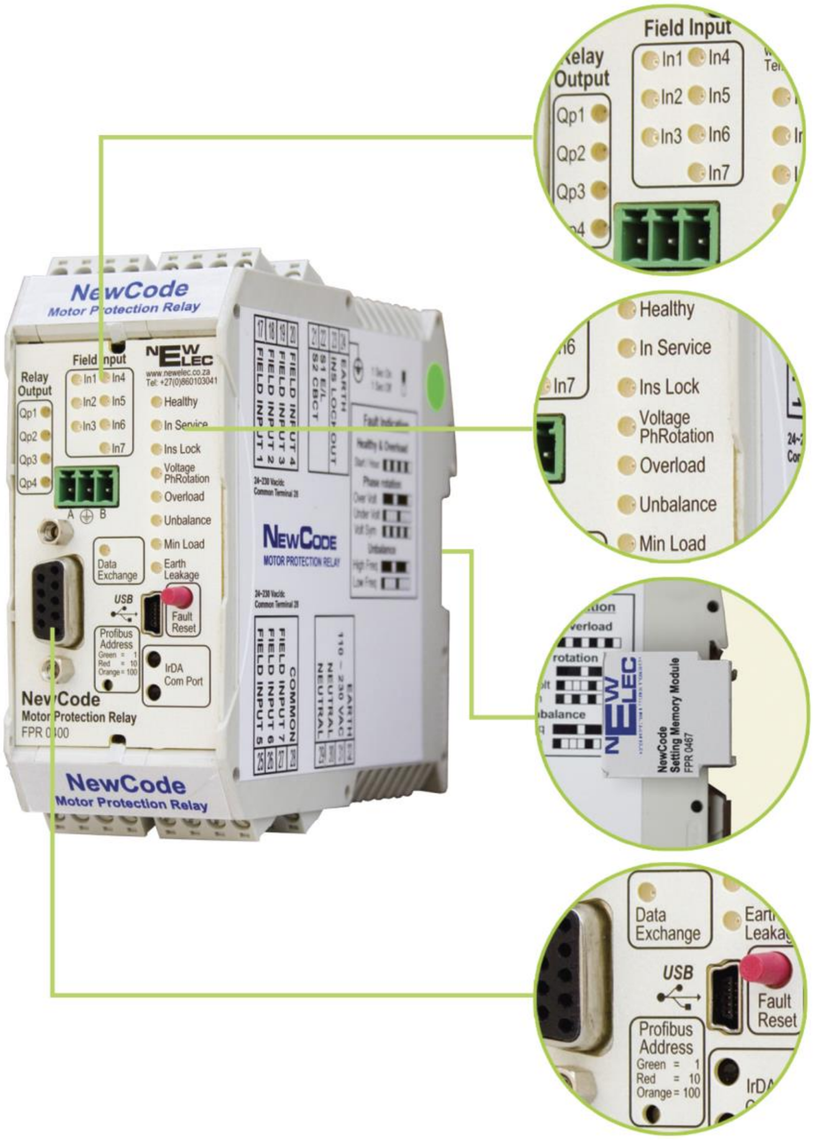
NEW ELEC
MOTOR PROTECTION & CONTROL TECHNOLOGY



NewCode Intermediate Level

Training Manual

Table of contents

Document History

Description	Revision	Date	Other
Draft	0	17-08-2014	
For Training	1		

Purpose of the document

The purpose of the document is to serve as Intermediate Level training manual for the NewElec product, NewCode Motor Protection and Control Relay. The document is designed to be used as part of a day-long training session and is to be used in conjunction with NewCode User Manual and associated Communication protocol documents.

The training is divided into 4 sections, as shown below, whereas this document is Section B:Intermediate Level. Each Section should last about 1-2 hours. Short-breaks can be inserted as necessary, in general about 15 minute leg-stretches every 1 hour.

Section A: Basic Level

Section B: Intermediate Level

Section C Advanced Level

Section D: Master Level

Appendices: Optional Reads

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 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 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)
Over current (Overload)	Current level above 100% of full load current
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)

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
MCC	Motor Control Centre

Section B: Intermediate Level

Welcome to the NewCode Motor Protection and Control Relay Intermediate training module.

This module is aimed at the user that has used the product and wants to further his / her understanding of the workings of the relay further. Intermediate training covers various in-depth topics relating to enhanced utilization of the NewCode Relay, such as connecting the relay to the plant network and using the relay as a starter.

Pre-requisite for successful completion of the module is Basic Level training of NewCode Relay.

Lessons Learnt

On completion of the course the prospect will have a clear understanding of:

- Further programming training of NewCode Motor Protection and Control Relay
- Be able to setup communication parameters for Modbus and Profibus,
- Configure NewCode Relay as a direct on-line (DOL) starter, more sophisticated starters will be handled in Advanced Level training.
- Use Three phase Recorder to display live running motor parameters, and record to csv and excel files.
- Run simulations and perform cold commissioning tasks on a drive.

Background of NewCode relay

The NewCode Protection and Control relay is primarily designed to cover a range of 1-300 Amperes, in low voltage applications. External interposing current transformers can be used to extend the operating range from 300 to 2000 Amperes as desired, and can still be used in medium voltage applications with the right power transformers.

The NewCode 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 NewCode relay is a micro-controller based precision instrument with protection and control features. It is designed for the low voltage motor protection market and is available in different current models. There are various accessories that can be purchased with NewCode relay, such as Temperature module with four inputs, Input-Output module with 8 inputs and 4 outputs, and 4-20 mA module with 2 inputs and 2 outputs. The relay can be used on a Profibus / Modbus/CanBus network, and this will be further developed on other protocols.

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 can 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. Nine starter types are selectable.

Functional Description of the NewCode relay

The NewCode 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 RS485 and mini-USB ports are used as the communication ports. The purpose of the front-end is to configure and select the required functionally of a specific application.

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 safe or fail safe 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.

Physical description of the NewCode relay

In addition to the basic relay, further expansion module and other accessories are available for use with NewCode motor protection and control relay. This is additional modules are shown in figure 1 below.

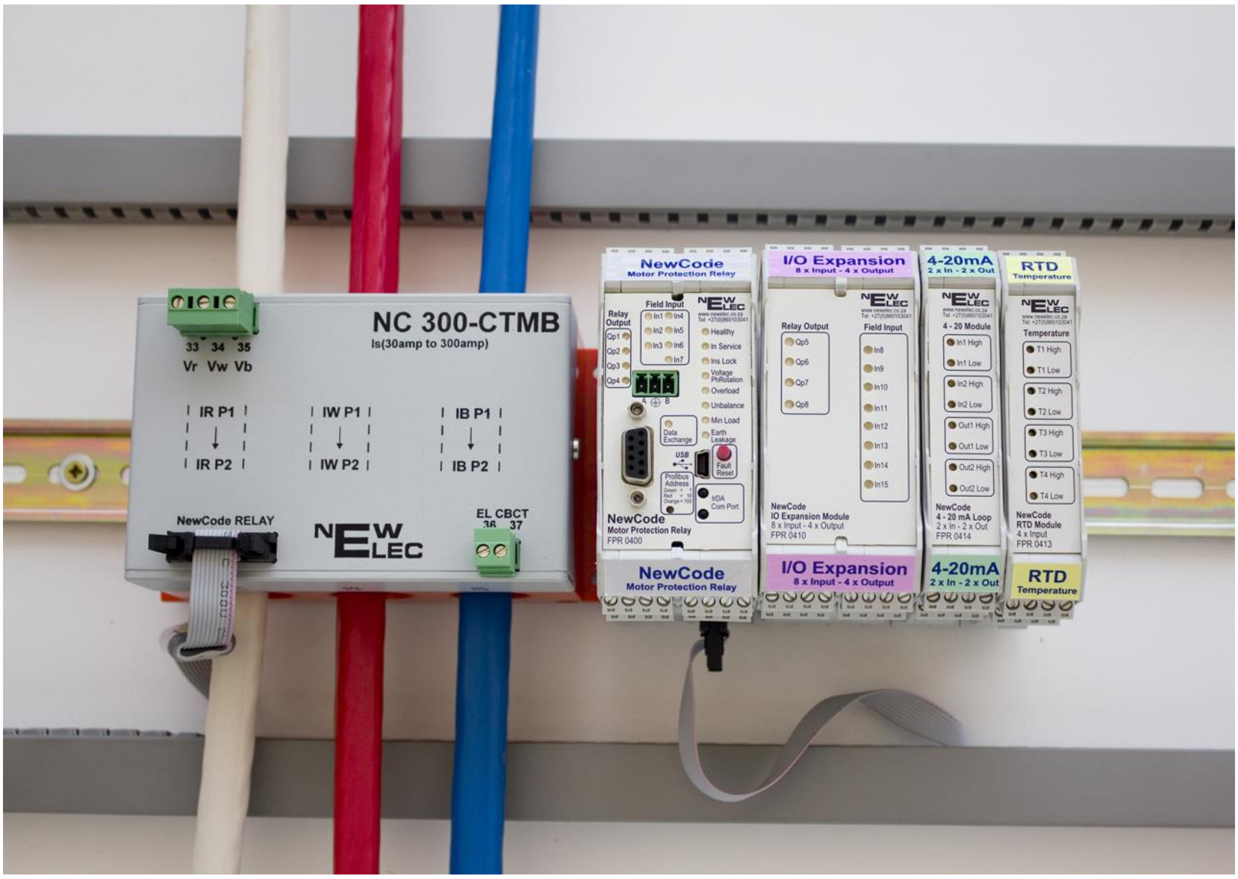


Figure 1: The picture of the NewCode relay, with I/O Expansion, 4-20 mA loop and RTD Modules, is shown.

The basic NewCode relay has 7 digital inputs and 4 relay outputs with LED for ON/OFF status indications. The relay also has eight (8) visual LEDs indications for all the faults and a reset button. There are several ports, RS232 port and a 3 wire connection port (for Modbus, Profibus and Canbus), lastly mini-USB port and IrDA ports for programming the relay. Additionally you can buy individual expansion modules, namely I/O module with 7 Inputs- 4 Outputs, RTD module with four PTC/PT inputs, and Analogue module with 2 inputs-2 outputs 4-20 mA. Some of the LED fault indications are used for multiple purposes, and this will be explained the next sections in more detail.

The dimensions relating to all the modules are as indicated on figure 2 and 3.

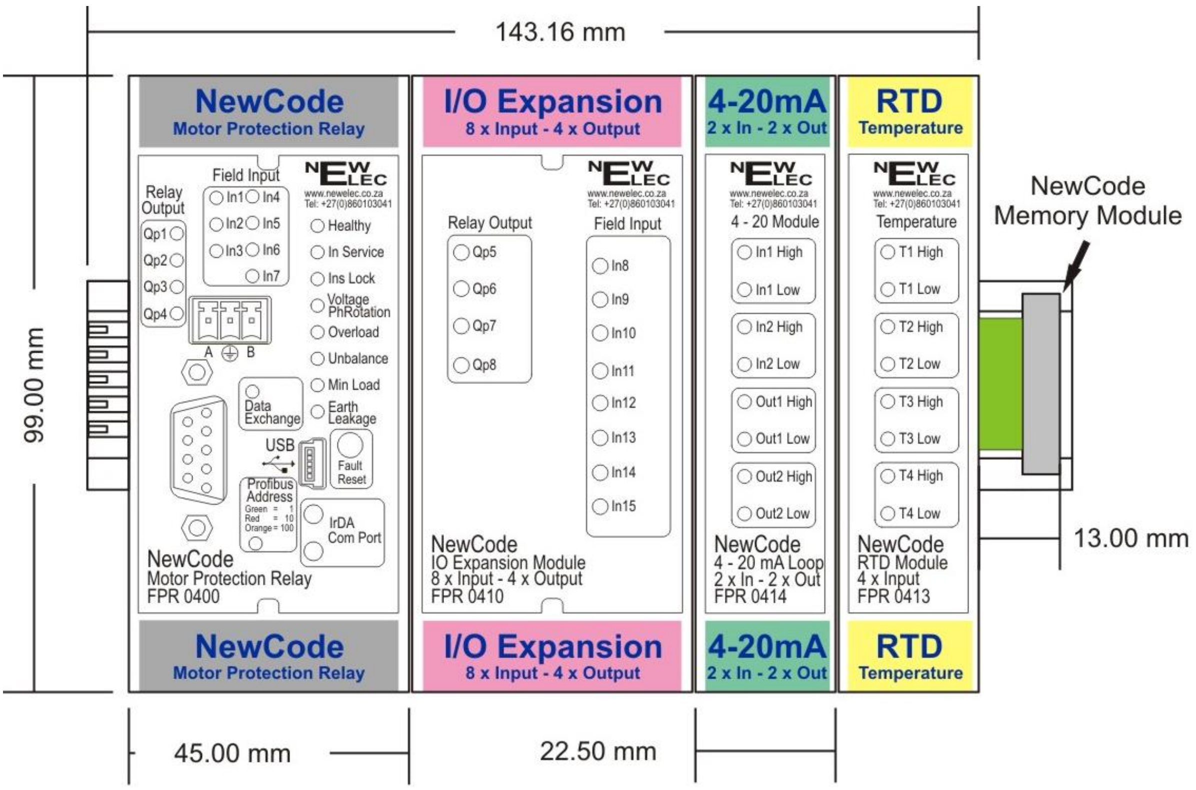


Figure 2: The front view dimension diagrams for NewCode relay and its accessories.

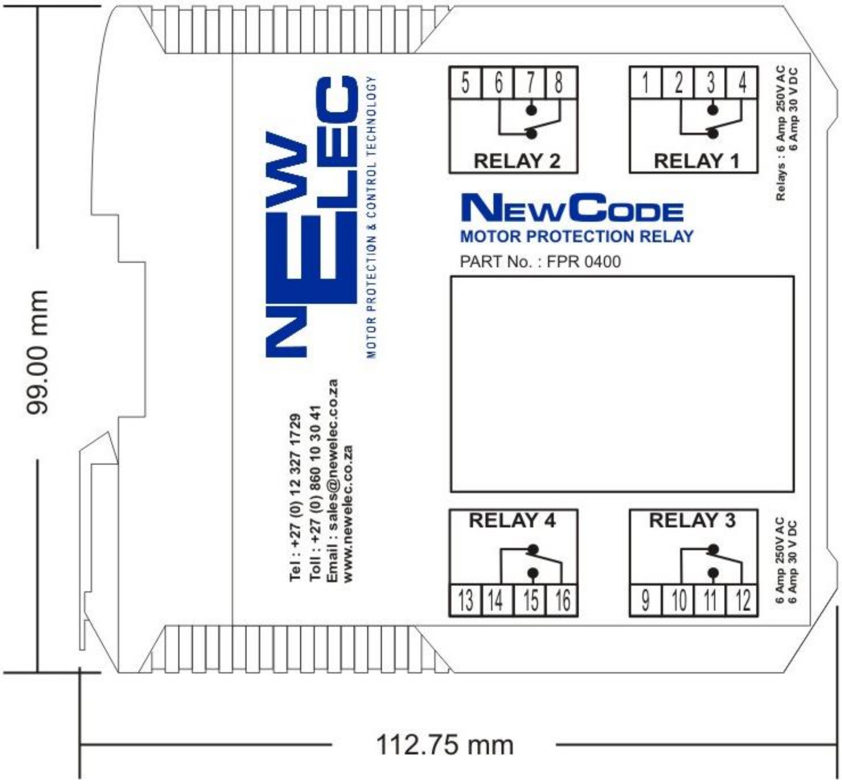


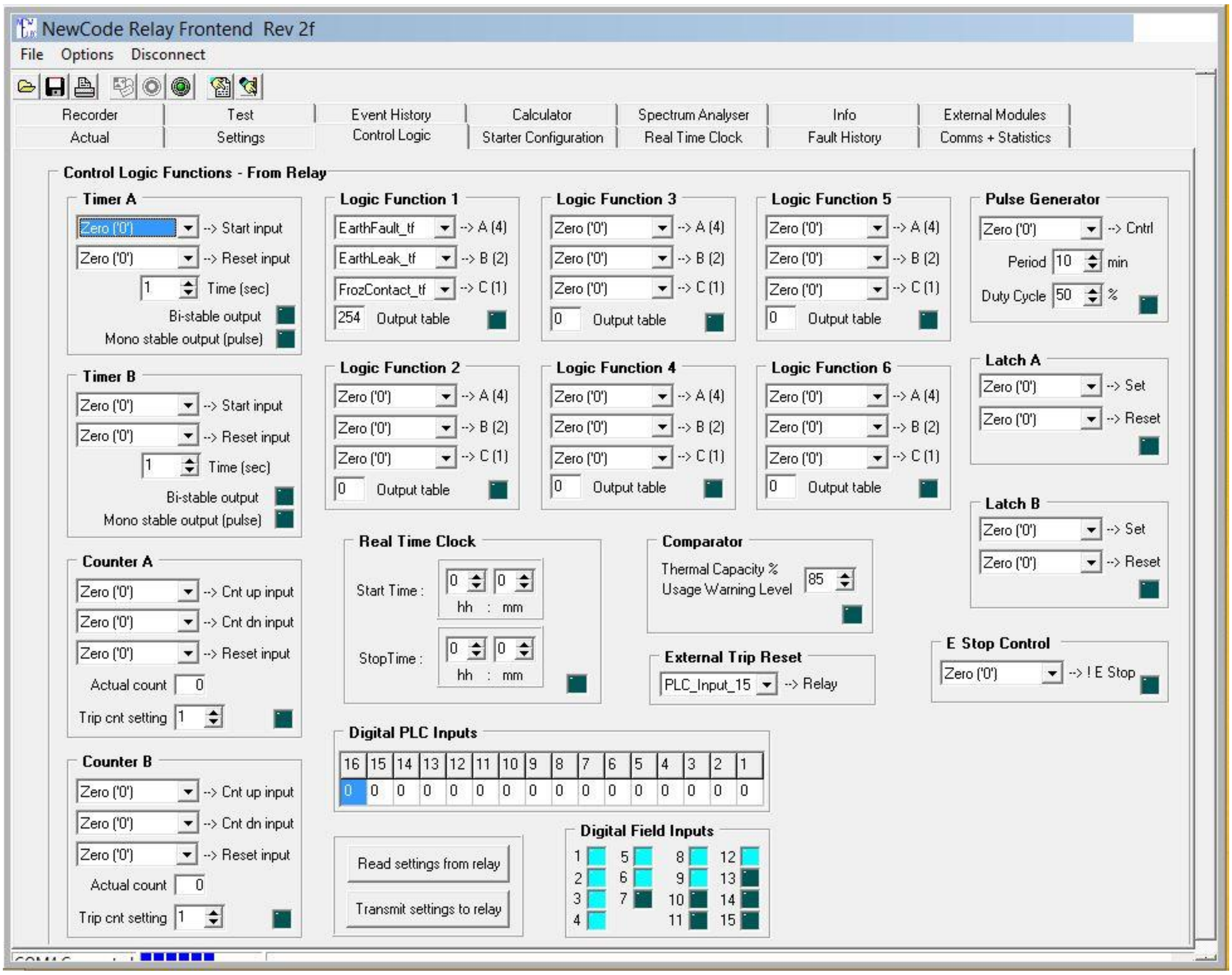
Figure 3: The side dimension diagrams for NewCode relay.

Programming the NewCode relay

To programme the NewCode relay, a very user-friendly NewCode Front-end with fourteen self-explanatory tabs / pages have been designed to assist with easy configuration or parameterization of the NewCode relay. “Actual” and “Settings” tabs of the NewCode relay were addressed at a basic level, which primarily looks at measured field values and basic protection settings respectively.

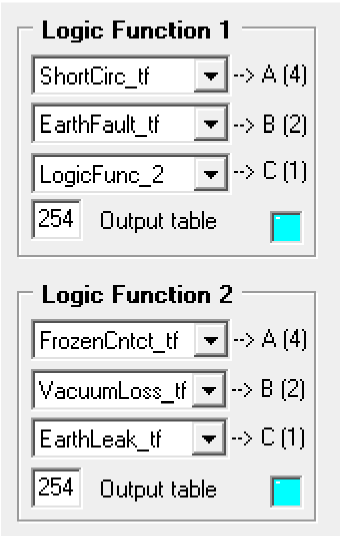
Firstly, adding on to the tabs already discussed (Actual and Settings), we will start with the Control Logic tab. This tab seeks to even enhance the use of NewCode further by implementing logical equations to protect and control your drive.

Control logic page

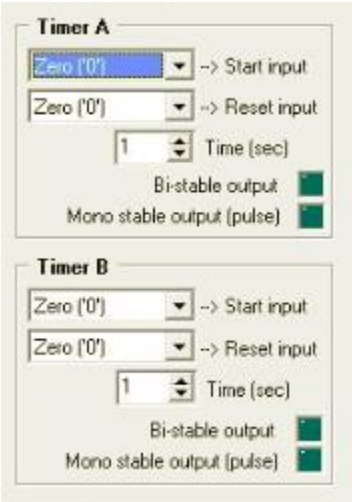


Figures 4: NewCode relay Control Logic page screen.

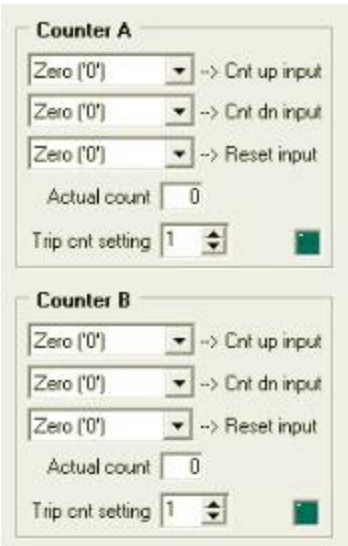
This page shows how to setup digital logics (OR/AND/XOR/XNOR etc.), timers, latches, counters and pulse generator as part of protection or configured starter inside the NewCode. Parameters such as "Emergency Stops", External Trip Reset can be configured here to interrupt the NewCode relay.



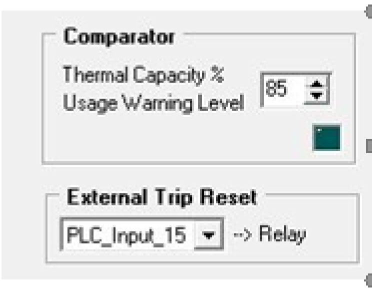
This page shows how to configure three input, one output control logic. There are six (6) logic functions in the NewCode relay, each with three inputs. The inputs can be digital field inputs or internally calculated parameters, such as flags. This is clearly demonstrated by logic function 1, which uses Short Circuit trip flag, Earth Fault trip flag and output of logic function 2 as inputs. In this case as a six input one output logic, built to trip the shunt breaker.



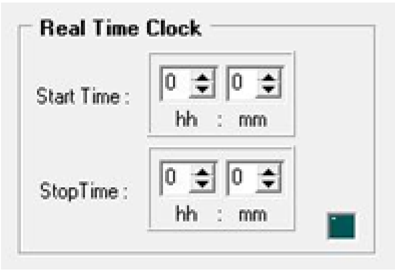
There are two Timers in the NewCode relay, Timer A and B. The inputs can be digital field inputs or relay internal calculated parameters.



There are two Counters in the NewCode, Counter A and B. The inputs can be digital field inputs or relay internal calculated parameters.



The comparator can be used to compare Thermal Capacity and issue out a warning alarm. This can be used in Crusher drives, to avoid the crusher tripping with material which will cause a lot of down time.

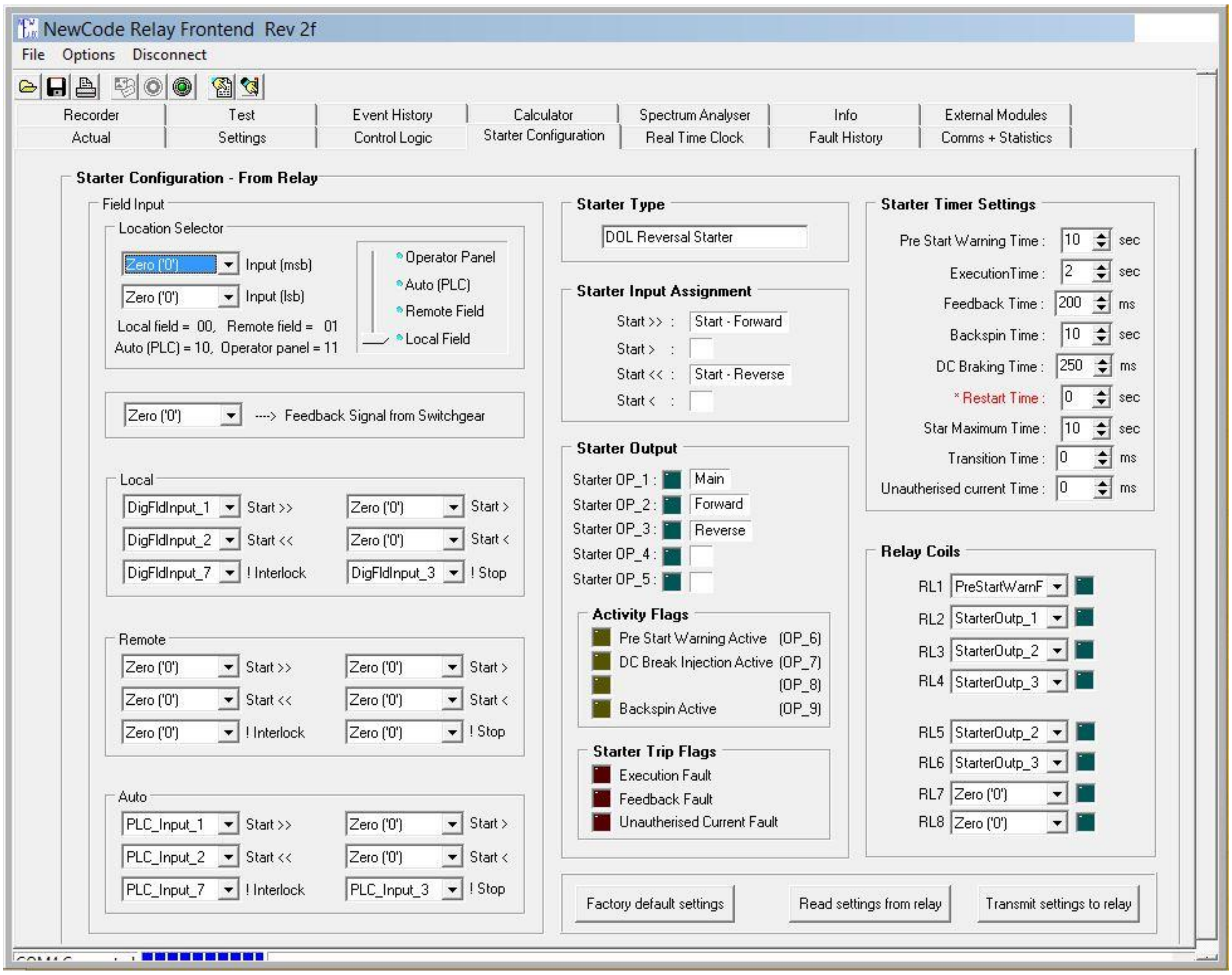


The Real Time Clock can be used in instances where protection or starting needs to be implemented for specific times. Or where a drive is only required to run for a specified time. There is a separate RTC page to program the clock.

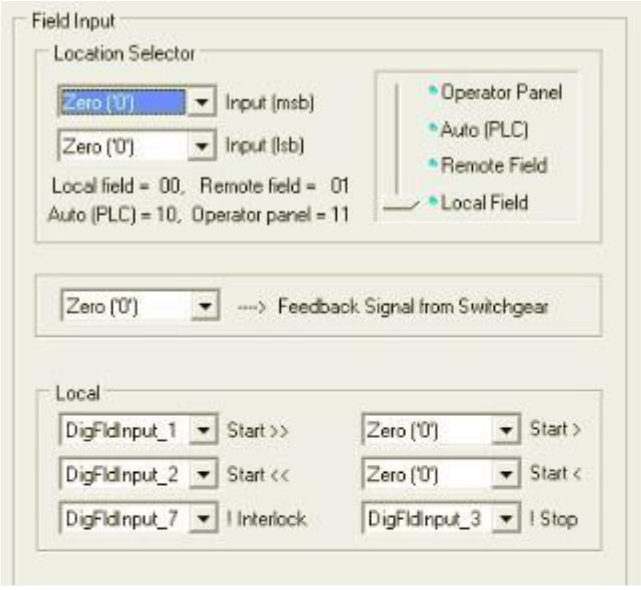
The '! Emergency Stop', which can be programmed as any input is shown here. An exclamation mark (!) shows that this field needs to be logic one to complete the circuit. The stop needs to be Normally Closed (NC). This standard is applied across all our product range, and that is also the standard applied in electrical schematics.

Starter Configuration page

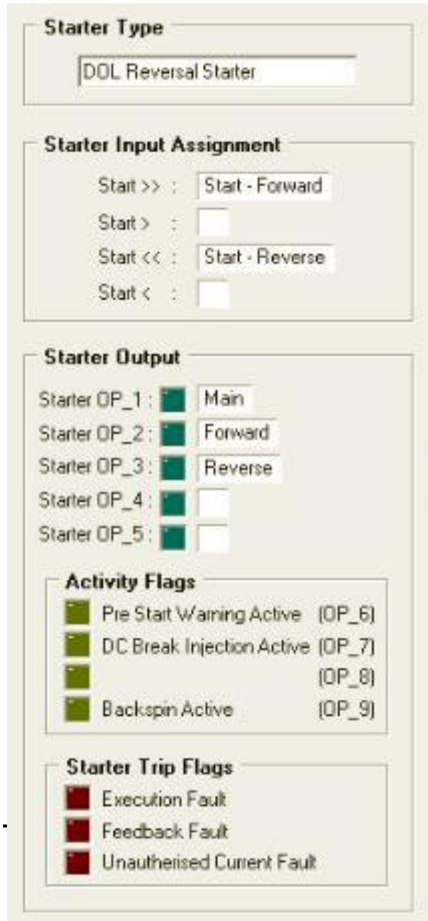
The starter configuration tab is used to configure the nine (9) starters that we have in NewCode Protection and Control relay. But for this course, we will only deal with DOL starter.



Figures 5: NewCode relay Starter Configuration page screen.



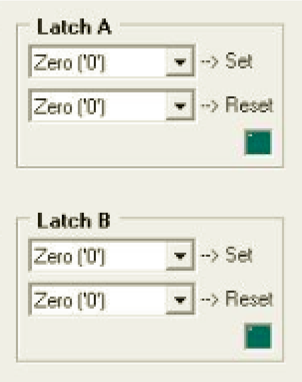
The Starter configuration has two input bits used for selection of location of operation, i.e. Operator Panel (or MMI), PLC, Remote Field and Local field. All this flags are available through the bus (Modbus or Profibus) for integration into the PLC code as desired.



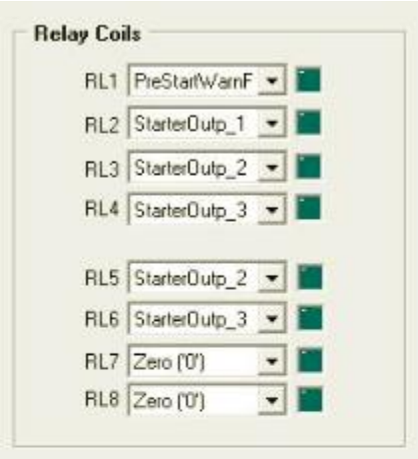
The NewCode can be configured as Protection relay, Direct On-Line (DOL) starter or any other. All the starters are listed in Appendices. In this case, a DOL Reversal starter is chosen.

All the relevant parameters for starters, as calculated by relay processor, are also shown, grouped into Starter Outputs, Activity Flags and Starter Trip Flags.

Further details of the starter will be discussed in Advanced level.

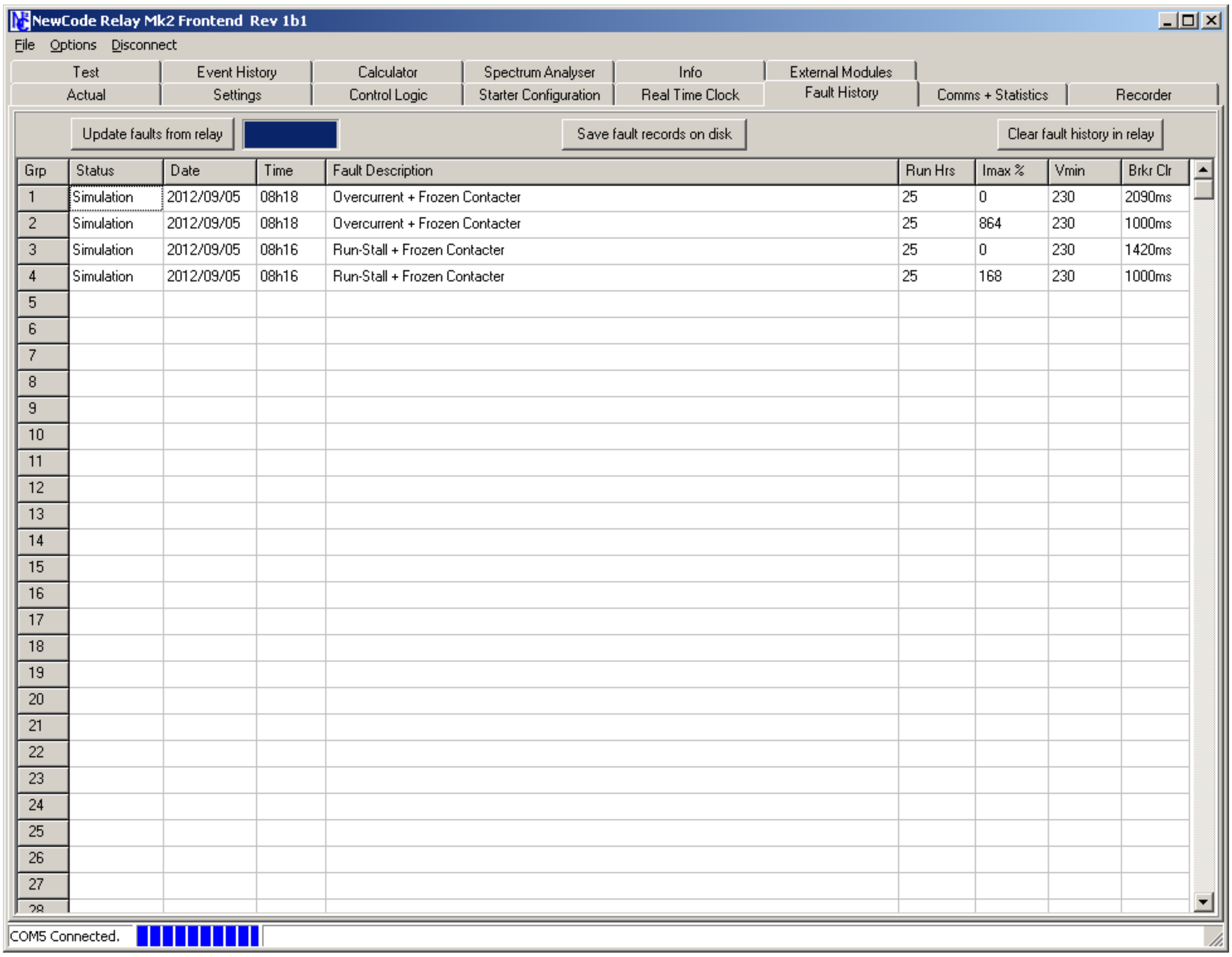


Latches A and B are shown. A latch, with a reset, which can be used for various purposes within the control logics is configured here.



The relay coils RL1-RL8 are shown. This shows that an extra I/O modules is used, hence 8 relays. The relays are programmable, with internally calculated parameters and measured values, as indicated in Table A1 in the appendix.

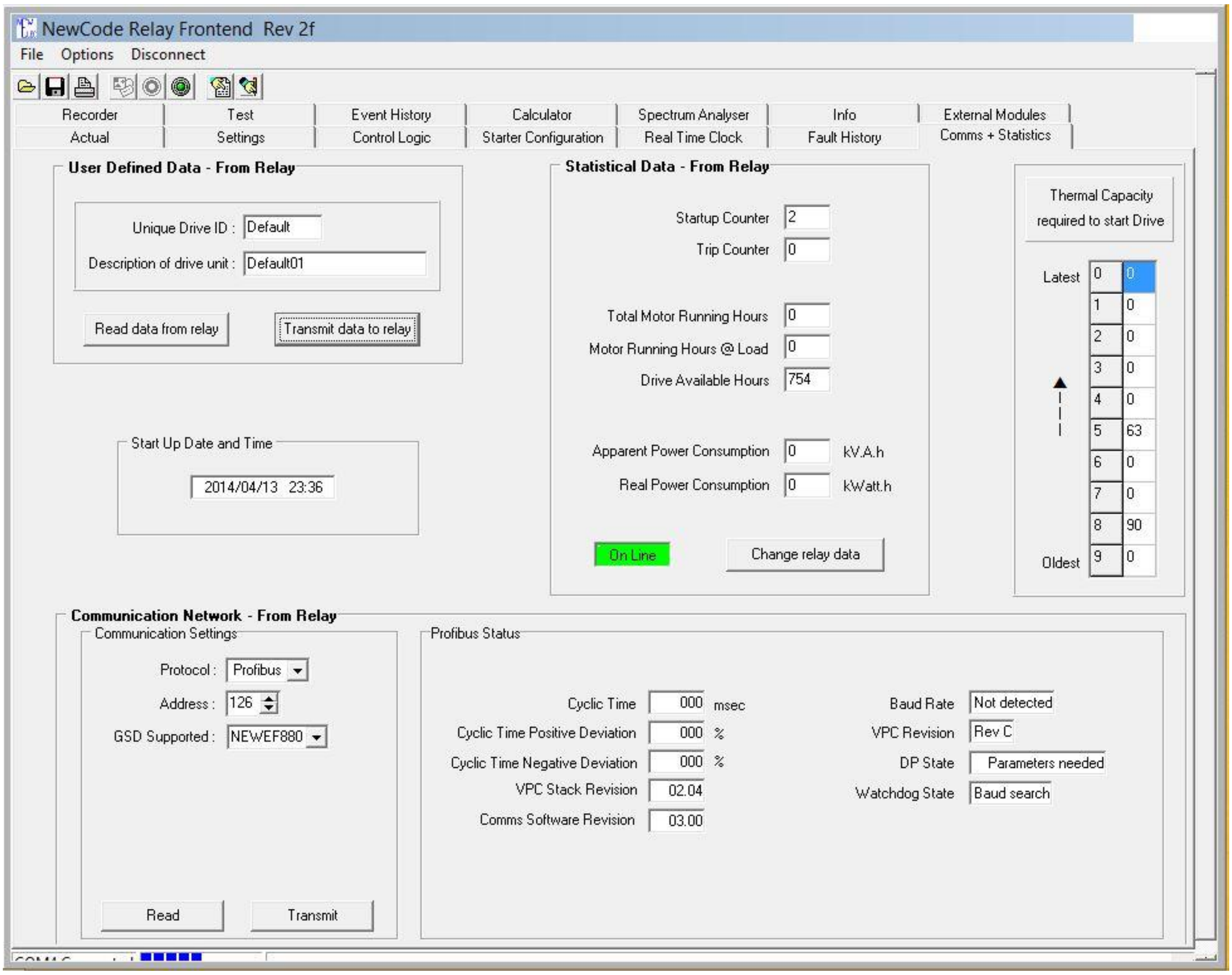
Fault History page



Figures 6: NewCode relay Fault History page screen.

A time stamped fault history, which stores up to 35 incidences, is useful for troubleshooting and auditing purposes. There is a separation of faults, to indicate the faults due to simulation and due to the running of the motor. Fault description, Running hours, Voltage, Current, Breaker Closing duration and state of DFIs are shown. The faults can be 'uploaded to be viewed on the screen' or 'saved on the disc' for further analysis or use in reports.

Statistics page



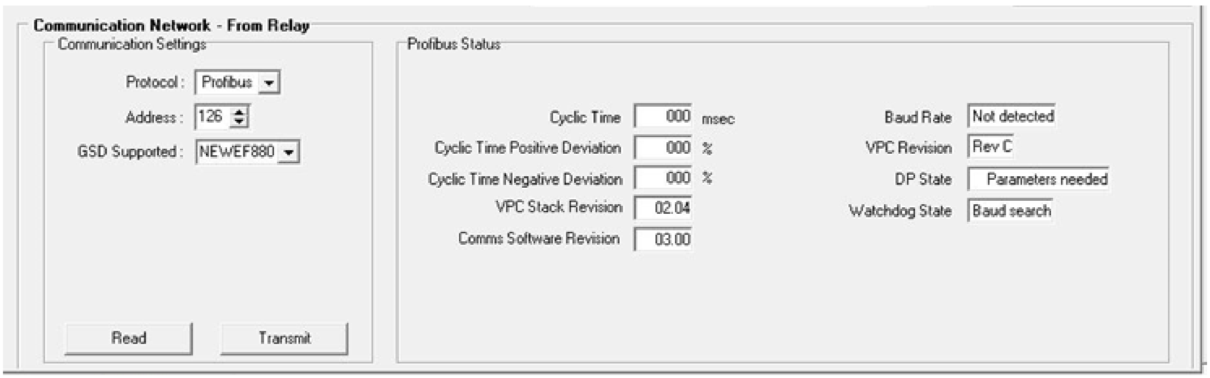
Figures 7: NewCode relay Comms + Statistics page screen.

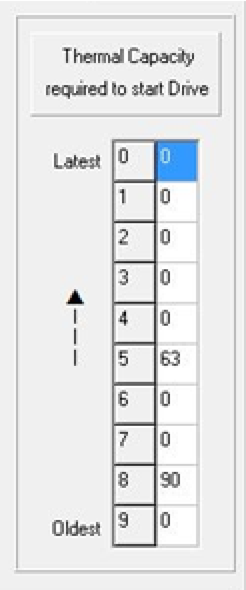
Various useful statistical parameters are shown on this page. Counters giving runtime and starting parameters, power usage and thermal capacity history are housed in this page.

User defined data can be input into the drive too. As this is memory mapped, all the data is accessible and can further be used in Programmable Logic Control (PLC) or higher level control systems.

Additional on the Statistics page, there is Start-up and trip counters, motor running hours with and without load which could be helpful in determining availability and utilisation of a motor. Power consumption data is also available, which can be red trough the bus for further analysis of energy consumption and efficiencies.

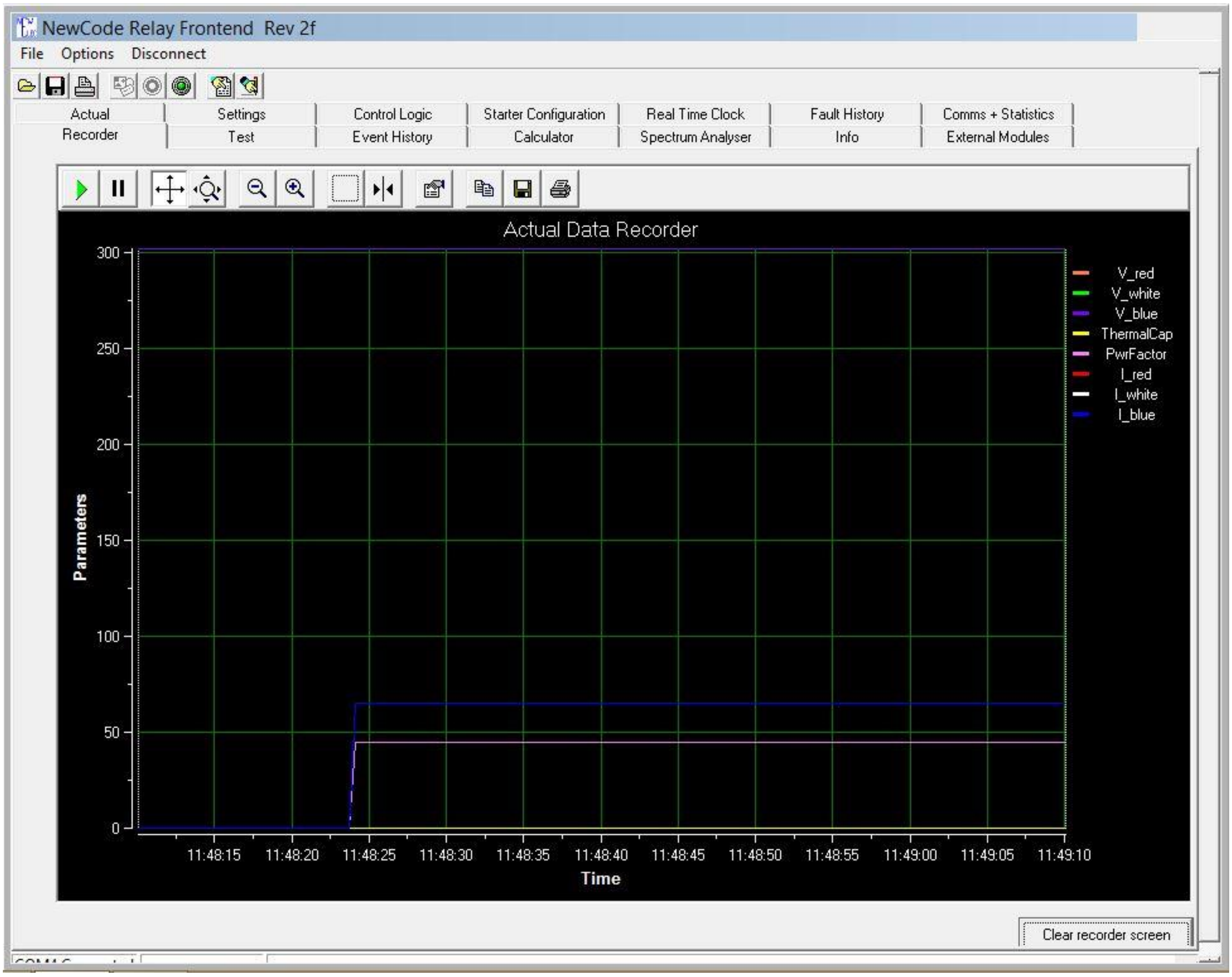
Below that, there is information parameters regarding the Communication network, be it Profibus or Modbus, and its associated performance parameters such as cyclic time and baud rate.





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. The relay will use this history of TC to determine the necessary capacity required, to effect a start-up.

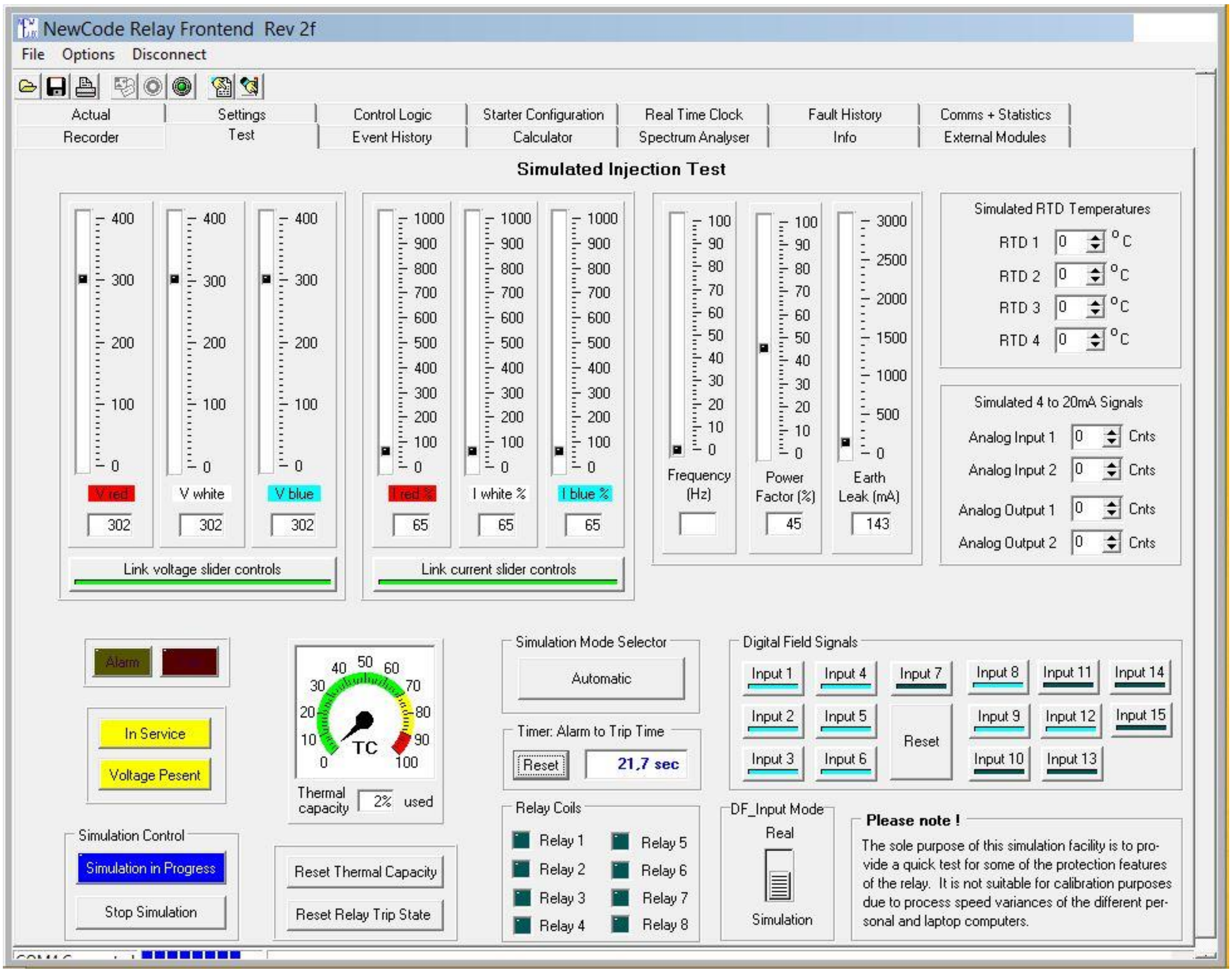
Recorder page



Figures 8: NewCode relay Recorder page screen.

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. The recorder can also be used to record commission data on MS Excel or CSV file, with laptop onsite, and the data can be further used in reports.

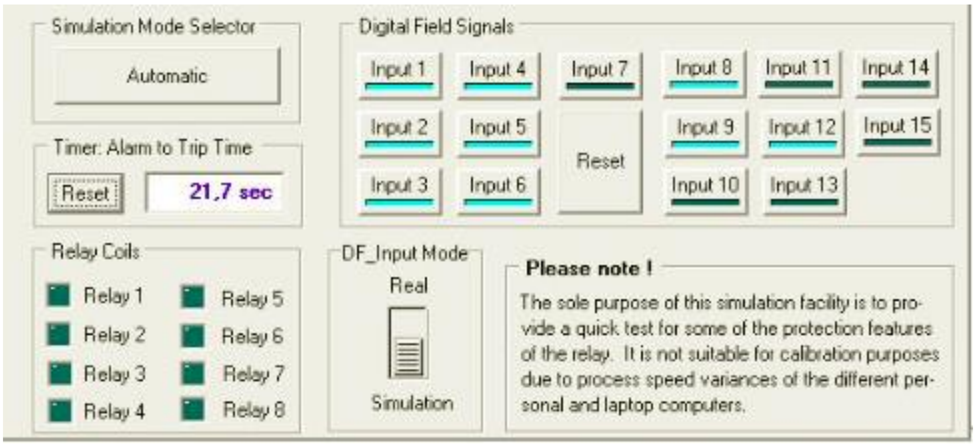
Test page (Simulation)



Figures 9: NewCode relay Test (Simulation) page screen.

The Test / Simulation page is used to test various functions of the NewCode relay. Simulated (on page buttons) or Real (electrical signal inputs into the physical relay) signals can be used. This feature is very useful for System Integrators during PLC logic checks and cold commissioning or as a training tool. There are two options for simulations either by using slider controls or self-built simulations in a table format, both to be explained in the following paragraphs.

Using the slider bars, one can simulate all the conditions for a running drive, specifically Phase Voltage, Phase Current, Frequency, Power Factor, Earth Leakage Current, Sensor Temperatures, 4-20 mA Loop current and Digital Inputs. That way faults can be simulated and switchgear boards can be tested for functionality.

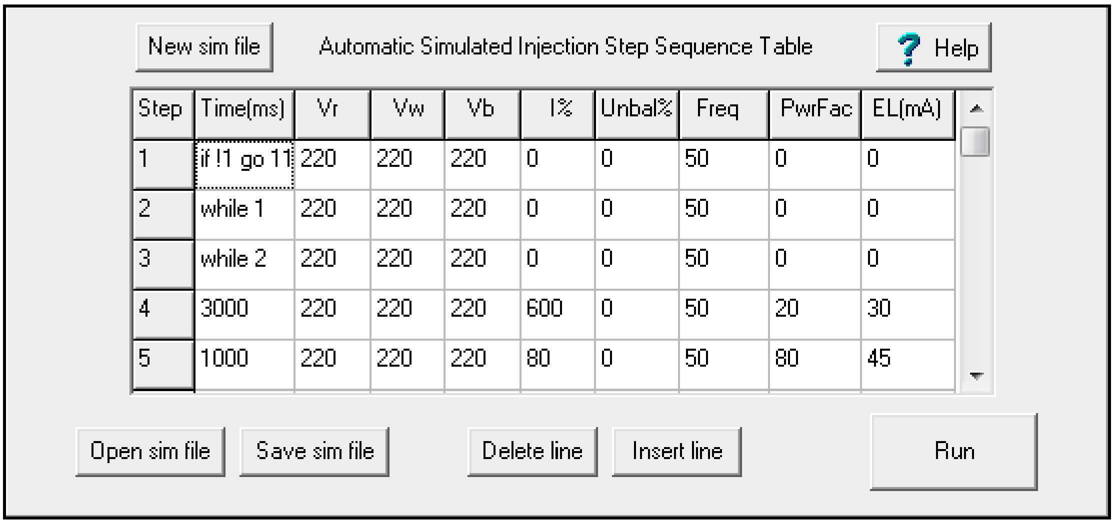


Figures 10: NewCode relay Test (Simulation) page controls.

The drive simulation is controlled from this lower half of the Test / Simulation page, shown as figure 10. **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 (Vb, Vr, PwrFac, EL (mA)) 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 7 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 NewCode relay inputs, terminals 1-14.

To bring up an alternative simulation method, one clicks “Automatic” bar on the test page and a manually programmable screen as below comes up.

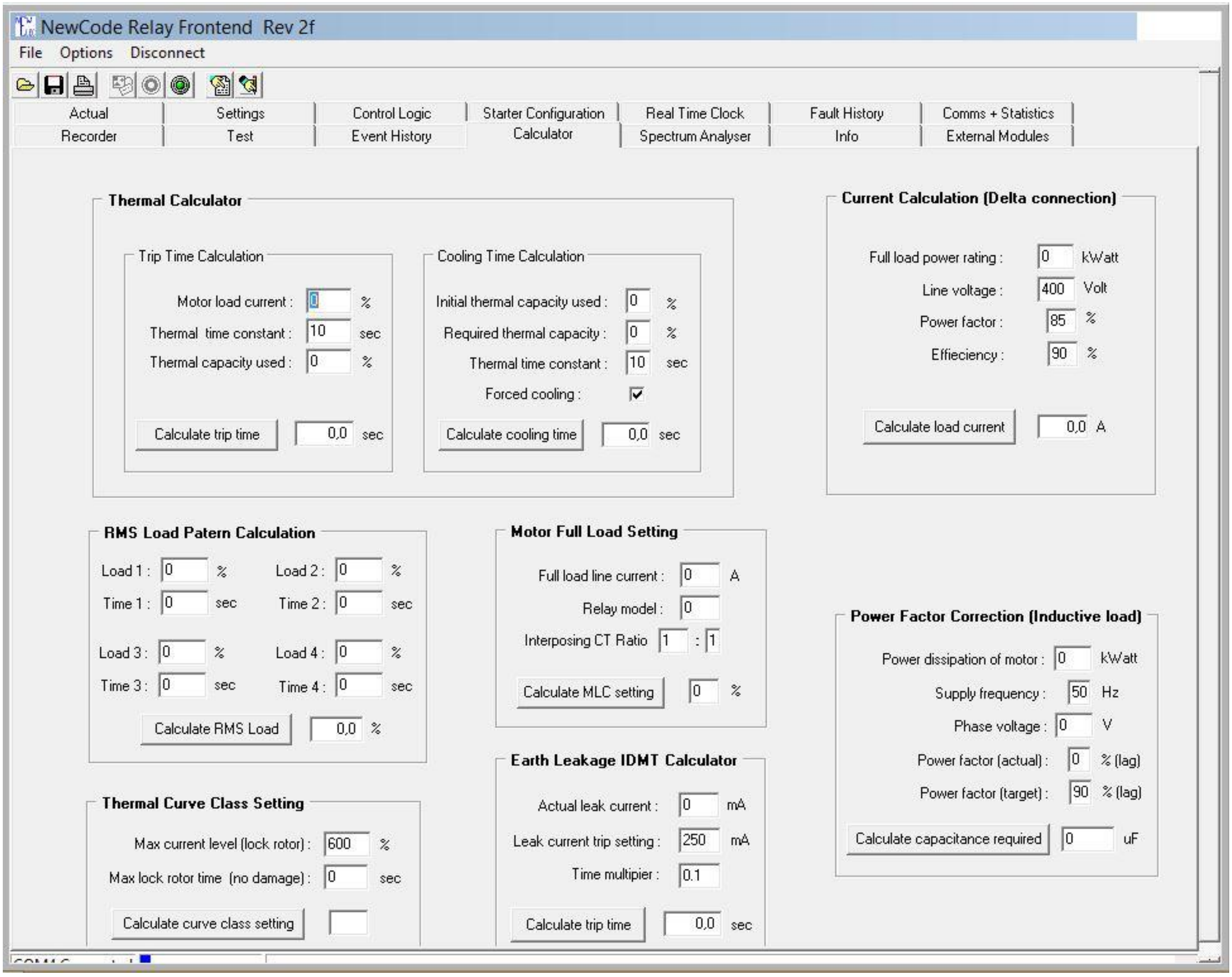


Step	Time(ms)	Vr	Vw	Vb	I%	Unbal%	Freq	PwrFac	EL(mA)
1	if !1 go 11	220	220	220	0	0	50	0	0
2	while 1	220	220	220	0	0	50	0	0
3	while 2	220	220	220	0	0	50	0	0
4	3000	220	220	220	600	0	50	20	30
5	1000	220	220	220	80	0	50	80	45

Figures 11: NewCode relay, manually programmable simulation page screen.

The self-built simulation is created in the form of statement list with timer for 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 the unused ones to zero (0) as shown in above example, otherwise the simulator will give a form error of “Not integer” when trying to run such a file. Simulation files can be saved and later opened in a location on your PC. Menus for those functions are neatly located as shown in the figure 10 above.

Calculator page



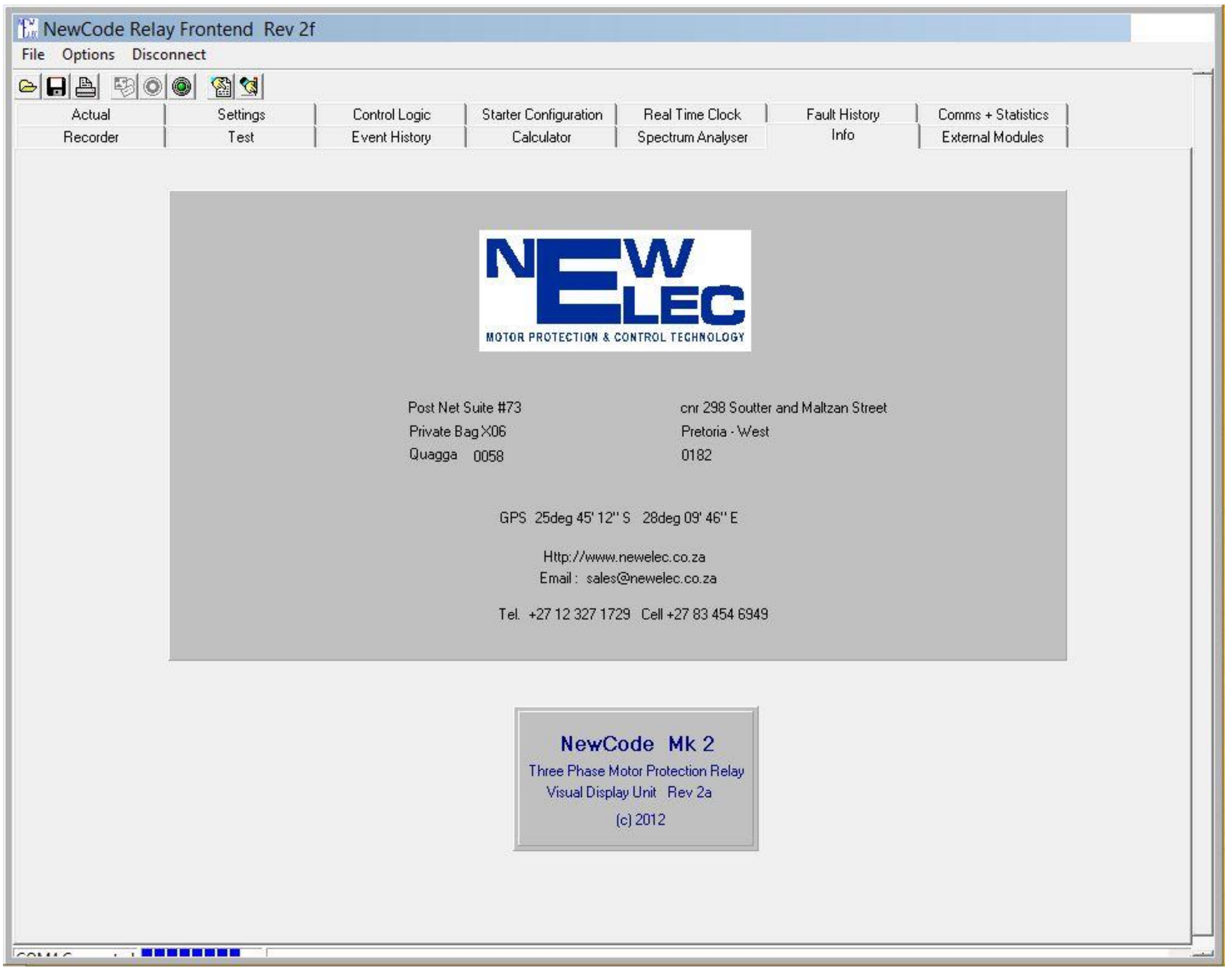
Figures 12: NewCode relay Calculator page screen.

This 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 addresses and contact details of NewElec, the designer and manufacturer of NewCode relay and various other relays.

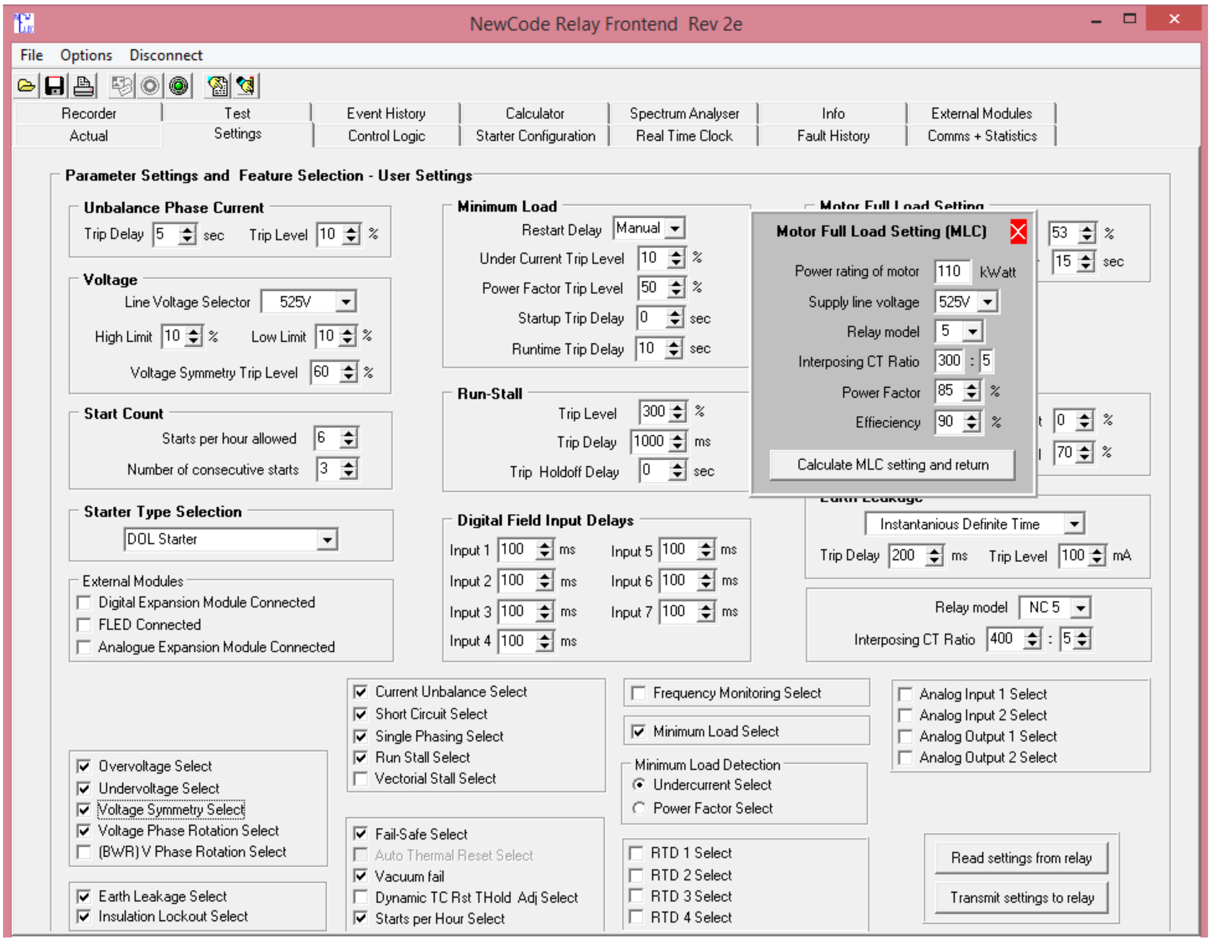


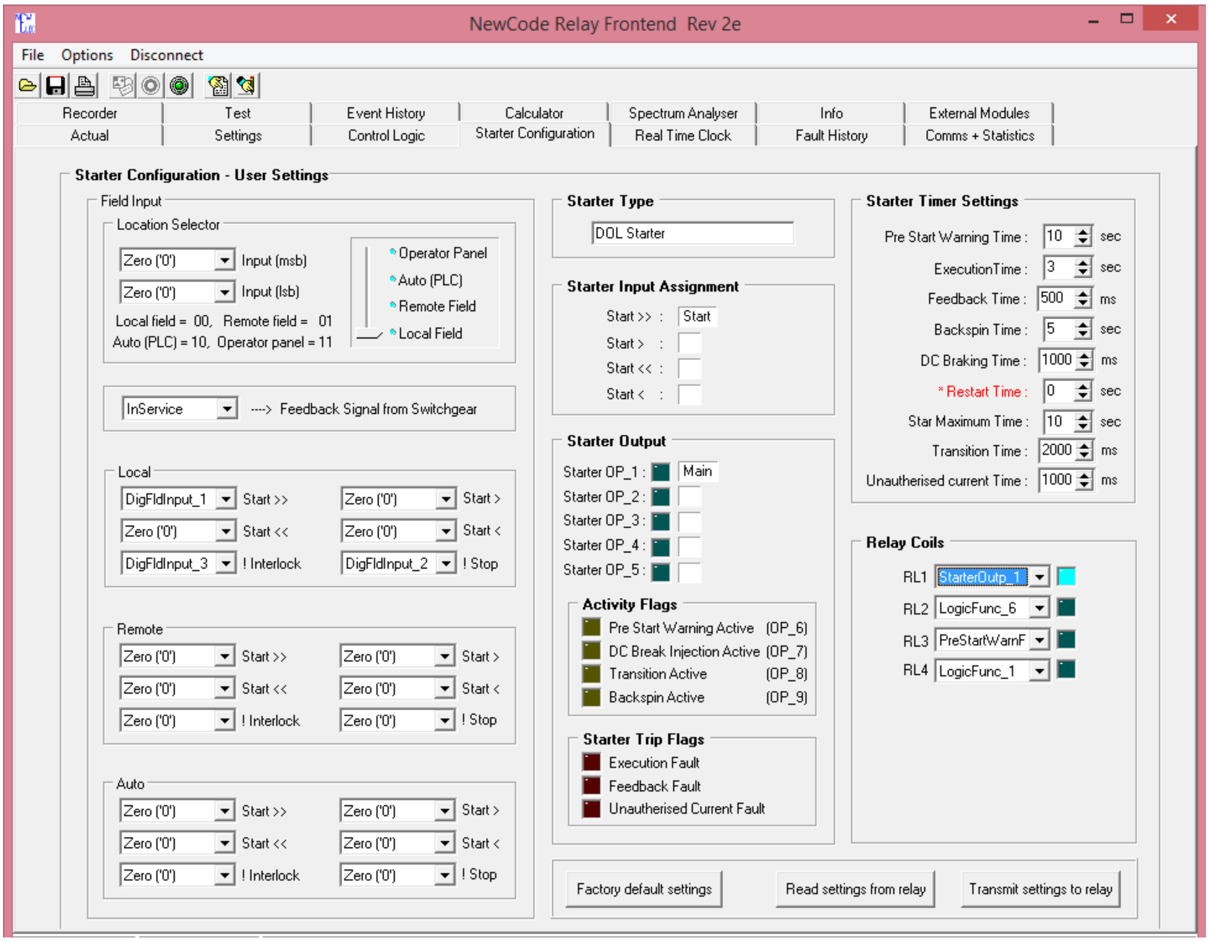
Figures 13: NewCode relay Info page screen.

Example 1:

NewCode configured and programmed as Direct-On-Line starter

A 110 kW, 525 volt motor is used to drive a conveyor. Only a NC-05 CT module is available, use suitable interposing CTs. Configure the relay as Direct Online Starter (DOL), only for a Local operation. Create a shunt trip on the Circuit Breaker with Relay Output 4 (RL4). Duplicate an extra trip flag on one of the outputs, for use as an indicator LED on the panel. Protection required is Overload, Under/Over voltage, unbalanced currents, Minimum load, stator resistance protection (Insulation Lockout) and Earth leakage. Use Digital Inputs (DI) 1, 2, 3, 4, 6 and 7 as necessary. DI 5 is reserved for external reset.


NewCode Relay Frontend Rev 2e
File Options Disconnect
Recorder
Test
Event History
Calculator
Spectrum Analyser
Info
External Modules
Actual
Settings
Control Logic
Starter Configuration
Real Time Clock
Fault History
Comms + Statistics
Parameter Settings and Feature Selection - User Settings
Unbalance Phase Current
Trip Delay 5 sec Trip Level 10 %
Voltage
Line Voltage Selector 525V
High Limit 10 % Low Limit 10 %
Voltage Symmetry Trip Level 60 %
Start Count
Starts per hour allowed 6
Number of consecutive starts 3
Starter Type Selection
DOL Starter
External Modules
Digital Expansion Module Connected
FLED Connected
Analogue Expansion Module Connected
Minimum Load
Restart Delay Manual
Under Current Trip Level 10 %
Power Factor Trip Level 50 %
Startup Trip Delay 0 sec
Runtime Trip Delay 10 sec
Run-Stall
Trip Level 300 %
Trip Delay 1000 ms
Trip Holdoff Delay 0 sec
Digital Field Input Delays
Input 1 100 ms
Input 2 100 ms
Input 3 100 ms
Input 4 100 ms
Input 5 100 ms
Input 6 100 ms
Input 7 100 ms
Motor Full Load Setting (MLC)
Power rating of motor 110 kWatt
Supply line voltage 525V
Relay model 5
Interposing CT Ratio 300 : 5
Power Factor 85 %
Effieciency 90 %
Calculate MLC setting and return
53 %
15 sec
0 %
70 %
Instantanious Definite Time
Trip Delay 200 ms Trip Level 100 mA
Relay model NC 5
Interposing CT Ratio 400 : 5
Current Unbalance Select
Short Circuit Select
Single Phasing Select
Run Stall Select
Vectorial Stall Select
Frequency Monitoring Select
Minimum Load Select
Minimum Load Detection
Undercurrent Select
Power Factor Select
Analog Input 1 Select
Analog Input 2 Select
Analog Output 1 Select
Analog Output 2 Select
Overvoltage Select
Undervoltage Select
Voltage Symmetry Select
Voltage Phase Rotation Select
(BWR) V Phase Rotation Select
Earth Leakage Select
Insulation Lockout Select
Fail-Safe Select
Auto Thermal Reset Select
Vacuum fail
Dynamic TC Rst THold Adj Select
Starts per Hour Select
RTD 1 Select
RTD 2 Select
RTD 3 Select
RTD 4 Select
Read settings from relay
Transmit settings to relay

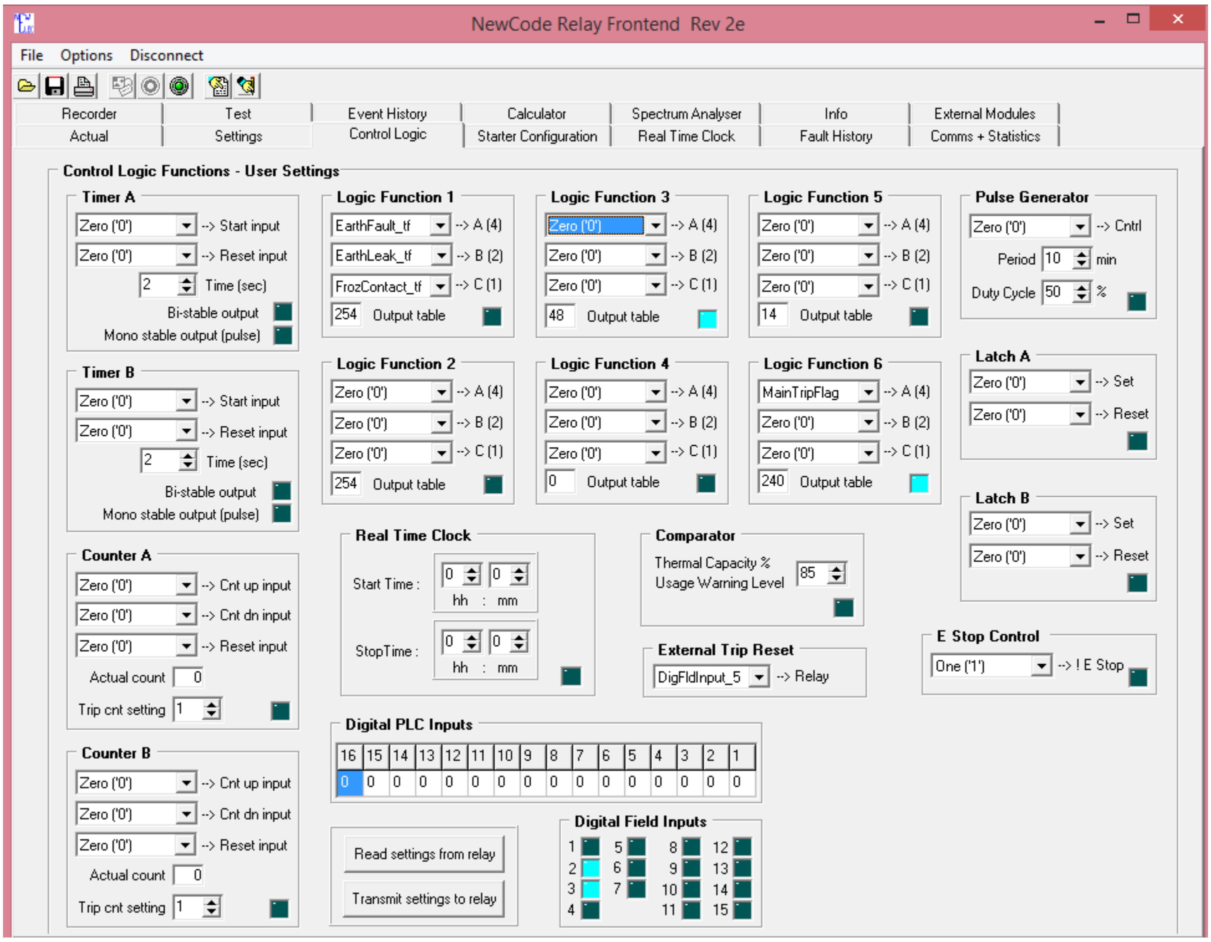


DI 1 = Start, DI 2 = Stop and DI 3 = Interlock.

Shunt trip on the Circuit Breaker with Relay Output 4 (RL4).

Extra Trip Flag duplicated on Relay Output 2, as Logic Function 6. See Control Logic page.

Pre Start Warning horn is blown for 10 second, through RL3.

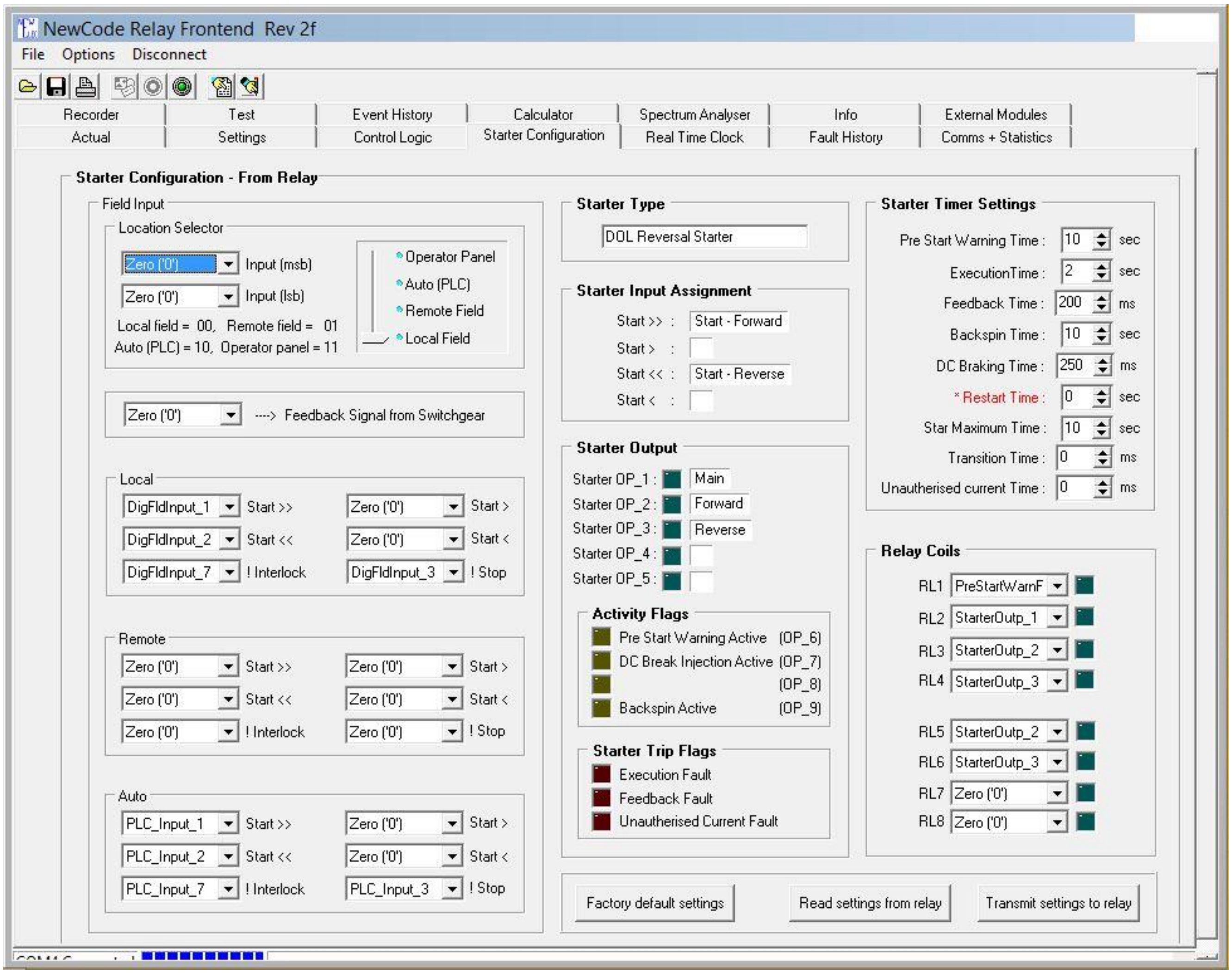


DI 5 = External Reset.

Example 2

NewCode configured and programmed as Forward / Reverse starter

For the same drive in example 2, create a reversible DOL.



An extra I/O module is used.

RL2 and RL3 are used to energize change in motor direction.

RL5 and RL6 are used as extra LED on the panel, to indicate motor direction.

Appendices

A1 : Motor Protection Principles Theory (Optional read)

It may be worth discussing the protection features required by the motor and to separate these protection features into two categories namely:

1. Basic non-negotiable and
2. Extended protection features offered by the present 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

What 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.

Why 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.

<u>How</u> 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”.

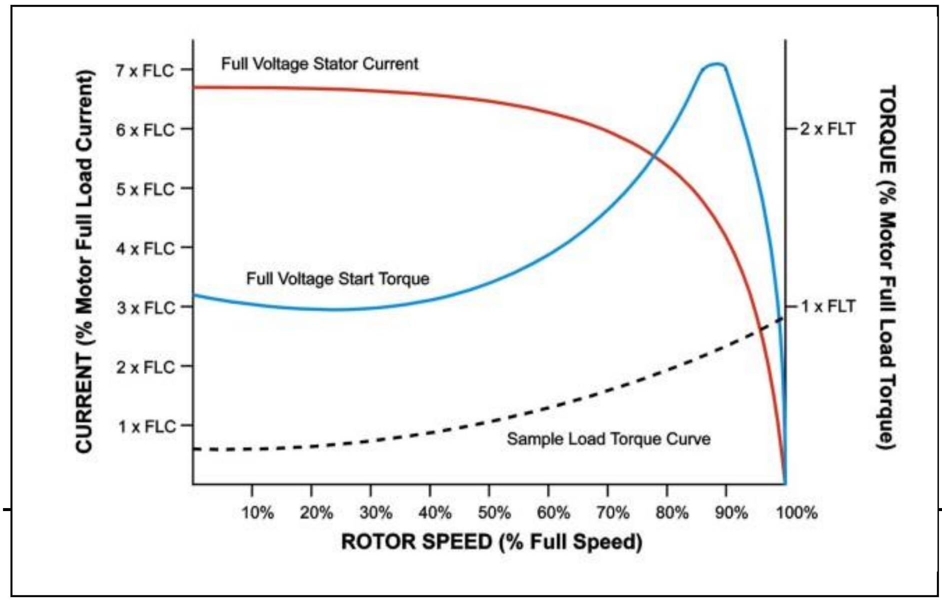


Figure 1: Torque and Current characteristics of an AC motor

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^2 T 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

Locked rotor detection

Vectorial stall rate of change power factor

Detection via speed switch or tachometer

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.

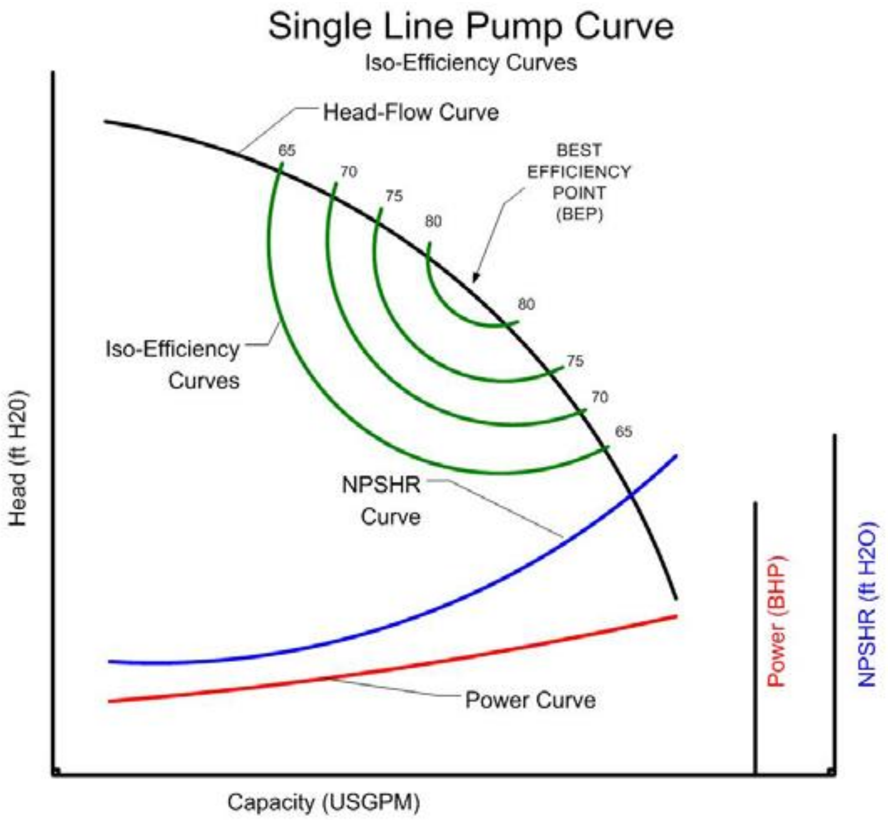


Figure 2: Pump efficiency curves (Source: www.jensenengineeredsystems.com / pump-curves)

<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 pump 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

<u>When</u> 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.

<u>How</u> 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.

<u>Where</u> 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

<u>What</u> 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,

<u>How</u> 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.

<u>When</u> or <u>where</u> 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

<u>What</u> 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).

<u>How</u> 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.

<u>When</u> or <u>where</u> 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

<u>When</u> or <u>where</u> 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 linearised 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.

How and where 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°C 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

A1: Flags

Table A1: Memory mapped parameters of the NewCode relay

Relay Parameters	**Alarm Flags**	**Trip Flags**	**Logic Parameters** (inverse logic = **!**)
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
	EarthFault_af	EarthFault_tf	! TmrB_Mon
	EarthFault_af	EarthLeak_tf	TmrB_Bi
	EarthLeak_af	MinLoad_tf	! TmrB_Bi
	MinLoad_af	OverVolt_tf	RTClock
	OverVolt_af	UnderVolt_tf	! RTClock
	UnderVolt_af	VoltSym_tf	LogicFunc_1,2 &3
	VoltSym_af	HiFreq_tf	! LogicFunc_1,2 &3
	HiFreq_af	LoFreq_tf	LogicFunc_4,5&6
	LoFreq_af	InsuLockOut_tf	! LogicFunc_4,5&6
	InsuLockOut_af	E_Stop_tf	TC_AvailLow
		PhaseRot_tf	StatusReporter
		StartsPerHr_tf	Flasher
		FrozenCntct_tf	PwrFacHiWarn
		System_tf	PwrFacLoWarn
		Execution_tf	Latch
		FeedBack_tf	! Latch
		UnAuthCrnt_tf	

A2: Fault indicator codes

Table A2: Fault indicator codes of the NewCode relay

Name of Fault	**Indication LED used**	**Display mode**
Over current	Overload	Solid on
Short circuit	Overload	Solid on
Minimum load	Min Load	Solid on
Phase Rotation	Phase Rotation	Solid on
Unbalance Phase Currents	Unbalance	Solid on
Single Phasing	Unbalance	Solid on
Insulation Failure	Insulation failure	Solid on
Run-Stall	Overload	Solid on
Vectorial-Stall	Overload	Solid on
Earth leakage	Earth leakage	Solid on
Earth fault	Earth leakage	Solid on
Over voltage	Phase rotation	3 sec on, 1 sec off
Under voltage	Phase rotation	1 sec on, 3 sec off
Voltage symmetry	Phase rotation	1 sec on, 1 sec off
Starts per hour	Overload & Healthy	Both 1 sec on, 1 sec off
High frequency	Unbalance	3 sec on, 1 sec off
Low frequency	Unbalance	1 sec on, 3 sec off

A3: Starter types

1. Direct On Line Starter
2. Reversible Direct On Line Starter
3. Star-Delta Starter
4. Reversible Star-Delta Starter
5. Dahlander Starter
6. Reversible Dahlander Starter
7. Soft Starter.
8. Reversible Soft Starter
9. Pulsed Output Direct On Line Starter

A4: Definition of Control Logic Parameters

As mentioned before, simulation can be conducted in manual or automatic mode. In this case, manual mode would be the preferred mode. The logic function blocks are three input logic function generators. The output table determines the logic equation (sum of products or product of sums). By clicking on the output table, a truth table will open to be edited. The truth tables can be connected together as well as with the other function blocks. It will allow the user to setup complicated logic functions.

The timer blocks each provide two outputs namely a bi-stable ( ) and a mono-stable (pulse) output. The timer is started with a positive edge triggered input signal and reset with a positive level signal. Please note that the timer will be kept in reset as long as the reset signal prevails. The timers have a time span that range from 1 to 3000 sec in steps of 1 sec.

The counters have a count range of 1 to 255. The up and down count inputs are positive edge triggered while the reset input is positive level triggered. Please note that while the reset signal prevails the counter will remain in a reset condition. The counter will give an output when the count value matches the count setting.

The latches have a positive edge triggered input while the reset input is positive level triggered. Please note that as long as the reset signal prevails the latch will stay in a reset condition.

The pulse generator is a controlled free running pulse generator with adjustable period and duty cycle settings. Period is the sum of time on (output active) and time off (output not active). Percentage duty cycle is time on (output active), divided by period and multiplied by 100.

The real time clock generates an output from start time to stop time. The real time clock can be adjusted on the real time clock screen. The real time clock is also adjustable via the network.

The comparator generates an output if the thermal usage level exceeds the set level.

A5: Notes on Simulation Facilities of NewCode

The simulation of control features requires a computer, a NewCode relay, connection cables, frontend and driver software for the USB connection of the relay. Field input signal can be simulated or generated from real switches.

The test screen is from where simulation is conducted. Simulation implies that simulated current, voltage, power factor, frequency and earth leakage current are injected on request from the frontend. The relay responds to it as if it is real. The process could better be described as emulation seen from the relay side. Two modes of simulation are provided namely manual and automatic. Manual mode is useful to test the relays protection features while automatic mode could be employed to model a plant to obtain the best settings for specific conditions. The difference between manual and automatic mode are as follows:

- Manual mode – Parameters (voltage, current etcetera) are changed by hand.
- Automatic mode – Parameters changes are executed by a time driven step sequencer. The sequence of simulated injections is saved into a simulation file and can be played back on request.

To test the protection features, parameters like current, voltage, power factor, earth leakage current and frequency injection are needed. The simulated injection of these parameters is useful for testing, modeling, training and demonstration purposes.

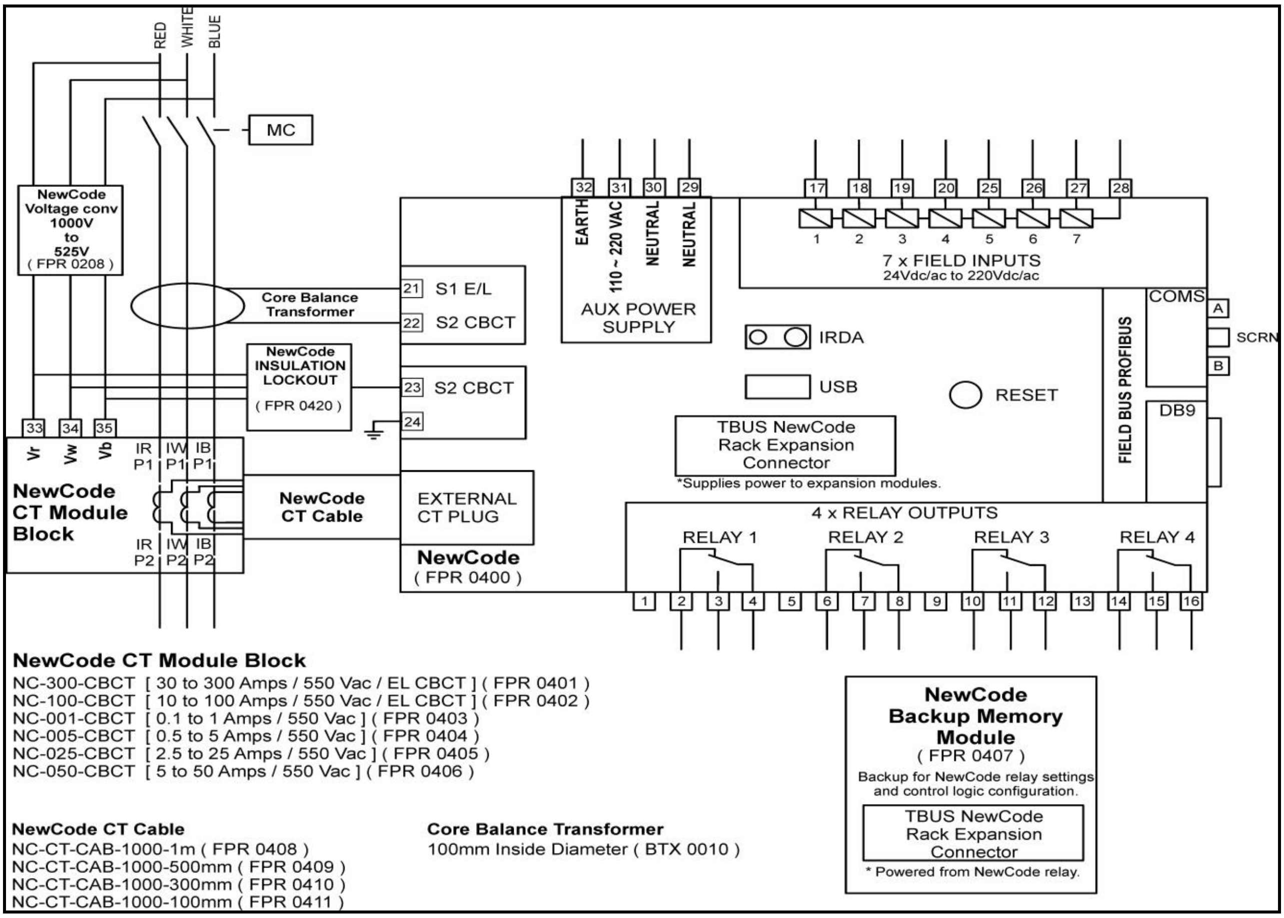
Overload (over current) is simulated (Test screen) by just raising the phase current injection above 100% (overload state). The overload alarm flag on the Actual screen should come on and the thermal capacity should continuously increase until it become 100%. This signifies that no reserve thermal capacity is left and the relay must trip immediately. If the phase current injection is lowered below 100% before 100% thermal capacity is reached, the relay will go into a cooling cycle state and the thermal capacity will decrease slowly. The rate of change of the thermal capacity level is directly related to the phase current injection level and the thermal curve class setting.

Run-stall is simulated by raising the phase current injection above 100%. The relay will arm in start mode. When lowering the phase current injection to below 100%, the relay will arm in run mode. If the phase current injection rises above 300% for longer then 1 sec the relay will interpret the condition as a run-stall fault and the relay will trip immediately.

A short circuit trip is differentiated by the power factor. In the case of simulation the power factor is also injected. The trip level of a short circuit condition is 850% when the power factor is above 80% and 300% when it is below 80%. Please note that the power factor is expressed as Cos Ø x 100%.

Vectorial stall protection is available to protect a motor with a heavy load and slow acceleration toward synchronous speed. After a start condition is registered the motor is monitored at intervals of 1 sec to ensure that the power factor improves. As the motor approaches synchronous speed the phase current should return to normal full load current (approximately 95%). Monitoring must be terminated and the process is interpreted as a successful start.

A6: NewCode Electrical wiring diagram and Part numbers



A7: Upgrading the NewCode relay Firmware

Since motor control and protection is an ever evolving technology discipline on its own, often there is a need to upgrade the products firmware. This will by no means say the older firmware versions are faulty, but they are upgraded for improvement. The reasons could be from simple front end look (aesthetic), change of methodology for computation, change of algorithms and so forth. Hence, the need to show to our client base a simple five minute procedure to upgrade NewCode firmware. This is done through the same mini USB port, used to configure motor in the field. Please do the upgrade only if you have studied this section thoroughly.

Firmware upgrade instructions

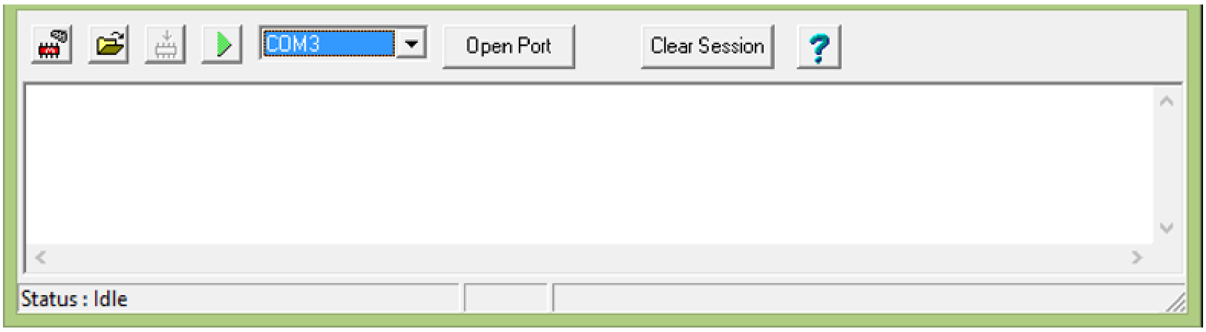
The relay has a boot loader program on board. The function of the boot loader is to facilitate the down load of new firmware revisions via the frontend and the USB bus onto the relay. Newer firmware revisions will become available when bug fixes were made and new functionality was added. When the user wants to upgrade the following steps must be followed to ensure success.

Step 1 - Ensure that a USB to mini-USB cable is plugged into the NewCode relay.

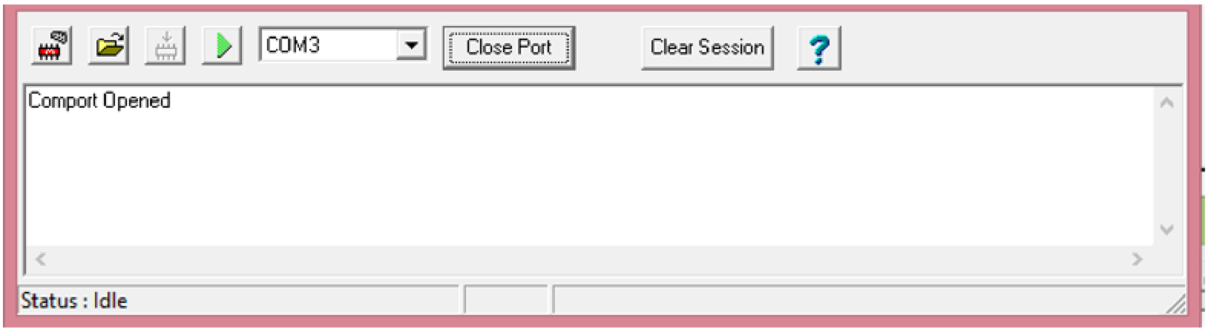
Step 2 - Power up the relay (either 110V or 220V AC) as per Electrical wiring diagram, in Appendix A6.

Step 3 - Launch the NewCode boot loader software Ver 1C from the CD provided.

Step 4 - Select the correct Communication Port from the drop down list. Once selected click “OPEN PORT”

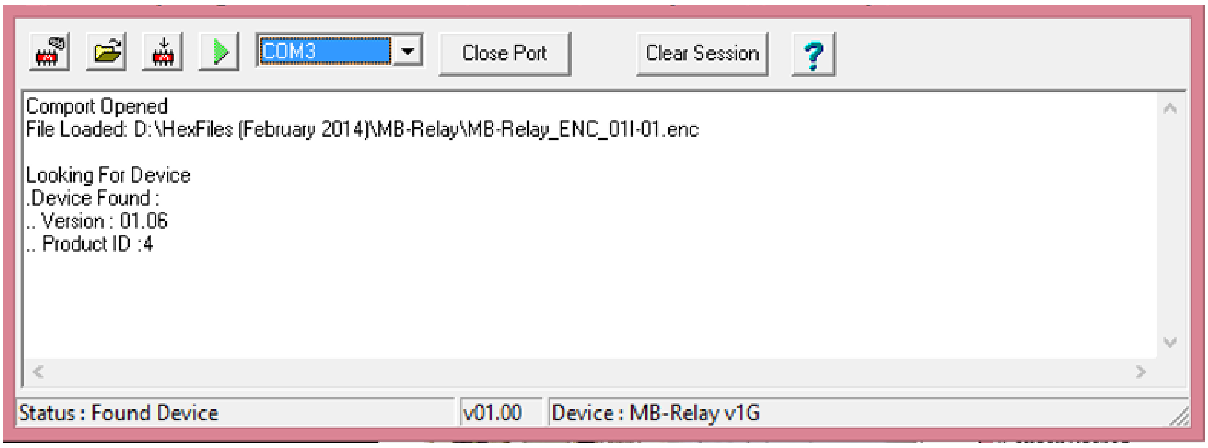


Step 5 - The “COMPORT OPENED” message will be displayed in the Session message box. Click on “SEARCH FOR DEVICE” Tab (Top Left RED Button). The ‘UNBALANCE’, ‘OVERLOAD’ and ‘INSULATION FAILURE’ LED’s will light up.



Step 6 - “Looking for Device” will be displayed in the Session Message Box. “Device Found”, will be displayed in the Session Message Box. “Version: xx.xx”, will be displayed in the Session Message Box. “Product ID :x”, will be displayed in the

Session Message Box. The ‘UNBALANCE’, ‘OVERLOAD’ and ‘INSULATION FAILURE’ LED’s will light up.

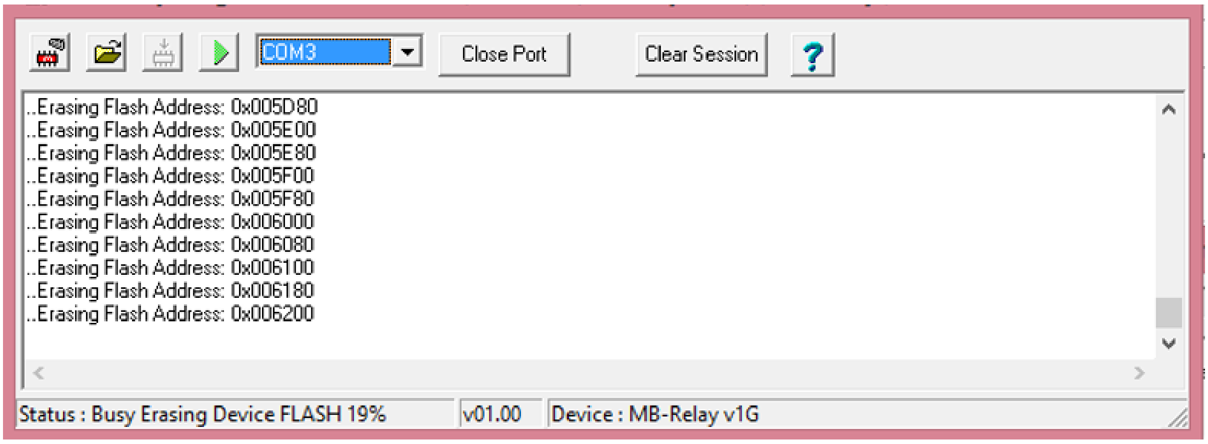


Step 7 - Click on “OPEN UPDATE FILE” (Second button from the left). Select the latest NewCode .enc file (example NC_ENC_1D-00.enc) Click on “OPEN”. The ‘UNBALANCE’, ‘OVERLOAD’ and ‘INSULATION FAILURE’ LED’s will light up.

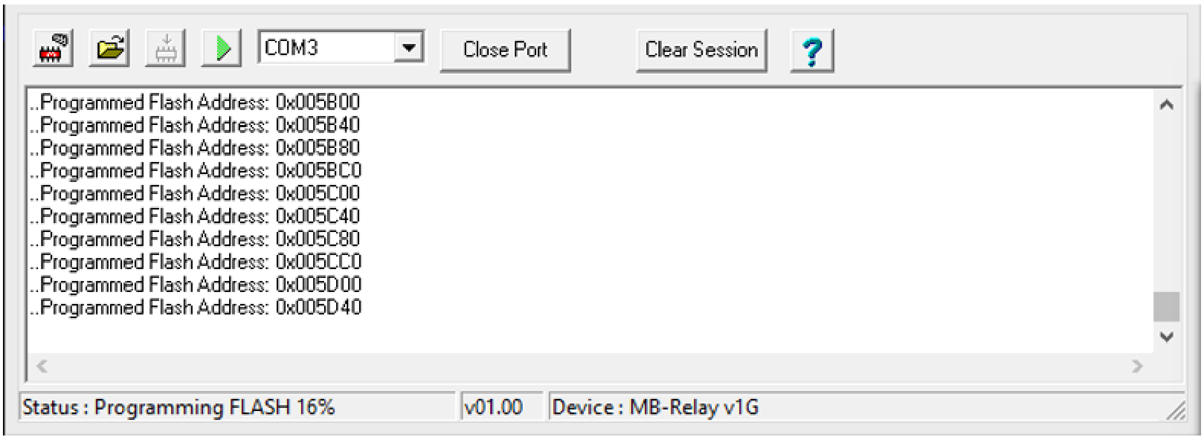
Step 8 - The Bootloader will now check the integrity of the selected file. “Status: Busy Checking Open File xx%” will be displayed in the bottom left corner of the Bootloader. This should take approximately 45 seconds (PC dependant). The ‘UNBALANCE’, ‘OVERLOAD’ and ‘INSULATION FAILURE’ LED’s will light up.

Step 9 - Once the file has been checked and no faults found, “File Loaded: ‘File Location’” will be displayed in the Session Message Box. The “UPLOAD FILE TO RELAY” Button will now be active (Third button from the left) Click on “UPLOAD FILE TO RELAY’ Button.

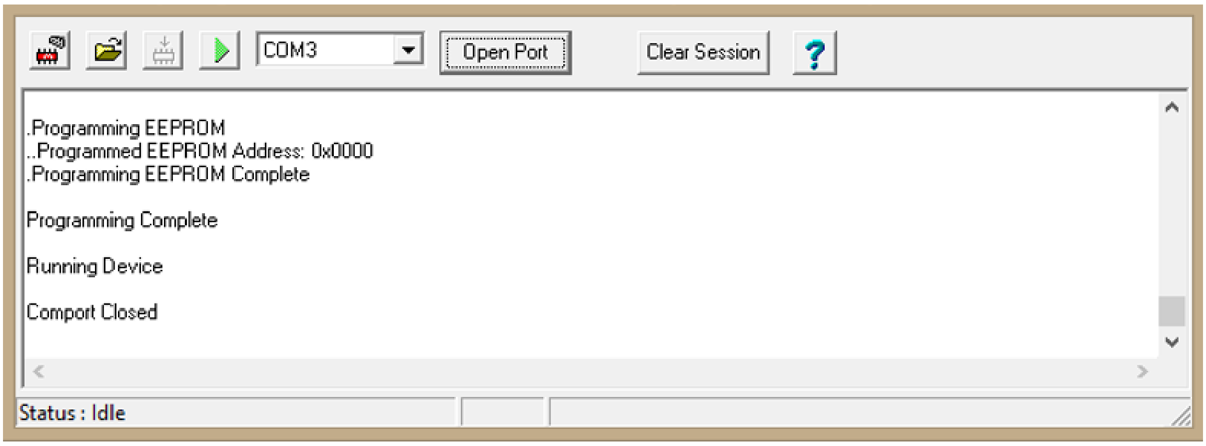
Step 10 - The Bootloader will erase the files currently stored in the Flash Memory on the relay and will automatically begin uploading the new firmware to the flash. This step may take approximately 5 minutes to complete. During the Erase Cycle, the 'UNBALANCE', 'OVERLOAD', 'PHASE ROTATION' and ' EARTH LEAKAGE' LED's will light up.



Then programming will start. During the Programme Cycle the 'MIN LOAD', 'PHASE ROTATION' and 'EARTH LEAKAGE' LED's will light up. During both cycles, the progress is displayed as a % in the bottom left of the Bootloader



Step 11 – Once the Programming is complete, the relay should automatically be returned to its normal mode and the GREEN LED indicating 'RELAY HEALTHY' will light up.



The Bootloader can now be closed and the NewCode Frontend must be re-opened.