MOTOR PROTECTION & CONTROL TECHNOLOGY

NewElec KD Relay

User Manual

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CONTENT

1. Abstract

The KD-Relay is a ISO9001:2000 compliant locally designed and manufactured three phase motor protection relay. It is a micro-controller based precision instrument with protection and control logic. The relay's design caters 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. External current transformers are used to extend the range from 100 to 400A.

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 with the MMI onto a memory stick for further analysis. All the settings are password protected. The relay has an on board database where time and date stamped records are kept. Two types of records are kept namely fault records (60 last faults) and event records (2000 events). In the case of event records, the user has limited access rights (read only). The front-end also has a data recorder which could be used to analyze motor performance.

The relay detects earth leakage currents with the aid of the external core balance current transformer and the relay is configurable to operate in inverse definite minimum time (IDMT) or instantaneous definite time (IDT).

A unique feature is added to the relay in the form of simulation. This function could be used for personnel training or relay functionality testing.

2. Specifications

2.1 Measurements

2.1.1 Current

- Three phase current
- Models: KD5, KD10, KD25, KD50, KD100, KD200 and KD400
- Range: KD5 is 0,5 to 5 Amp, KD10 is 1 to 10Amp, ... , KD400 is 40 to 400 Amps.
- Dynamic range: 0% to 1000%
- Expanded models: KD100 (100Amp), KD200 (200Amp) and KD400(400Amp) will make use of 100:5, 200:5 and 400:5 CTs respectively.

2.1.2 Voltage

- Range: 110V, 400V, 525V and 1050V (1050V requires an additional attenuator circuit)
- Range selection: Manual or Automatic selection at power up. (1050V is only manual selectable)

2.1.3 Frequency

- Range: 30Hz to 100Hz

2.1.4 Power Factor

- Range: 0 to 100% (leading / lagging)

2.1.5 Earth Leakage

- Range: 30mA to 3 Amps
- Trip time delay: Inverse Definite Minimum Time (IDMT) / Instantaneous Definite Time (IDT)

2.1.6 Real Time Clock

- 24 hour clock (Year, month, date, hours and minutes)
- Battery backup (5 days with a 1 Farad super capacitor)
- Time and date stamping (Fault and event records)

2.1.7 Breaker Fault Clearance Time

- Measurement range: 10 ms to 1000ms
- Resolution: 10ms steps.

2.1.8 Insulation Resistance

- Measurement range: 1 to 199 kOhm
- Resolution: 1 kOhm steps.

2.2 Protection Features

(All resets are subjected to sufficient thermal capacity gain)

2.2.1 Over Current (Overload) Detection

- Curve class settings: 3 seconds to 40 seconds
- IEC 60255-8 specification
- Motor full load setting (MLC): 10% to 100% (on front panel)
- Reset: Manual or three automatic resets per hour (when selected)
- Reset threshold setting: Fixed at 70% thermal capacity or dynamic threshold adjustment determined over 10 last restarts.

2.2.2 Undercurrent (Minimum load) Detection

- Trip level adjustment: 10% to 100% (on front panel)
- Selection: Current level or power factor
- Trip delay time: 1 to 10 seconds
- Startup delay: 1 to 200 seconds (To facilitate pump priming)
- Reset time: Manual or 10 seconds to 6 hours (9 steps)
- Feature selectable

2.2.3 Unbalance Phase Currents Detection

- Trip level adjustment: 0 to 50%
- Trip delay time: 1 to 10 seconds
- Feature selectable
- Reset: Manual

2.2.4 Single Phasing (Phase lost) Detection

- Trip delay time: 1 second fixed
- Feature selectable
- Reset: Manual

2.2.5 Run-Stall Detection

- Stall current trip level adjustment: 110% to 300%
- Stall trip delay time: 0 to 120 seconds adjustable
- Feature selectable
- Reset: Manual

2.2.6 Vectorial-Stall Detection

- Trip: Static or decreasing power factor
- Trip delay: 33% of curve class setting.
- Feature selectable
- Reset: Manual

2.2.7 Starts per Hour Control

- Starts setting: 1 to 30 starts adjustable
- Consecutive starts: 1 to 3 starts per interval adjustable
- Feature selectable
- Reset: Automatic

2.2.8 Short Circuit Detection

- Articulated detection: If (I_{LOAD} > 950% and Power factor < 85%) or (I_{LOAD} > 300% and Power factor > 85%)
- Trip delay time: 1 second fixed
- Reset: Manual

2.2.9 Voltage Symmetry Detection

- Trip delay time: 10 seconds fixed
- Trip level adjustment: 70% to 100%
- Feature selectable
- Reset: Manual

2.2.10 Over Voltage Detection

- Trip delay time: 10 seconds fixed
- Trip level: Factory settings
- Feature selectable
- Reset: Manual

2.2.11 Under Voltage Detection

- Trip delay time: 10 seconds fixed
- Trip level: Factory settings
- Feature selectable
- Reset: Manual

2.2.12 High or Low Frequency Detection

- Trip delay time: 10 seconds fixed
- Trip level: Factory settings (45Hz to 55Hz)
- Feature selectable
- Reset: Manual

2.2.13 Voltage Phase Rotation

- No trip delay time
- Auto reset once fault is fixed
- Feature selectable (forward, reverse, none)

2.2.14 Insulation Failure Detection

- Detection: Only in static state (motor not running)
- Trip delay time: 1 second fixed

- Trip level: Resistance < 20 kOhm (fixed)
- Feature selectable
- Reset: Manual

2.2.15 Earth Leakage Detection (I_{EL} < 2A)

- Selection between Instantaneous Definite Time or Inverse Definite Minimum Time.
- Instantaneous Definite Time (100 ms ≥ t ≥ 1000 ms), (50 ms steps)
- Inverse Define Minimum Time (t ≥ 130 ms)
- Harmonic filtering (suitable for variable speed drives and soft starters)
- Trip level: Adjustable
- Feature selectable
- Reset: Manual

2.2.16 Earth Fault Detection (I_{EL} ≥2A)

- Harmonic filtering (suitable for variable speed drives and soft starters)
- Trip delay time: 1 second fixed
- Trip level: 2A fixed
- Feature selectable
- Reset: Manual

2.3 Control logic

- Configurable inputs can be connected with signal listed in the table below:

Zero ('0')	MinLoad_af	SinglePhase_tf	StartsPerHr_tf	LogicFunc_3
One ('1')	OverVolt_af	EarthFault_tf	Timer_A	! LogicFunc_3
InService	UnderVolt_af	EarthLeak_tf	! Timer_A	Restart
VoltPresentF	VoltSym_af	MinLoad_tf	Timer_B	FrozenContact
OverCrnt_af	HiFreq_af	OverVolt_tf	! Timer_B	TCap > THold
ShortCirc_af	LoFreq_af	UnderVolt_tf	RTClock	
RunStall_af	IsoLockOut_af	VoltSym_tf	! RTClock	
I_Unbal_af	OverCrnt_tf	HiFreq_tf	LogicFunc_1	
SinglePhase_af	ShortCirc_tf	LoFreq_tf	! LogicFunc_1	
EarthFault_af	RunStall_tf	IsoLockOut_tf	LogicFunc_2	
EarthLeak_af	I_Unbal_tf	PhaseRot_tf	! LogicFunc_2	

2.3.1 Timers

- Timer A and Timer B
- Time setting: 0 to 50 minutes
- Start input: Configurable
- Reset / Inhibit input: Configurable

2.3.2 Real Time Clock (24 Hour)

- Start time: Hours and minutes configurable

- Stop time: Hours and minutes configurable

2.3.2 Logic function blocks
- Logic function 1, Logic function 2 and Logic function 3
- Three fully configurable inputs per logic function block
- Sum of product or product of sums operation

2.3.3 Relay 2
- Input: Configurable
- Single set of potential free switch-over contacts

2.4 Statistical Data Capturing

2.4.1 Running hours: Adjustable (0 to 65535 hours)

2.4.2 Startup counter: Adjustable (0 to 65535)

2.4.3 Trip counter: Adjustable (0 to 65535)

2.5 Trip Fault Recording

2.5.1 Database capacity: 60 last faults

2.5.2 Trip fault record content:
- Status: (Actual / simulated)
- Date: Year, month, date
- Time: Hour, minute
- Fault description
- Run hours
- Max trip current
- Minimum trip voltage
- Breaker fault clearance time.

2.6 Event Recording

2.6.1 Database capacity: 2000 last events

2.6.2 Event record content:
- Status: Actual, Simulated, Settings adjust, Power up, Calibration
- Date: Year, month, date
- Alarm flags

- Trip flags
- Run hours
- Max trip current
- Min trip voltage
- Breaker fault clearance time

2.6.3 Down load control

- Last events: 1 to 2000 selectable for down load.
- Front-end will creates a spread sheet type of file (Can be viewed by MS Excel(TM) or equivalent program)

2.7 Physical dimensions

2.7.1 Size of foot print: 100mm x 60mm (DIN Rail mount / screw fix mount)
2.7.2 Length: 150mm

2.7.3 Mass: 425gram

2.8 Auxiliary power supply

2.8.1 Voltage requirements: 110 Vac ± 10% or 230 Vac ± 10%

2.8.2 Power requirements: 2,2 Watt

2.9 Operating environment

2.9.1 Temperature: 0 – 50° Celsius

2.9.2 Relative humidity: < 85%

3. Definitions and Terminology

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)
Earth leakage fault	It is leakage current up to 2 amps exceeding a trip level setting. (See also core balance current transformer)
Full load current	Current drawn by the motor at full load operation (90% to 100%)
In Service	Phase current above 10% of full load current
Isolation lockout / Insulation failure	The insulation resistance of the motor is measured while in a static (not in service) condition. If the resistance drops below 20 kOhm the relay will trip and will prevent a start.
Motor full load 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
Phase rotation	Normal phase rotation is Red, white and blue. Reverse rotation is blue, white and red.
Power factor	It is die relationship between real power and apparent power Power factor % = ((V x I x Cos Ø) / (V x I)) x 100% Power factor = Cos Ø
Run-Stall	The motor went through the normal start procedure and the current level return to normal full level. If the rotor jam and the current rise above the stall setting (110% to 300%) it is recognized as a Run-Stall fault condition.
Starts per hour	Starts per hour define the time interval in which a restricted amount of starts are allowed. (See also consecutive starts)
Thermal capacity	It is a temperature related quantity expressed in percentage, which also takes in consideration the physical size, mass, construction, type of material used etc. of the motor. It is normally indicated as capacity used unless otherwise stated.
Thermal curve class continue ...	It is the particular curve that go through the maximum lock rotor current point and the maximum time point where the motor can survive in lock rotor condition. It is derived from the unit curve (1 second) with multiplication to create the appropriate curve for proper protection. (See diagram 6.7)

Undercurrent (Minimum load)	Current level when motor run at no load condition or below acceptable threshold.
Vectorial-Stall Vectorial-Stall continue ….	It is detected during the start-up procedure of the motor. A motor normally start-up with a bad power factor and gradually improve it as full speed is approached. If no power factor improvement is detected for longer then 33% of the curve class time the motor is tripped to prevent thermal and mechanical damage.
Volatile memory	It is memory that will loose data during a power supply interruption. (see also non volatile memory)

4. Functional Description

The KD-relay is controlled by a micro-controller. 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 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. The uploading is done from a personal computer or laptop via the RS232 port. This feature also enables the user to do future software upgrades without factory assistance.

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 setup adjustments required at the installation phase will be discussed in the next chapter dealing with installation instructions.

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 will be activated. It will be energized or de-energized (non fail save or fail save respectively) depending on what mode of operation 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. The layout of the trip record is discussed in chapter 2 that deals with specifications.

Event records are also time and date stamped. It is more comprehensive and saved in non volatile memory. Only read access is given to the user. This information can be used for insurance claims and liability cases. The layout of the event record is discussed in chapter 2 (specifications).

Six fault indication light emitting diodes (red) are placed on the front panel. The green light emitting diode will come on only if the relay is in a healthy state. A healthy state signifies that the motor could be static or in operation within it's save operating parameters. The fault indications are displayed on the front panel as follows:

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

The reset button is used to acknowledge and reset trip faults. A reset will only take affect if sufficient thermal capacity is regained during the cooling period and no phase current flows. If the reset button is pressed during the cooling cycle the Overload LED will start flashing (1 second on, 1 second off) to signify cooling. Once the required thermal capacity level is reached, the relay will reset.

The real time clock is running from a battery or super capacitor which is continuously charged by the auxiliary power supply. The real time clock should be able to run for another 5 days if the auxiliary supply went down. The real time clock provides time and date for record keeping and also participates in the control functions.

The main trip relay has a dedicated function and is exclusively used for protection. Relay 2 is configurable and is available to participate in the control functions.

5. Installation Instructions

5.1 Front-end requirements

A Pentium personal computer or laptop is required to setup the KD-relay. The computer must be equipped with a RS232 port. If only USB ports are available an USB to RS232 converter may be used. The operating system software requirement is MS Windows 2000, MS Windows XP or later versions. The front-end software is free but remains the property of NewElec (Pty) Ltd. It is supplied with the purchase of new relays.

5.2 Setup procedure of the relay

Once the wiring has been done and checked by qualified personnel, the relay is ready to be configured. The two most important front-end screens is the settings (diagram 6.4) and control logic screen (diagram 6.5). These two screens enable the user to set parameters, select protection functions and determine control strategy. These two screens are also linked and when settings are saved to disk or retrieved from disk.

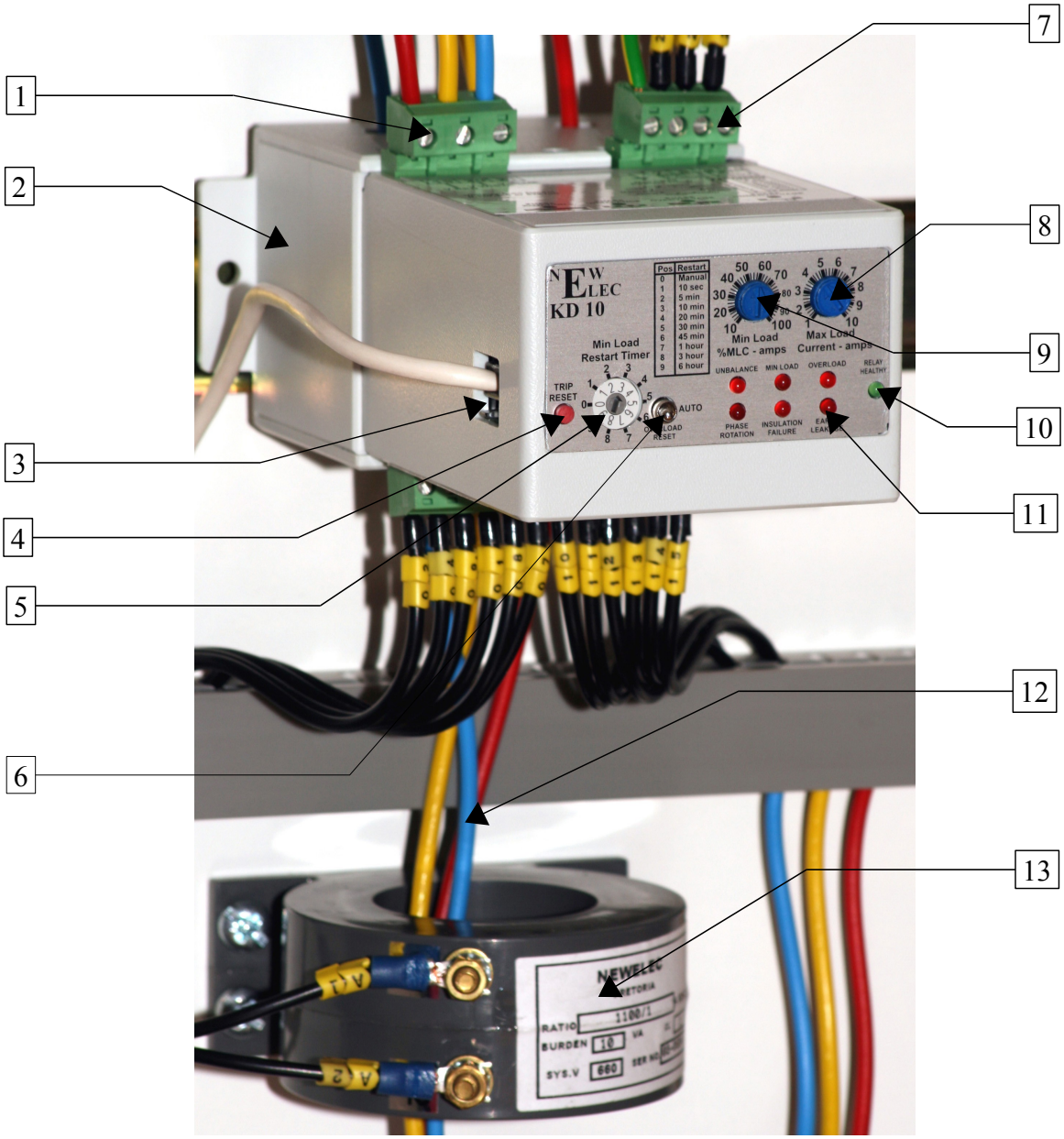
When setting changes are made it has to be transmitted to the relay to become effective. Changes on the control logic screen can only be made when off line is selected. When on line is selected again, the settings are transmitted to the relay. Relays are shipped to the user with a set of default settings and may be appropriate in some cases.

To determine the full load current setting the motor has to be started and allowed to run at full load capacity. Press the reset button (diagram 6.1 – 4) and turn the max load dial (diagram 6.1 – 8) till the overload indication (diagram 6.1 – 11) just switches off. Release now the reset button. The front-end can be used to confirm that the load current level indicated is between 90% and 99%. The minimum load setting adjustment (motor run with no load) is done in a similar way with the aid if the reset button (diagram 6.1 – 4), minimum load setting dial (diagram 6.1 – 9) and the minimum load indication (diagram 6.1 – 11).

The real time clock should be checked and adjusted to the correct time setting.
The fault history can also be erased to start afresh.

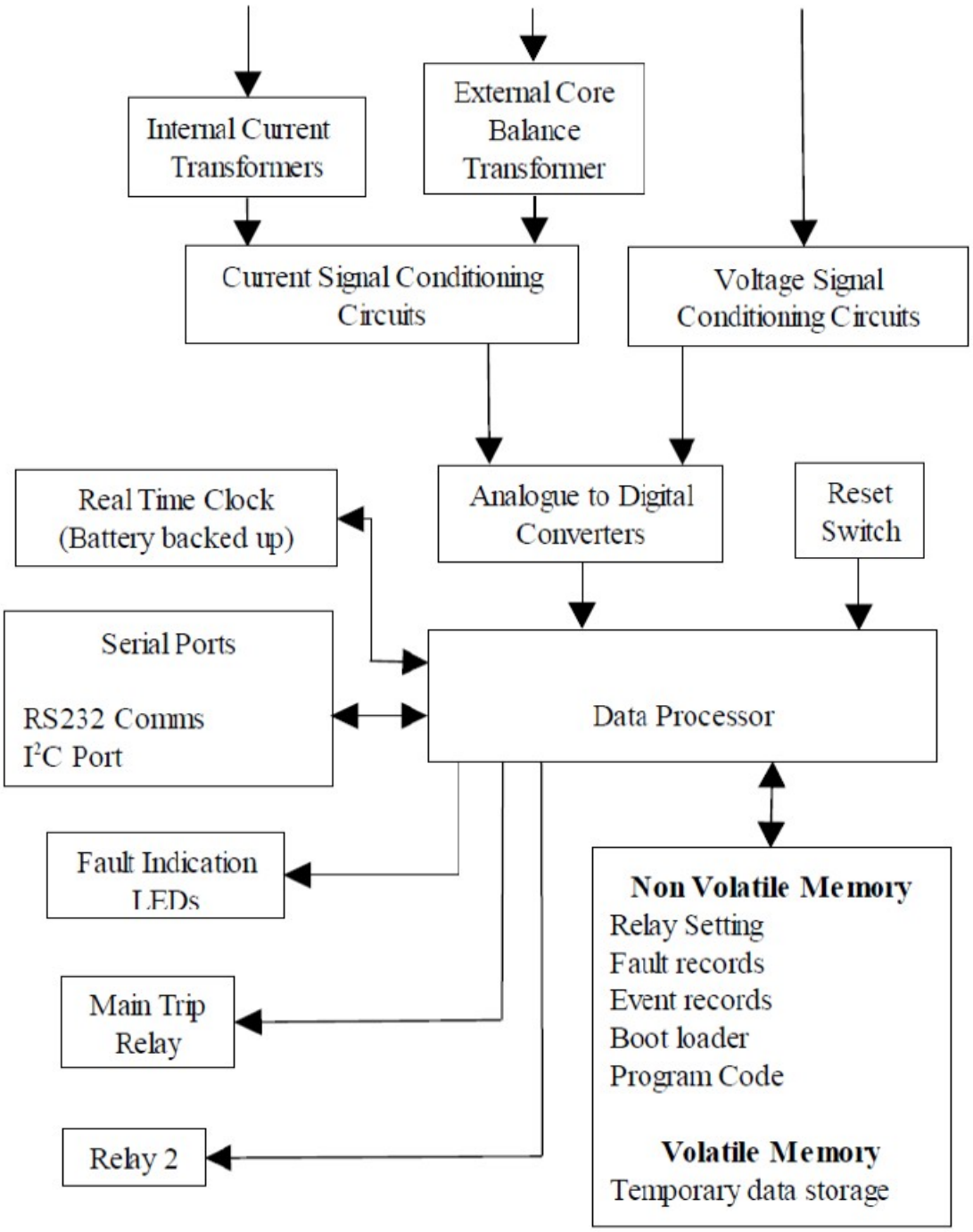
6. Diagrams

6.1 Physical layout of the KD-Relay

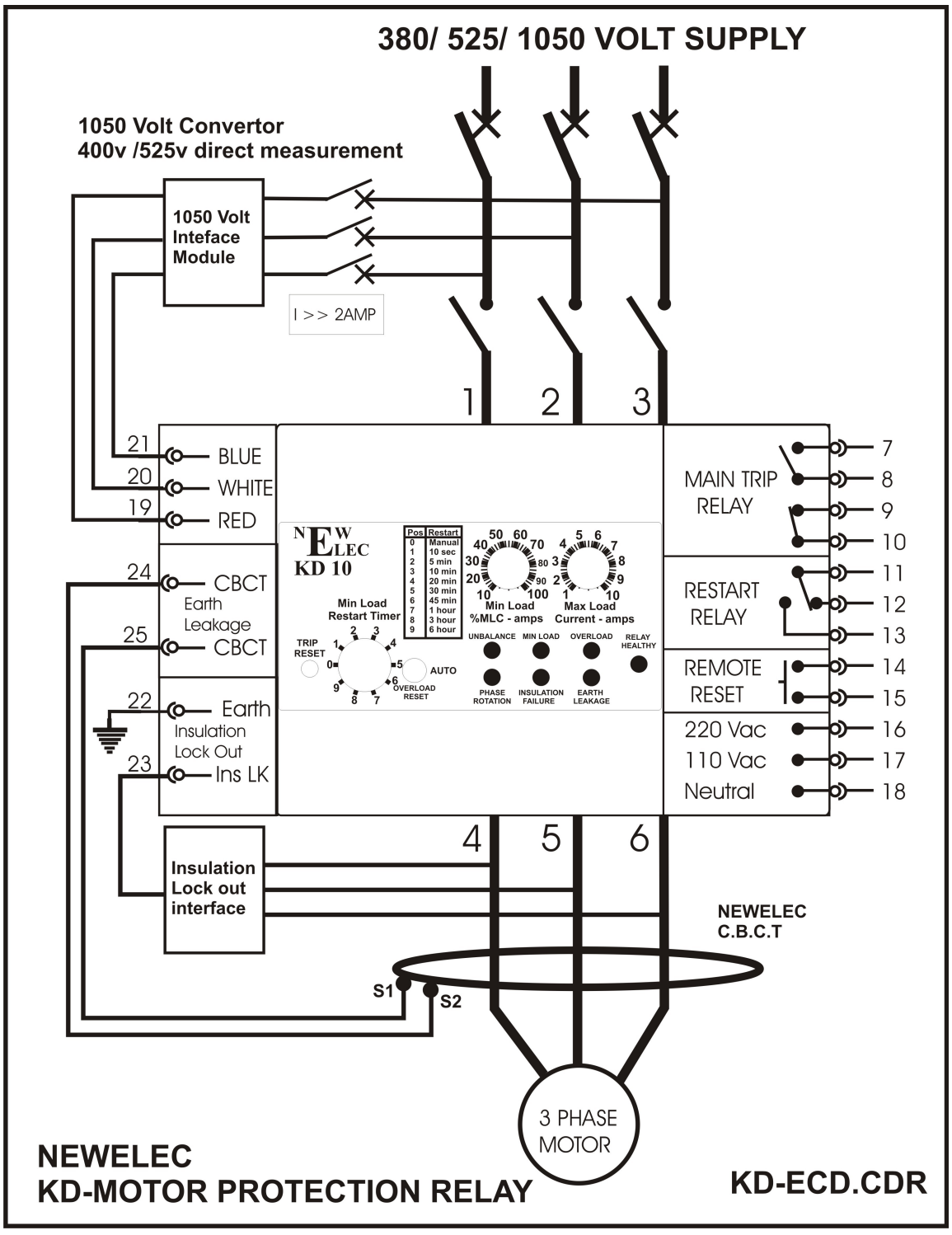


1	Three phase voltage connector	8	Motor full load setting dial (MLC)
2	Internal integrated current transformers	9	Minimum load setting dial
3	Serial Data Port (RS232 / I^2C)	10	Healthy indication
4	Reset switch	11	Fault indication light emitting diodes
5	Minimum load reset time selector	12	Three phase power supply
6	Auto / manual switch (Thermal reset)	13	Core balance current transformer
7	Auxiliary power supply (110V / 230V)		

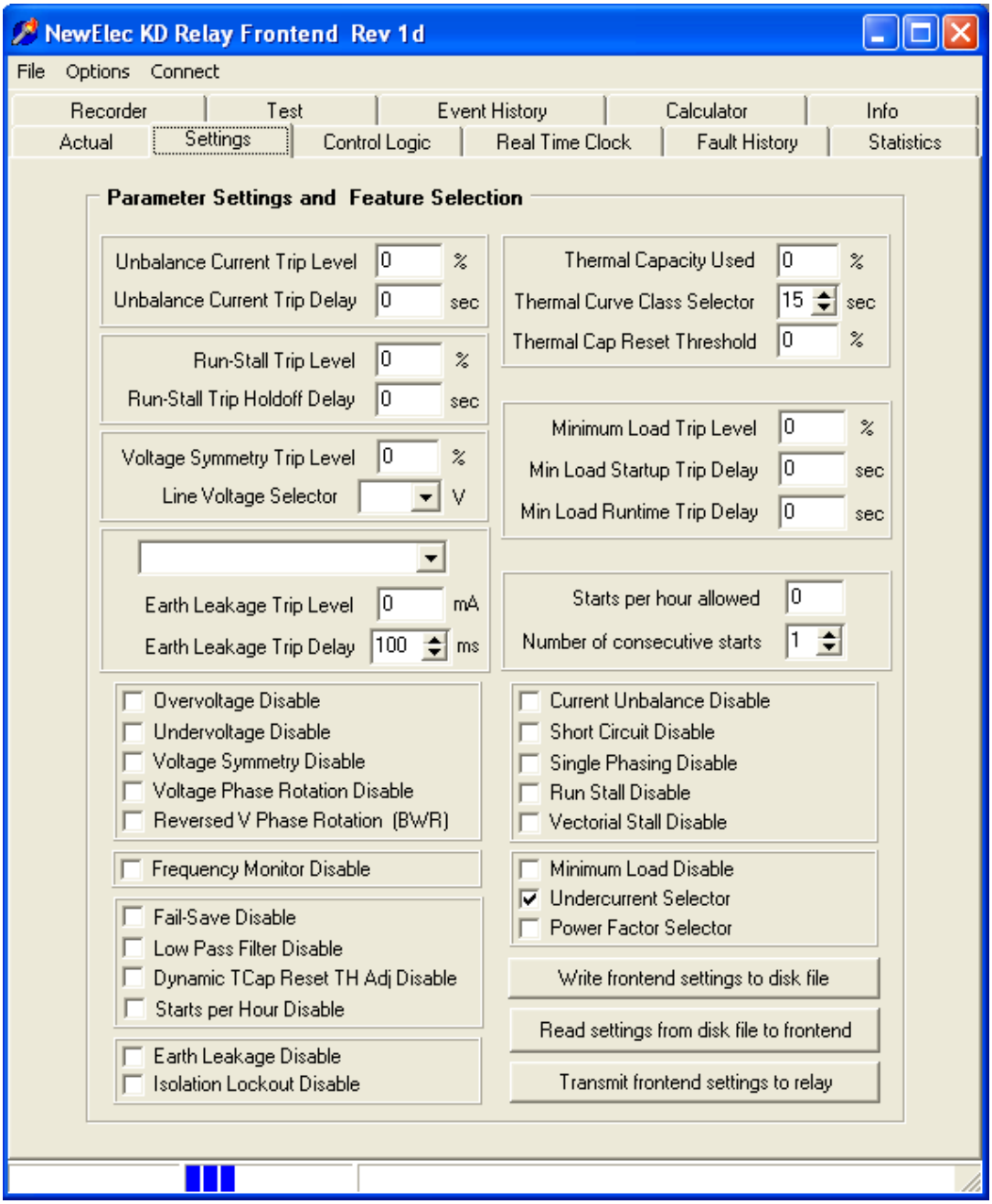
6.2 Block diagram of the KD-Relay



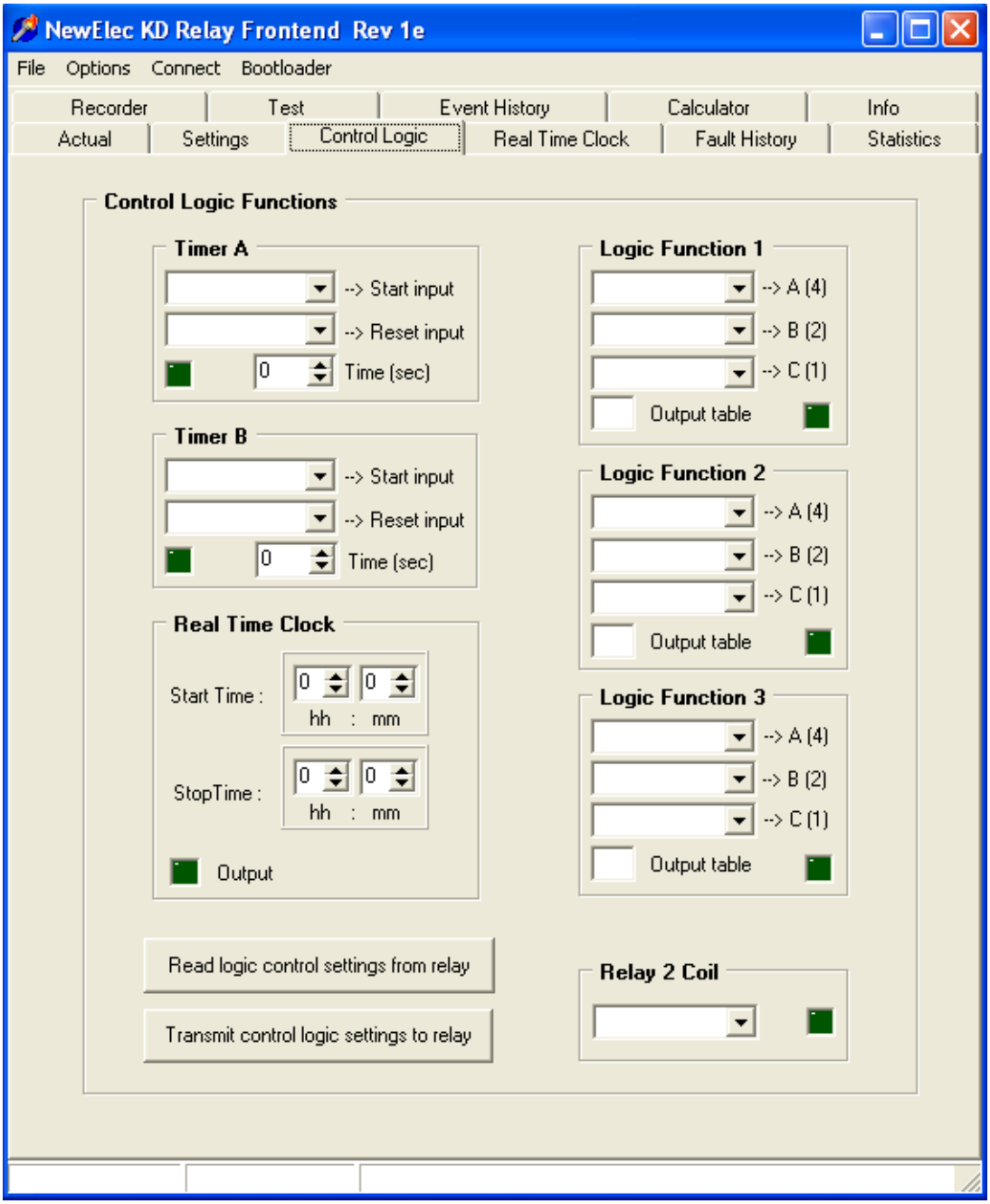
6.3 Wiring diagram of the KD-Relay



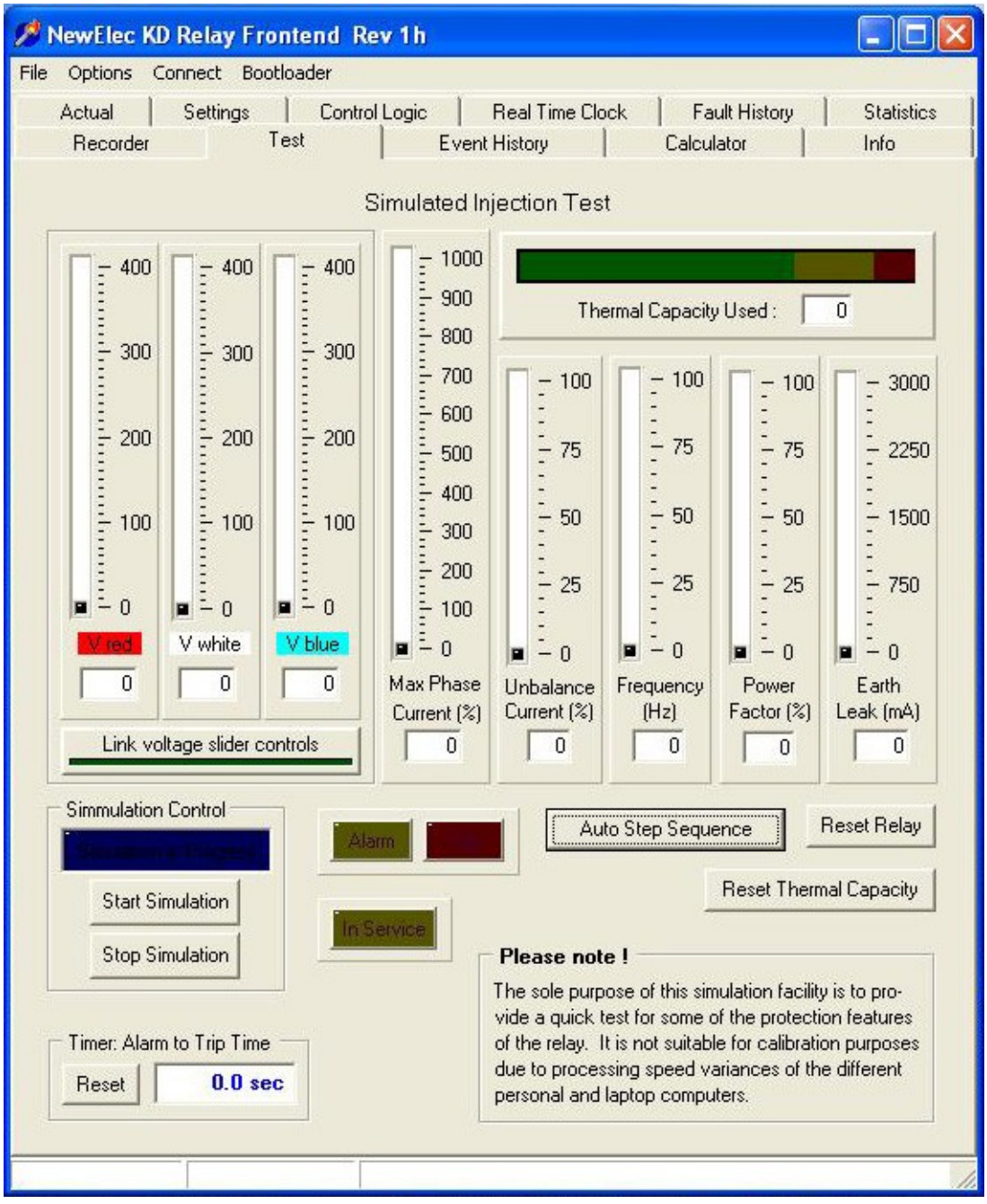
6.4 Front-end settings screen



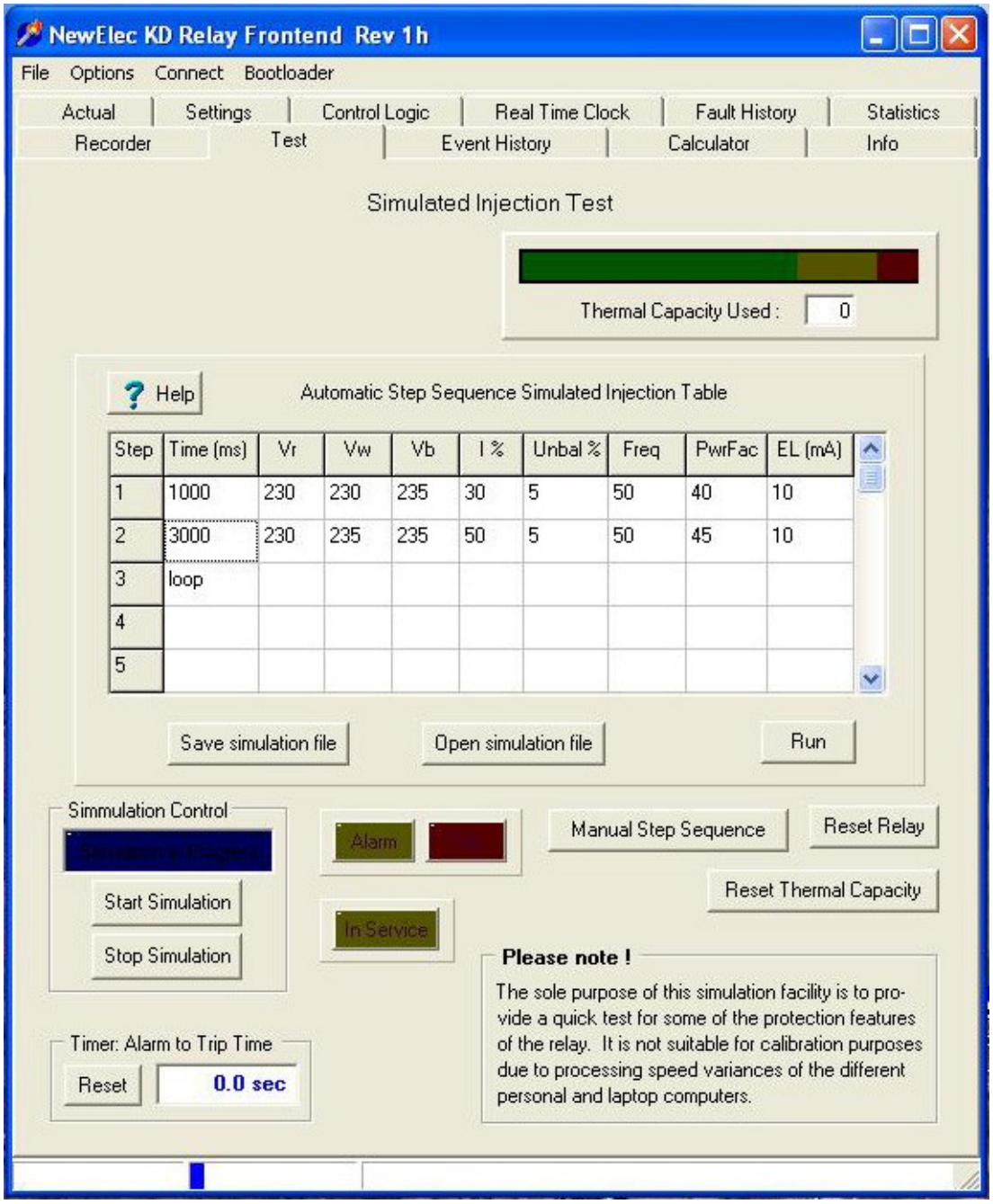
6.5 Front-end control screen



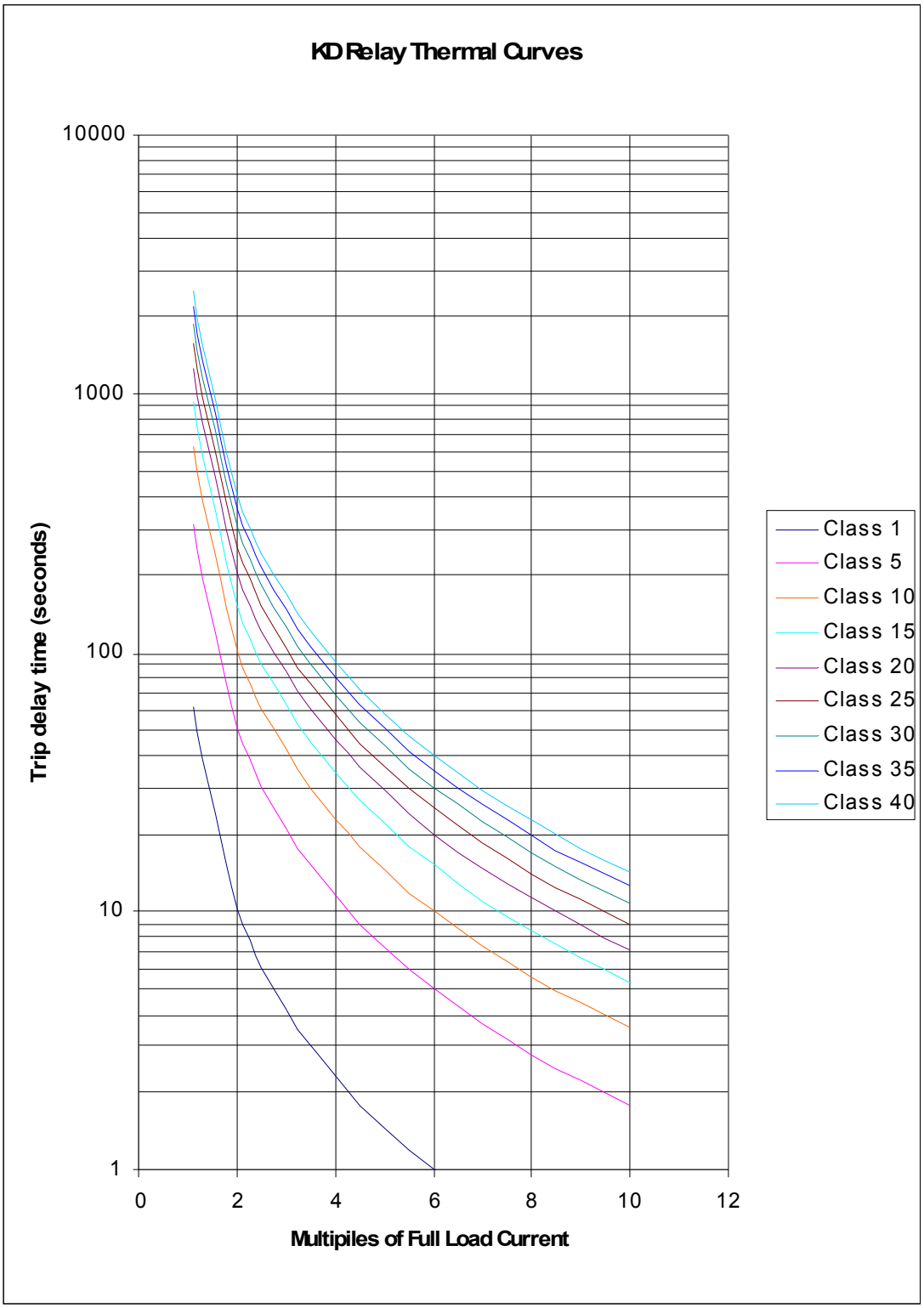
6.6 Front-end test screen (Manual Control)



Front-end test screen (Automatic Control)



6.7 Relay trip times

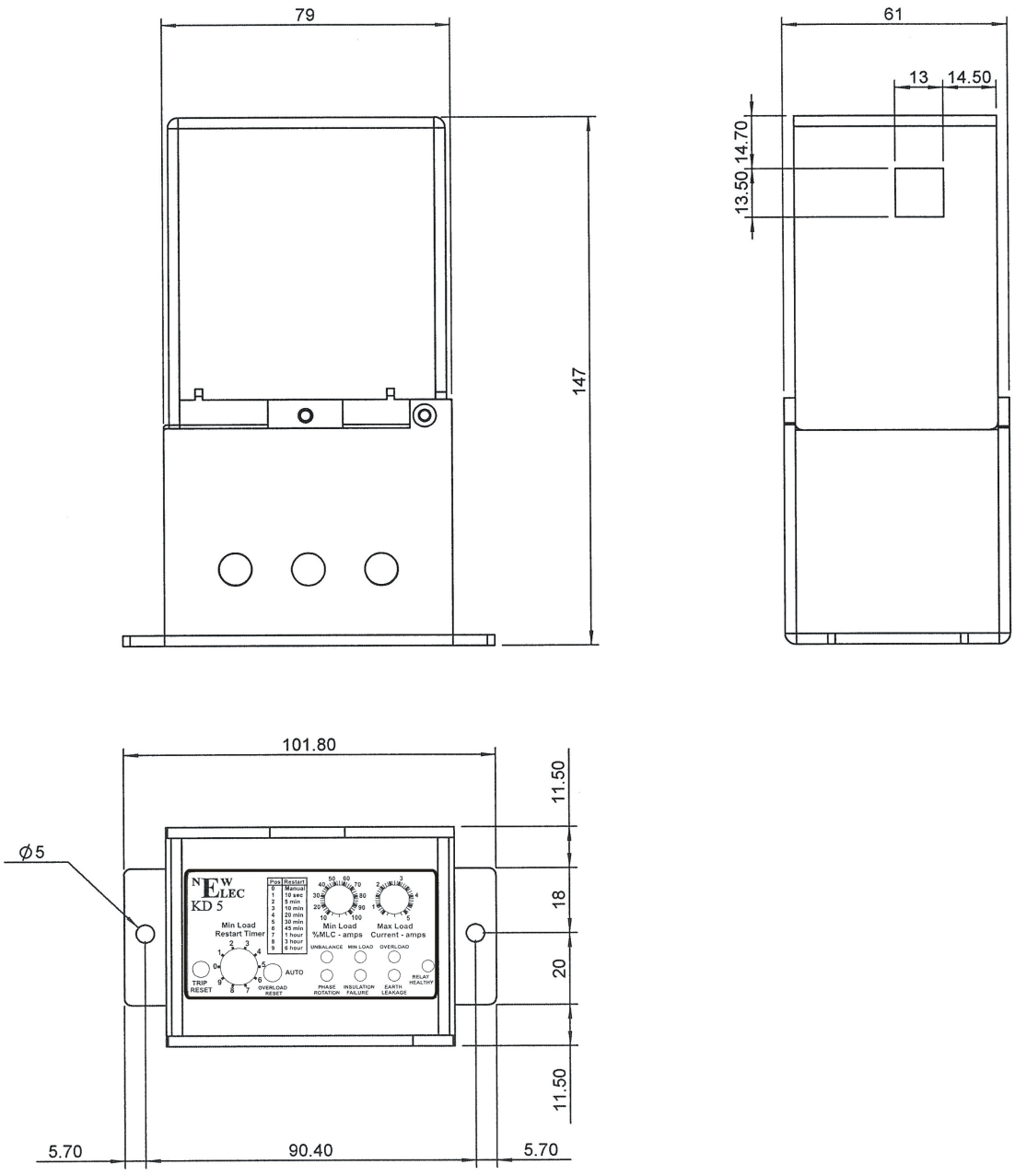


6.8 Relay setting ranges and default settings

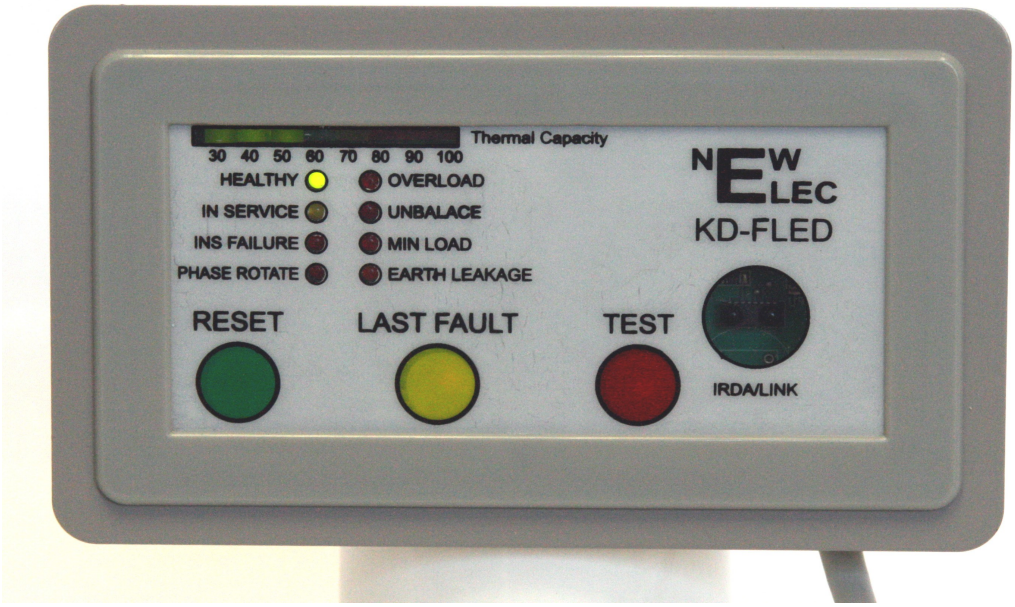
Parameter	Settings Range	Factory Default
Unbalance Current Trip Level	5 to 50%	15%
Unbalance Current Trip Delay	1 to 10 seconds	10 seconds
Run-Stall Trip Level	110 to 300% I fl	300%
Run-Stall Trip Level Trip Hold Off Delay	1 to 10 seconds	0 Sec
Voltage Symmetry Trip Level	85 to 100%	85%
Line Voltage Selector	110; 380; 525 or 1000 V a.c	Auto
Earth Leakage Curve Selection	DMT OR IDMT	DMT
Earth Leakage Trip Level	30 to 1000 mA	250 mA
Earth Leakage Trip Delay	100 ms to 1 second	150 ms
Thermal Curve Class Selector	5 to 40 seconds	15 seconds
Thermal Capacity Reset threshold	10 to 50 %	70%
Minimum Load Trip Level	10 to 100%	33%
Minimum Load Start Up Trip Delay	1 to 200 seconds	1 second
Minimum Load Run Time Trip Delay	1 to 10 seconds	10 seconds
Starts per hour allowed	1 to 30	6
Number of consecutive starts allowed	1 to 3	3

Feature Selection	Factory Preset
Overvoltage Disable	No
Undervoltage Disable	No
Voltage Symmetry Disable	No
Voltage Phase Rotation Disable	No
Reverse Voltage Phase Rotation BWR	No
Current Unbalance Disable	No
Short Circuit Disable	Yes
Single Phasing Disable	No
Run Stall Disable	No
Vectorial Stall Disable	No
Frequency Monitor Disable	Yes
Fail Safe Disable	No
Low Pass filter Disable	No
Dynamic T Cap Reset / Th adjust disabled	Yes
Starts per hour disabled	Yes
Earth Leakage Dissable	No
Isolation Lockout Disable	Yes
Minimum Load Disable	No
Under Current Selector	Yes
Power Factor Selector	No

6.9 Mechanical drawing of the KD Relay

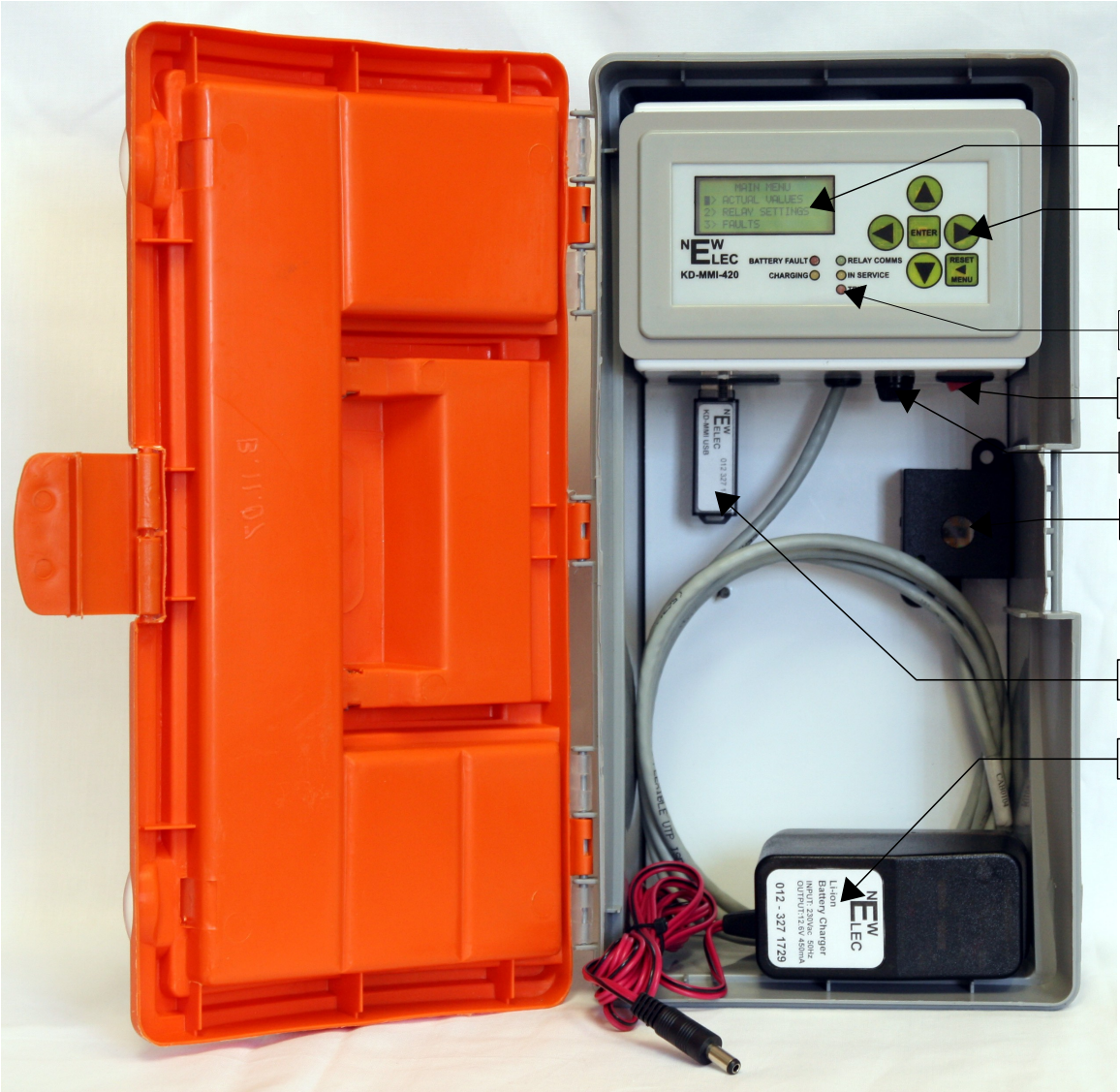


6.10 FLED (Field Light Emitting Diode Display)



6.11 RDU (Remote Display Unit)

6.12 KD-MMI-420-EP (Man Machine Interface)



1. Liquid Crystal Display (4 x 20)	2. Keyboard
3. Indication lights (LED)	4. Switch (On / Off)
5. Fuse (1 Ampere – slow blow)	6. Infrared Interface (IrDA)
7. USB Memory Stick	8. Li-Ion Battery Charger

7. Accessories

7.1 FLED (Part number: KD-I2C-FLED)

It is a field / door mount display unit connected to the relay. This unit relies on power supply from the relay and communicates via the I^2C bus with the relay. The FLED display all the fault conditions similar to the front panel of the relay, thermal capacity used (30% to 100%) and last fault. The FLED has three switches and is allocated as follows:

- Reset switch
- Last fault
- Test switch

The reset switch is similar to the reset switch on the front panel. The last fault switch, when pressed, will replace the current fault indication with the last fault display. When the motor is static and no real current is flowing, the test switch will simulate a phase current injection of 600%. The relay will respond as if it is a true over current condition and calculate thermal capacity usage. An overload trip will result if all the thermal capacity is used.

7.2 IrDA interface (Part number: IRDA-KD)

This an infra red link that can be used in an intrinsic safe environment where isolation is required between the relay and external devices like remote display units (RDU), man-machine interface units (MMI), laptops etc.

7.3 Remote Display Unit (RDU) (Part number: KD-RDU-420)

It is a display unit with a 4 x 20 character LCD display and a simplified keyboard. The RDU can perform about 80% of the setup and display functions of the front-end software.

7.4 Man Machine Interface (MMI) (Part number: KD-MMI-420-EP)

It is similar to the RDU. The unit is packed into a plastic toolbox with it's own battery power supply. The unit is designed for mobility and to be functional in intrinsic safe environments.

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