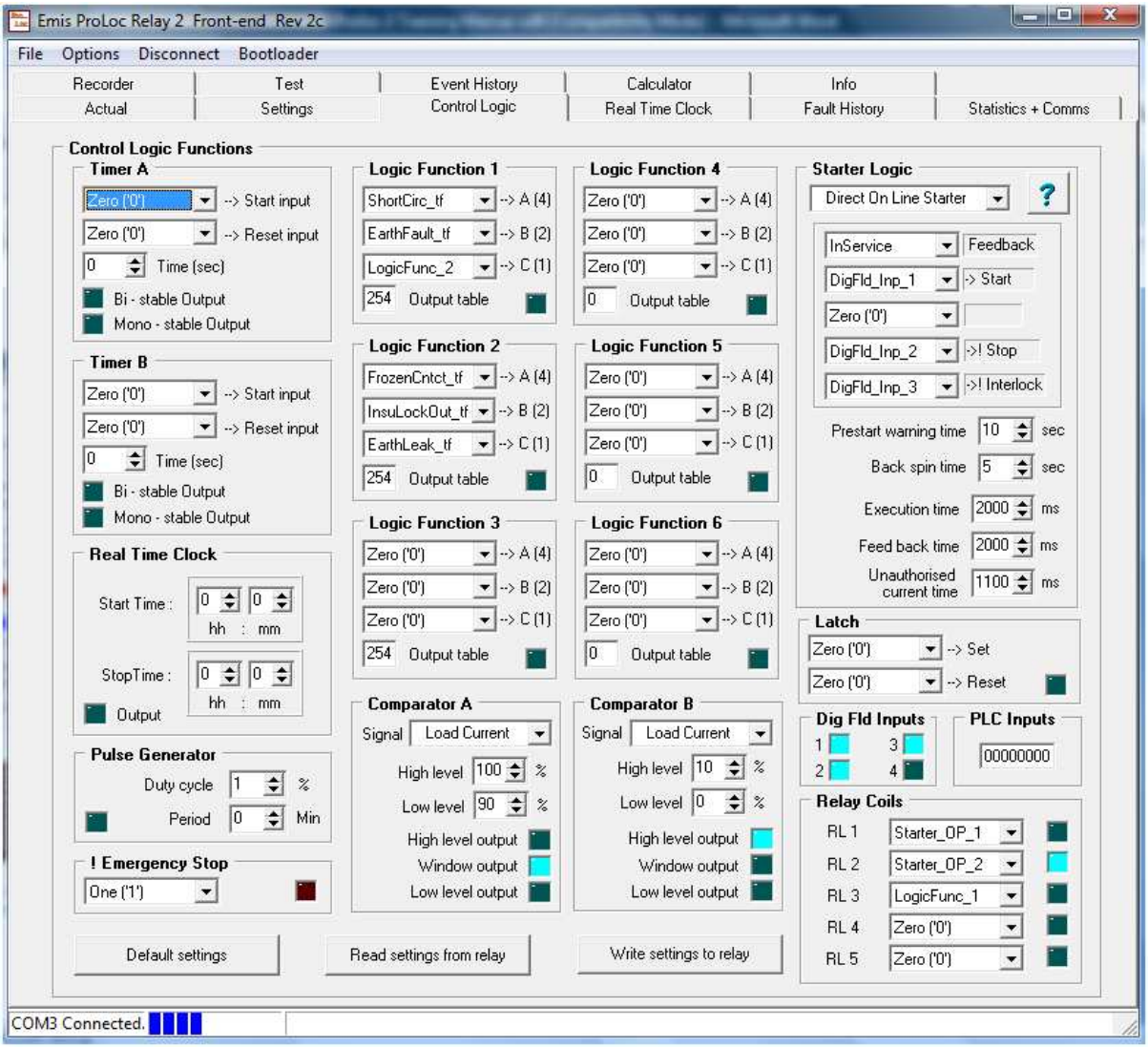

Emis ProLoc Relay 2 Front-end Rev 2c
File Options Disconnect Bootloader
Recorder Test Event History Calculator Info
Actual Settings Control Logic Real Time Clock Fault History Statistics + Comms
Control Logic Functions
Timer A
Zero ('0') --> Start input
Zero ('0') --> Reset input
0 Time (sec)
Bi - stable Output
Mono - stable Output
Timer B
Zero ('0') --> Start input
Zero ('0') --> Reset input
0 Time (sec)
Bi - stable Output
Mono - stable Output
Real Time Clock
Start Time : 0 0 hh : mm
StopTime : 0 0 hh : mm
Output
Pulse Generator
Duty cycle 1 %
Period 0 Min
! Emergency Stop
One ('1')
Logic Function 1
ShortCirc_tf --> A (4)
EarthFault_tf --> B (2)
LogicFunc_2 --> C (1)
254 Output table
Logic Function 2
FrozenCntct_tf --> A (4)
InsuLockOut_tf --> B (2)
EarthLeak_tf --> C (1)
254 Output table
Logic Function 3
Zero ('0') --> A (4)
Zero ('0') --> B (2)
Zero ('0') --> C (1)
254 Output table
Comparator A
Signal Load Current
High level 100 %
Low level 90 %
High level output
Window output
Low level output
Logic Function 4
Zero ('0') --> A (4)
Zero ('0') --> B (2)
Zero ('0') --> C (1)
0 Output table
Logic Function 5
Zero ('0') --> A (4)
Zero ('0') --> B (2)
Zero ('0') --> C (1)
0 Output table
Logic Function 6
Zero ('0') --> A (4)
Zero ('0') --> B (2)
Zero ('0') --> C (1)
0 Output table
Comparator B
Signal Load Current
High level 10 %
Low level 0 %
High level output
Window output
Low level output
Starter Logic
Protection Relay
InService Feedback
Zero ('0')
Zero ('0')
Zero ('0')
Zero ('0')
Prestart warning time 0 sec
Back spin time 5 sec
Execution time 2000 ms
Feed back time 2000 ms
Unauthorised current time 1100 ms
Latch
Zero ('0') --> Set
Zero ('0') --> Reset
Dig Fld Inputs
1 3
2 4
PLC Inputs
00000000
Relay Coils
RL 1 Main Trip Relay
RL 2 LogicFunc_1
RL 3 Zero ('0')
RL 4 Zero ('0')
RL 5 Zero ('0')
Default settings
Read settings from relay
Write settings to relay
COM3 Connected.

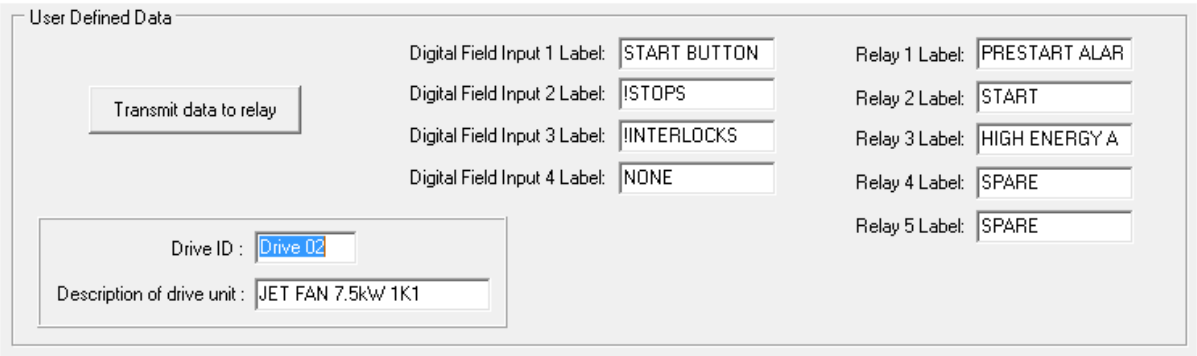
2. *ProLoc 2 configured and programmed as Direct-On-Line starter*

Typical Settings, Control logic and Actual pages for a ProLoc 2 relay, PL 10, as a Direct Online starter for a 7.5 kW Jet Fan, on a 1100 Volts system. Configure your high energy faults to back trip into the MCCB. Configure your Start and Stop buttons and Interlocks on Digital field inputs 1-4.



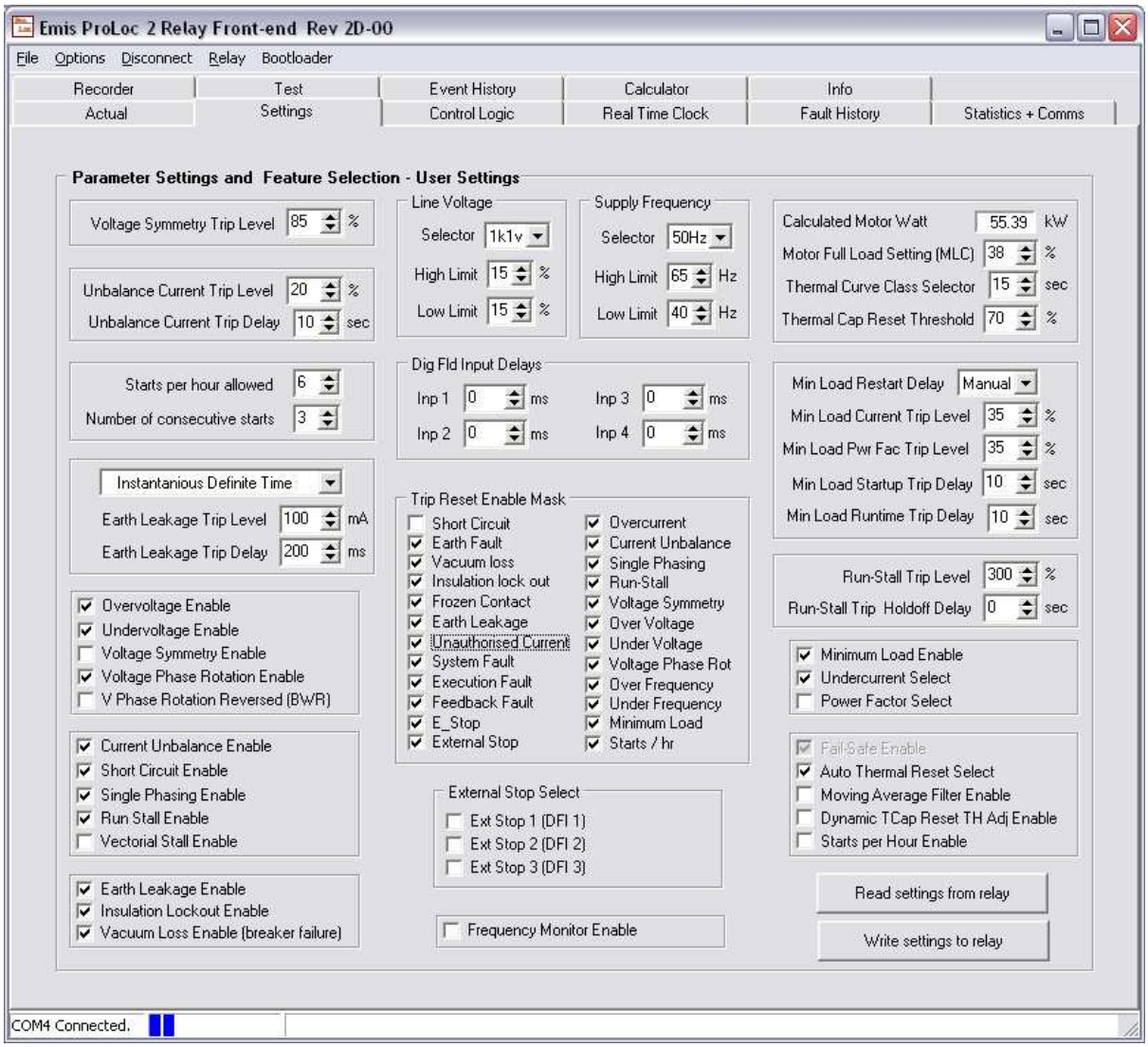
Emis ProLoc Relay 2 Front-end Rev 2c
File Options Disconnect Bootloader
Recorder Test Event History Calculator Info
Actual Settings Control Logic Real Time Clock Fault History Statistics + Comms
Drive ID : Drive 02
Drive Description : JET FAN 7.5kW 1K1
Thermal Curve Class Setting 10 sec
Thermal Trip Time Remainder Infinite sec
Actual Current Level 97 %
True Phase Current Level 3.20 A
Actual Current Unbalance 0 %
Phase Voltage Level 635 V
Phase Voltage Level 635 V
Phase Voltage Level 635 V
Voltage Symmetry 100 %
Apparent Power Dissipation 3.5 kVA
Real Power Dissipation 0.0 kWatt
Earth Leakage Current 0 mA
Insulation Resistance Infinite kOhm
Thermal Capacity Used
14 %
Thermal Reset
600 800 400 1000 200 1200 0 1400
V Line
40 50 60 70 30 80 20 90 10 100 0 110
% I Load
Trip Reset
Input from PLC
00000000
Running Hours 0
In Service (Motor running)
All Phase Voltages Present
Line Voltage Selection 1k1v
Line Voltage (max) 1100 V
Supply Frequency 50 Hz
Power Factor 0 %
Date 2013/02/05 Time 14h37m33s
Firmware Rev 2c Model PL 10
Serial Nr 00199708 Ext CT 1:1
Digital Field Inputs
Inp 1 START BUTTON
Inp 2 !STOPS
Inp 3 !INTERLOCKS
Inp 4 NONE
Relay Coils
RL 1 PRESTART ALAR
RL 2 START
RL 3 HIGH ENERGY A
RL 4 SPARE
RL 5 SPARE
Alarm and Trip Flags
Overcurrent
Vectorial / Run Stall
Current Unbalance
Single Phasing
Minimum Load
Low Frequency
High Frequency
Phase Rotation Error
Short Circuit
Overvoltage
Undervoltage
Voltage Symmetry
Isolation Lockout
Earth Leakage
Earth Fault
Starts per Hour Limit
Vacuum loss
Frozen Cntct
Emergency stop
External stop
System fault
Execution fault
Feedback fault
Unauthorised cmt
COM3 Connected.

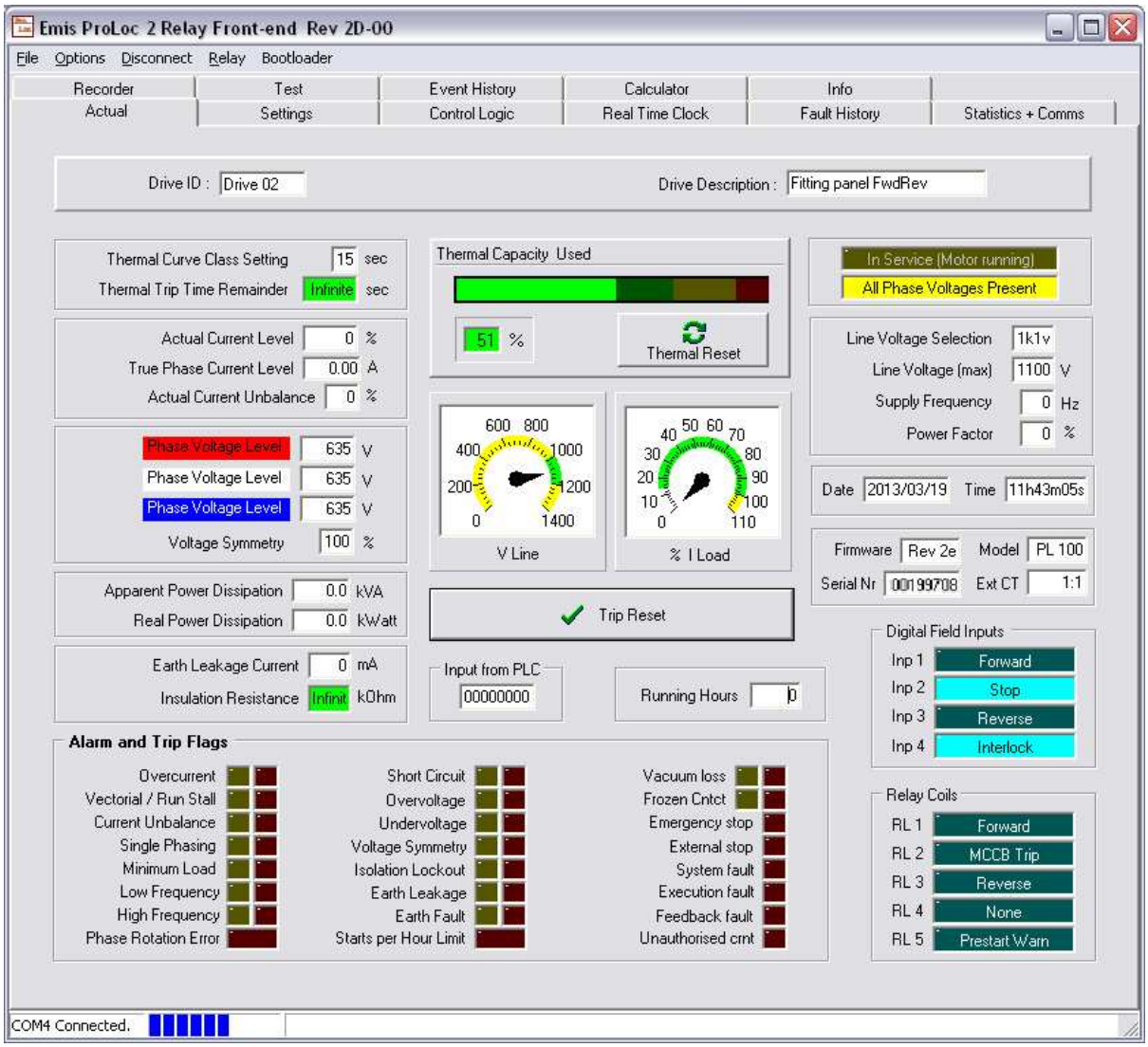

Emis ProLoc Relay 2 Front-end Rev 2c
File Options Disconnect Bootloader
Recorder Test Event History Calculator Info
Actual Settings Control Logic Real Time Clock Fault History Statistics + Comms
Control Logic Functions
Timer A
Zero ('0') --> Start input
Zero ('0') --> Reset input
0 Time (sec)
Bi - stable Output
Mono - stable Output
Timer B
Zero ('0') --> Start input
Zero ('0') --> Reset input
0 Time (sec)
Bi - stable Output
Mono - stable Output
Real Time Clock
Start Time : 0 0 hh : mm
StopTime : 0 0 hh : mm
Output
Pulse Generator
Duty cycle 1 %
Period 0 Min
! Emergency Stop
One ('1')
Logic Function 1
ShortCirc_tf --> A (4)
EarthFault_tf --> B (2)
LogicFunc_2 --> C (1)
254 Output table
Logic Function 2
FrozenCntct_tf --> A (4)
InsuLockOut_tf --> B (2)
EarthLeak_tf --> C (1)
254 Output table
Logic Function 3
Zero ('0') --> A (4)
Zero ('0') --> B (2)
Zero ('0') --> C (1)
254 Output table
Logic Function 4
Zero ('0') --> A (4)
Zero ('0') --> B (2)
Zero ('0') --> C (1)
0 Output table
Logic Function 5
Zero ('0') --> A (4)
Zero ('0') --> B (2)
Zero ('0') --> C (1)
0 Output table
Logic Function 6
Zero ('0') --> A (4)
Zero ('0') --> B (2)
Zero ('0') --> C (1)
0 Output table
Comparator A
Signal Load Current
High level 100 %
Low level 90 %
High level output
Window output
Low level output
Comparator B
Signal Load Current
High level 10 %
Low level 0 %
High level output
Window output
Low level output
Starter Logic
Direct On Line Starter
InService Feedback
DigFld_Inp_1 -> Start
Zero ('0')
DigFld_Inp_2 ->! Stop
DigFld_Inp_3 ->! Interlock
Prestart warning time 10 sec
Back spin time 5 sec
Execution time 2000 ms
Feed back time 2000 ms
Unauthorised current time 1100 ms
Latch
Zero ('0') --> Set
Zero ('0') --> Reset
Dig Fld Inputs
1 3
2 4
PLC Inputs
00000000
Relay Coils
RL 1 Starter_OP_1
RL 2 Starter_OP_2
RL 3 LogicFunc_1
RL 4 Zero ('0')
RL 5 Zero ('0')
Default settings
Read settings from relay
Write settings to relay
COM3 Connected.

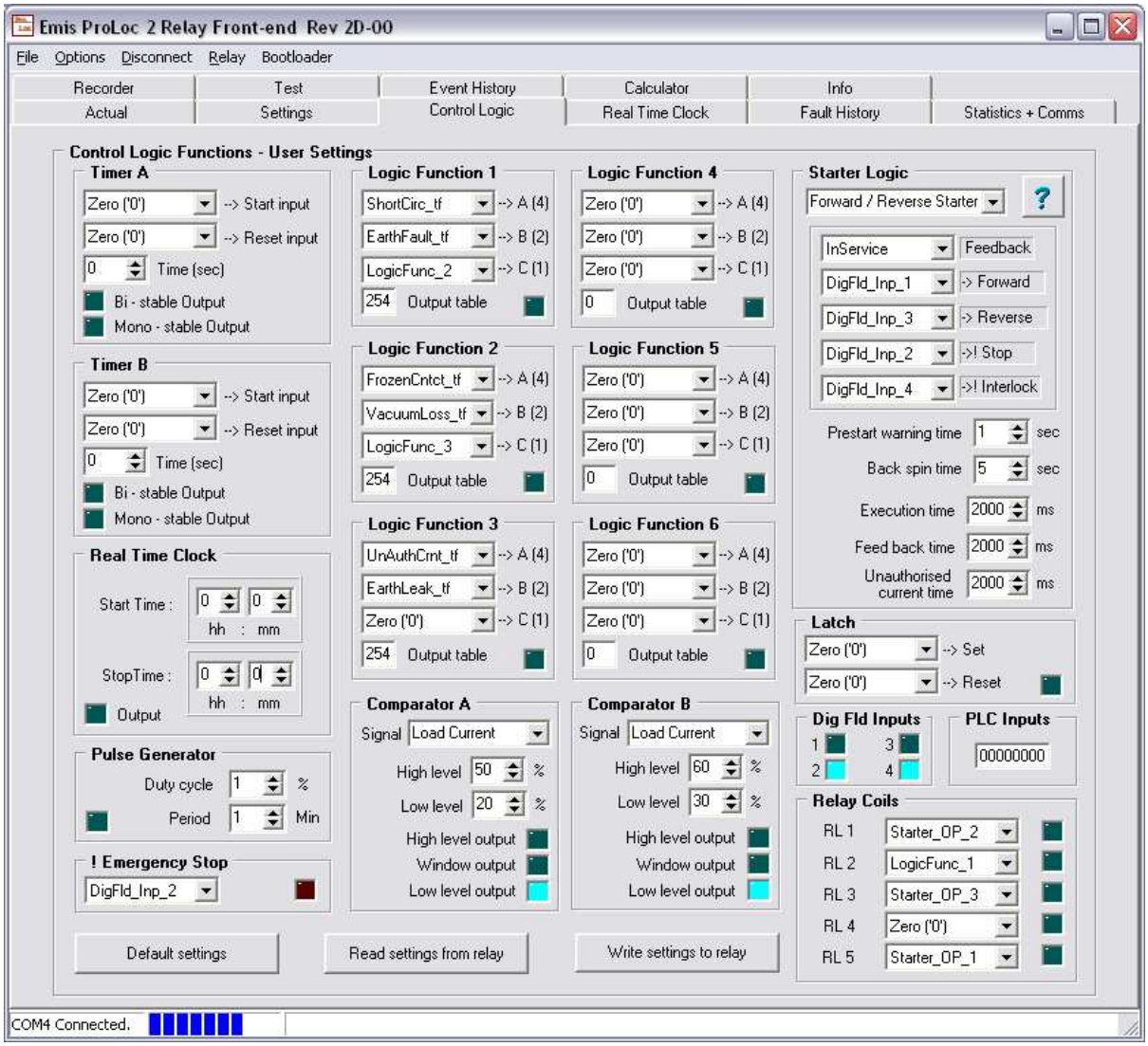

User Defined Data
Transmit data to relay
Digital Field Input 1 Label: START BUTTON
Digital Field Input 2 Label: !STOPS
Digital Field Input 3 Label: !INTERLOCKS
Digital Field Input 4 Label: NONE
Relay 1 Label: PRESTART ALAR
Relay 2 Label: START
Relay 3 Label: HIGH ENERGY A
Relay 4 Label: SPARE
Relay 5 Label: SPARE
Drive ID : Drive 02
Description of drive unit : JET FAN 7.5kW 1K1

3. ProLoc 2 configured and programmed as Forward / Reverse starter

Typical Settings, Control logic and Actual pages for a ProLoc 2 relay, as a Forward/Reverse starter for a 55 kW Crane motor, on 1100 Volts system. Configure your high energy faults to back trip into the MCCB. Configure your Forward/Reverse buttons and Interlocks on Digital field inputs 1-4.




Emis ProLoc 2 Relay Front-end Rev 2D-00
File Options Disconnect Relay Bootloader
Recorder Test Event History Calculator Info
Actual Settings Control Logic Real Time Clock Fault History Statistics + Comms
Drive ID : Drive 02
Drive Description : Fitting panel FwdRev
Thermal Curve Class Setting 15 sec
Thermal Trip Time Remainder Infinite sec
Actual Current Level 0 %
True Phase Current Level 0.00 A
Actual Current Unbalance 0 %
Phase Voltage Level 635 V
Phase Voltage Level 635 V
Phase Voltage Level 635 V
Voltage Symmetry 100 %
Apparent Power Dissipation 0.0 kVA
Real Power Dissipation 0.0 kWatt
Earth Leakage Current 0 mA
Insulation Resistance Infinit kOhm
Thermal Capacity Used
51 %
Thermal Reset
V Line
% I Load
Trip Reset
Input from PLC
00000000
Running Hours 0
In Service (Motor running)
All Phase Voltages Present
Line Voltage Selection 1k1v
Line Voltage (max) 1100 V
Supply Frequency 0 Hz
Power Factor 0 %
Date 2013/03/19 Time 11h43m05s
Firmware Rev 2e Model PL 100
Serial Nr 00199708 Ext CT 1:1
Digital Field Inputs
Inp 1 Forward
Inp 2 Stop
Inp 3 Reverse
Inp 4 Interlock
Alarm and Trip Flags
Overcurrent
Vectorial / Run Stall
Current Unbalance
Single Phasing
Minimum Load
Low Frequency
High Frequency
Phase Rotation Error
Short Circuit
Overvoltage
Undervoltage
Voltage Symmetry
Isolation Lockout
Earth Leakage
Earth Fault
Starts per Hour Limit
Vacuum loss
Frozen Cntct
Emergency stop
External stop
System fault
Execution fault
Feedback fault
Unauthorised cmt
Relay Coils
RL 1 Forward
RL 2 MCCB Trip
RL 3 Reverse
RL 4 None
RL 5 Prestart Warn
COM4 Connected.


Emis ProLoc 2 Relay Front-end Rev 2D-00
File Options Disconnect Relay Bootloader
Recorder Test Event History Calculator Info
Actual Settings Control Logic Real Time Clock Fault History Statistics + Comms
Control Logic Functions - User Settings
Timer A
Zero ('0') --> Start input
Zero ('0') --> Reset input
0 Time (sec)
Bi - stable Output
Mono - stable Output
Timer B
Zero ('0') --> Start input
Zero ('0') --> Reset input
0 Time (sec)
Bi - stable Output
Mono - stable Output
Real Time Clock
Start Time : 0 0 hh : mm
StopTime : 0 0 hh : mm
Output
Pulse Generator
Duty cycle 1 %
Period 1 Min
! Emergency Stop
DigFld_Inp_2
Logic Function 1
ShortCirc_tf --> A (4)
EarthFault_tf --> B (2)
LogicFunc_2 --> C (1)
254 Output table
Logic Function 2
FrozenCntct_tf --> A (4)
VacuumLoss_tf --> B (2)
LogicFunc_3 --> C (1)
254 Output table
Logic Function 3
UnAuthCrnt_tf --> A (4)
EarthLeak_tf --> B (2)
Zero ('0') --> C (1)
254 Output table
Logic Function 4
Zero ('0') --> A (4)
Zero ('0') --> B (2)
Zero ('0') --> C (1)
0 Output table
Logic Function 5
Zero ('0') --> A (4)
Zero ('0') --> B (2)
Zero ('0') --> C (1)
0 Output table
Logic Function 6
Zero ('0') --> A (4)
Zero ('0') --> B (2)
Zero ('0') --> C (1)
0 Output table
Comparator A
Signal Load Current
High level 50 %
Low level 20 %
High level output
Window output
Low level output
Comparator B
Signal Load Current
High level 60 %
Low level 30 %
High level output
Window output
Low level output
Starter Logic
Forward / Reverse Starter
InService Feedback
DigFld_Inp_1 -> Forward
DigFld_Inp_3 -> Reverse
DigFld_Inp_2 ->! Stop
DigFld_Inp_4 ->! Interlock
Prestart warning time 1 sec
Back spin time 5 sec
Execution time 2000 ms
Feed back time 2000 ms
Unauthorised current time 2000 ms
Latch
Zero ('0') --> Set
Zero ('0') --> Reset
Dig Fld Inputs
1 3
2 4
PLC Inputs
00000000
Relay Coils
RL 1 Starter_OP_2
RL 2 LogicFunc_1
RL 3 Starter_OP_3
RL 4 Zero ('0')
RL 5 Starter_OP_1
Default settings
Read settings from relay
Write settings to relay
COM4 Connected.