Megger®

DC High Current Circuit Breaker Tester

BALTO Modular 4,000A to 40,000A

BALTO Compact 4,000A

User Guide

This manual supersedes all previous issues of this manual. Please ensure that you are using the most recent issue of this document. Destroy any copies that are of an older issue.

Declaration of Conformity

Hereby, Megger Instruments Limited declares that radio equipment manufactured by Megger Instruments Limited described in this user guide is in compliance with Directive 2014/53/EU. Other equipment manufactured by Megger Instruments Limited described in this user guide is in compliance with Directives 2014/30/EU and 2014/35/EU where they apply.

The full text of Megger Instruments EU declarations of conformity are available at the following internet address:

megger.com/company/about-us/eu-dofc

Contents

1. Introduction

This instruction manual contains information regarding the correct use and handling of the BALTO in full safety and should be considered an essential component of the BALTO System.

The BALTO family consists of 2 models :

- The BALTO Modular with a capacity of 20,000 A expandable up to 40,000 A in a Master-Slave configuration
- The BALTO Compact 4000 with a fixed capacity of 4,000 A

Unless the specific product name is mentioned, the description in this manual applies to both models.

This handbook must be at hand when using the System.

Please ensure to consult the chapter 'Safety Regulations'. This chapter contains information regarding your personal safety when using the system.

Read the ensuing safety regulations attentively before using this device.

This document is not contractual and the information that it contains corresponds to the technological status at the time of its compilation.

Megger reserves all rights of modification or improvement of the product, which is described in this document resulting from new product requirements.

The responsibility to inform oneself of the conditions and the requirements of the product rests solely with the customer, regardless of the circumstances.

1.1 Product description

Railway operators involved in the service and maintenance of the railway network are challenged with testing DC high speed circuit breakers and in particular when it comes to the control and the adjustment of the threshold circuit breaker trip current, known as lds, and when comparing results to the circuit breaker OEM specification.

The solution is the Megger BALTO. Designed with the user in mind this innovative mobile Megger BALTO system is useable for up to 40,000 A which meets the challenges of the manufacturers and users of DC high speed circuit breakers.

The Megger BALTO DC High Current Circuit Breaker Tester was developed to generate very high and precise DC test currents in order to carry out functional tests on DC high speed circuit breakers. These very high currents are injected in the main circuit of DC high speed circuit breaker and allow control of the entire circuit including the measurement elements, current converters and protection relays..

1.2 Features

To meet the needs of the market, Megger provides the innovative Megger BALTO system based on the requirements of the DC high speed circuit breakers' manufacturers and from various railway networks managers and users.

Each Megger BALTO system consists of ...

- An operator terminal
- Current Generator(s), sometime called power unit(s). One unit can generate a maximum current of 4,000 A
- Batteries, ultra-cap(s) and battery charger(s).
- Cable Set(s) – Connection(s) to the test piece

Both models are modular in design and are easily transportable. The system is easy to setup and straightforward to connect to the device under test.

User safety is paramount and the Megger BALTO provides the automated monitoring of the system and temperature guarding of the ultra-caps.

The Megger BALTO provides :

- A Quick test to determine the approximate Circuit Breaker Trip Current - Ids.

- An Automatic test with current increase slope according to IEC 61992-2 (Traction Power Substations) and IEC 60077-2 (Rolling Stock) for accurate testing of Ids

- Measurement of the DC high speed circuit breaker's opening time

- Testing of the DC protection

- Voltage drop measurement according to the DC high speed circuit breakers manufacturer's procedure

- Calibration of the external devices

- Automatic recognition of the Current Generator(s)

- Auto diagnostic – Control and calibration of current measurement per Current Generator

- Flexible current increase management

- Graphical display of measurement results

1.3   Applications

The Megger BALTO System was developed for specific applications in the railway field, namely:
- Tests of DC high speed circuit breakers for substations and their protections
- Tests of DC high speed circuit breakers in locomotives, train sets, subways, undergrounds and tramways
- Tests of electromagnetic contactors (control and main) in tramways and trolley buses

The Megger BALTO system can also be used for other applications where very high currents are required e.g. mining, steel factories, marine and solar.

1.4   Company web site

Occasionally an information bulletin may be issued via the Megger web site. This may concern new accessories, new usage instructions or a software update. Please occasionally check on the Megger web site for anything applicable to your Megger instruments.

www.megger.com

2. Safety Warnings and Standards

These safety warnings must be read and understood before the instrument is used. Retain for future reference.
When designing the BALTO System, special attention was given to safety, health and environment.
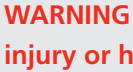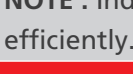
2.1 Fundamental rule

The BALTO System is designed to international safety standards and meets national safety legislation where it applies.
Nevertheless, those responsible for the operation of this equipment must understand hazards that can arise and
ensure that safe working procedures are in place to protect operators and other personnel.
If this equipment is operated in a manner not specified by the manufacturer, the protection provided by the
equipment may be impaired.

2.2 Warnings, Cautions and Notes

This user guide follows the internationally recognised definition. These instructions must be adhered to at all times.

Description
DANGER : Indicates a dangerous situation which, if ignored, could lead to death, serious injury or health problems.
WARNING : Indicates a potentially dangerous situation which, if ignored, could lead to death, serious injury or health problems.
ATTENTION : Indicates a dangerous situation which, if ignored, could lead to injuries or health problems.
CAUTION : Indicates a situation which could lead to damage of the equipment or environment
NOTE : Indicates important instructions to be followed to perform the relevant process safely and efficiently.

Icon	Description
	EN ISO 7010 P007 Interference to the operation of or damage to active implanted cardiac devices from this equipment which generates strong electromagnetic fields. No access for people with active implanted cardiac devices.
	EN ISO 7010 W006 Strong magnetic field present
	EN ISO 7010 W001 Consult the user instructions. Caution is necessary when operating the device or control close to where this symbol is placed, or to indicate that an operation needs operator awareness and protective action in order to avoid hazardous situations.
	High voltage Risk of electric shock
	Pinch-point DO NOT hold the Controller cover by the edges: fingers will be pinched in the gap.
	Earth/Ground

2.3 Staff Obligations

Legal regulations concerning industrial safety – either within the company or imposed by status laws - must be obeyed.

Controls are subject to these provisions which may vary for each country of the European Community (for example: Belgian Regulation ARAB and CODEX).

It is necessary to ensure that those who operate the BALTO System are suitably trained and qualified.

Those using the BALTO System must have received instruction relating to operation, connections and handling of the BALTO System.

Moreover, these people must be informed about the dangers and risks relating to the system and be provided with written safe working procedures and protective means as necessary.

2.4 User manual

Make sure each person using the BALTO System has read and understood this instruction manual.

CAUTION : The complete manual must be to hand when operating the equipment. Working with an incomplete copy could lead to serious damage and injury.

2.5 EMC

This device complies with the emission requirements for IEC 61326-1 and Part 15 of the FCC Rules for a Class B device: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

The emission limits are designed to provide reasonable protection against harmful interference in an industrial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, is likely to cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

In particular, when testing high current DC circuit breakers, electromagnetic interference which may disturb the operation of nearby equipment is radiated. Before use, make sure that sensitive equipment that may be affected is switched off or located at least 30 m from the test setup. Medical implants may be affected by high energy pulses; this equipment must not be operated by or near people with active implanted cardiac devices.

2.6 Installation - Maintenance - Handling

Make sure that the device will be handled, assembled, maintained and moved by personnel that are suitably trained and qualified.

To guarantee operational safety, use only genuine spare parts provided by the manufacturer.

- Before assembly of the various components, it is mandatory to read the warnings concerning the equipment carefully. The warnings must be obeyed.
- The output terminals of the DC Current Generators, the cables and the connection points on the test object may get hot during Current Injections.
- To prevent the Support Carriage from moving abruptly during system assembly, it is necessary to put the Support Carriage in working position by locking the wheels (applicable to BALTO Modular only).
- Carefully follow the instructions concerning the assembly of the device, in particular the steps regarding the DC Current Generators and Power Connections.
- Always use the handle provided to close the Compact Controller cover for transport and to open it for operation. DO NOT hold the Controller cover by the edges: fingers will be pinched in the gap.

■ Do not use the Compact Controller cover handle to lift the controller: use the carrying handles on each side: two-person lift.

2.7 Unauthorised use

Neglecting or overriding any safety functions by the operator or the responsible body is strictly forbidden.

2.8 Requirements for safe operation

To ensure that the BALTO System can operate safely and correctly, it is necessary to consider the following:

■ Only qualified personnel are authorized to work with the device.

■ These personnel must have read and understood this instruction manual, and be adequately trained and qualified.

■ The equipment must be checked before use.

■ If any parts are damaged, the equipment must be taken out of service for repair. It must not be used until repaired by manufacturer-qualified service personnel.

■ The equipment must be operated only within the environmental conditions specified by the manufacturer.

■ The device must be transported safely.

■ Suitable storage, within the environment specified by the manufacturer, must be provided..

WARNING : The voltages and currents generated by the BALTO System can cause serious injury in the event of incorrect use.

DANGER : EN ISO 7010 P007

According to Directive 2013/35/EV, the ELV (Exposure Limit Value) for static magnetic fields in controlled working conditions is 8 T (Tesla). During an injection, a magnetic field is generated by the Power Flex-cables.

The generated field is much lower than 8 T, even at 1 cm from the cables. However, one should not touch the Power Flex cables during an injection.

WARNING : Read and understand the instructions on the DC Current Generators before installing or removing them.

WARNING : Set the Emergency Stop button to STOP before handling test leads.

WARNING : If a test connection must be changed, in particular the replacement of the device under test, make sure that all the current injections are completed. Before replacing the test object it is necessary to put the Control Panel in Safety Mode before disconnecting any Power Connection.

DANGER : Do not open any mains power supply modules: there are no user serviceable parts

WARNING : The generated currents can heat the terminals of the DC Current Generators and connection points to levels that may cause burns. Make sure the connections are cool before handling and use protective equipment as necessary

WARNING : The BALTO System must be grounded by using the Ground Connection.

WARNING : Take the following matters into account:

■ Always use cables or systems that are rated by the manufacturer for the high currents generated by the equipment and rated for the environment in which the equipment is operated.

■ Never connect the BALTO System to a mains voltage or power supply that is different to the one specified on the system.

■ Never carry out repairs on the BALTO System. When opening the modules of the equipment, for operator-maintenance or configuration, dangerous voltages and high electrical energy sources are exposed.

■ When shutting down the device from Operation Mode, place the Emergency Stop isolating handle in the OFF position and follow the instructions in chapter: 'Operating - section: Exit BALTO System' in the following cases:

   ▪ The equipment is not in use,

   ▪ The equipment is not connected,

   ▪ The equipment is not being monitored,

   ▪ During storms,

   ▪ Before carrying out maintenance or cleaning.

■ To clean the BALTO System, use a damp cloth.

   ▪ Do not use liquid detergents or aerosols. Make sure the equipment is dry before use.

   ▪ Do not operate the BALTO System in wet conditions.

   ▪ Keep water and other liquids away from the equipment. If it is necessary to return the BALTO System to the factory for repair or calibration, use the original packaging or suitable protective alternative. If not, the equipment may be damaged during transport.

CAUTION : Follow the transport instructions, which are part of the delivery.

CAUTION : To avoid damage during the installation and uninstallation, put on the brakes to lock the wheels (BALTO Modular only).

DANGER : When connecting the BALTO System to the High-Speed DC Circuit Breaker and during start-up of the software, the High-Speed DC Circuit Breaker should be isolated, grounded and in the open position. In case of enclosed DC Switchgears, the draw-out part should be in 'test' or 'service' position.

2.9   Packing and Shipping.

There are specific instructions relating to the transport and unpacking of the equipment. Read these instructions before unpacking the equipment.

Check that the equipment and the options which are part of the delivery are in conformity with your order.

Despite the robust construction of the equipment, it is desirable to protect the BALTO System against vibrations and violent shocks.

It is highly recommended that the original packaging is retained to use for any later transport of the equipment.

3. Principles of operation

3.1 General characteristics

The innovative BALTO System is designed and built to carry out examinations when maintaining, repairing and adjusting trip levels on High-speed DC Circuit Breakers in Traction DC Power Systems and Rolling Stock.

This system meets the requirements for the use in an industrial environment.

The BALTO system is designed to not rely on an industrial three-phase power supply for the source of energy. Instead, a standard single-phase mains supply suffices.

The BALTO system is designed to reach currents up to 4,000 A (BALTO Compact 4000) or 20,000 A (BALTO Modular), using DC Current Generator modules of 4,000 A. To reach 40,000 A, a second BALTO Modular system can be connected in a Master/Slave configuration.

Current injections can be performed using a current increase of 200 A/s, in accordance with IEC railway standards:

- Electric equipment for Rolling Stock: IEC 60077-1/60077-2
- Fixed installations - DC switchgear: IEC 61992-1/61992-2

The System has a number of predefined standard functions and can realise a wide array of current injections.

 NOTE : The assembly of the BALTO System is easy and fast, moreover the deployment is logically intuitive. The installation and connections must be realised as described in this manual in order to generate optimal output as prescribed in the technical specifications.

The BALTO system is available for use with a mains power supply of 230 VAC / 50 Hz or 120 VAC / 60 Hz.

The BALTO System has built-in protection mechanisms, such as :

- Monitoring system of ADC III Benning rectifier.
- Monitoring of ultracap Maxwell Technologies or equivalent.
- Monitoring of battery voltage and charging current.

Standard measured results are accurate to 1.5%. Better accuracies are available upon request.

Moreover, this version perfectly meets the needs of tramway networks, Traction DC Power Systems and Rolling Stock.

3.2 General diagram
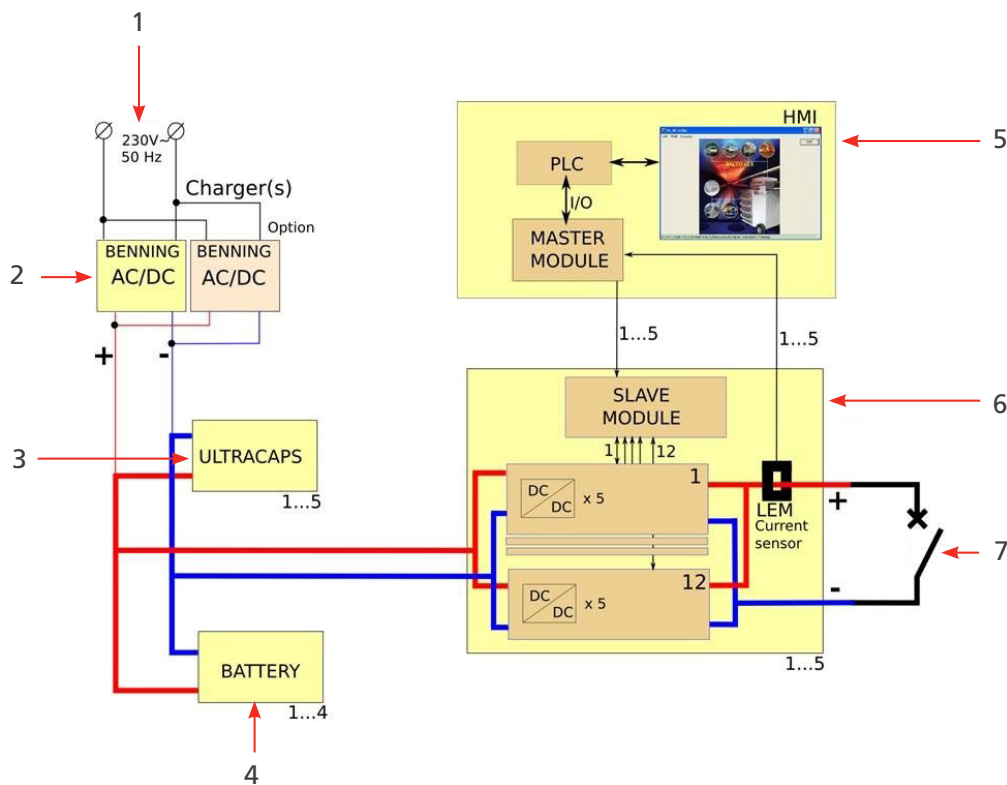
Fig 1: *General diagram of the BALTO System.*

Item	Description	Item	Description
1	Mains Supply: 230 VAC / 50 Hz or 120 VAC / 60 Hz	5	Control Unit
2	Battery charger(s)	6	DC Current Generator(s) of 4,000 A each
3	Ultracapacitor(s) as buffer for the batteries -	7	Device under test - High-speed DC Circuit Breaker
4	Batteries		

When fully charged, the voltage over the batteries will be approximately 15.6 VDC. When performing an injection, the output voltage of the Current Generator(s) will not exceed 4.7 VDC.

3.3 Testing modes

Current Injections can be generated in different modes, such as:

- Quicktest Mode : high slope during injection
- Auto Mode : slope of 200 A/s
- Manual Mode
  - Protection relay mode : steep slope (higher than short circuit slope)
  - Shunt mode : fixed current during maximum 60 seconds.

4. BALTO Modular hardware

The BALTO Modular System consists of:

- Support Carriage, including:
  - Compartment containing the Battery Charger(s).
  - Compartment containing the ultracap(s) Maxwell Technologies or equivalent
  - Compartment containing the Enersys Cyclon batteries.
  - Connectors for up to five DC Current Generators.
  - Power supply and fuses.
  - Work surface cover.
- DC Current Generator(s) of 4,000 A - combined up to 20,000 A and in Master/Slave configuration up to 40,000 A.
- Control Unit including MMI (Man Machine Interface)
- Connections for the device under test: Set of Power Flex-cables for each DC Current Generator.
- Set of measurement cables for measuring voltage drop.

The equipment is designed for horizontal mobility, and special attention was given to providing mobility for moving between cells in Traction DC Power Systems.

The Support Carriage provides a transport mode and a fixed-in-place working position mode.

Fig 2: *BALTO Modular System 20,000 A*

The DC Current Generators and Control Unit are plug-ins and can be separated from the device. The Support Carriage itself cannot be dismantled for transport purposes.

The contents and total weight of the Support Carriage depends on the system power configuration.

4.1   Support Carriage

The Support Carriage is the mobile part to facilitate the handling of the device on-site.

This carriage includes the energy supply, connectors for the DC Current Generators, a Control Unit platform and a work surface.

The energy supply consists of:

- Battery Chargers (1)
- Ultracapacitors (2)
- Batteries (3)

Fig 3: *Support Carriage: Compartment overview.*

Item	Description	
1	Compartment for the Battery Chargers. This compartment contains one or two Benning ADC III rectifiers. The rectifier is based on switch mode technology. The number of installed battery chargers depends on the system's maximum configuration:	

Maximum Configuration	Chargers
8,000 A	1
12,000 A	2
20,000 A	2

2	Compartment for the Ultracapacitors
	The energy storage modules - used as a buffer for the Batteries - are of type 16 V and consist of 6 cells of 3,000 F placed in series.
	The compartment can hold up to 5 modules of 16 V connected in parallel.
	The number of installed modules depends on the system's maximum configuration:

Maximum Configuration	Modules
8,000 A	3
12,000 A	4
20,000 A	5

3	Compartment for the Batteries.
	This compartment contains the Batteries, placed in rows of 7 cells connected in series, cells being 2 V 25.0 Ah each.
	Type: Enersys Cyclon 0820-0004.
	The compartment can hold up to 4 rows connected in parallel.
	The number of installed rows depends on the system's maximum configuration:

Maximum Configuration	Battery Rows
8,000 A	2
12,000 A	3
20,000 A	4

The standard Support Carriage configurations are typically sufficient for normal testing conditions.

For increased testing capabilities, it is possible to use a Support Carriage with an increased energy compartment. For example, an 8,000 A system can benefit from using a Support Carriage designed to support up to 20,000 A as it contains a larger energy supply.

4.2   Emergency Stop Device

The Emergency Stop Device physically breaks the circuit and disconnects the DC Current Generators from the energy supply.

- The Emergency Stop Device is located inside the Support Carriage and the operating lever is mounted on top.
  Operate only using the lever.
  Switch off and on is performed manually.

- When the lever is switched to the ON position 'CONNECT', the energy supply is connected and the system can be used normally.
  To disconnect the energy supply, switch the lever to 'DISCONNECT'.

Fig 4: *Support Carriage: Emergency Stop Device.*

CAUTION : Use the Emergency Stop Device only in case of an emergency. Excessive operation may cause wear and damage to the contacts.

CAUTION : Before switching the lever back on, please consult the chapter 'Troubleshooting' - section 'Emergency Stop Device'.

4.3   Supply, Fuses and Charge Connector
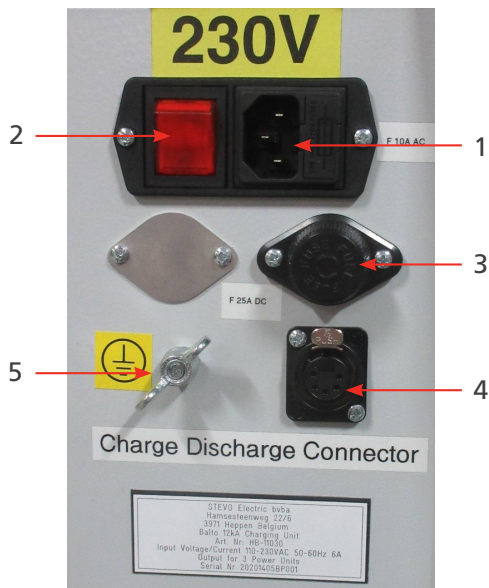
Fig 5: *Support Carriage: Compartment overview.*

Item	Description	Item	Description
1	Mains supply: 230 VAC / 50 Hz or 120 VAC / 60 Hz. Fuse: 10 A AC	4.	Charge connector (XLR) for charging the DC Current Generators
2	Mains switch	5	Ground connection
3	Battery charger fuses: 25 A DC, one per charger.		

NOTE : When the test object is not in an isolated position, ground both the test object and the BALTO Modular System in accordance with the Traction DC Power System grounding.

4.4   Power Connections

The number of included Power Flex-cables depends on the number of DC Current Generators:

Power Range	Power Flex-cables
4,000 A	2
8,000 A	4
12,000 A	6
16,000 A	8
20,000 A	10

Two Power Flex-cables of 2 m - Ø 240 mm² are used per DC Current Generator.

By default, these Power Flex-cables are fitted with cable lugs on one end, and Power Junction Connectors on the other.

4.5   Sockets for the DC Current Generators

Up to five DC Current Generators can be connected to the Support Carriage.
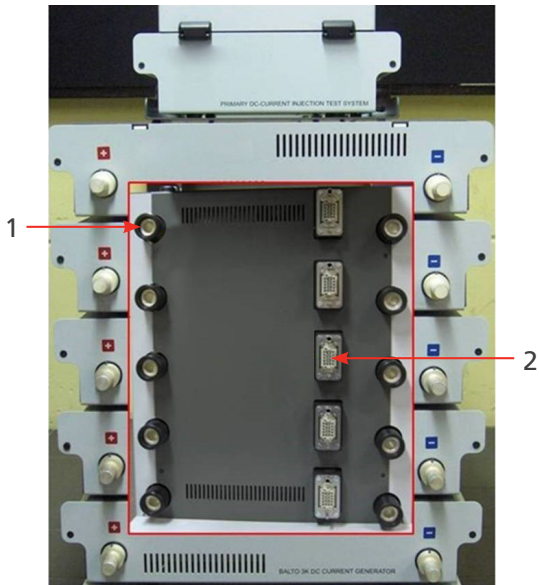
Fig 6: *Overview - Support Carriage connectors.*

Item	Description
1	Power Connectors for connecting the DC Current Generators to the energy supply.
2	System Connectors for connecting the DC Current Generators to the control system.

The Support Carriage is equipped with wheels for mobility:

- Two rotating wheels, with brakes for in-place locking.
- Two wheels with inflated tyres.

4.6   The Control Unit (Incl. Protection Test Module)

The Control Unit sits on top of the BALTO Modular and consists of :

- A touch screen Interface to operate the BALTO
- An emergency stop, various buttons and connectors (see chapter "Control Panel")
- On the back, the necessary I/O's to perform secondary Injection
- Three connectors to connect to the support carriage.

The Control Unit has the following connectors:
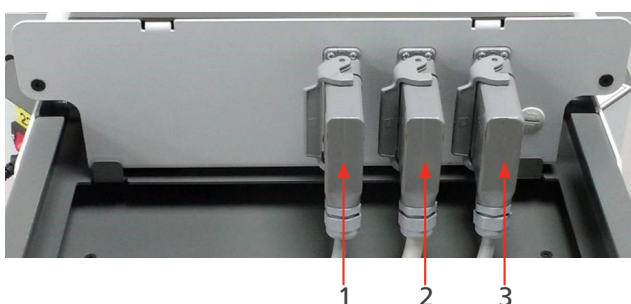
Fig 7: *Control Unit: Connectors*

Item	Description	
1	Supply Connector	Provides the Control Unit with mains power.
		Carries Support Carriage monitoring signals.
		Provides protective earth connection.
2	Signal Connector	Carries DC Current Generator control signals.
		Carries DC Current Generator current measurement signals.
3	Power Connector	Detects connected DC Current Generators.
		Powers the DC Current Generator electronics.
		Provides protective earth connection.

The interface for testing DC Protective Relays is positioned at the rear of the Control Panel. The 'Trip input 1' is also used for measuring High-speed DC Circuit Breaker reaction times.

Fig 8: *Control Unit: Interface DC Protection Relay.*

Item	Description	
1	Output mA	used for secondary injection.
2	Output mV	used for secondary injection.
3	Trip Input 1	input for potential-free trip signals.
4	Trip Input 2	input for potential-free trip signals.

4.7 Work surface cover

A work surface cover is provided to create a working surface for administrative purposes.

Fig 9: *Work surface cover.*

5. BALTO Compact 4000 Hardware

The BALTO Compact System consists of:

- Main Unit containing :
  - Control Panel
  - Battery Charger.
  - Ultracapacitor Maxwell Technologies or equivalent.
  - Enersys Cyclon batteries.
- DC Current Generator of 4,000 A.
- Set of Power Flex-cables for connecting the DC Current Generator to the device under test.
- Set of measurement cables for measuring voltage drop.

Fig 10: *BALTO Compact System 4000 A*

5.1 Main Unit.

The main unit contains:

- Energy compartment and utilities.
- Command and Service Board with integrated Control Unit.
- Protection Relay module for testing DC Protective Relays and measurements regarding reaction times of High-speed DC Circuit Breakers.
- Connection socket for the DC Current Generator.
- Emergency Stop Device.

Fig 11: *BALTO Compact System: Main Unit.*

The energy supply consists of:

1. Battery Chargers.
2. Ultracapacitors.
3. Batteries.
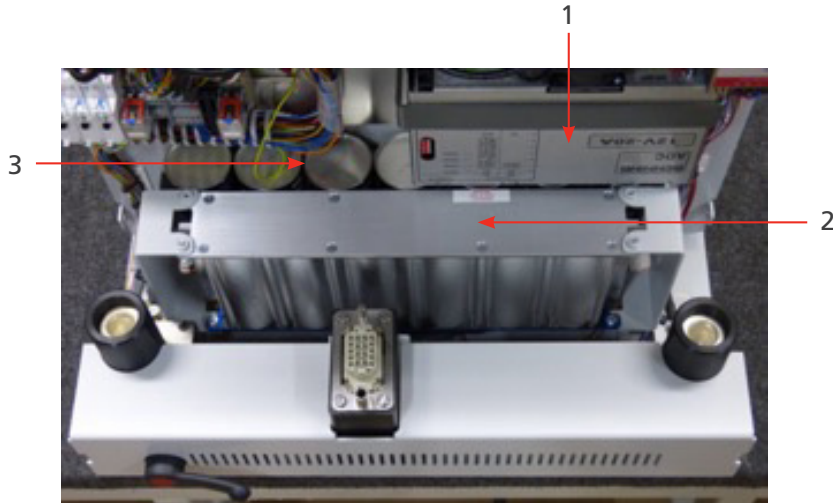
Fig 12: *Main Unit: Utilities*

Item	Description	
1	Compartment for the Battery Charger.	
	This compartment contains one Benning ADC III rectifier.	
	The rectifier is based on switch mode technology.	
2	Compartment for the Ultracapacitor.	
	The energy storage module - used as a buffer for the Batteries - is of type 16 V and consists of 6 cells of 3,000 F placed in series.	
	The compartment contains one module of 16 V.	
3	Compartment for the Batteries.	
	This compartment contains the Batteries, placed in a row of 7 cells connected in series, cells being 2 V 25.0 Ah each.	
	Type: Enersys Cyclon 0820-0004.	
	The compartment holds one row	

5.2 DC Current Generator Connection Panel.

The connection panel connects the DC Current Generator to the Main Unit.
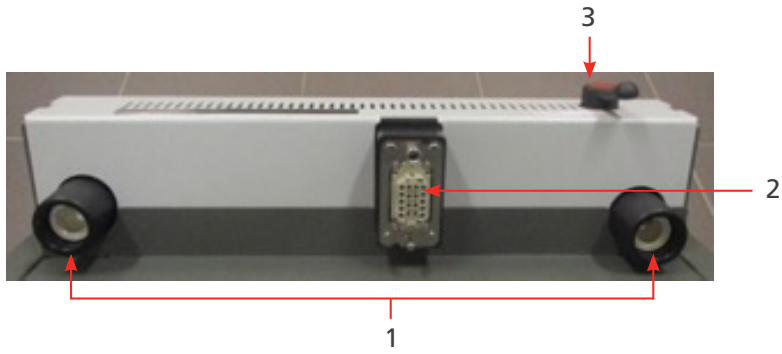
Fig 13: *Main Unit - Connection Panel.*

Item	Description	
1	Power Connectors for connecting the DC Current Generator to the energy supply.	
2	System Connector for connecting the DC Current Generator to the control system.	
3	Emergency Stop Device physically breaks the circuit and disconnects the DC Current Generator from the energy supply	

5.3   Emergency Stop Device

The Emergency Stop Device physically breaks the circuit and disconnects the DC Current Generators from the energy supply.

- The Emergency Stop Device is located inside the Main Unit and the operating lever is mounted on the Connection Panel. Operate only using the lever. Switch off and on is performed manually.

- When the lever is switched to the ON position 'CONNECT', the energy supply is connected and the system can be used normally.
  To disconnect the energy supply, switch the lever to 'DISCONNECT'.

Fig 14: *Emergency Stop Device.*

CAUTION : Use the Emergency Stop Device only in case of an emergency. Excessive operation may cause wear and damage to the contacts

5.4   Supply, Fuses and Charge Connector

Fig 15: *Supply, fuses and charge connector*

Item	Description	Item	Description
1	Mains supply: 230 VAC / 50 Hz or 120 VAC / 60 Hz. Fuse: 10 A AC	4.	Charge connector (XLR) for charging the DC Current Generators
2	Mains switch	5	Ground connection
3	Battery charger fuse: 25 A DC, one per charger.		

NOTE : NOTE : When the test object is not in an isolated position, ground both the test object and the BALTO Compact 4000 System in accordance with the Traction DC Power System grounding.

5.5 Protection Test Module

The interface for testing DC Protective Relays is located on the Main Unit. The 'Trip input 1' is also used for measuring High-speed DC Circuit Breaker reaction times.

Fig 16: *DC Protection Relay Interface*

For further information regarding Protective Relay secondary injections, consult the 'chapter on secondary injection.

Item	Description	
1	Output mA	used for secondary injection.
2	Output mV	used for secondary injection.
3	Trip Input 1	input for potential-free trip signals.
4	Trip Input 2	input for potential-free trip signals.

6. Control Panel

Fig 17: *Control Panel of the BALTO Modular.*

Fig 18: *Control Panel of the BALTO Compact 4000*

Item	Description	Item	Description
1	Display.	5	External measurement inputs.
2	Start button.	6	USB Interface.
3	System ready indicator.	7	RJ45 Ethernet Interface.
4	Emergency Stop Button.	8	Buzzer.

These components are described in further detail below.

6.1 Display with embedded PC

The control panel display is designed for industrial applications and consists of a 5.7" TFT touch-screen display.

The display provides optimal performance for operating the BALTO system. The display is connected to an embedded PC which runs the BALTO software, handles the I/O's, stores the BALTO reports, etc. Important remarks on the embedded PC :

■ The battery must be replaced every five years. A badly inserted battery, or inserted with incorrect polarity, can explode and can cause damage. Only use original batteries: CR2032 (lithium) from Sanyo or Panasonic. The battery is not rechargeable.

■ Never abruptly remove the CF (Compact Flash) modules. Software data could be destroyed, lost or damaged. Megger cannot be held responsible for damage caused in this manner. It is not covered by warranty.

For more information and precautionary measures regarding battery replacement, consult the appropriate user manual available from the Beckhoff website: www.beckhoff.de

Fig 19: *Control Panel: Touch Screen Display - HMI*

Specific responsibilities

Environmental conditions

- Extreme environmental conditions should be avoided at all costs.
- The necessary precautions should be taken against dust, moisture and heat building up in the device.
- Particularly, prevent rapid environment fluctuations - variations in temperature or humidity - as moisture can condense on or in the device leading to risk of short-circuiting.
- When placing the device outdoors in humid conditions, do not connect any voltage to the BALTO System. The system should be given time to adapt to the ambient temperature first.
- Do not place the device in close proximity to heating sources.
- Always let the device adapt to the ambient temperature before utilisation when placing the device outdoors.
- A waiting period of about 12 hours is required.

No dismantling

- The control panel display should not be dismantled by the user.
- There are no serviceable parts inside.

Switching the Control Panel on and off

- The Control Panel does not have its own switch.
- Switching the Control Panel on and off is carried out automatically.
- Do not disconnect any connection when the device is powered, software data could be lost or damaged.

Operation

The Control Panel may only be operated by qualified and authorised personnel. Furthermore, all personnel must be familiar with the Windows operating system and the application software.

The handling of the touch screen may only be done with a clean finger or touch screen stylus.

If gloves are worn, ensure that they do not contain any sharp particles such as metal shavings or glass shards.

__Functionality:__

The Control Panel provides:

- Display of the various dialogs.
- Control of the various testing modes, and providing access to measurement storage.
- Operational control and calibration.
- Notifications and interaction.

6.2   External measurements

Connection terminals for measuring voltage (up to 10 V) are provided. The terminals are primarily used for 'Measurement of the voltage drop' (mV / µΩ test).

Fig 20: *Connection terminals*

The external measurement terminals are also used during system calibration. Consult chapter Calibration on page 122
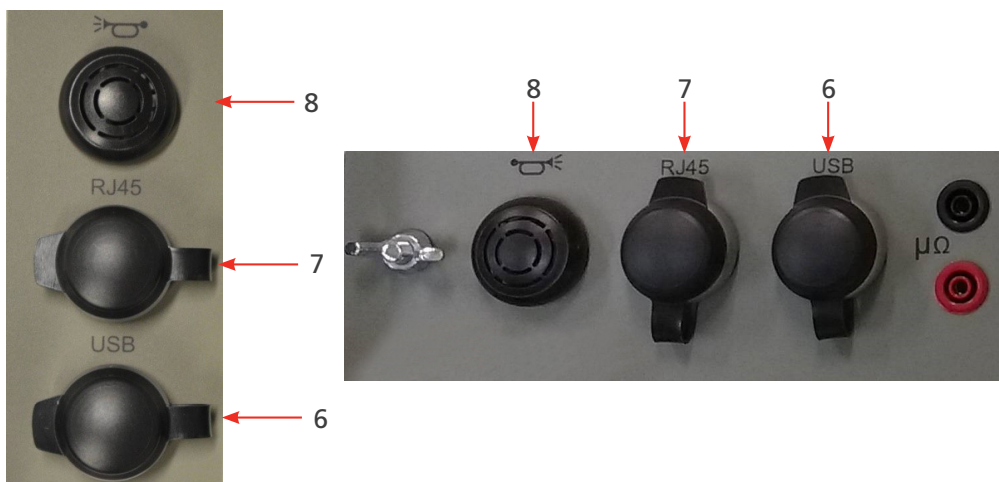
6.3   Communication interfaces

Fig 21: *Connection interfaces*

8. Buzzer

Passes auditory alerts through the Control Unit casing.

7. Ethernet Interface

Provides communication and operation to a PC or laptop running the BALTOWin software.

Connecting the system's ethernet interface in other ways (e.g. to a network) is not advised.

- Ethernet interface according to EIA/TIA-568 and TSB-36.
- Shielded twisted-pair cable.
- Maximum length: 100 m.

6. USB Interface

- Provides storing measurement results to a USB stick.
  The data can be processed by BALTOWin.
- Supports the connection of a keyboard.
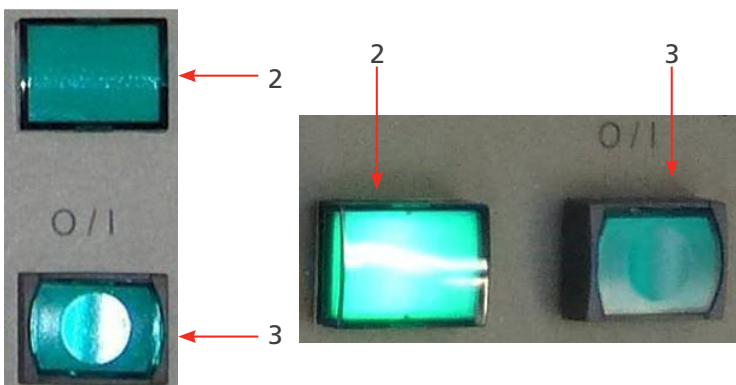
6.4   Start button - System ready indicator

Fig 22: *Start button - System ready indicator*

3. Start button :

When the BALTO System is ready to be started, the button will illuminate. Press the button to initiate system start-up.

During operation, the button is deactivated. The button will re-activate after completing a system shut-down.

2. System ready indicator :

The 'System ready' indicator is illuminated after a successful system start-up. This means the Control Unit and PLC are operational and the BALTO system is ready for use.

6.5   Emergency Stop

In case of an emergency, press the Emergency Stop Button.

Fig 23: *Emergency Stop*

Activating the Emergency Stop Button will immediately halt any ongoing Current Injection and prevents further Current Injections in hardware.

7.   DC Current Generator

The DC Current Generator (also called Power Unit) contains 60 DC/DC current converters, each providing up to 67 A of current, assembled in parallel.

The unit is controlled using pulse-width modulation (PWM).

Each unit contains its own current measuring device.

Two Power Flex-cables of 2 m - Ø 240 mm² are used for connecting the DC Current Generator to the device under test.

By default, these Power Flex-cables are fitted with cable lugs on one end, and Power Junction Connectors on the other.

The DC Current Generator 4,000 A consist of:

- On the front panel:

Power connectors '+' and '−' for connecting the test object to the system using the Power Flex-cables.

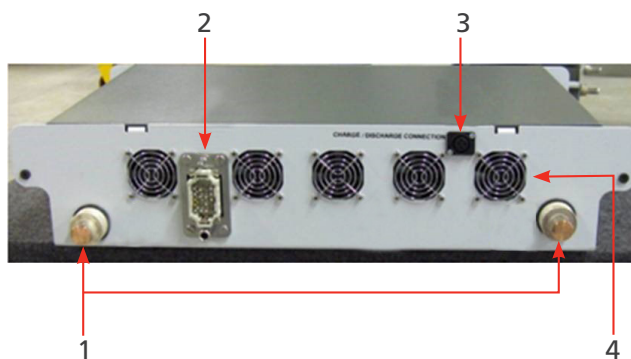**Fig 24:** *DC Current Generator: Front panel*

- On the rear panel:

Fig 25: *DC Current Generator: Rear panel.*

Item	Description
1	Power Junction Connectors for energy supply from the energy compartment
2	System Connector for management and control signals.
3	Charge Connector (XLR) for connecting the charge/discharge tool.
4	Cooling fans.

8. Installation

This chapter describes the proper assembly of the BALTO System and making it operational for testing.

8.1 Safety Warnings

- Before assembly of the various components, it is mandatory to read the warnings concerning the equipment carefully. The warnings must be obeyed.
- The output terminals of the DC Current Generators, the cables and the connection points on the test object may get hot during Current Injections.
- To prevent the Support Carriage from moving abruptly during system assembly, it is necessary to put the Support Carriage in working position by locking the wheels (BALTO Modular only).
- Carefully follow the instructions concerning the assembly of the device, in particular the steps regarding the DC Current Generators and Power Connections.

8.2 Preparation : charge the BALTO beforehand

The Batteries of the Energy Supply should always be charged before performing tests with the BALTO System.

WARNING : During the charging of the BALTO System, gases are produced and diffused by the batteries. For this reason, the BALTO Systems battery must be charged in a sufficiently ventilated room.

NOTE : The BALTO System must be charged - connected to mains power - at least 48 hours a week, even if the system is not in active use.

Prolonged periods in which a battery cell's voltage is below 2 V may cause irreversible chemical damage.

NOTE : Chemical damage occurring in batteries left without charge for prolonged periods is irreversible and cannot be undone by recharging.

Damaged or end-of-life batteries must be disposed of according to local waste disposal regulations.

Do not ship damaged batteries.

8.3 Charging the current generators

Before connecting the DC Current Generator(s) to the Support Carriage (BALTO Modular) or the Connection Panel (BALTO Compact), the DC Current Generator(s) voltage must be charged to match the voltage of the energy compartment.

Fig 26: *Charge/discharge tool.*

The charge/discharge tool, included as a system accessory, shall be used for charging the DC Current Generators.

The module must be connected to the XLR 5-pin connector on one side and to the XLR 3-pin connector of the DC Current Generator. The XLR-5 connector can be found on the support carriage of the BALTO Modular or on the main unit of the BALTO Compact 4000.

To charge the DC Current Generator, press the black button. Pressing the red button will discharge the DC Current Generator.

Fig 27: *Charging a DC Current Generator.*

The LED lights will illuminate representing the DC Current Generator charge. The green LED being illuminated means it is safe to connect the DC Current Generator.

 CAUTION : Checking the DC Current Generator charge must be performed every time before connecting the Current Generator to the energy compartment.
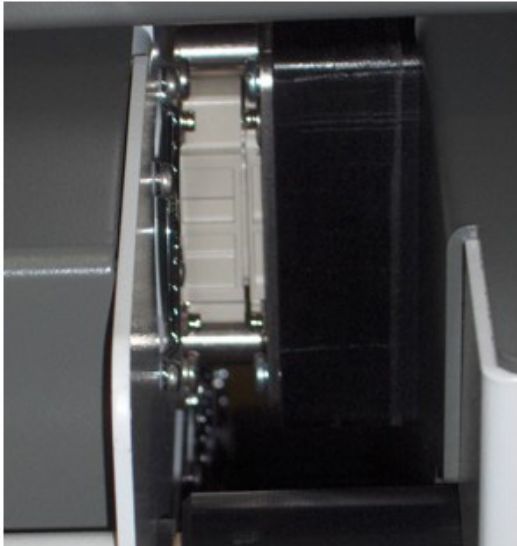
Ensure that all connectors are properly plugged in.

Fig 28: *Plugged in DC Current Generator.*

NOTE : It is important to discharge each Current Generator before transport. First disconnect the Current Generator completely. Connect the charge/discharge tool as described above and press the red button (Discharge). In this way, short circuiting the Current Generator's power junction connectors will not cause any damage.

8.4   How to use the Power Flex-cables.

To ensure that spurious currents cannot be generated whilst handling the test circuit, ensure that the Emergency Stop button is pressed down in the STOP position before connecting or disconnecting test leads.

Each DC Current Generator is provided with two Power Flex-cables (Ø 240 mm², length 2 m) to connect to the High-speed DC Circuit Breaker. The Power Flex-cables are equipped with Power Junction Bayonet Connectors and cable lugs.

Exercise care when connecting the DC Current Generators to the High-speed DC Circuit Breaker.

Fig 29: *Power cables wiring.*

CAUTION : Before connecting the Power Junction Connectors to the DC Current Generators, please ensure that the contact bands - both front and rear - are intact and positioned properly within the connector. The contact bands are important for providing good contact and the least possible impedance.
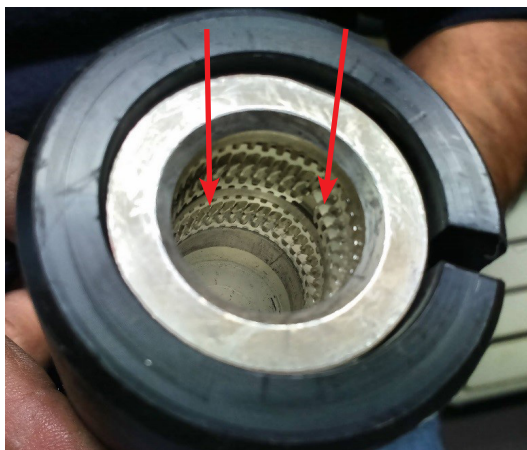
Fig 30: *Power cable: Power Junction Bayonet Connector.*

The Power Junction Bayonet Connectors must be plugged in smoothly. It is recommended to hold the Power Flex-cable just below the connector, and to align it with the Power Junction Connector on the DC Current Generator. Then, push in the cable with a short forward motion.

Avoid holding the Power Flex-cable by the connector, as it may hinder making the connection. Rough handling of the connector may also damage the contact bands.

Once the connection is made, lock the bayonet connector.

Please ensure that the correct polarity is respected at both ends, as indicated on the High-speed DC Circuit Breaker and the DC Current Generator.

For easier connectivity, breaker clamps can be used for connecting the Power Flex-cables to the High-speed DC Circuit Breaker. These are available as a separate part.
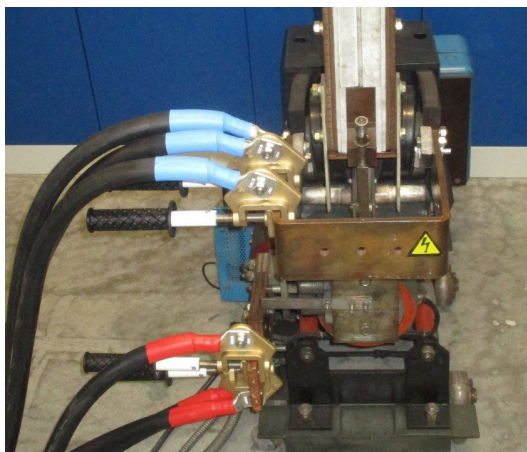

Fig 31: *Connections using breaker clamps.*

8.5 Connecting the High-speed DC Circuit Breaker.

It is imperative to follow these instructions carefully and to follow standard procedures, including performing a risk analysis, before starting.

DANGER : The High-speed DC Circuit breaker to be tested must be disconnected and switched off from the mains network.
All safety precautions applicable to the low or high voltage installations must be followed.
Ensure that, in any case, the mains high voltage network (e.g. 3,000 VDC, 1,500 VDC) is never connected to the test system

The procedures and risk mitigation, as specified by the applicable safety regulations by the company or test site, must be followed at all times.

CAUTION : The High-speed DC Circuit Breaker must be in the open position.

Furthermore, to reduce impedance, please take the following into account:

- The connection points must be clean.
- Respect the + and – polarity with regards to the High-speed DC Circuit Breaker.
- Measuring elements (e.g. shunts) that are not being tested should be excluded from the circuit.

NOTE : Connecting the High-speed DC Circuit Breaker is to be done using the Power Flex-cables.

8.6   Assembly of the BALTO Modular on site

4. Put the Support Carriage in working position by applying the brakes and hence blocking the wheels. This prevents the Support Carriage from moving abruptly during assembly.

5. The BALTO Modular System can be grounded using the grounding terminal, which is located on the Support Carriage. Use the grounding cable included as a system accessory, or a properly rated equivalent cable.

6. Put the Control Unit on top of the Support Carriage and connect the 3 connectors from the Support Carriage to the Control Unit.

7. Put the Work Surface Cover over the connectors.

8. Connect the BALTO System to mains power. Ensure that the mains voltage matches the mains voltage displayed on the Support Carriage.

9. Switch on the main switch (red) on the Support Carriage, this will charge the battery compartment. The I/O button on the Control Unit will be lit.

10. Before installing the DC Current Generators, make sure they are charged. Then insert them one by one into the Support Carriage.

11. Connect the Power Flex-cables to the Current Generators as described above.

12. Connect the Power Flex-cables to the DC High Speed Circuit Breaker. Make sure the circuit breaker is in the "Open" position.

13. Press the I/O button on the Control Unit, the BALTO Modular will start booting.

The BALTO Modular System 8,000 A / 12,000 A includes only two or three DC Current Generators slots (if no future expansion is planned or desired).

The remaining space can be used to store the Power Flex-cables and system accessories.

Fig 32: *BALTO Modular System with only two slots.*

The DC Current Generators have assigned positions on the Support Carriage. When assembling the system, please follow the ordering as indicated.

- The mechanical positions of the Power Junction Connectors are aligned specifically for the indicated ordering.

- The system calibration is performed specifically using the indicated ordering.

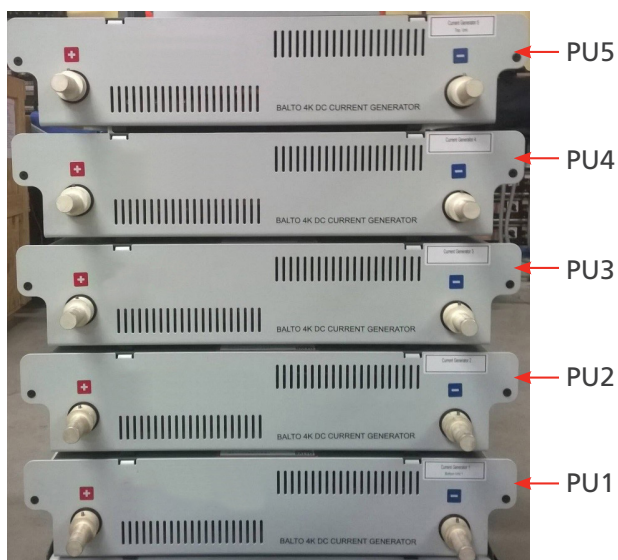The DC Current Generators are labelled 'PU1' (Power Unit 1 - bottom) to 'PU5' (Power Unit 5 - top).

Fig 33: *BALTO Modular System with PU indication.*

Configuration of a BALTO Modular System 20,000 A

SLOT	PU	SYSTEM CAPACITY	Remarks
POS. 1	PU 1	4,000 A	Position used for Auto-Verification.
POS. 2	PU 2	8,000 A	
POS. 3	PU 3	12,000 A	
POS. 4	PU 4	16,000 A	
POS. 5	PU 5	20,000 A	

Configuration of a BALTO Modular System 12,000 A

SLOT	PU	SYSTEM CAPACITY	Remarks
POS. 1			Not used
POS. 2			Not used
POS. 3	PU 1	4,000 A	Position used for Auto-Verification.
POS. 4	PU 2	8,000 A	
POS. 5	PU 3	12,000 A	

Configuration of a BALTO Modular System 8,000 A

SLOT	PU	SYSTEM CAPACITY	Remarks
POS. 1			Not used
POS. 2			Not used
POS. 3			Not used
POS. 4	PU 1	4,000 A	Position used for Auto-Verification.
POS. 5	PU 2	8,000 A	

8.7   Assembly of the BALTO Compact 4000 on site

1. Insert the Main Unit into the proper position of the transport unit (flat surface with wheels).

2. The BALTO Compact 4000 can be grounded using the grounding terminal, which is located on the Main Unit. Use the grounding cable included as a system accessory, or a properly rated equivalent cable.

3. Connect the BALTO Compact 4000 to the mains power. Ensure that the mains voltage matches the mains voltage displayed on the Support Carriage.

4. Switch on the main switch (red) on the Main Unit, this will charge the battery compartment. The I/O button on the Control Unit will be lit.

5. Before installing the DC Current Generator, make sure it is charged. Then insert the Current Generator in its position.

6. Connect the Power Flex-cables to the Current Generator as described above.

7. Connect the Power Flex-cables to the DC High Speed Circuit Breaker. Make sure the circuit breaker is in the "Open" position.

8. Press the I/O button on the Main Unit, the BALTO Compact 4000 will start booting.

9. Operation

The following instructions must be read carefully before performing tests using the BALTO System.

WARNING : Ensure that all safety precautions required by the company, test site or state laws are followed at all times.

WARNING : Ensure that all safety precautions described in this user manual are followed at all times
Consult chapter 2. Safety Warnings and Standards on page 3.

DANGER : In case of open DC Switchgears, the High-speed DC Circuit Breaker to be tested must be disconnected and grounded.
In case of enclosed DC Switchgears, the draw-out part should be removed from the DC Switchgear.
In both cases, the High-speed DC Circuit Breaker should be placed in 'test' or 'service' mode.

WARNING : Read and follow the instructions displayed on the DC Current Generators.

CAUTION : After testing has finished, it is advised to switch off the High-speed DC Circuit Breaker, so as to prevent any further current from flowing, which would discharge the batteries unnecessarily.

CAUTION : Safety regarding the current injection cables.
During testing, current injections can consist of extremely high currents. The resulting magnetic forces can cause the current injection cables to move, and may cause injury to personnel in close vicinity.
It is imperative to keep distance from the current injection cables during testing.

CAUTION : Faulty operation.
The use of inadequate or faulty cables or components may impact the system's indicated technical specifications. Furthermore, the use of inadequate equipment may cause considerable damage to the system.

CAUTION : Caution : Proper use of DC Current Generators on BALTO Modular
All DC Current Generators connected to the Support Carriage MUST be connected to the DC High Speed Circuit Breaker as well. Leaving one or more DC Current Generators connected to the Support Carriage without being connected to the DC High Speed Circuit Breaker may damage the properly connected DC Current Generators when performing an injection.

9.1 Test procedures.

This section includes guidelines for the proper testing of a High-speed DC Circuit Breaker.

9.1.1 To determine the release threshold.

Use the Auto Mode to accurately determine and check a known over-current release Imax/I$_{ds}$.

If the value of the over-current release Imax/I$_{ds}$ is not known, the operator can use the Quicktest Mode first. The over-current release observed during this test is automatically used as a reference in Auto Mode.

In Auto Mode, the BALTO System generates current with a fast rising slope up to a given level of the I$_{ds}$ threshold. The current increase then continues with 200 A/s, up to a level slightly above the I$_{ds}$ threshold.

Using this procedure, the requirements of the IEC standard are met.

In case of a deviation - or if an adjustment of the release threshold is necessary - adjust the High-speed DC Circuit Breaker and repeat the procedure until a stable release value - according to the allowed tolerance drawn up by the manufacturer - is obtained.

9.1.2 To determine the opening time.

To determine the opening time, the Opening Time Test under Manual Mode can be used. This test determines the mechanical response time of the High-speed DC Circuit Breaker.

The parameters of this test are adjusted automatically based on the results obtained in Auto Mode.

The value of this opening time should be reflected in the property sheet of the test object as specified by the manufacturer.

9.1.3 To determine the voltage drop.

For this measurement, use the test labelled 'mV'.

The expected value, and the conditions under which the test must be performed, should be included in the property sheet of the test object as specified by the manufacturer.

For High-speed DC Circuit Breakers on rolling stock, it is advised to additionally perform the following tests:

The manual closing/opening time test (Reaction Time Tests) and the proper functioning of the auxiliary contacts (I_Max No - NC).

9.2 Software structure.

This section describes the various application features and display modes in further detail.

9.2.1 General information.

Dialog box.

General information regarding the structure of the BALTO dialog box.
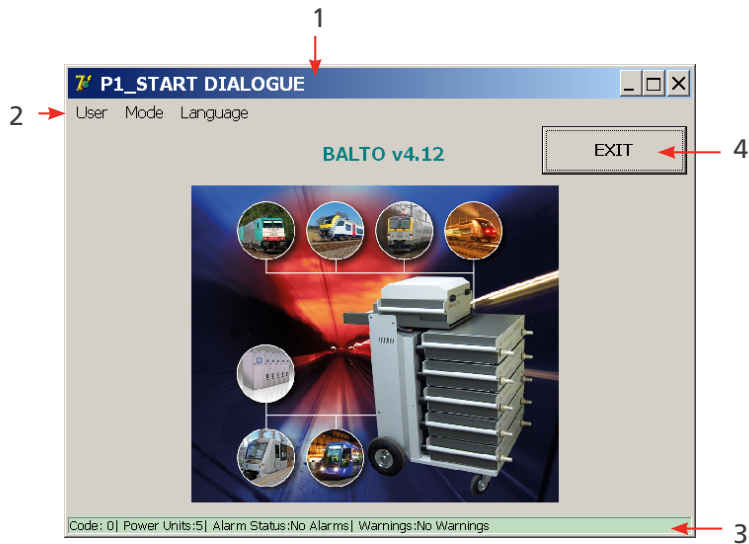
Item	Description	
1.	Main header.	Information about the dialog box being displayed.
2.	Menu bar.	Menu selection.
3.	Status bar.	
4.	Exit program.	

Exit.

For more information regarding exiting the program, Consult chapter 9.14 Exiting the BALTO application. on page 93.

For more information regarding the colour of the background, Consult chapter 9.2.2 Background. on page 37

Reference values.

NOTE : The reference values in this manual are indicative values for settings and parameters. Consult the device calibration report for the actual parameters.

Setting I_ref

The I_ref threshold can be modified in the dialog displayed by pressing 'Set I_ref'.

Example
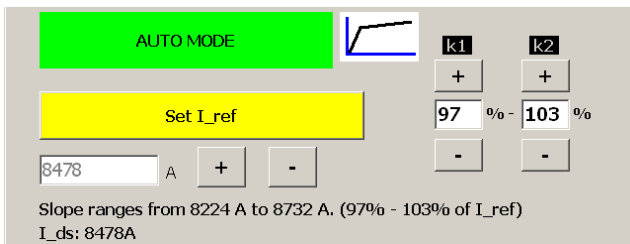
The following dialog will appear when the button 'Set I_ref' is pressed.
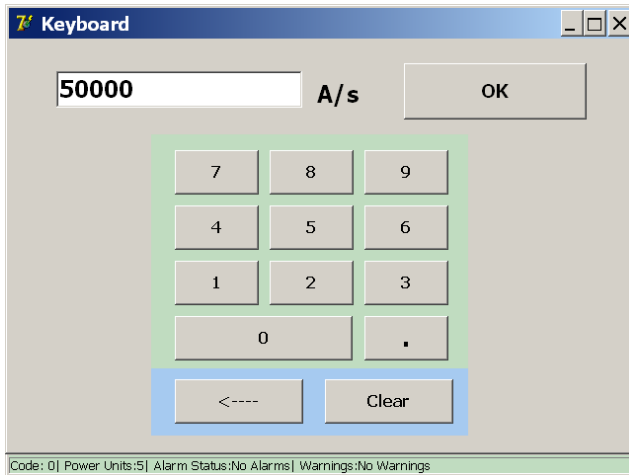
Adjusting current increase.

To adjust the duration of the 200 A/s slope, configure the K1 and K2 parameters accordingly in the 'Auto Mode' dialog.
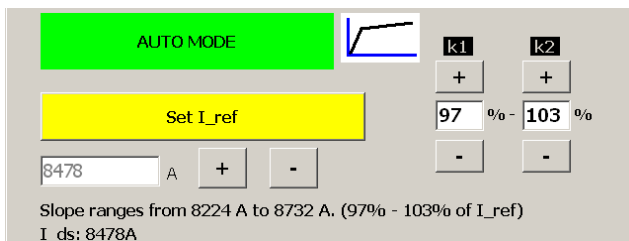
K1   Starting Point 'e' of the 200 A/s slope

K2   Ending Point 'f' of the 200 A/s slope

K1 and K2 are given as a percentage of the specified I_ref.

Curves display.
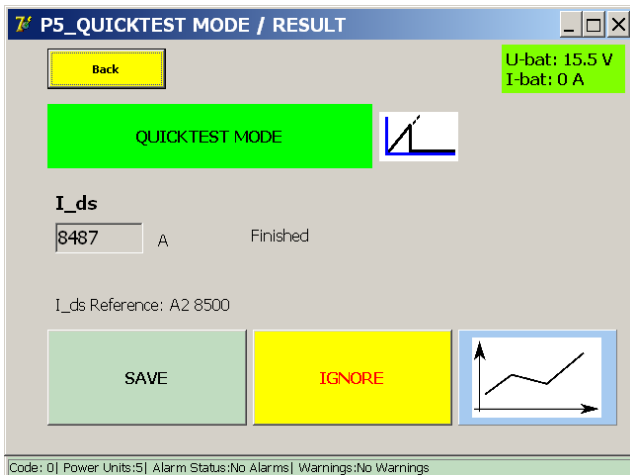
In this dialog, the curve of the last measurement can be re-examined by pressing the graph button.

NOTE : The graph button appears after the first measurement has been made.

Displayed values.

The values displayed here only serve as an example. The displayed values will differ depending on the type of test performed.

9.2.2   Background.

Under some circumstances, the colour of the background of the dialogs will change:

Colour	Reason
Grey	Normal operation
Orange	Warning
Red	Error
Yellow	Master/Slave

WARNING :
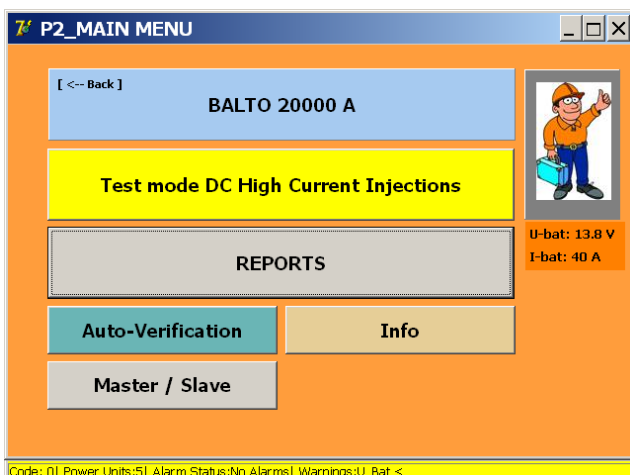
Operation

An active warning message still allows operation of the device.

The reason for the warning is displayed in abbreviated form in the status bar.

NOTE : The voltage value of the batteries, as well as the charging current, are also displayed in all dialogs and dialog boxes.

- ■ Normal operation = green.
- ■ I > 5A = orange.
- ■ U < alarm threshold= red.

Example

Error. - Consult chapter 15.2 Info dialog status. on page <?>
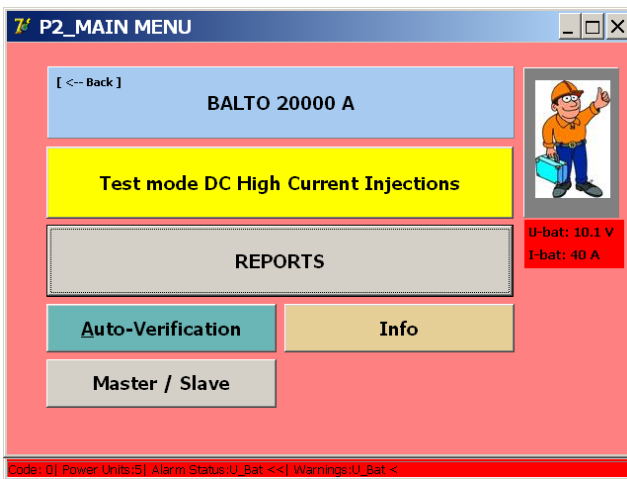
An active error prevents device operation and restricts further injections.

The reason for the error is displayed in abbreviated form in the status bar.

The varying background colours are not displayed on the start dialog. However, error and warning messages will still be displayed in the status bar.

- ■ Status bar: Error and warning messages.

9.2.3 Message management.

The system manages displayed messages using codes:

Operation codes.	
Code 1 - 57	Messages relating to system status, warnings or errors, displayed in the status bar, or full screen dialog messages requiring user input by clicking 'OK' to confirm the message or 'Cancel' to abort.
Code 200 - 205	Messages requiring user choice.
Test result error codes:	
Code 100 - 106	Test-related notifications in result dialogs.

Example

Following dialog with a pop-up window:
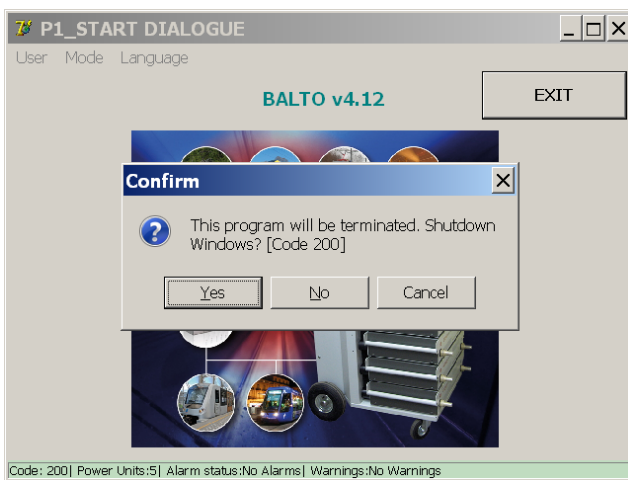
For more information regarding these codes, Consult chapter 15.4 Message codes. on page <?>

9.3 Booting up the BALTO System.

Carry out the assembly and all connections as described in the previous chapter.

The High-speed DC Circuit Breaker must be in the OFF position.

9.3.1 Start procedure.

Connect the system to the mains supply.

The indicator light of the O/I button should illuminate.

Pressing the O/I button begins the automated start-up procedure.

Several dialogs will be presented on the screen while the system starts up.
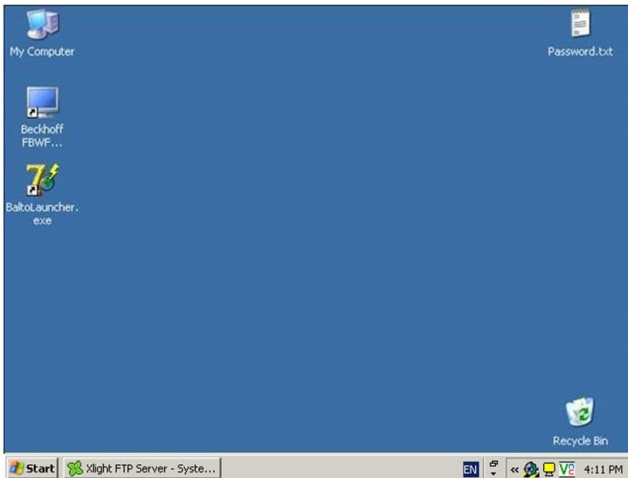
The 'TwinCAT' and 'BALTO Launcher' applications will start automatically.

'TwinCAT' is activated.
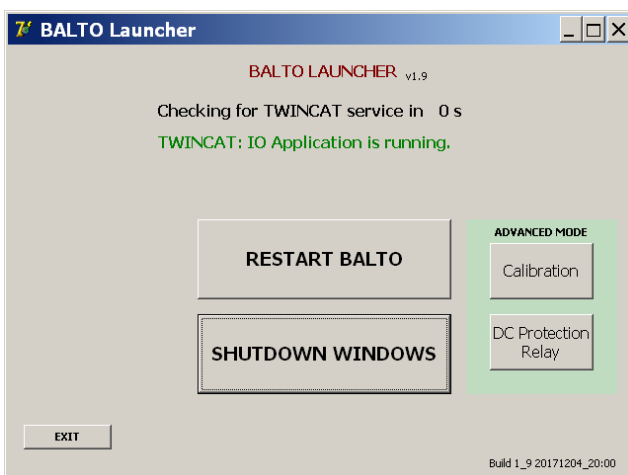
'BALTO Launcher' will open the main BALTO application automatically.

NOTE : 'TwinCAT' is software by Beckhoff for managing the PLC hardware.

Under 'ADVANCED MODE' there are two additional programs:

- Calibration - Option.
- DC Protection Relay - Option.

During the start-up process, the text in red above can appear briefly until 'TwinCAT' has finished starting.

CAUTION : If this text is displayed continuously, and the main BALTO program is not started, there may be a system failure. Please contact your supplier if this occurs.

The start-up dialog should appear, and the 'System ready' indicator will illuminate.

After this procedure has been completed, the High-speed DC Circuit Breaker can be switched on.

CAUTION : If the start dialog is not reached, or if the start dialog fails to start the main program - signalling the 'System ready' indicator - the system will shut down after 2 minutes.

Please wait 20 seconds before attempting to start the system again. If start-up problems are not resolved, please contact customer support.

9.4 Operating conditions.

9.4.1 Power Capacity.

In the table below the full test durations of a Current Injection depending on the Power Range are listed, considering the least favourable conditions.

Power Range	Test duration
4.000 A	2.50 Sec
8.000 A	3.10 Sec
12.000 A	4.00 Sec
16.000 A	3.00 Sec
20.000 A	1.80 Sec

NOTE : The ideal duration of tests will correspond to the degree of consistency of the High-speed DC Circuit Breaker. It is recommended to keep injections as short as possible to conserve battery energy.

Configuration.

The BALTO Modular System is configured and calibrated for a Current Range from 4,000 A up to 20,000 A. The Power Range depends on the number of DC Current Generators used in the device (ranging from 1 to 5).

If the number of DC Current Generators deviates from the default configuration, warning messages are displayed.

System warnings.

Changes from the default factory configuration are displayed using the following dialogs.

Example:

NOTE : It is not always necessary to connect all Power Units. The number of Power Units depends on the required Current Injection to carry out the test.

By using all available Power Units, the full Current Injection range is available, which may be beneficial during some test procedures.

NOTE : When upgrading an existing system by adding additional Power Units - for example adding a new Power Unit to an existing 16,000 A system - a system re-calibration is necessary.

Other examples:
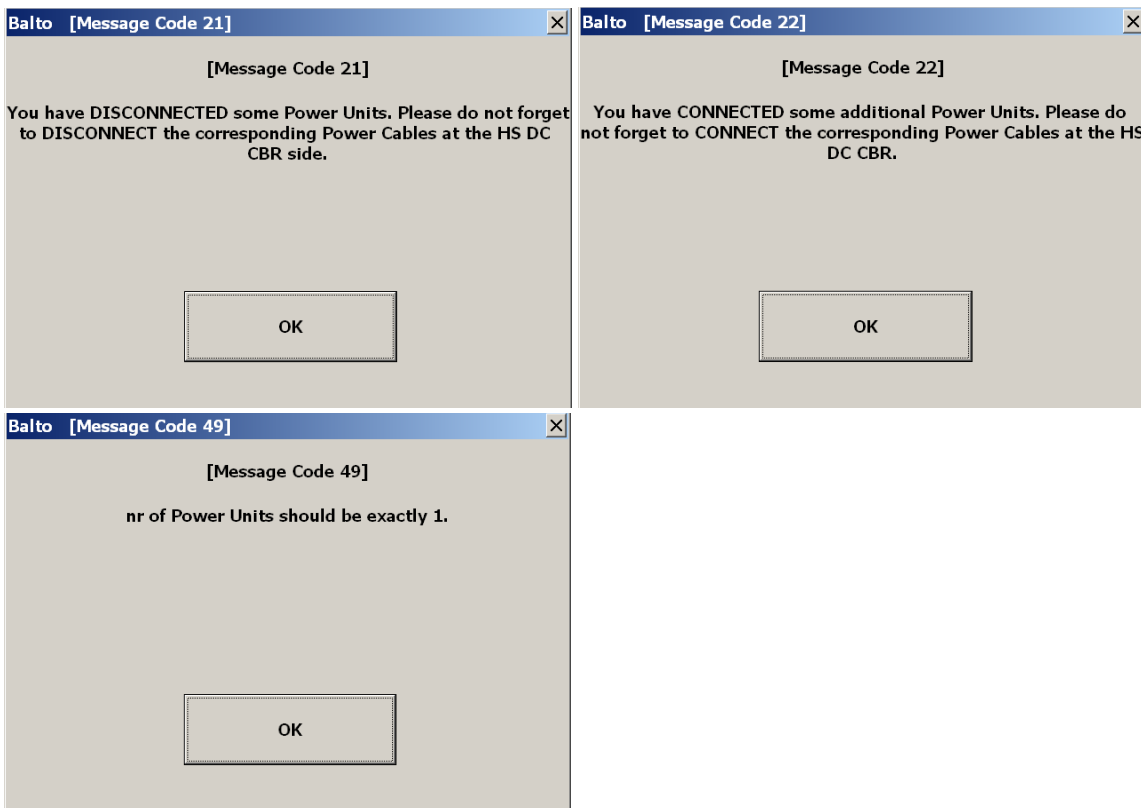
Fault conditions.

The BALTO System may alert the user about technical malfunctions through warning and error messages.

These messages are displayed in the status bar of each dialog, and in the 'Info' dialog.

Current Injections may be blocked by some errors. Further testing is only possible once the error is resolved.

Battery Supply.

In each dialog, the levels of the Battery Voltage and Charge Current are displayed.

Green indication:	Battery level optimal for Current Injections.
Orange indication:	Battery is charging, but Current Injections may still be performed.
Red indication:	Battery needs time to recharge, Current Injections are blocked.

Example:

Error display: these messages can be displayed in all dialogs.
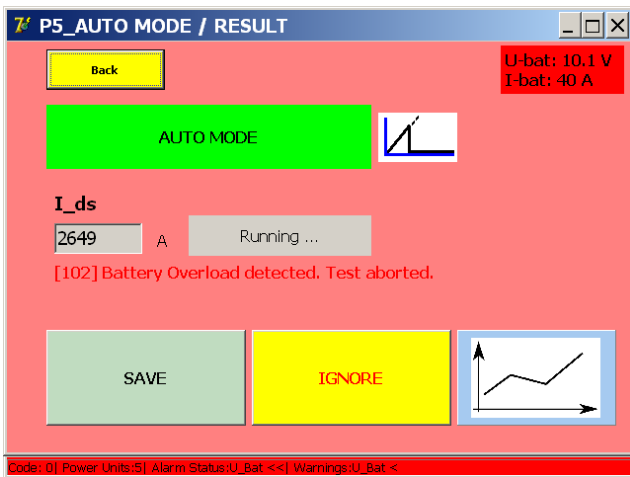
Temperature.

Following each Current Injection, the fans of the Power Units will power on for some time depending on the injected current.

9.5 Flow chart Primary BALTO System.

Functional diagram and operation of the Primary BALTO System.
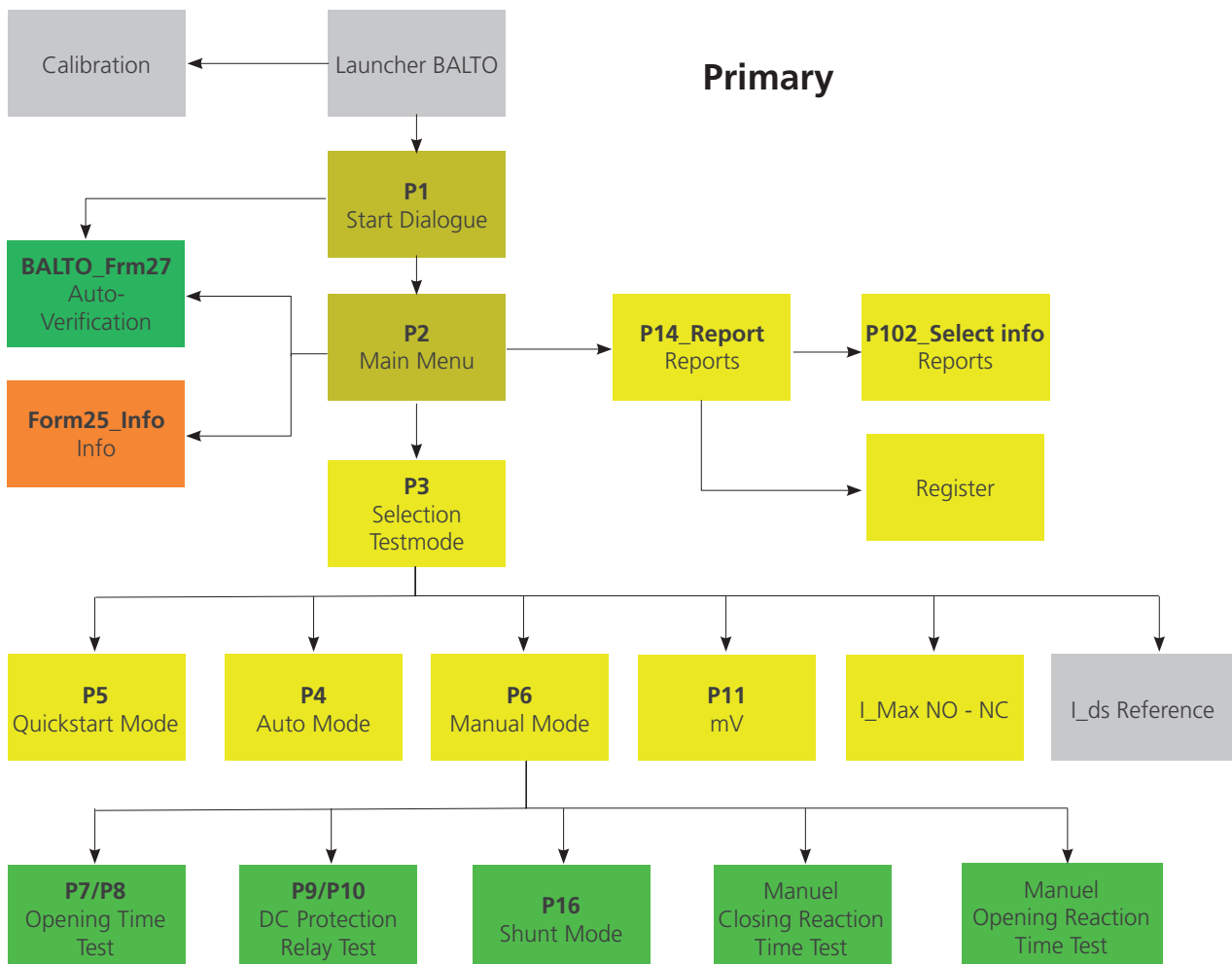
Fig 34: *Flow chart Primary BALTO System.*

9.5.1   Start Dialog.

After the start-up procedure has completed, the following dialog is displayed:
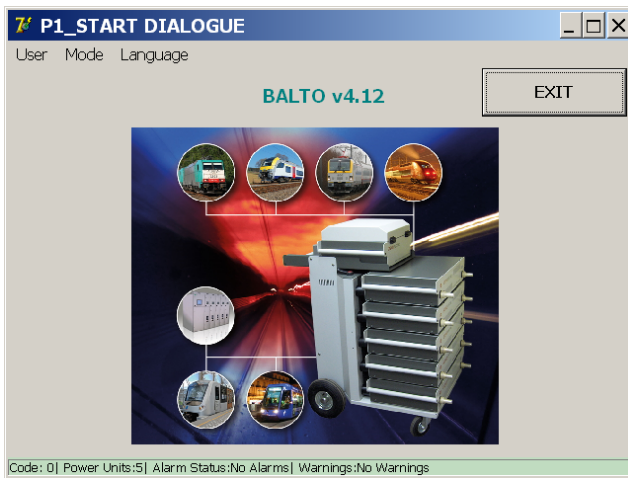
Main Title Bar.

Information regarding the current menu or sub-menu.

Menu Bar.

Menu option: User.

- Standard (active by default): Normal user.
- Administrator: Used by BALTO service staff, only accessible with a password.

Menu option: Mode.

Dropdown menu:

Selection from dropdown menu:

- Auto-Verification: Self-checking of Power Units.
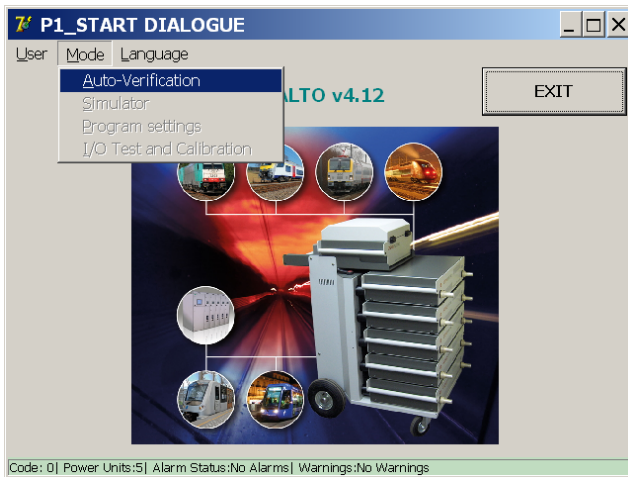
For more information, Consult chapter 9.12 Auto-Verification on page 90

Menu option: Language.

Dropdown menu:

Selection from dropdown menu:

Available languages:

English, French, Dutch, German, Italian, Spanish, Chinese and Czech.
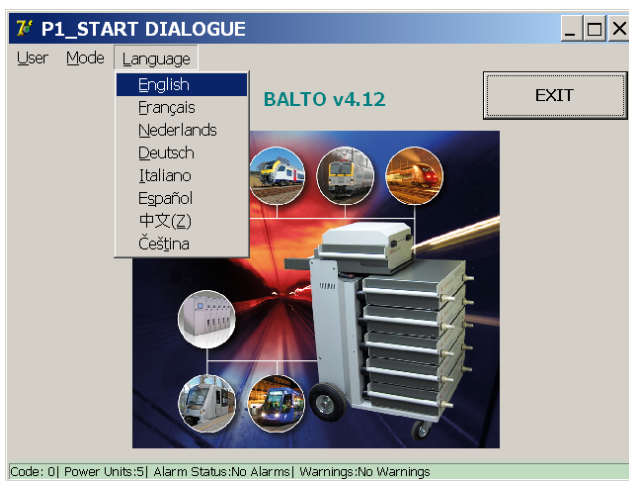
Changing the language in this menu will also affect the BALTO Launcher and Calibration programs.

9.6   Main Menu.

The Main Menu contains all the functions required to test a

High-speed DC circuit breaker extensively.

Press the centre image in the 'Start Dialog' to open the Main Menu.

The 'Main Menu' is displayed as follows:
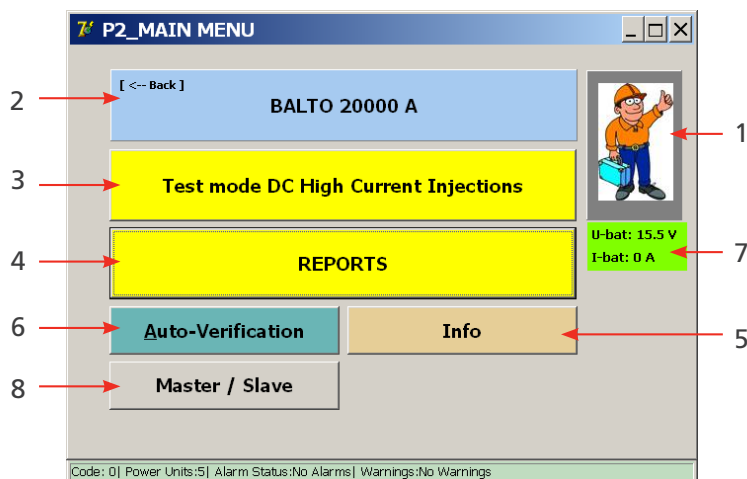
In the Main Menu, the operator can choose from the following sub-menus or functions:

Item	Description
1	Activate Safety Mode.
2	Back button for returning to the 'Start Dialog', also displays the system's active configuration.
3	Access to the various test modes: Quicktest Mode, Auto Mode, Manual Mode, µOhm Measurement and Measurement of auxiliary contact.
4	Measurement reports: ■ Displayed in grey: no measurements recorded. ■ Displayed in yellow: contains measurements.
5	'Info' dialog containing system status and information.
6	Opens the 'Auto-Verification' dialog: Test function for DC Current Generators.
7	The system battery voltage and charging current at this time.
8	Master/Slave configuration. (Only applicable to BALTO Modular.)

9.7   Information BALTO range.


```
[ <-- Back ]
              BALTO 20000 A
```
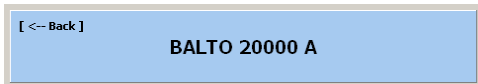
The system's active configuration displayed in button $\boxed{2}$ in the Main Menu is based on the number of connected DC Current Generators detected by the system.

To return to the Main Menu, press the [<--Back] button.

9.8   Safety Mode.

ATTENTION : **This mode must be activated when the connections must be adjusted or altered while testing a device.**

Select the option from the Main Menu:

Press the button $\boxed{1}$ in the Main Menu.

The following dialog will be displayed:
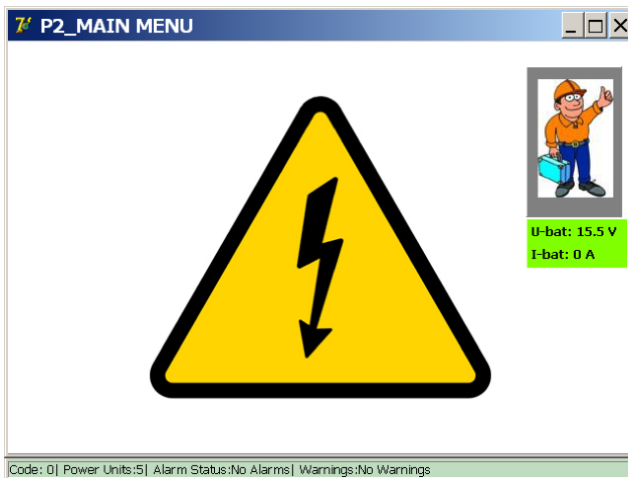
This mode prevents any Current Injections from being made. After the necessary changes are completed, return to the Main Menu by pressing anywhere on the warning symbol.

CAUTION : **It is recommended to utilize this function whenever the system must be left unattended for a short period of time or during breaks between Current Injections.**

9.9   Emergency Stop

The following symbol is displayed in the 'Info' dialog when the Emergency Stop Button is pressed down.
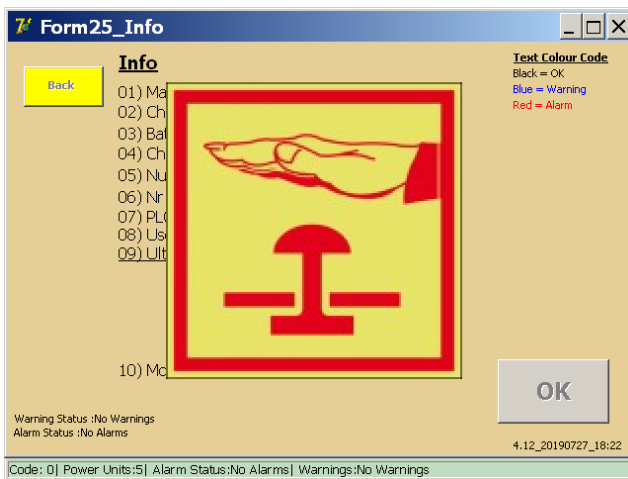
All mechanisms related to Current Injections are blocked while this mode is active.

ATTENTION : **In case of an emergency, when the Emergency Stop Button fails to abort an ongoing Current Injection, the Emergency Stop should be operated manually to interrupt the power flow to the DC Current Generators.**

After deactivating the Emergency Stop Button, dismiss the 'Info' dialog by pressing 'OK'.

9.10   Test mode.

To open Test Modes, press the 'Test mode DC High Current Injections' button $\boxed{3}$ in the Main Menu.

The 'Selection Testmode' dialog will be displayed:
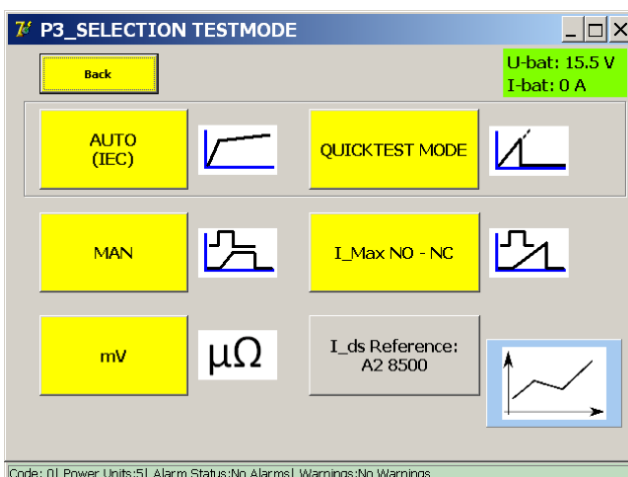
This dialog contains the following test modes:

Test Modes:

- Quicktest Mode.
- Auto Mode (IEC)
- Manual Mode - MAN
    - Opening Time Test.

- DC Protection Relay Test.
- Shunt Mode.
- Reaction Time Tests.

■ Voltage drop measurement - mV/µΩ

■ I_Max NO - NC for testing auxiliary contacts

Information:

■ I_ds Reference.

The expected trip level of the High-speed DC Circuit Breaker can be entered here to compare it to measured test results. The value will also be included in the report.
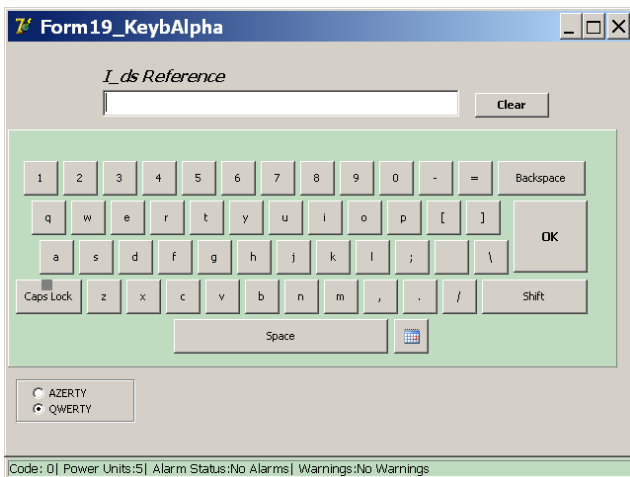
To enter a value, press the 'I_ds Reference' button and use the on-screen keyboard. Confirm the entry by pressing 'OK'.

In order to determine the position of the High-speed DC Circuit Breaker, a current Icheck of 100 A per connected DC Current Generator is injected before and after every test.

The test current is represented in the following graph:
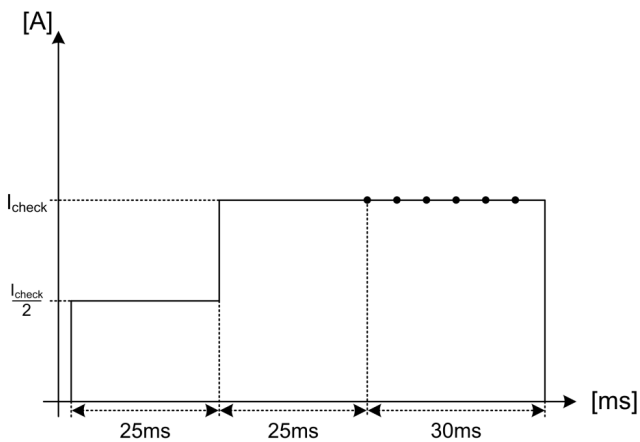
If the system detects the High-speed DC Circuit Breaker in an incorrect position, the following message is displayed:
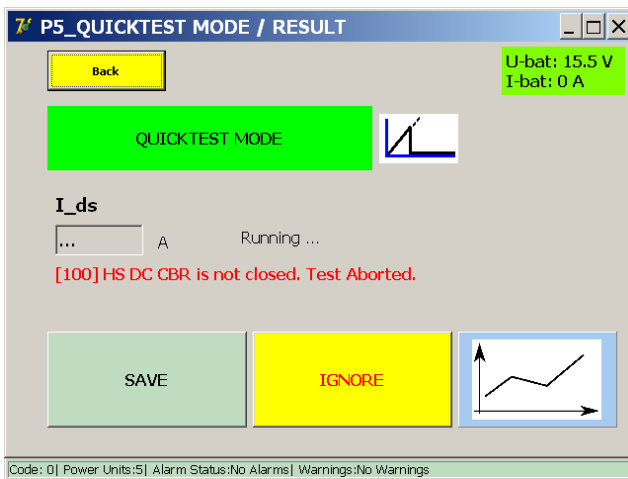
9.10.1   Quicktest Mode.

From the 'Main Menu', open 'Test mode DC High Current Injections' and press 'Quicktest Mode'.

Select the Quicktest Mode in the following situations:

- To obtain an estimate of the trip level value in case the exact value is unknown.
- To quickly determine whether the High-speed DC Circuit Breaker is functioning.

In the dialog 'Selection Testmode':
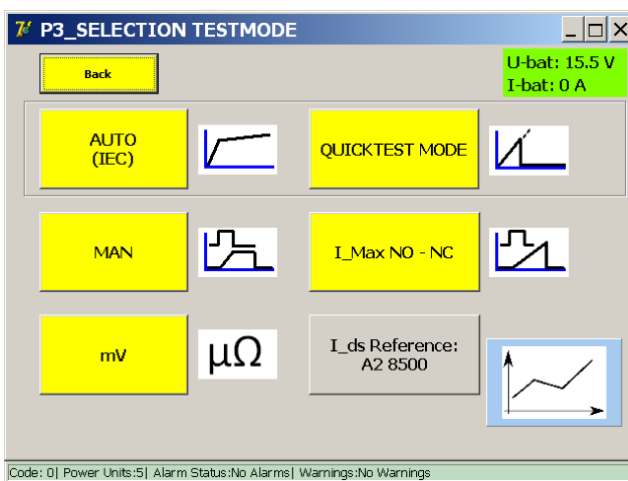
Select 'Quicktest Mode'.

The following dialog will be displayed:
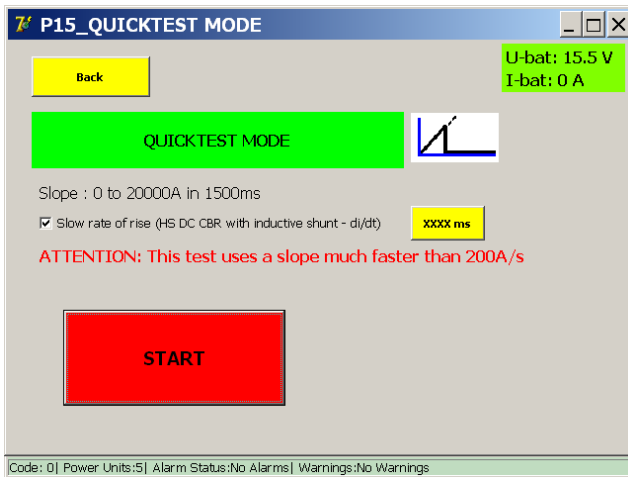
Slow rate of rise:

This option configures the rate of rise of the injection. The standard value (unchecked) is a slope of 600 ms.

When checked, the slope duration is increased to 1,500 ms. Increasing the slope duration may be necessary for High-speed DC Circuit Breakers designed to trip sooner for high rates of current rise (e.g. equipped with an inductive shunt).

The value can be customized further by pressing 'XXXX ms':
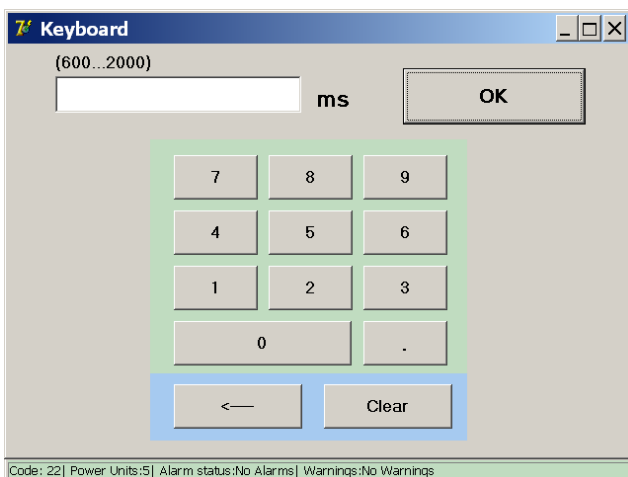
The slope duration can be customized to any duration between 600 and 2,000 ms.

 NOTE : The obtained result in the Quicktest Mode is automatically used as the reference for Auto Mode.

Measurement principle.
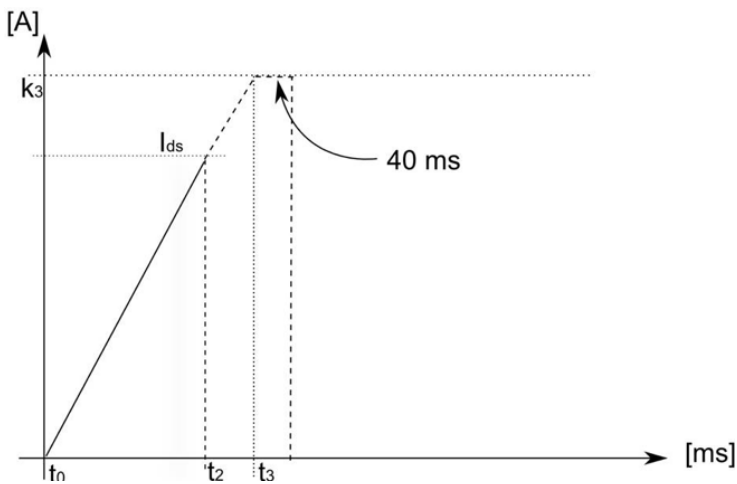
The test performs a linear injection up to the maximum available current. If the High-speed DC Circuit Breaker is functioning, and its I_{ds} level is within the available current range, it will trip during the slope and interrupt the flowing current.

t2 =	Time at which the trip occurs.
t3 =	Total injection time (600 - 2,000 ms).
k3 =	Maximum current, which depends on the number of connected DC Current Generators.
40ms =	Sustained current duration for I_{ds} in close proximity to the maximum current.

Power Range	Imax
4,000 A	4,000 A
8,000 A	8,000 A
12,000 A	12,000 A
16,000 A	16,000 A
20,000 A	20,000 A

For High-speed DC Circuit Breakers equipped with an inductive shunt (di/dt sensitive), the operator may need to perform the test at slower rates of rise to determine the actual I_{ds} trip level.

If the found trip level in the Quicktest Mode is due to the high rate of current rise, it will not elicit a trip in the Auto Mode test.

To start the test, press the 'Start' button.

Operation

<u>**Measurement results.**</u>
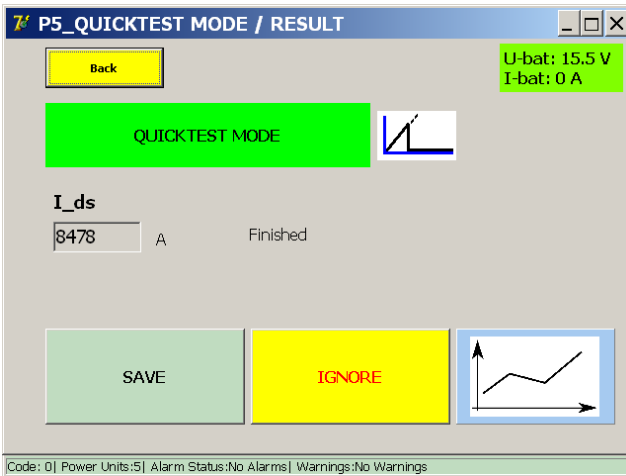
The test result is displayed in the following dialog:

To store the result into the current report file, press the 'Save' button.

The graph button opens the graph dialog illustrating the performed measurement.
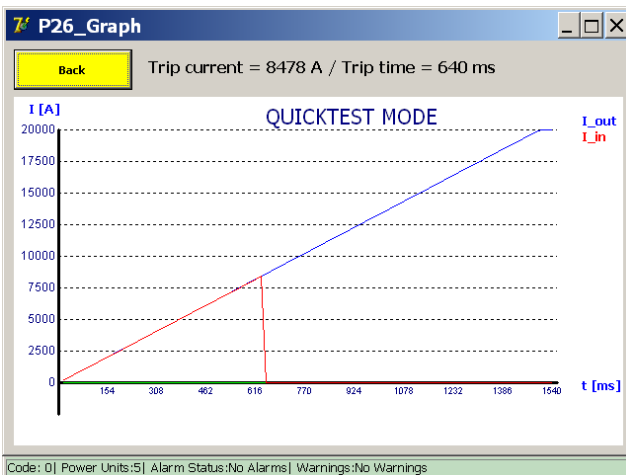
If the High-speed DC Circuit Breaker does not trip during the current injection, the following dialog is displayed:
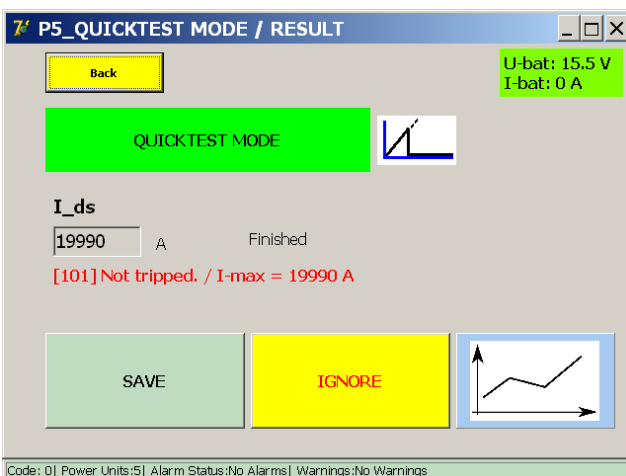
This could mean that the main circuit or over-current release mechanism of the High-speed DC Circuit Breaker malfunctioned, or that the I_{ds} was simply not reached by the injected current.

9.10.2 Auto Mode

Auto Mode is used in the following situations:

- To determine the tripping threshold after repairs or adaptations to the main circuit.
- To accurately measure the tripping threshold.

Auto Mode is opened by pressing 'Auto (IEC)' in the 'Selection Testmode' dialog.
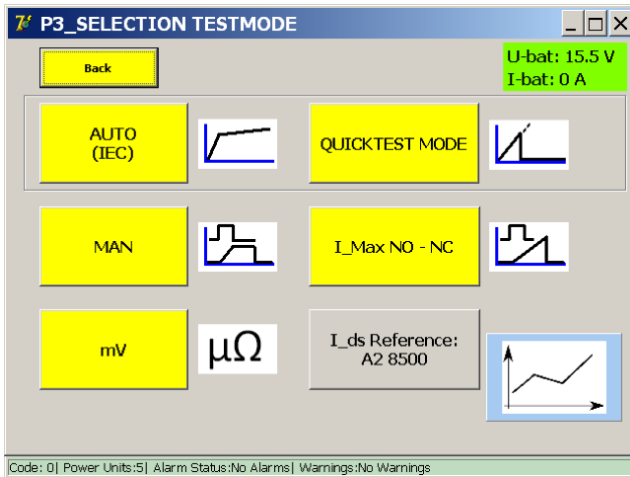
The following dialog is displayed:
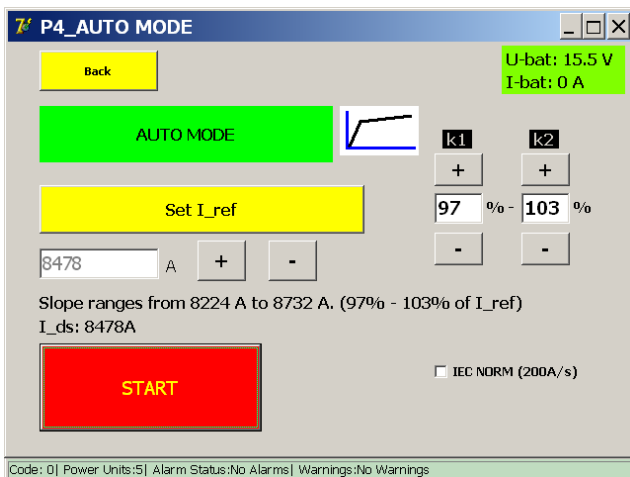
If the Quicktest Mode was performed, I_ref will already be set to the value measured earlier. Otherwise, specify the expected trip level manually using 'Set I_ref'. Small adjustments can be made using the + and - buttons.

To adjust the measurement interval, use:

- K1   Starting point 'e' of the measurement interval, 90% to 99% of I_ref
               if I_ref < 0.75 * 4,000 * (number of power units)

- K2   End point 'f' of the measurement interval, 101% to 110% of I_ref
               if I_ref < 0.75 * 4,0000 * (number of power units)
               If I_ref > 75% of the maximum current capacity of the BALTO Modular, K1 and K2 are restricted.

E.g. for 5 power units K1 will always be 99% and K2 will be 101%

To start the test, press 'Start'.

Interpretation IEC NORM (200 A/s)

The 'IEC norm' function is always active up to I_ref values of 8,000 A. This means that the measurement interval is always performed at a current rise of 200 A/s.

For I_ref values higher than 8,000 A, the system uses slightly higher current rises to conserve battery power by default. However, if the operator wishes to perform the measurement at 200 A/s, the 'IEC norm' option can be checked.

If the option is unchecked, the system will use the following current rises during the measurement interval:

- Up to 8,000 A: 200 A/s.
- Above 8,000 A, up to 16,000 A: 500 A/s.
- Above 16,000 A: 1,000 A/s.

The current rise selection depends on the entered I_ref value, not on the number of DC Current Generators connected to the Support Carriage.

Measure procedure

I_{ds}

The value displayed under I_{ds} is the result of the last test.

An I_ref value obtained from the Quicktest Mode will be overwritten by the first successful Auto Mode test, to provide a better measurement interval. Ideally, the tripping of the High-speed DC Circuit Breaker occurs in the centre of the measurement interval.

The system assumes that 'K1' and 'K2' are not altered and that the High-speed DC Circuit Breaker is consistent in its trip value. If this is not the case, manual re-adjustment of I_ref may be necessary.

Measurement principle

Auto Mode performs the following current injection:
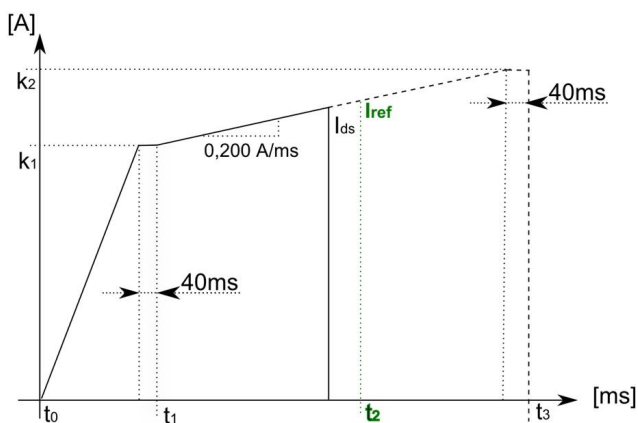
t1 =	1,000 ms. For high current injections, 500 ms is used to conserve battery power.
k1 =	Point e, start of the measurement interval.
I_{ds} =	Measured release current.
k2 =	Point f, end of the measurement interval.
t3 =	The test duration, depends on the e and f values and applied current rise.

| Iref = | The reference point of the measurement interval. |

For an Iref of 2,500 A, 'K1' of 97% and 'K2' of 103%, the values would become:

| t1 = | 1,000 ms. |
k1 =	97% of I_ref = 2,425 A.
k2 =	103% of I_ref = 2,575 A.
t3 =	t1 + measurement interval at 200 A/s + 40 = 1,790 ms.

A trip occurring outside of the assigned measurement interval (before point e) will be considered invalid.

If the trip occurs before point e, the new Iref value will be the value at which the breaker tripped.

The following screens will be displayed when the trip occurs before point e :
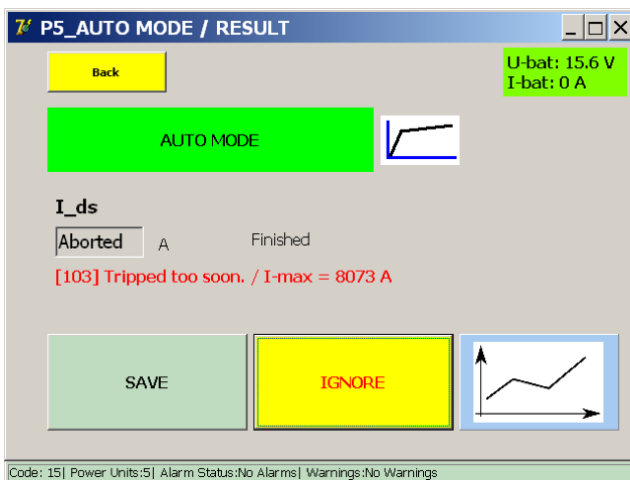
When selecting the graph-button, the following screen will be displayed :
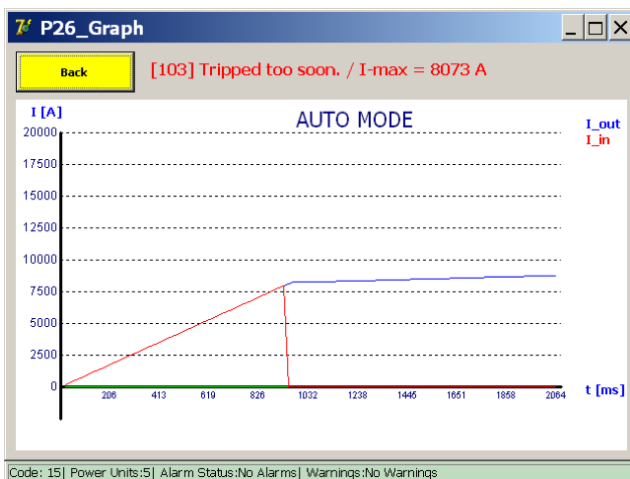
Perform a new AUTO-test, with the new I_ref value, until the breaker trips in the 200A/s interval.

Measurement results

The test result is displayed in the following dialog:
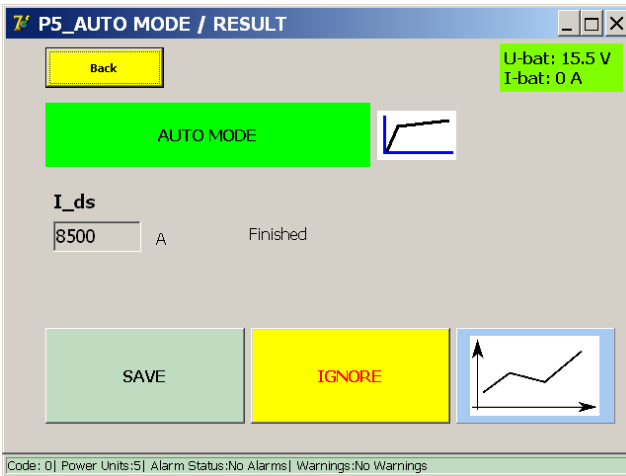
To store the result into the current report file, press the 'Save' button.

The graph button opens the graph dialog illustrating the performed measurement.
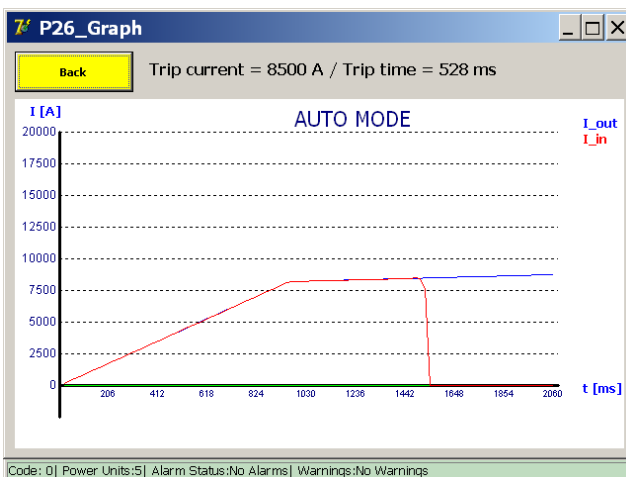
CAUTION : It is recommended to perform the Auto Mode test three times.
The obtained results should be consistent and within the e - f measurement interval.
Inconsistency in the measured values could indicate a malfunction of the High-speed DC Circuit Breaker
opening mechanism. Also see the 'Opening Time Test'.

If no trip occurs, the following dialog is displayed:
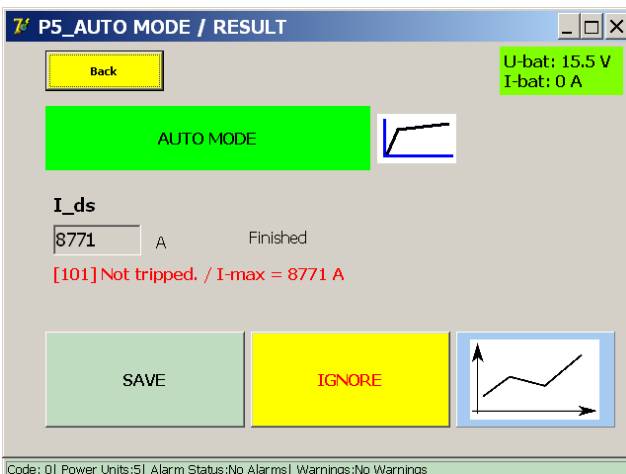
Assuming that the High-speed DC Circuit Breaker performs normally in the Quicktest Mode, the Auto Mode injection may not be reaching the trip level. In this case, adjust the measurement interval manually by increasing 'Iref' or 'K2'.

Alternatively, it could mean that the main circuit or the over-current release of the High-speed DC Circuit Breaker malfunctioned.

9.10.3   Manual Mode.

In the 'Selection Testmode' dialog, press 'MAN' to open Manual Mode.
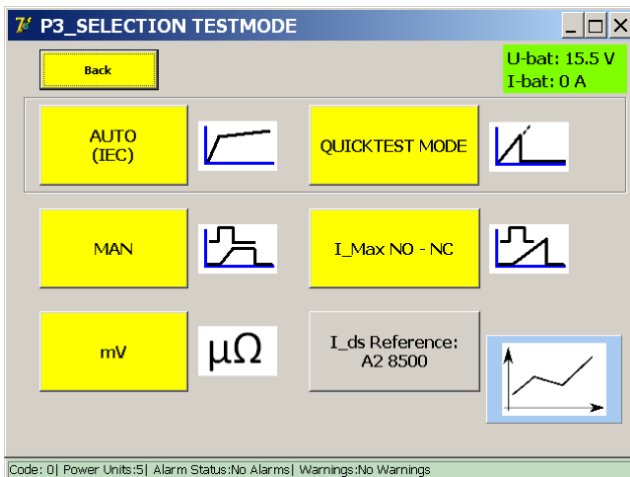
The following menu is displayed:
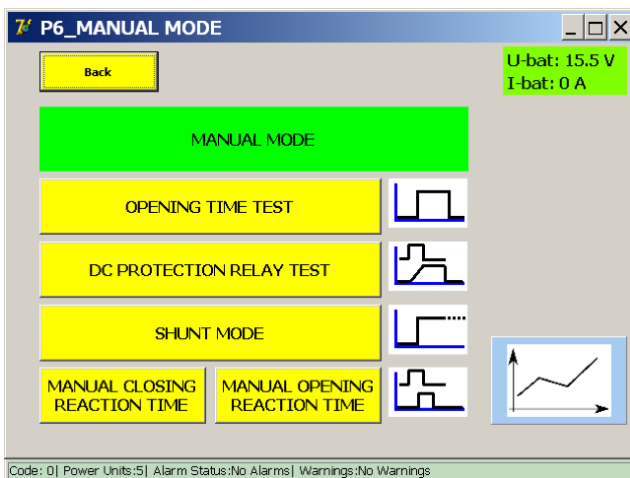
The menu contains the following tests:

- Opening Time Test.
- DC Protection Relay Test.
- Shunt Mode.
- Reaction Time Tests (if supported by the system).

9.10.3.1   Opening Time Test.

This test determines the mechanical response time of the High-speed DC Circuit Breaker.

The mechanical response time is only part of the total electrical interruption time during a real overcurrent event, as

illustrated below.

Example:

According to EN 50123 for fixed installations
IEC 61992-1/61992-2:
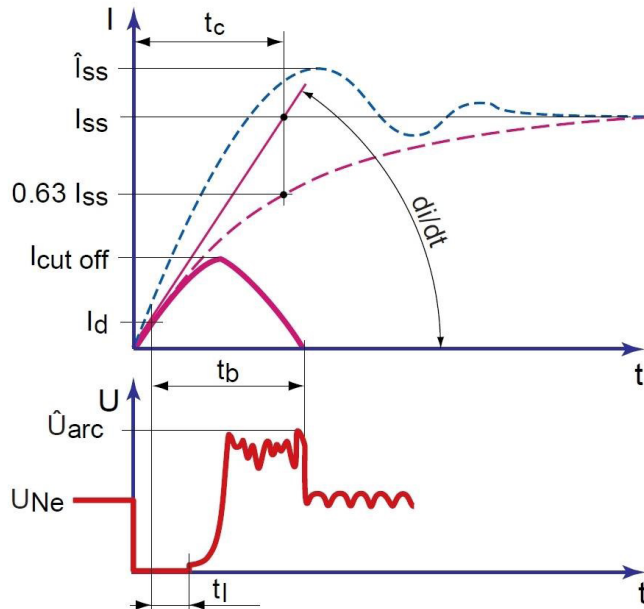
The mechanical response time consists of the measurement of the over-current trigger and the reaction of the over-current release device opening the main contact.

Abbreviations:

Iss	Prospective sustained short circuit current
Îss	Peak of Iss
Icut off	Cut off current
Id	Setting of maximum current release I_{ds}: Current direct setting
di/dt	Initial current rate of rise
UNe	Rated voltage
Ûarc	Maximum arc voltage
tb	Total break time
tc	Time-constant of the circuit
tl	Mechanical response time

Select 'Opening Time Test' in the 'Manual Mode' menu.

The following dialog is displayed:

Dialog information:
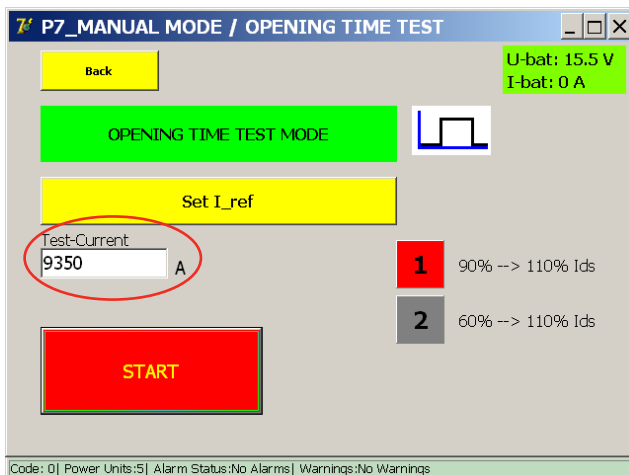
The test current configured is automatically set according to the result in Auto Mode: 110% of the measured I$_{ds}$.

When entering a value manually, ensure that it is higher than the trip level of the High-speed DC Circuit Breaker.

The type of injection can be selected (active selection is marked red):

1. 90% to 110% (default option)
2. 60% to 110%

High-speed DC Circuit Breakers with an inductive shunt (di/dt sensitive) may trip during the rising slope of the injection. For this reason, the 60% to 110% option is available to avoid a trip during the rising slope.

To start the test, press the 'Start' button.

Measurement principle.

The test performs the following current injection:
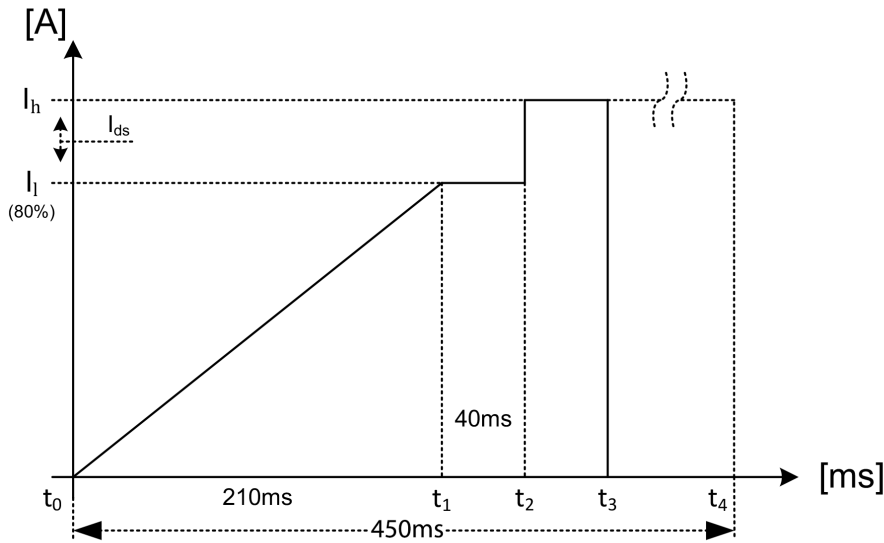
Ih =	Iref → I_{ds} + 10% or set manually → high value.
Il =	Depending on the type of test selected:
	80% of Iref → low value. (80% of Iref ≅ 90% I_{ds}.)
	-or-
	50% of Iref → low value. (50% of Iref ≅ 60% I_{ds}.)
t0 → t1 =	The rising slope to Il during 210 ms.
t1 → t2 =	Current is held constant during 40 ms.
t2 =	At this point, the current rises to Ih as fast as is available to the BALTO System.
t2 → t3 =	The measured opening time.
t4 =	Time limit of the measurement → 450 ms.

When entering the Iref value manually, ensure that the I_{ds} value is somewhere between Il and Ih. Otherwise, the High-speed DC Circuit Breaker may not trip, or may trip too soon.

Result:

If the measured trip falls outside of the range t2 → t4, (200ms) the measurement is considered invalid.

Measurement results.
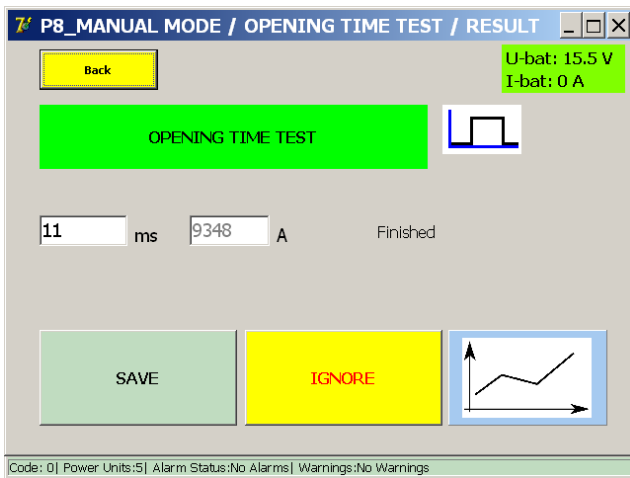
The test result is displayed in the following dialog:
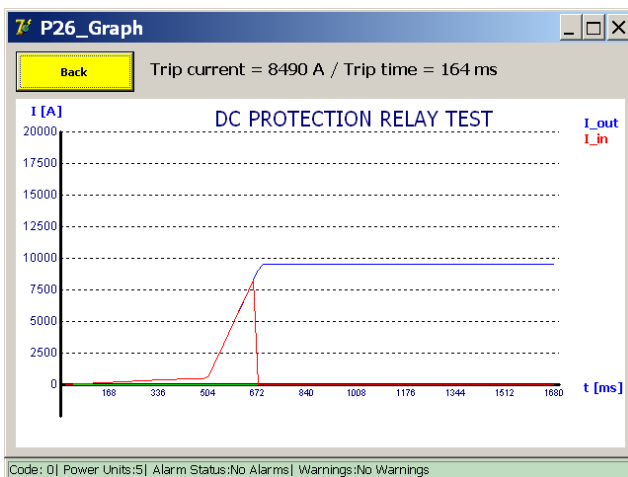

To store the result into the current report file, press the 'Save' button.

The graph button opens the graph dialog illustrating the performed measurement.
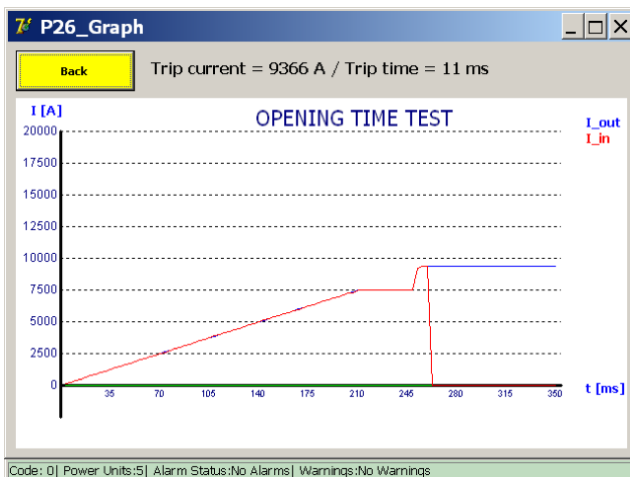
Measurement results.

Type 60% to 110%.
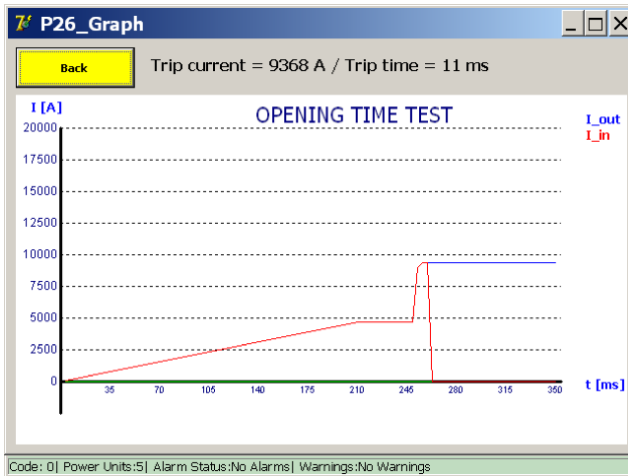
If the Iref value exceeds the maximum allowed current, the following dialog is displayed:

Please reduce the test current to perform the test.

NOTE : that Opening Time Test results saved to the report are labelled 'Pulse Mode'.

9.10.3.2   DC Protection Relay Test.

This function is used for testing DC Protective Relays by using a Primary Current Injection.

Several parameters of the DC Protective Relay can be verified. To carry out the test, the DC Protective Relay's measuring element (e.g. a shunt) must be included in the circuit of the Primary Injection.

Depending on the configuration, the complete response chain can be verified, as well as the thresholds of the DC Protective Relay parameters.

Select 'DC Protection Relay Test' in 'Manual Mode' menu.

The following dialog is displayed.

Linear test principle.
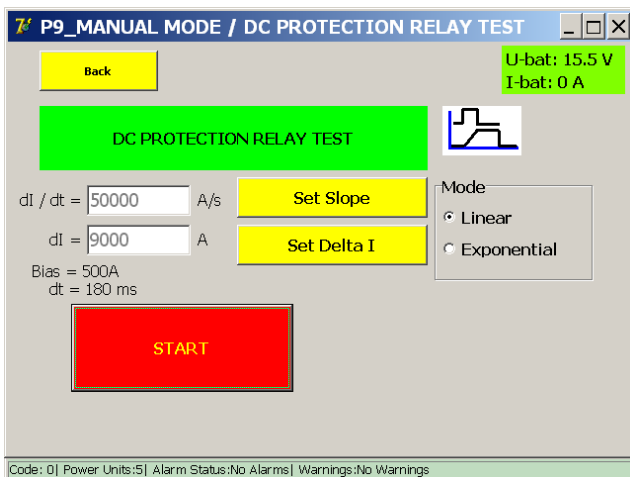
To start the test, press 'Start'.

Example:
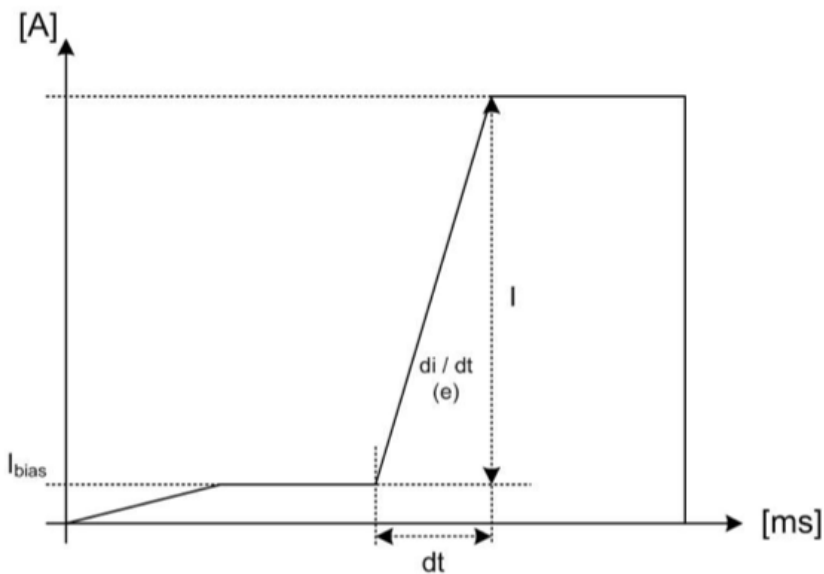
Ibias =	Bias current used for simulating a starting condition. Fixed at 100 A per connected DC Current Generator.
I =	Specified current increase by the user (dI).
di / dt =	Specified current slope by the user (dI / dt).
dt =	Calculated automatically based on the specified current increase and slope.

Measurement results.

Test results are displayed in the following dialog:
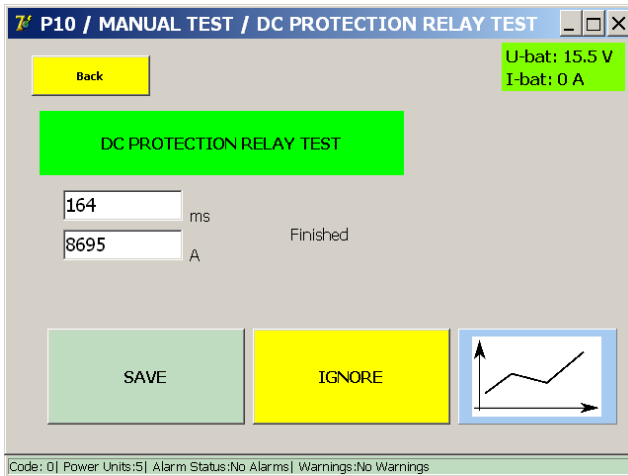
To store the result into the current report file, press the 'Save' button.

The graph button opens the graph dialog illustrating the performed measurement.

The result shows the disconnection of the High-speed DC Circuit Breaker after receiving a trip from the Protective Relay. The tripping of the Protective Relay can be measured directly if it provides a voltage-free 'NO' (Normally Open) trip output contact. This contact can be connected to the 'trip' terminals of the 'PROTECTION TEST' hardware.

Trip detections will typically also display on the Protective Relay itself.

Exponential test principle.

The exponential mode provides a more realistic simulation of a short-circuit current when provided with the time constant of the system.
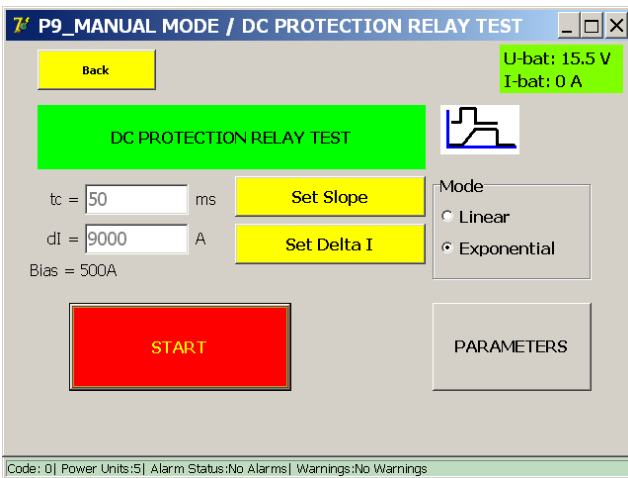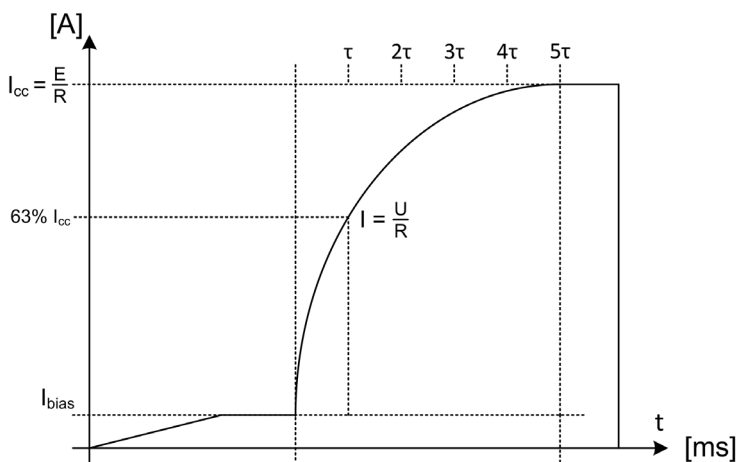

If the time constant is unknown, a theoretical calculation can be made based on the line characteristics. Press 'Parameters' to open the time constant calculator. The following dialog is displayed:
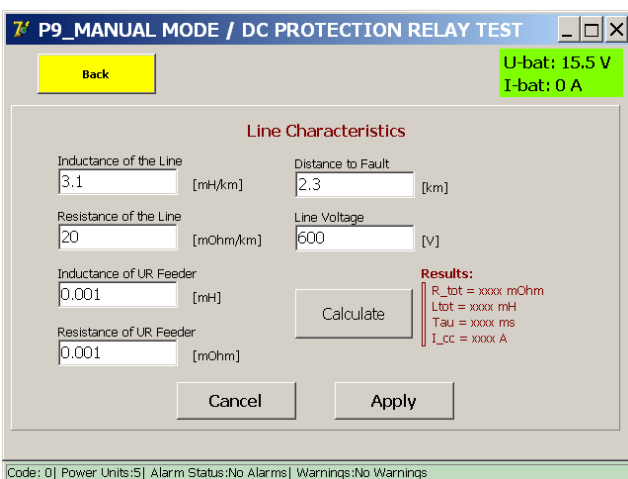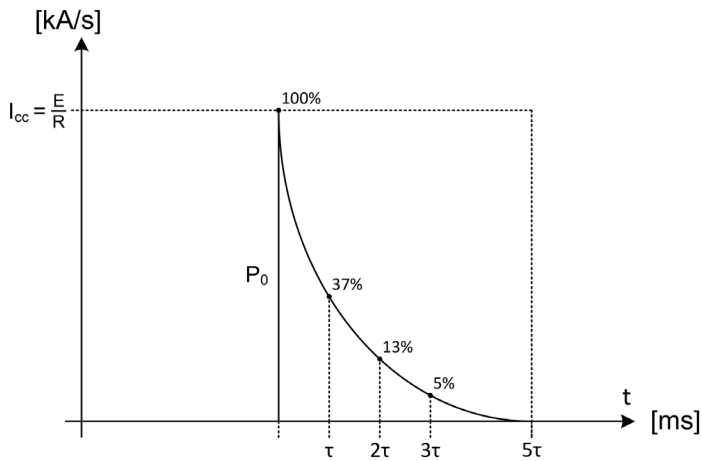

In this dialog, the line characteristics can be provided.

To calculate the time constant, press 'Calculate'. Press 'Apply' to use the calculated time constant.

Example:

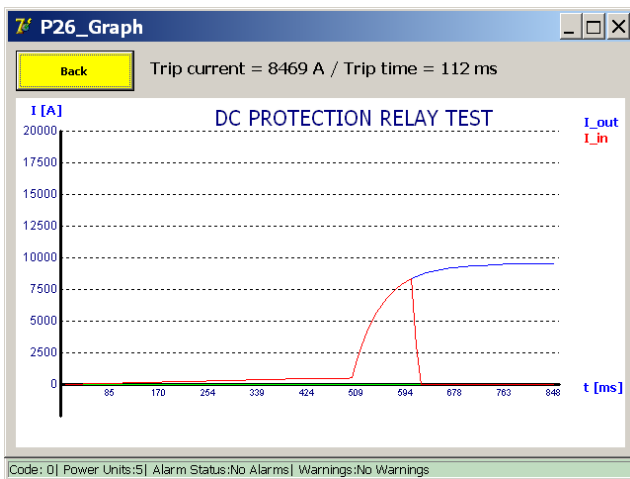| Ibias =	Bias current used for simulating a starting condition. Fixed at 100 A per connected DC Current Generator.
Icc =	Specified current increase by the user (dI).
т =	Specified time constant by the user (tc).
I =	63% of Icc injected during т, R=U/I.
P0 =	di/dt0 → Icc/т → U/L.

Measurement results.
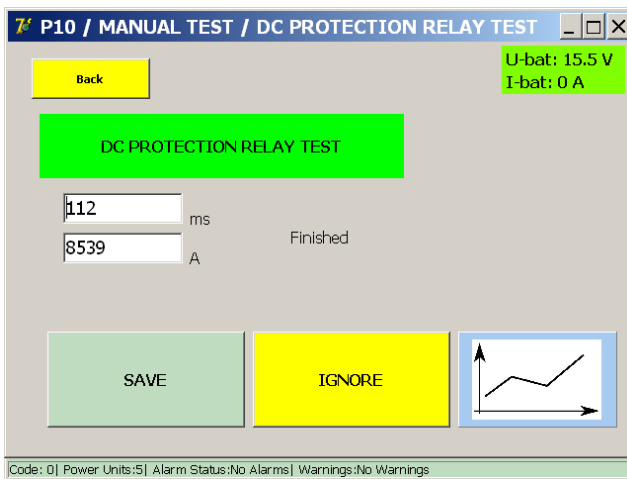
The test result is displayed in the following dialog:

To store the result into the current report file, press the 'Save' button.

The graph button opens the graph dialog illustrating the performed measurement.

The result shows the disconnection of the High-speed DC Circuit Breaker after receiving a trip from the Protective Relay. The tripping of the Protective Relay can be measured directly if it provides a voltage-free 'NO' (Normally Open) trip output contact. This contact can be connected to the 'trip' terminals of the 'PROTECTION TEST' hardware.

Trip detections will typically also display on the Protective Relay itself.

9.10.3.3   Reaction Time Tests.

The reaction time test measures the reaction time of the High-speed DC Circuit Breaker when receiving a manual closing or opening command.

Preparations:

To measure the closing and opening commands, a voltage-free 'NO' (Normally Open) contact representing the command should be connected to the 'Trip' input (3) of the 'PROTECTION TEST' interface.

Fig 35: *PROTECTION TEST Modular*   *PROTECTION TEST COMPACT 4000*
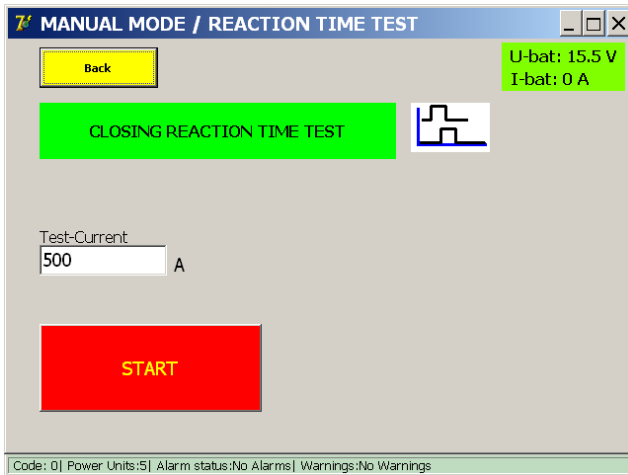
Measuring reaction time.

Manual closing.

Select 'Manual Closing Reaction Time' in the 'Manual Mode' menu.

The High-speed DC Circuit Breaker must be in the open position.

The used test current is fixed at 100 A per connected DC Current Generator.

Press 'START' to begin the measurement, then send the manual close command to the High-speed DC Circuit Breaker. If no closing is measured, the test will time out after 20 seconds.

Measurement principle

When started, the system will begin to attempt sending current in pulses. When the High-speed DC Circuit Breaker closes, current will successfully flow through the circuit. The resulting reaction time is the time between the command input and the measured flowing of current.

Due to the self-regulating design of the system, the current that flows once the breaker closes may be higher than the specified test current for a brief moment. The generated current is corrected within a few milliseconds.

Measurement results
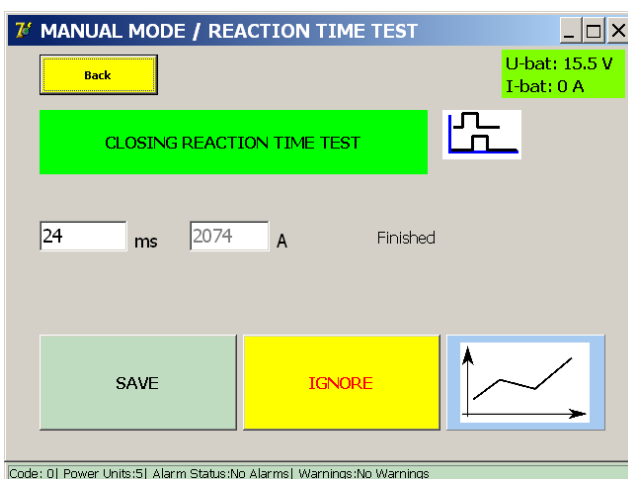
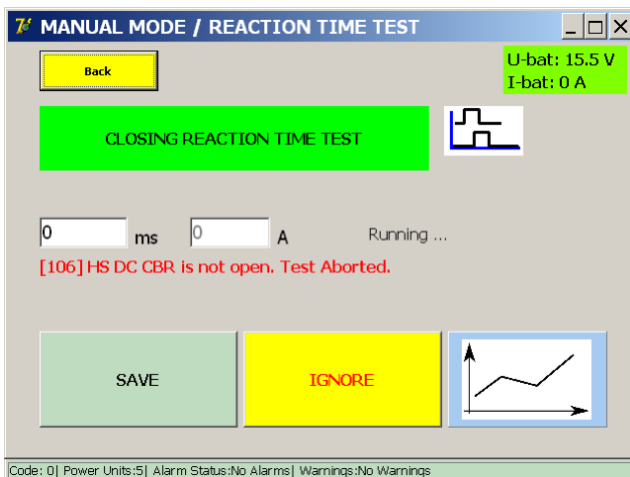The test result is displayed in the following dialog:

The graph button opens the graph dialog illustrating the performed measurement.
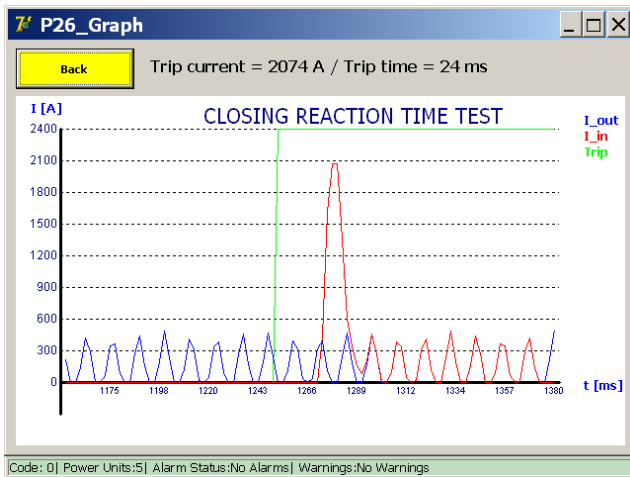
Error message

> Example:

If an error code is displayed, please check for the following:

- Faulty connections of the measurement cables.
- Incorrect connection of the command button.
- Faulty connections on the High-speed DC Circuit Breaker.
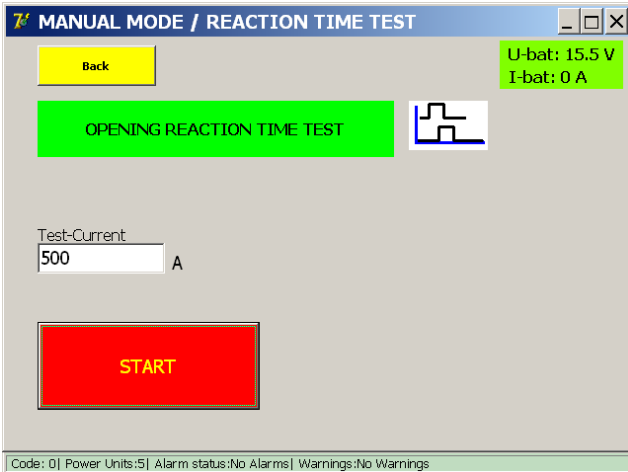- The time-out is exceeded.

9.10.3.4 Measuring reaction time

Manual opening

Select 'Manual Opening Reaction Time' in the 'Manual Mode' menu.

The High-speed DC Circuit Breaker must be in the closed position.

The used test current is fixed at 100 A per connected DC Current Generator.

Press 'START' to begin the measurement, then send the manual open command to the High-speed DC Circuit Breaker. If no opening is measured, the test will time out after 20 seconds.
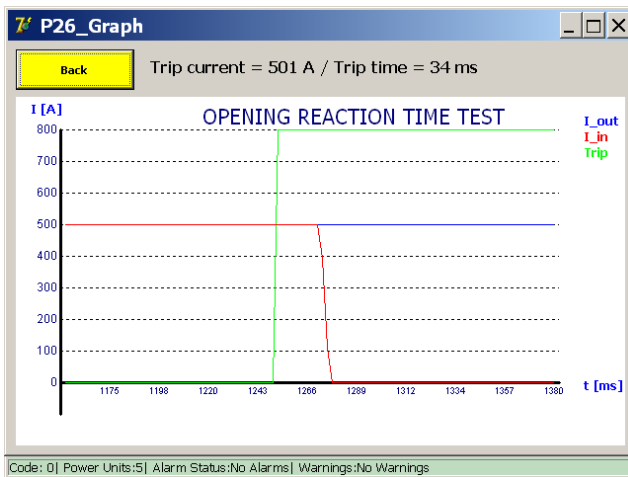
Measurement principle

When started, the system will begin sending the test current. The resulting reaction time is the time between the command input and the measured interruption of current.

Measurement results
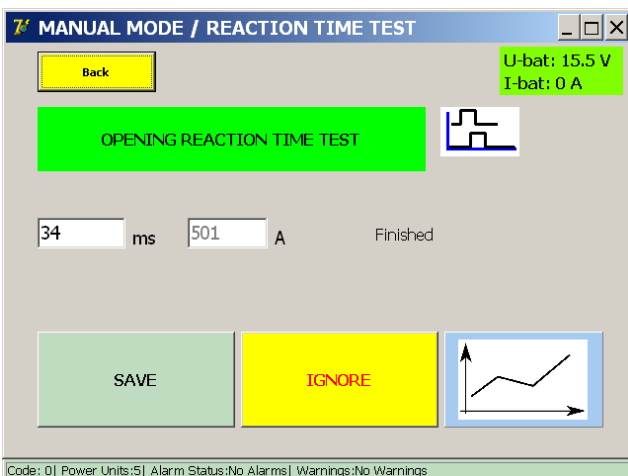
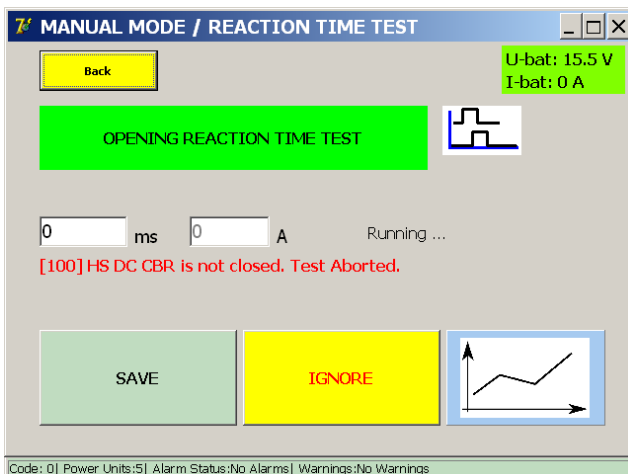The test result is displayed in the following dialog:

The graph button opens the graph dialog illustrating the performed measurement.

Error message

Example:

If an error code is displayed, please check for the following:

- Faulty connections of the measurement cables.
- Incorrect connection of the command button.
- Faulty connections on the High-speed DC Circuit Breaker.
- The time-out is exceeded.

9.10.3.5 Shunt Mode

This function is used for performing a Current Injection at a constant specified current. It can be used for calibrating current monitoring systems.
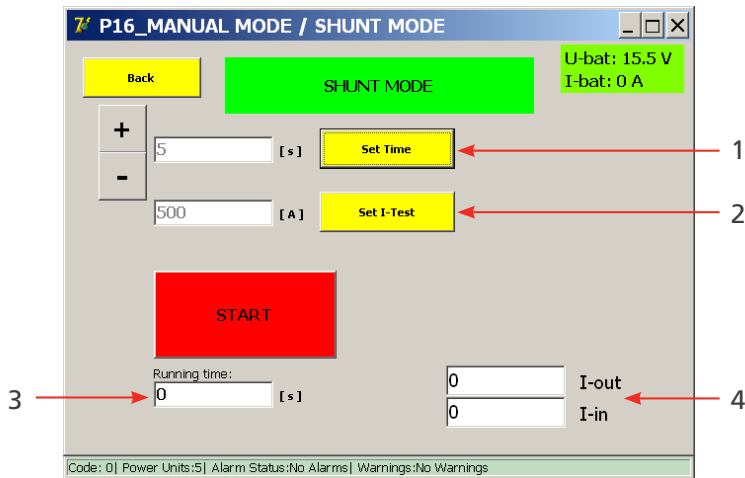
Select 'Shunt Mode' in the 'Manual Mode' menu.

The maximum allowed duration of the Current Injection is limited to 60 seconds. However, if the battery level becomes too low, the test will stop automatically.

Operation

The following dialog is displayed:

Dialog information:

Available settings:

1. Duration of the Current Injection.
   Set duration using '+'/'-' or 'Set Time'.

2. Current level of the Current Injection.
   Set current using 'Set I-Test'.

Displayed information:

3. Running time of an ongoing Current Injection.

4. Display of the output and input current.
   I-out: the configured current value.
   I-in: the measured current value.
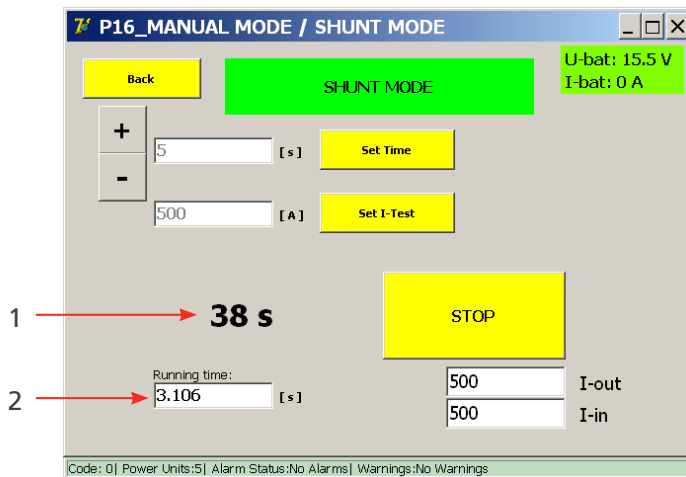   (These values should be more or less identical.)

Measurement principle.
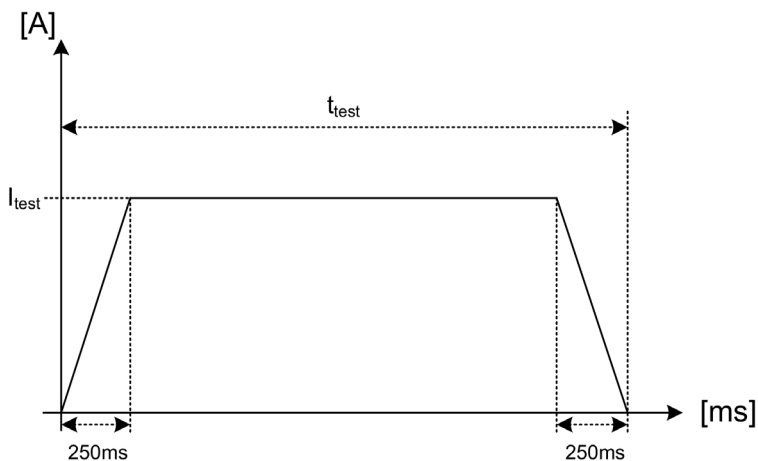
The desired test current Itest is injected during the configured duration t test. During the first and last 250 ms, the change in current is applied gradually. These durations are fixed.

To start the test, press the 'Start' button.
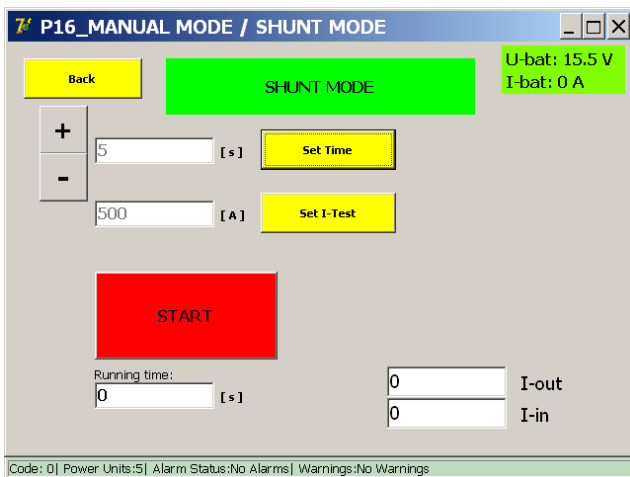
The following dialog is displayed:

- Running time of the ongoing Current Injection. (2)
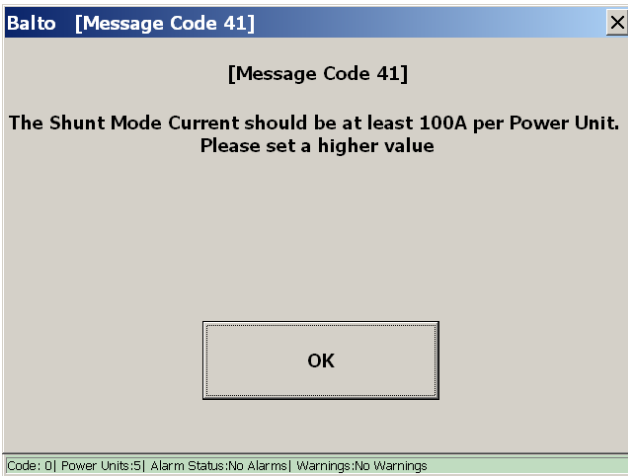- The remaining time until the next injection. (1)

The Current Injection can be terminated early by pressing the 'Stop' button.

<u>**Faulty settings.**</u>

Incorrect inputs.

1. The following dialog is displayed if the test current is set too low:
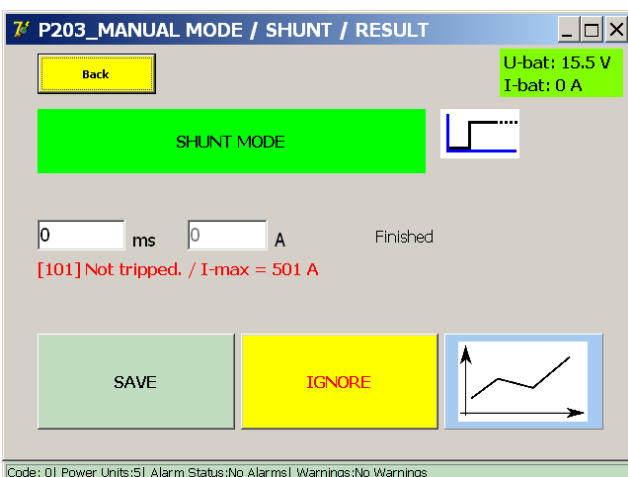

2. The following dialog is displayed if the test current is set too high:
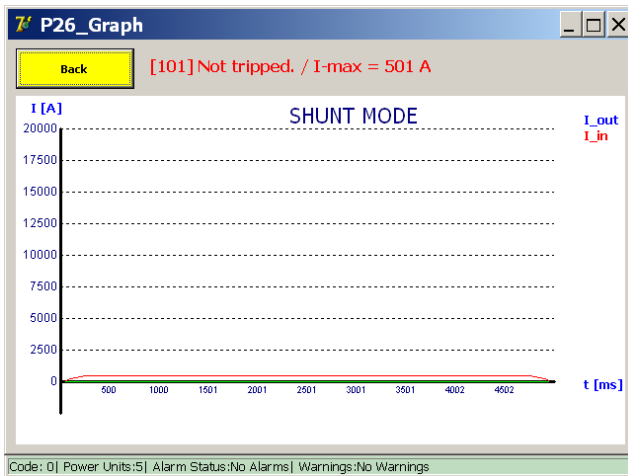

Measurement results.

The test result is displayed in the following dialog:

This dialog is displayed when the Current Injection finishes, or is stopped manually.

To store the result into the current report file, press the 'Save' button.

The graph button opens the graph dialog illustrating the performed measurement.

9.10.4   Voltage drop Measurement

For the measurement of the voltage drop - or more precisely the measurement of the resistance of the main circuit contacts of a High-speed DC Circuit Breaker - link up the connection contacts of the main circuit of the High-speed DC Circuit Breaker to the µOhm measurement input of the Control Panel.

Preparation

Please consult the technical specifications of the manufacturer of the device before proceeding.

Establishing the connection for the measurement between the following devices:

Fig 36: *Control Panel: µOhm measurement connection.*

1. The Control Unit - External measurement.
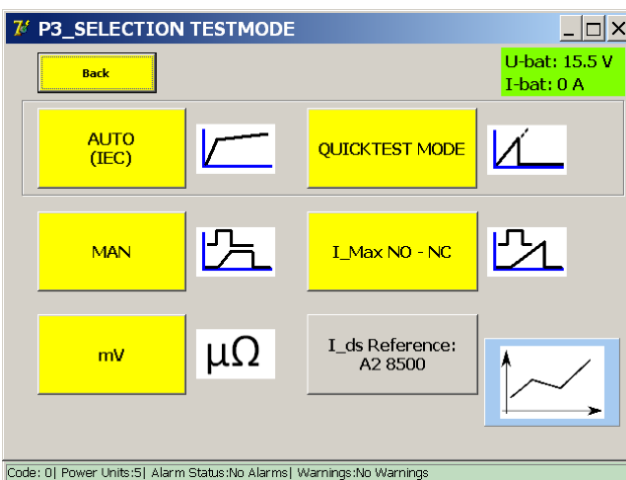2. The High-speed DC Circuit Breaker main contact.

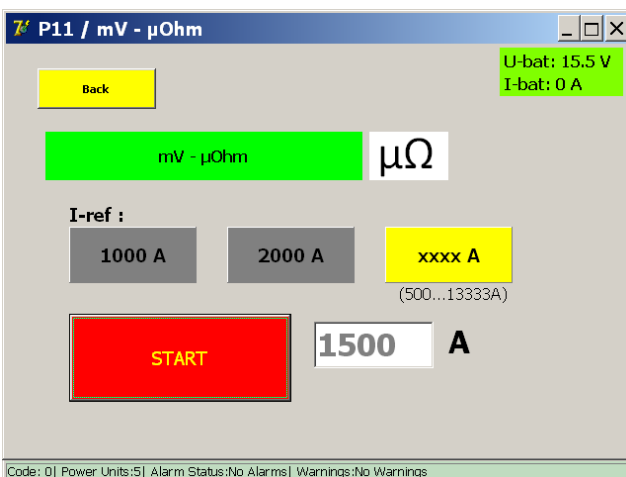**Fig 37:** *Test object: Measurement connection.*

NOTE : Please disconnect the voltage drop test leads after the voltage drop measurement has been completed.

Making a measurement

Select 'mV' in the 'Selection Testmode' menu.


The following dialog is displayed:

The following test currents are supported:

- 1,000 A
- 2,000 A
- Custom user selection:
  - Minimum of 100 A per connected DC Current Generator.
  - Maximum of 2/3 of the total available current.

CAUTION : It is advised to follow the High-speed DC Circuit Breaker manufacturer procedure concerning the test current and allowed values of the voltage drop.

Measurement principle
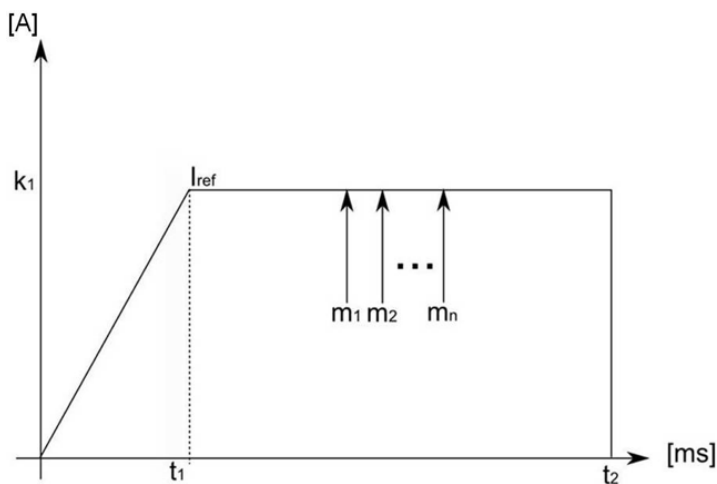
t1 =	250 ms
t2 =	1,000 ms
m1=	First value measured at 500 ms
mn=	Last value measured at 600 ms
n =	(600-500) / sampling rate
R =	(m1 + m2 + … + mn) / n [μΩ]
k1 =	I_ref (selected test current).

Several samples are measured between 500 ms and 600 ms; the average value is displayed in the result. The measured voltage is converted to resistance using Ohm's law.

Example:

Testing with 2,000 A:

Operation
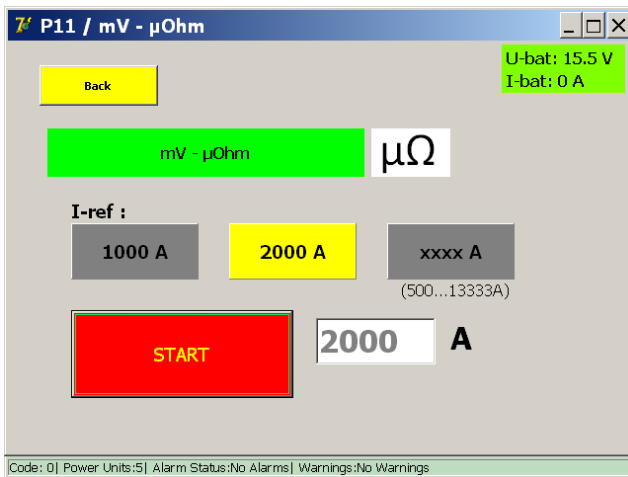
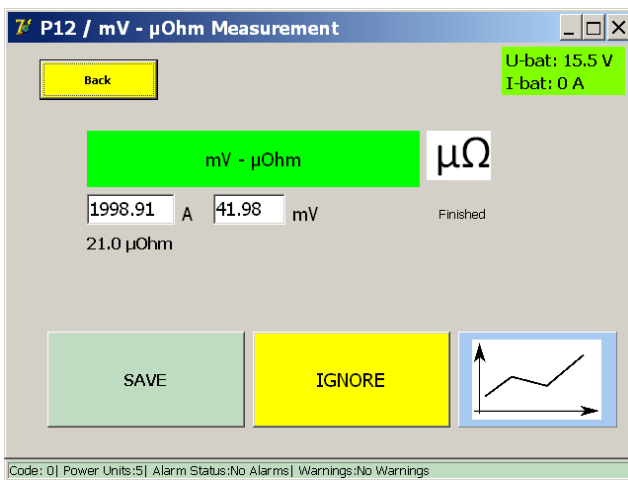To start the test, press the 'Start' button.

Measurement results

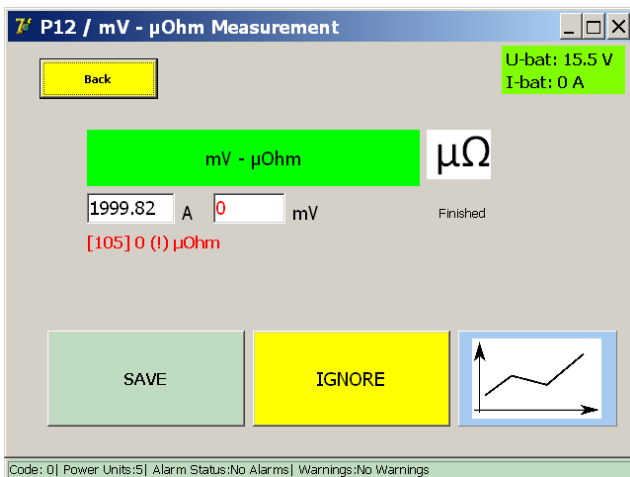The test result is displayed in the following dialog:

NOTE : For information regarding the tolerable voltage drop values and testing procedure, please consult the technical specifications provided by the device manufacturer.

The graph button opens the graph dialog illustrating the performed measurement.
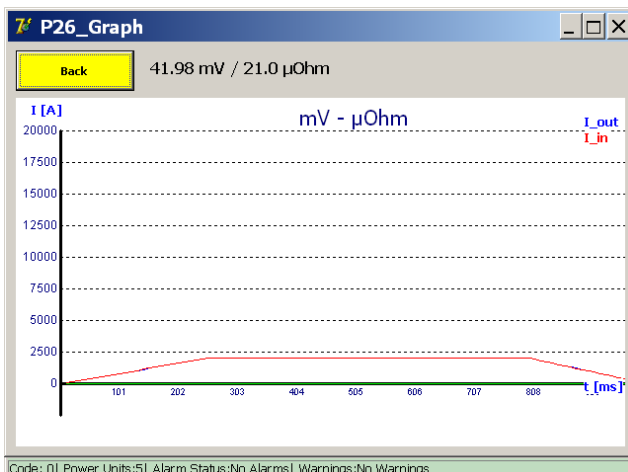
Error message.

Example:

If an error code is displayed, please check for the following:

- Faulty connection of the measurement cables.
- Incorrect placement of the measurement cables on the High-speed DC Circuit Breaker.

9.10.5   I_Max NO - NC

With this function it can be checked whether the auxiliary contacts (NO and NC) of the DC High Speed Circuit Breaker function properly.

Preparation.

The High-speed DC Circuit Breaker must be in an "open" position.

Connect the High-speed DC Circuit Breaker's auxiliary contacts NO/NC to be tested to the trip inputs of the PROTECTION TEST hardware of the BALTO System.

- Contact NC - Trip 1 (3)
- Contact NO - Trip 2 (4)

Fig 38: *PROTECTION TEST module of the BALTO Modular*

PROTECTION TEST module of the BALTO COMPACT 4000

Example :

Double-contacts switches B

Contact NC - Trip 1 (3) - # 2/4

Contact NO - Trip 2 (4) - # 1/3

Double-contact switches E

Operation

Contact NC - Trip 1 (3) - # 8/10

Contact NO - Trip 2 (4) - # 7/9
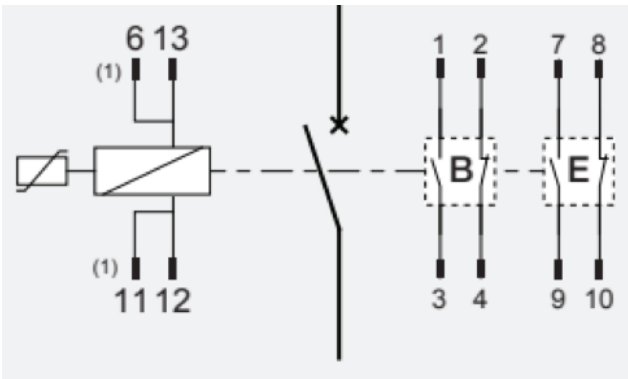
Dialog information:

In the dialog box 'P3_Selection Testmode', choose the option 'I_Max NO - NC'.
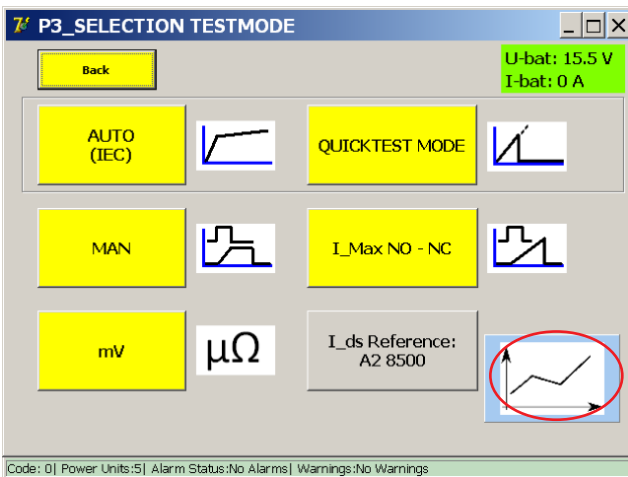
The following dialog will be displayed:

The test current will be determined by the number of Power Units of the BALTO System.

The increase of the slope has been fixed to 600 ms and is not changeable.

The operating principle is identical to the Quicktest Mode.

Close the High-speed DC Circuit Breaker and start the test by pressing the 'Start' button.

Time-out measurement 600 ms

Time-out commutation NO/NC 100 ms

Measurement results.

The test results will be displayed in the following dialog:
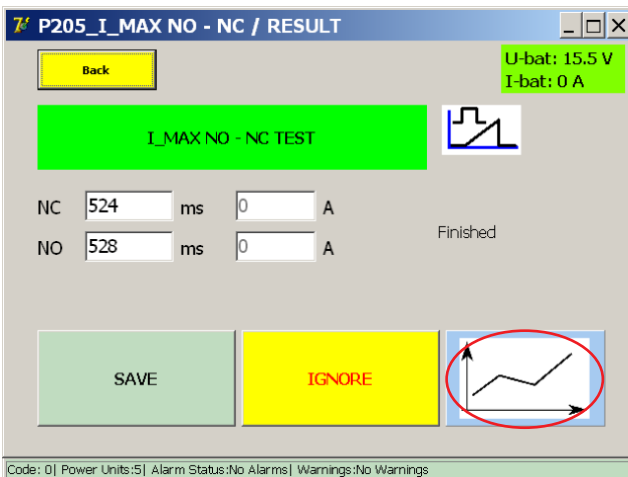
The graph key opens a 'P26_Graph' dialog with the result of the performed measurement illustrated in a graph.
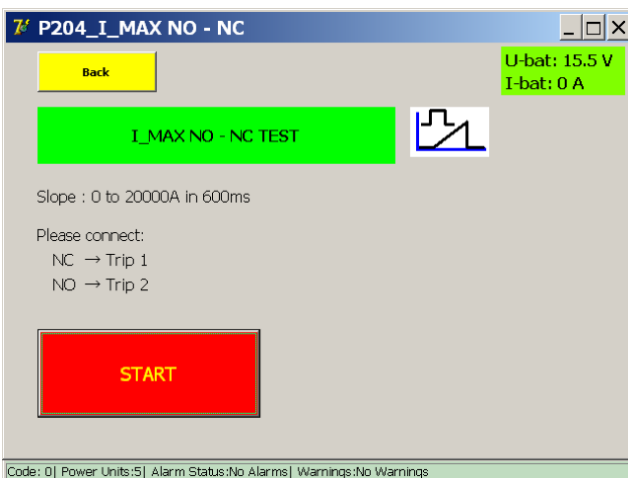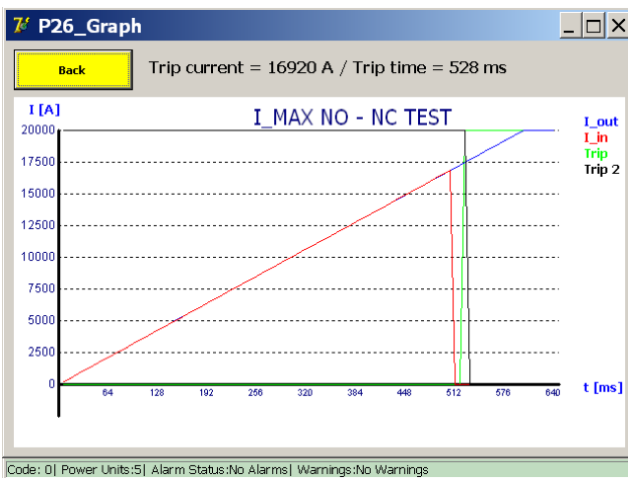

> **Remark:**

The green line shows the NO auxiliary switch status and the black line shows the NC auxiliary switch status.

The blue continuous line is the current increase slope as determined by the system while the red line is the actual current as measured. The point where the red line doesn't follow the blue line anymore is when the breaker opens.

The switching NO/NC has to occur in this zone.
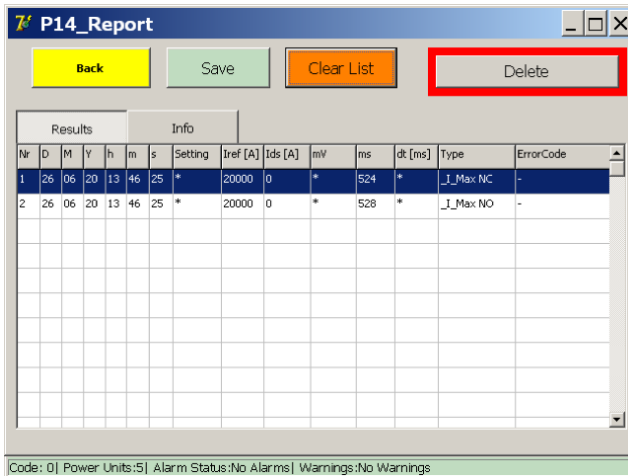
The indicated values Trip Current /Trip time in the 'P26_Graph' dialog are not really relevant as they depend on the I_{ds} of the breaker and the slope generated by the BALTO.

The values are only displayed when the functioning of the contacts NO/NC is correct.

Report:

The NO and NC values are recorded in 'P14_Report' file after saving in the 'P_205_I_Max NO – NC' dialog.
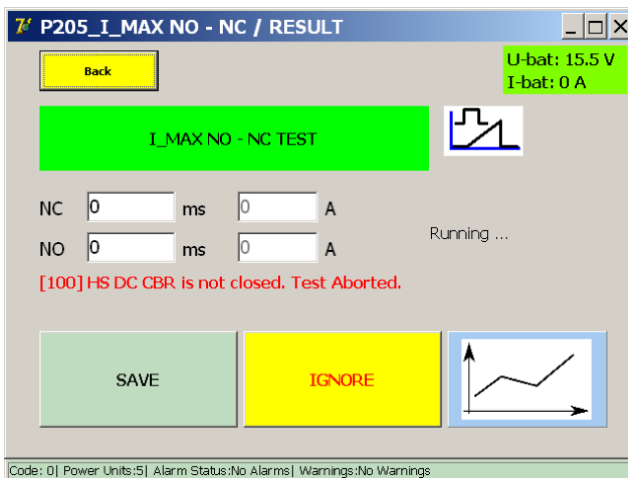
Error codes test results.

These error codes are test-related and are displayed in the test result dialog.

Default error code.

Code 100.

■ Close the breaker and try again.

Error codes test results I_Max NO - NC

Code 111.
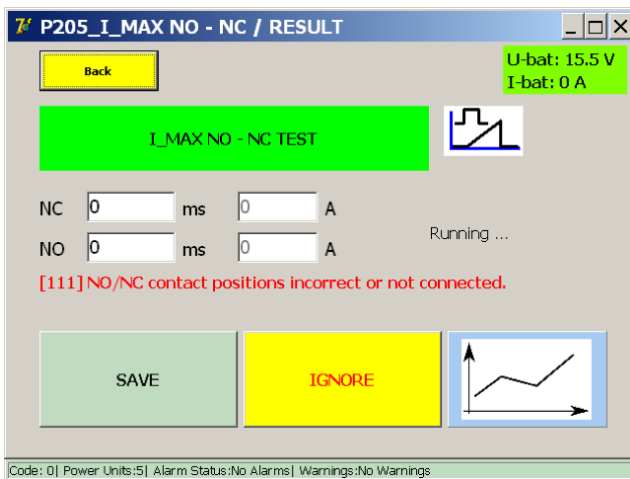
- Check the connections and mechanical state of the NO/NC auxiliary contacts.

Code 112
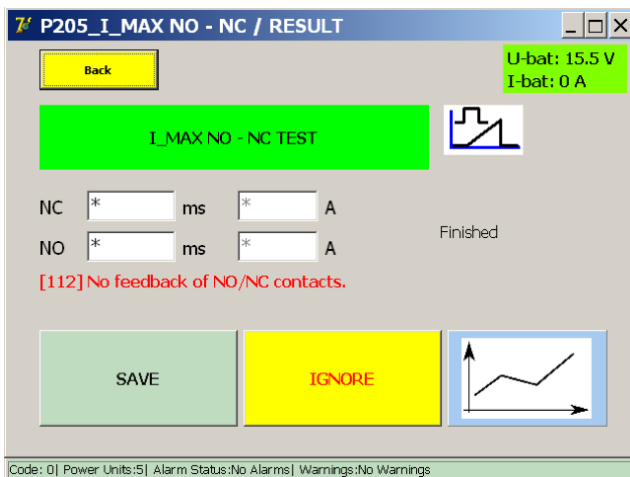
- Check the connections and mechanical state of the NO/NC auxiliary contacts.

Code 113
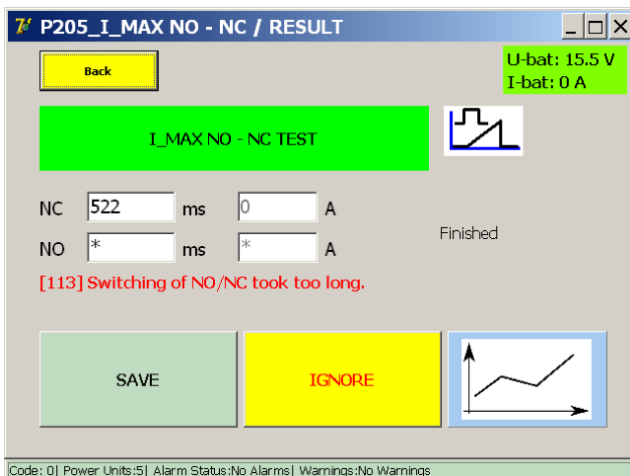
- Check the connections and mechanical state of the NO/NC auxiliary contacts.

9.11   Reports.

The reports dialog is opened by pressing the 'Reports' button in the Main Menu.
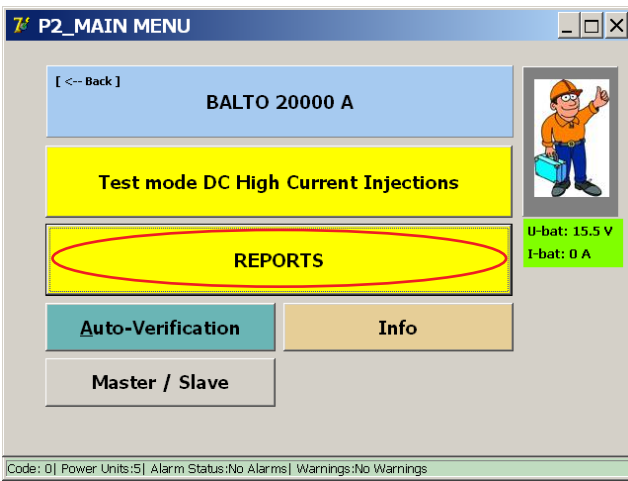
9.11.1   Report info.

Information regarding the performed tests can be added to the current report by opening the 'Info' tab. Here, the operator can specify things such as the test location, test object serial number or additional comments.
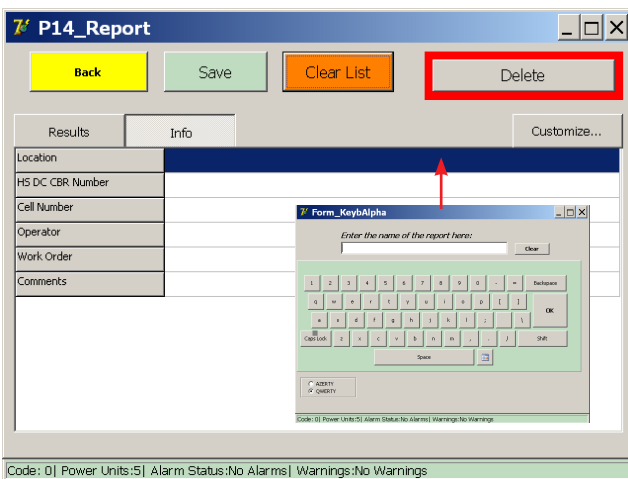
Pressing an empty field on the screen will open the virtual keyboard for text entry.

Report information can be entered at any point during testing.

Info field selection:

The displayed information fields can be changed by pressing the 'Customise' button. The following dialog is displayed:
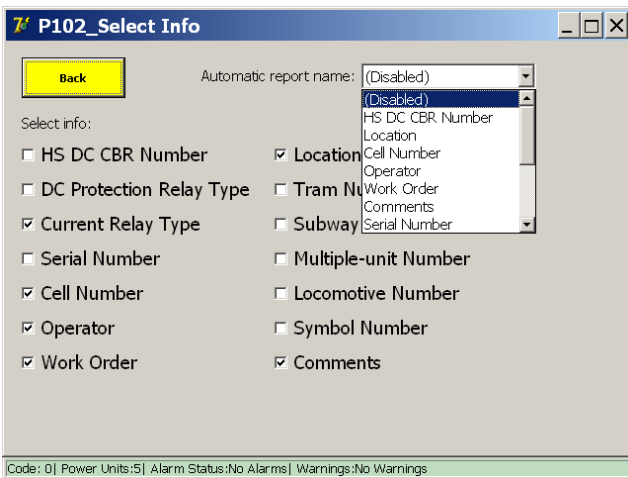
To show or hide an information field, toggle the field's checkbox.

An automatic report name can be selected to use a field's entered value as the name for the report automatically.

NOTE : By selecting a field to use as the automatic report name, the operator must enter the field to save the report.

If the field is left blank, the following dialog is displayed:

9.11.2 Saving and exporting.

The 'Reports' button is highlighted in yellow if the current report contains at least one measurement, as shown below:
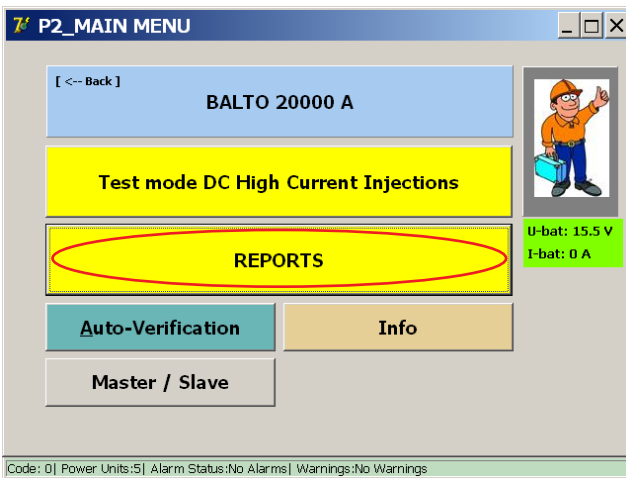
Pressing 'Reports' will open the reports dialog:
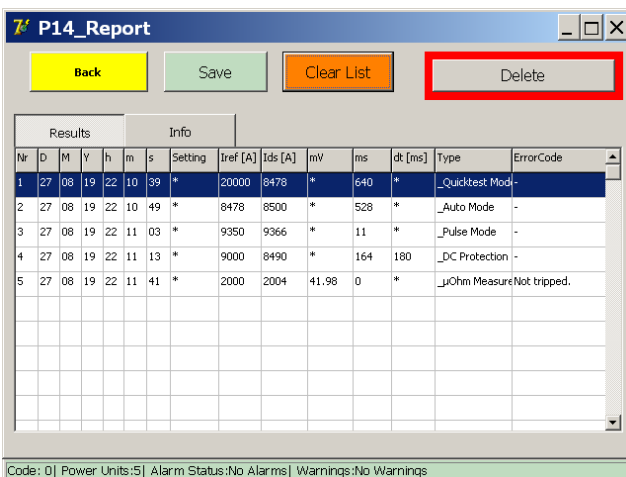
Stored measurements are displayed in the measurements table under the 'Results' tab.

This table shows the date and time of the measurement, the measurement parameters and results, and the type of measurement.

The measurements table stores up to 20 measurements.

The values contained in the measurements table can be saved to a report file by pressing 'Save'. The following dialog will be displayed:

Enter the desired report file name and press 'OK' to confirm. The system will notify the operator when the report has been saved successfully.

To cancel the save, press 'OK' without entering a report name.

After saving, the system will automatically prompt to clear the list of measurements. Press 'Yes' to clear the list of measurements and begin a new report.

NOTE : If the measurements table limit is reached, the operator must save the current measurements to a report file, or clear the measurements by pressing 'Clear List':
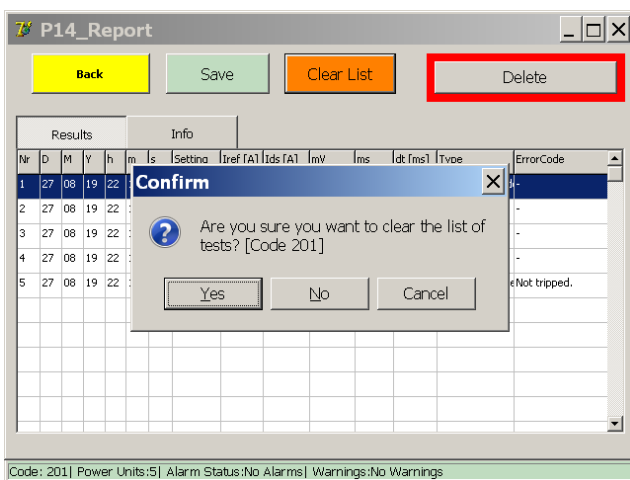
Report files saved into the system can be exported using the BALTOWin software or by connecting a USB stick.

When connecting a USB stick to the USB interface all report files stored in the system will be automatically copied to the USB stick.

Report files are stored and exported in BALTOWin format, CSV format and PDF format (which includes the measurement injection graphs).

To clear all report files stored in the system, press the 'Delete' button. Confirm by pressing 'Yes' in the displayed pop-up window:
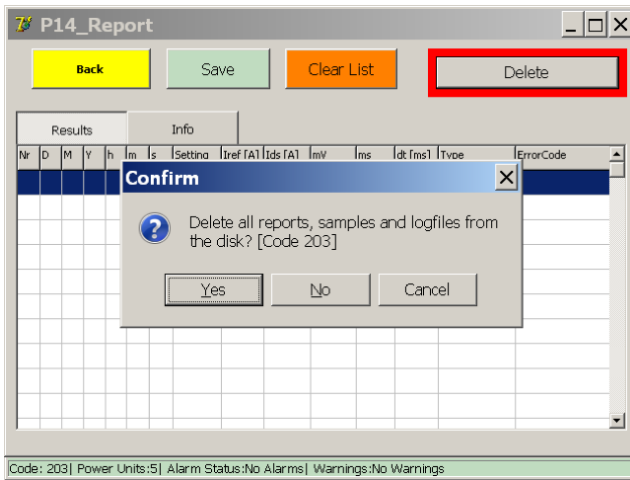
CAUTION : Please note that deleting the report files cannot be reversed. Ensure the reports have been exported successfully before deleting them.

9.12   Auto-Verification

The 'Auto-Verification' dialog can be used to verify the proper functioning and accuracy of a DC Current Generator, using the built-in current measurement.

The dialog can be opened from the start dialog, as well as from the Main Menu.

When opened, the following dialog is displayed:
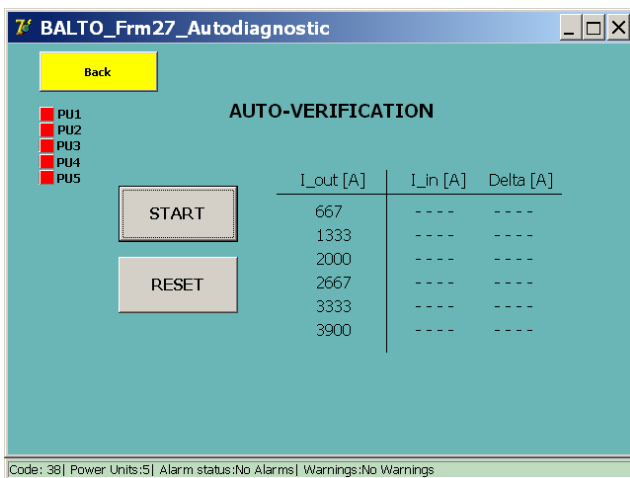
Auto-Verification can only be performed on one DC Current Generator at a time. The recommended testing procedure is to disconnect all DC Current Generators, and use the bottom slot for testing each DC Current Generator one by one for the BALTO Modular.

For the BALTO COMPACT 4000, there is only one slot. The indicators on the left-hand side indicate which slots are currently connected to a DC Current Generator.

NOTE : The slots are numbered according to the internal system configuration, and may differ from the numbering displayed on the DC Current Generator labels.

It is strongly advised to connect the DC Current Generator to a High-speed DC Circuit Breaker to perform the test. The trip level must be high enough to allow the full current range to be injected.

NOTE : If no High-speed DC Circuit Breaker with a sufficiently high trip level is available, the DC Current Generator can be connected in a closed circuit using the Power Flex-cables.

Attempting to start the Auto-Verification without a connected DC Current Generator, or with more than one connected, will display an error message with code no. 49.

Press 'START' to begin the Auto-Verification process. The system will inject various levels of current and display the measured current and measured current difference.

The results are displayed in the table as follows:
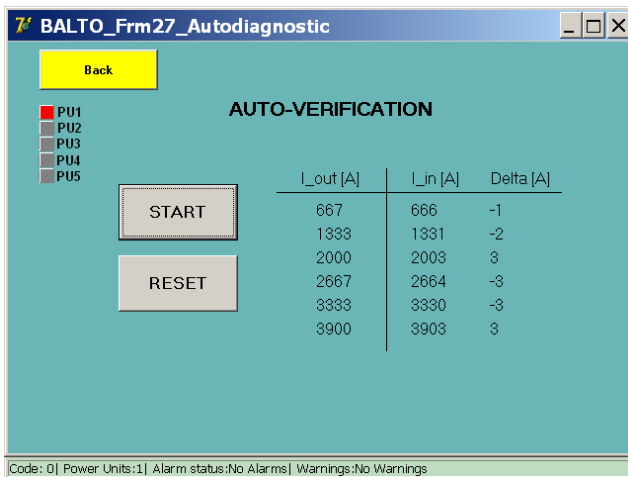
Current differences that exceed 5% of Iout are shown in red, indicating a problem with the DC Current Generator or system calibration:
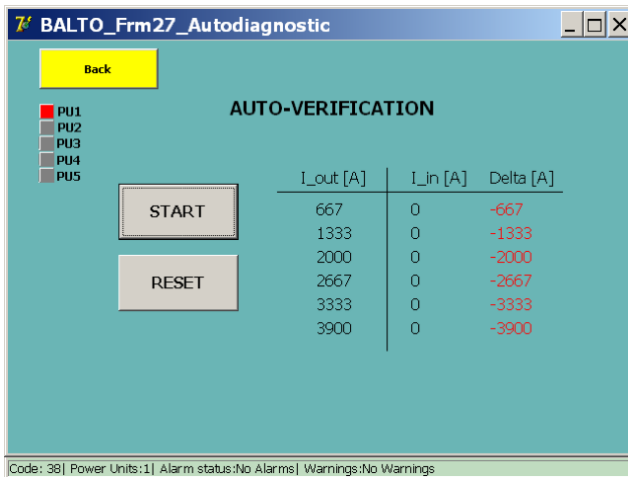
Pressing 'RESET' will clear the results table for performing another test.

9.13   Info dialog

The information dialog is opened by pressing the 'Info' button in the Main Menu.
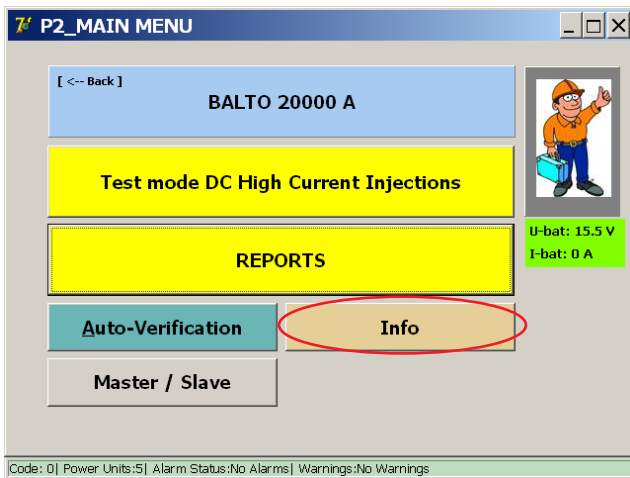
The following dialog is displayed:
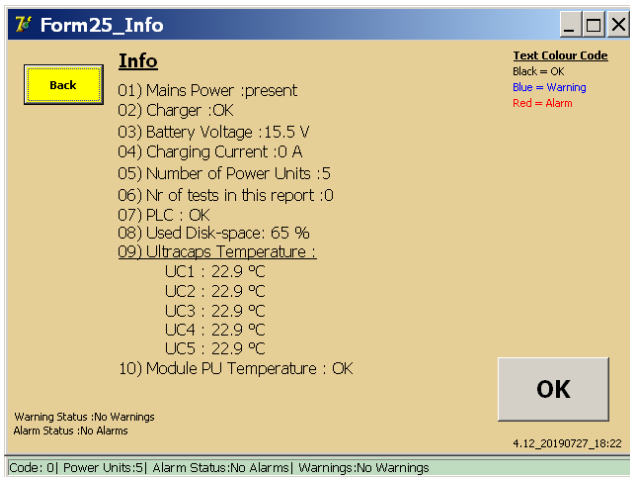
Press 'OK' to confirm any active warnings or alarms.

9.14   Exiting the BALTO application.

After testing has finished, the procedure for shutting down the system is as follows:

1. The device being tested must be disconnected or in the open position.
2. Press the 'Back' button in the Main Menu to return to the 'Start Dialog'.
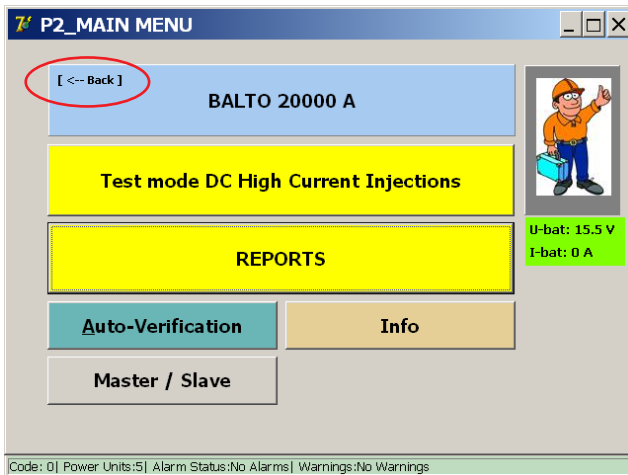
3. Press the 'EXIT' button.

4. To shut down the system, confirm by pressing 'Yes' in the displayed pop-up window:
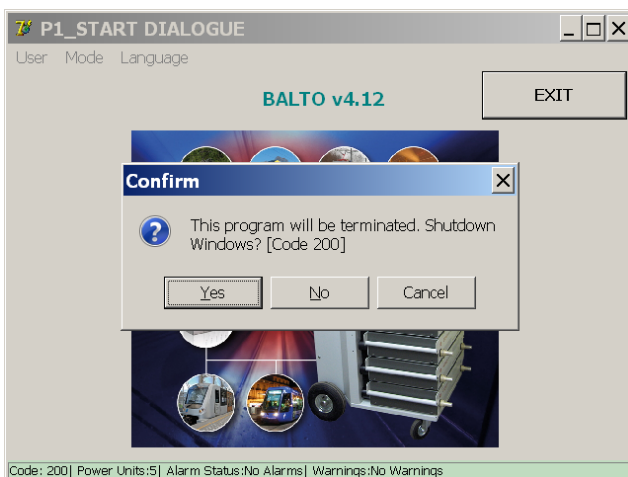
5. Please wait for the system to shut down safely. This may take up to a minute.

Important information.

The following message is displayed on the screen when the system has shut down completely:

CAUTION : The system will automatically turn off the power. Please wait for the screen to turn off and the start button to illuminate. After this, the system may be disconnected from mains power.

Once the start button is illuminated, the system can also be restarted.

If the operator chooses to not shut down the system, exiting the BALTO application will display the launcher dialog:
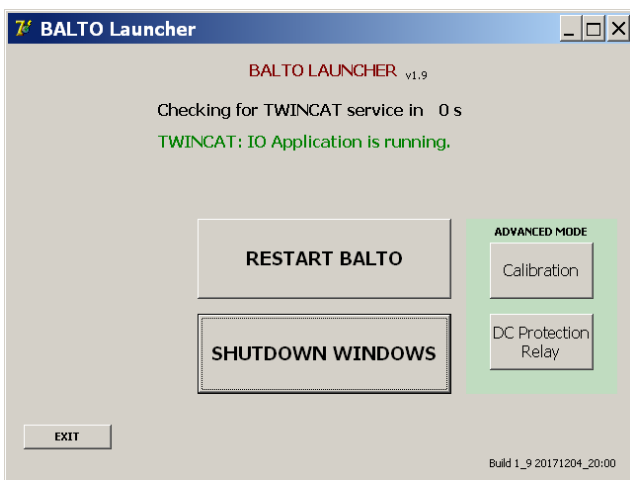
In this dialog, press 'SHUTDOWN WINDOWS' to begin shutting down the system.

ATTENTION : If the BALTO System is being shut down and disassembled for transportation, it is highly recommended to discharge the DC Current Generators using the charge/discharge tool.

Fig 39: *Discharging a DC Current Generator.*

10. Master/Slave version.

Using the 'Master/Slave' configuration, two BALTO Modular Systems can be connected in parallel to reach a maximum current of up to 40,000 A. The Control Units must be fitted with Master/Slave connectors to do this.
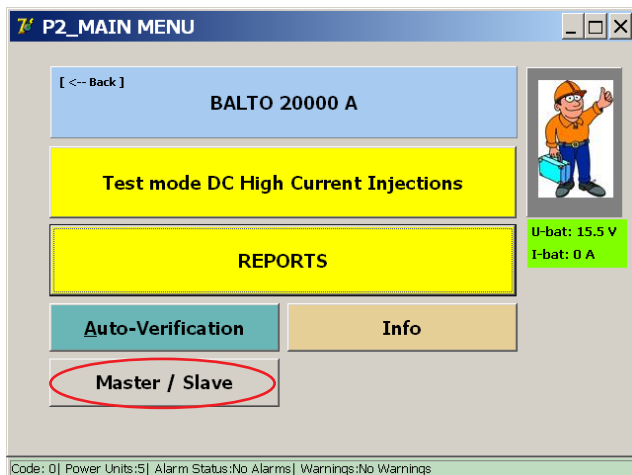
10.1 System Assembly.

Each BALTO Modular comes with a fully equipped energy compartment, i.e. with 4 rows of batteries and 5 ultracapacitors.

3 versions are available :

- BALTO Modular 24000-40 with 6 current generators
- BALTO Modular 32000-40 with 8 current generators
- BALTO Modular 40000 with 10 current generators

When used in a Master-Slave configuration, it is recommended that both BALTO Modular systems are equipped with an equal amount of current generators.

When used as separate systems, each BALTO Modular can be equipped with 5 current generators to reach the maximum current (20.000A).

10.1.1 Identification of the Control Units.

In a Master/Slave configuration, one Control Unit will act as the "Master", the other one as the "Slave" The Master Controller has a male connector on the back, the Slave Controller has a female one :

Master Control Unit.
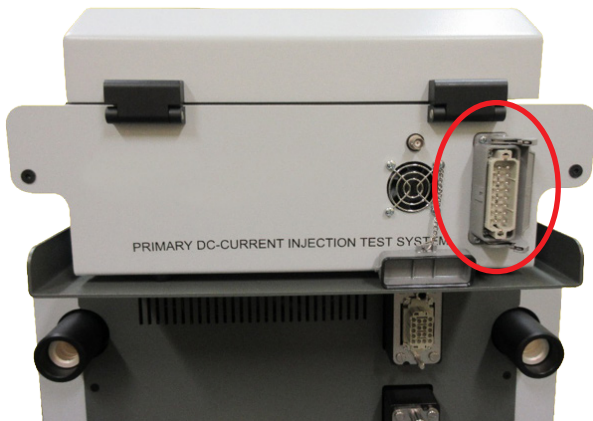
Fig 40: *Control Unit: Master.*

▪ Male connector for system cable.

Slave Control Unit.
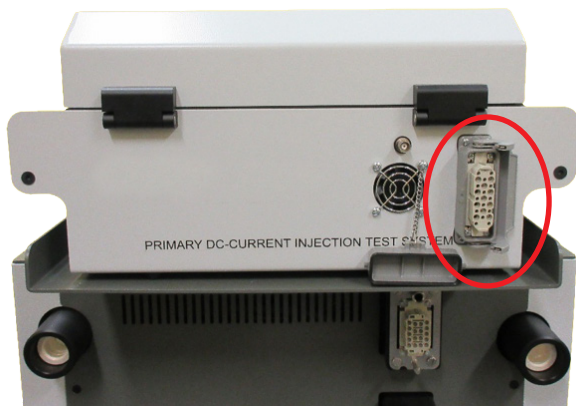
Fig 41: *Control Unit: Slave.*

▪ Female connector for system cable.

10.2   Start-up master/slave.

Boot up both BALTO Modular systems independently. When both systems are ready connect the cable between the two Control units.

Master/Slave version.
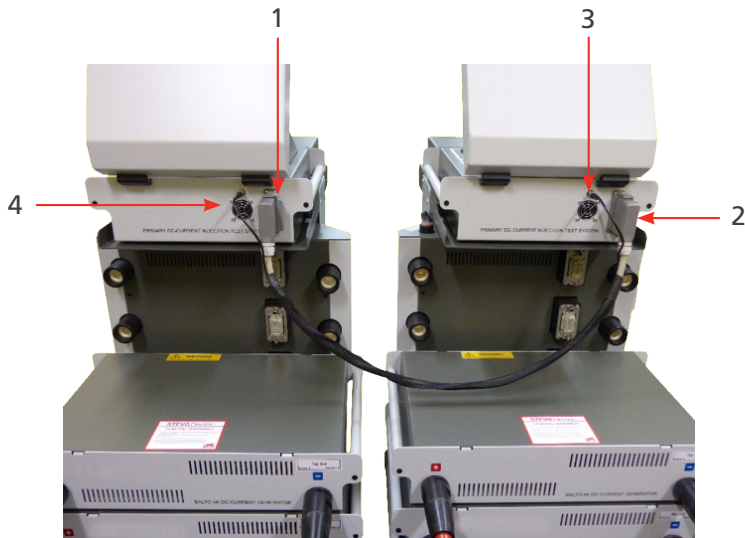
Fig 42: *BALTO Master/Slave connexion with system cable.*

Plug the connectors 1 and 2 of the system cable on the respective control units (for control and commands), and de BNC connectors 3 (for PWM).

The following images are displayed on both Control Units:

Master Control Unit.
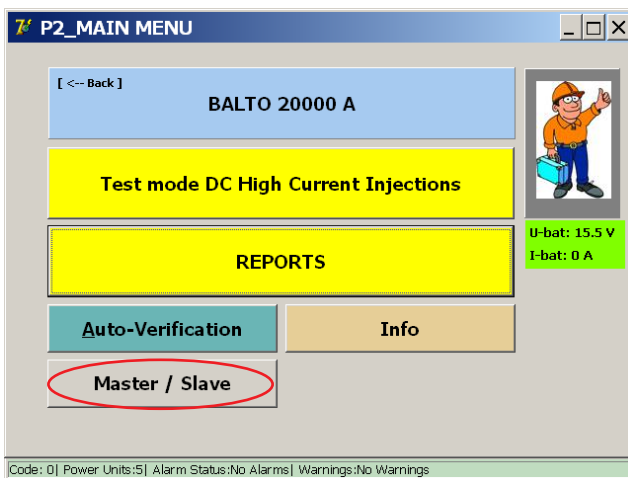
Slave Control Unit.
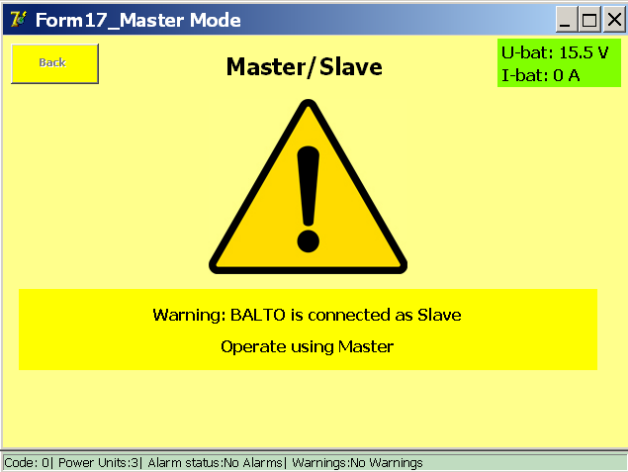
10.2.1 Operating Master/Slave.

The operation of the Master/Slave versions remains identical to all other versions. The only difference is that a maximum current of 24.00 0A, 32.000 A or 40.000 A can be injected depending on the model.

Example:
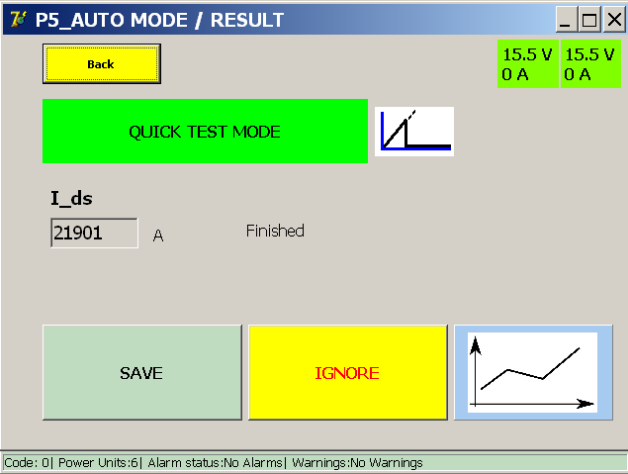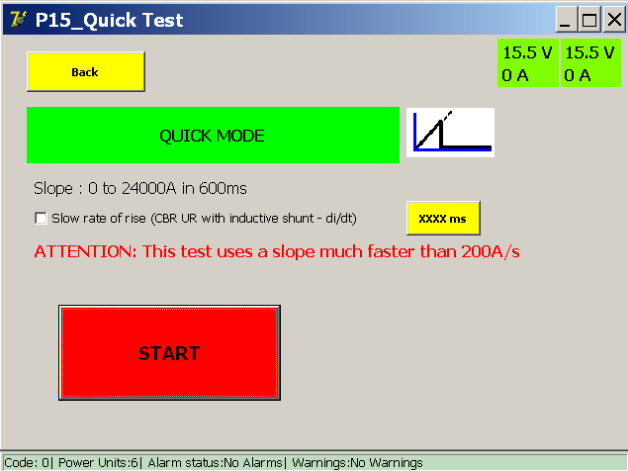
10.2.2   Status reporting.
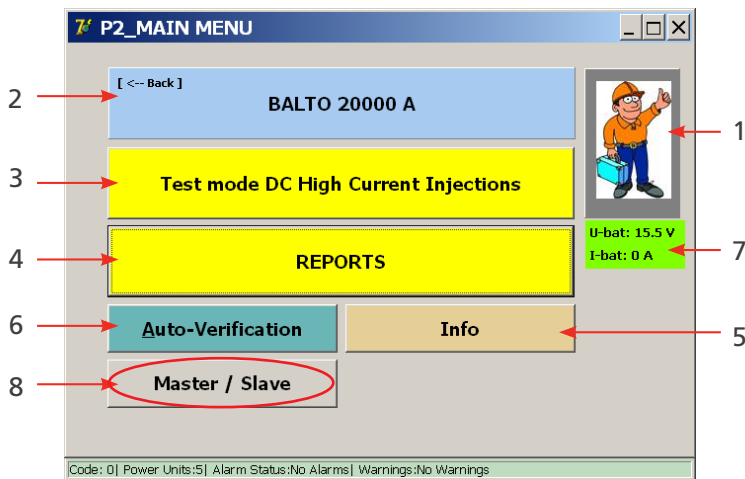
By activating the 'Master/Slave' button 8 the following information is available:
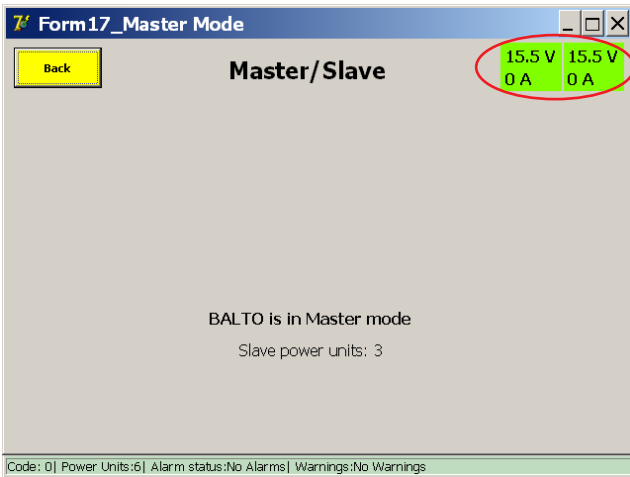
Information on the voltage and charging current 7 of the Batteries from both BALTO Modular systems is displayed. When pressing button 8 without the two BALTO Modular systems connected together, the following screen will be displayed :

10.3 Info Master/Slave.

From the Main Menu, press the button 'Info' to go to the information sub-menu.
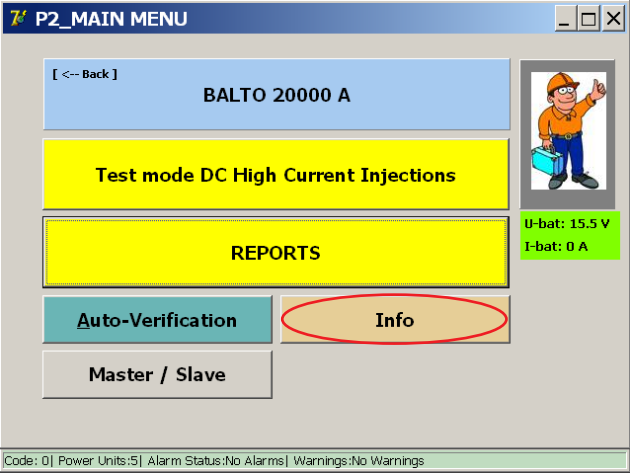
The following information is displayed:
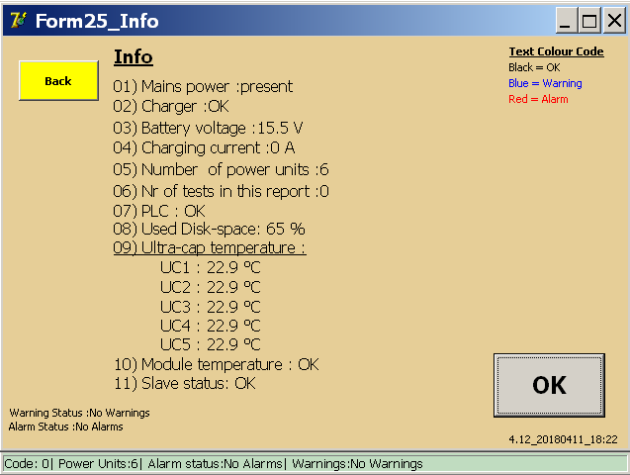
The extra line - position 11 - gives the information on the Master/Slave Status.
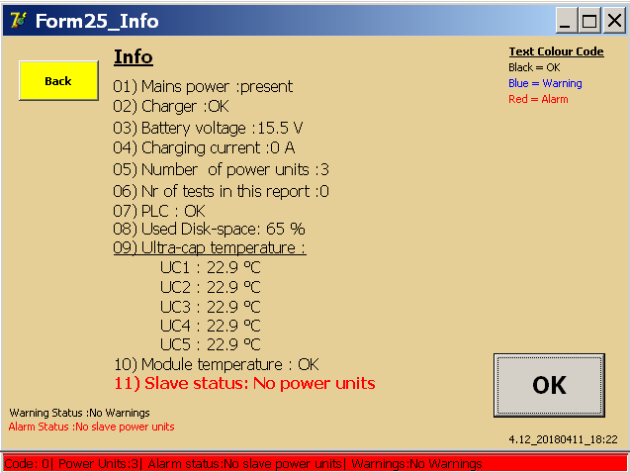
The connected Slave BALTO System has no Power Units (Current Generators) placed in the Support Carriage.

- All tests are blocked.

Master/Slave version.
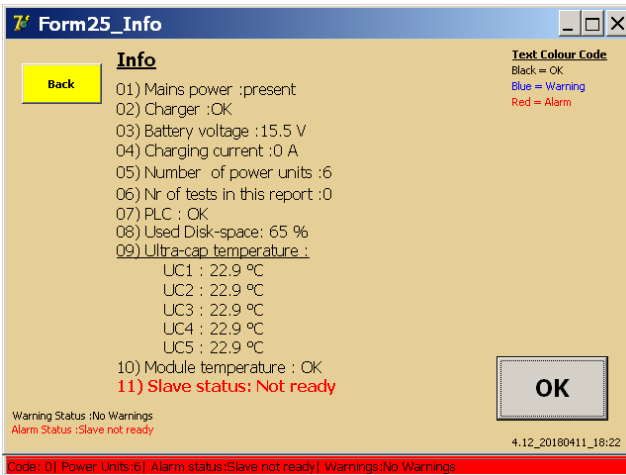
The Slave BALTO system hasn't finished the start-up procedure yet. Disconnect the cable between the two BALTO Modular systems and start them up properly.

- All the tests are blocked.
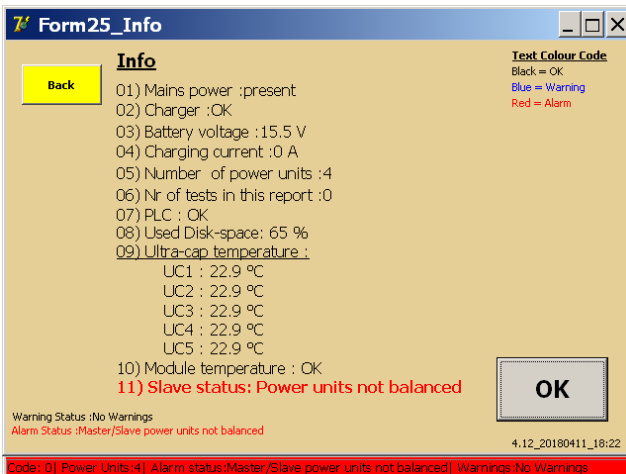
It is recommended to have an identical amount of Power Units on both the Master and the Slave system. A maximum deviation of one Power unit between both systems is allowed. If the difference is more than one Power Unit, all tests will be blocked.

A difference of 1 Power Unit is allowed, for example:

Master 3 - Slave 2

Master 3 - Slave 4

However, use of an asymmetrical amount of Power Units may have an effect on the lifetime of the batteries.
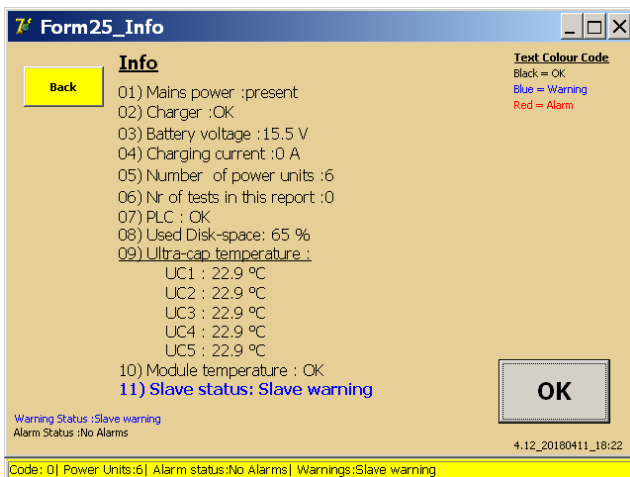
The Slave BALTO System is in a warning status. To have a view on the nature of the warning, please consult the display of the slave BALTO system. All tests are permitted.
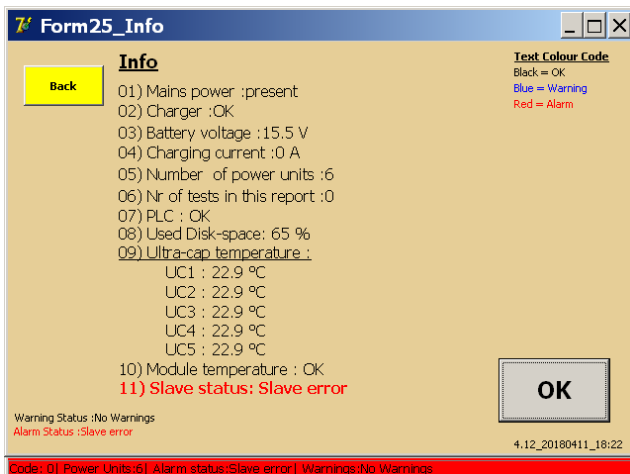
The Slave BALTO System is in an Error Status. To have a view on the nature of the warning, please consult the display of the Slave BALTO System.

- All tests are blocked.
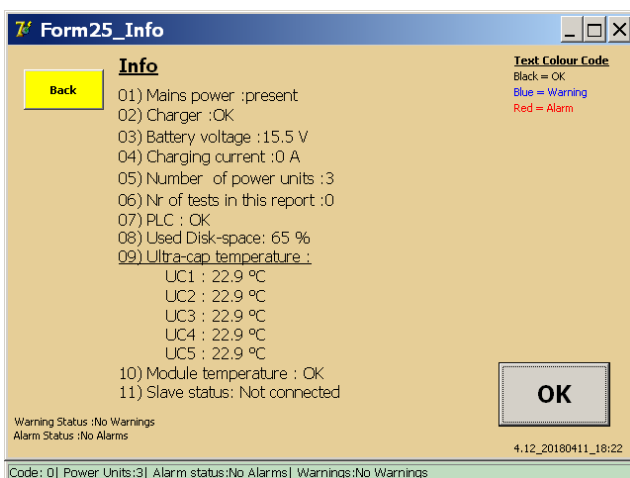
There is no connection between the Master and the Slave.

'OK' - With this button confirm warnings and alarms.

10.4   Stop master/slave.

To stop the master/slave application, go back to the main menu on the Master and disconnect the cable between the two systems.

11. Secondary Injection.

11.1 Introduction.

The BALTO PROTECTION TEST module can be used for performing secondary injection testing, i.e. testing of the protective relay connected to the DC High Speed Circuit Breaker.

Note that a software licence key is required to enable the functionality. Make sure you have the software key at hand when starting the secondary injection application. Insert the key when prompted for it.

11.2 Principle of operation.

The breaker itself can only trip on its built-in primary release mechanism. This mechanism opens the breaker when the set current (I_{ds}) is exceeded.

Very often a secondary release mechanism is used. This is done by adding a protective relay to the system. The protective relay receives the information of the current going through the breaker by means of a shunt. The algorithms running in the protective relay can decide at any moment depending on the current pattern to trip the breaker.

Typical trip algorithms are :

- The current stays too long above a certain level, e.g. 10 seconds higher than 5.000 A
- A current rise which is too high at a certain point in time, e.g. 50.000 A/s

In order to test the protective relay, it should be disconnected from the breaker. The shunt input is replaced by the output of the BALTO PROTECTION TEST module, in this way the BALTO can simulate the output of the shunt. A trip contact of the protective relay is fed into the trip input of the BALTO PROTECTION TEST module. In this way the BALTO can register the trip command of the protective relay.

On the next page it is depicted how the protective relay is connected in a live environment and in conjunction with the BALTO PROTECTION TEST module.
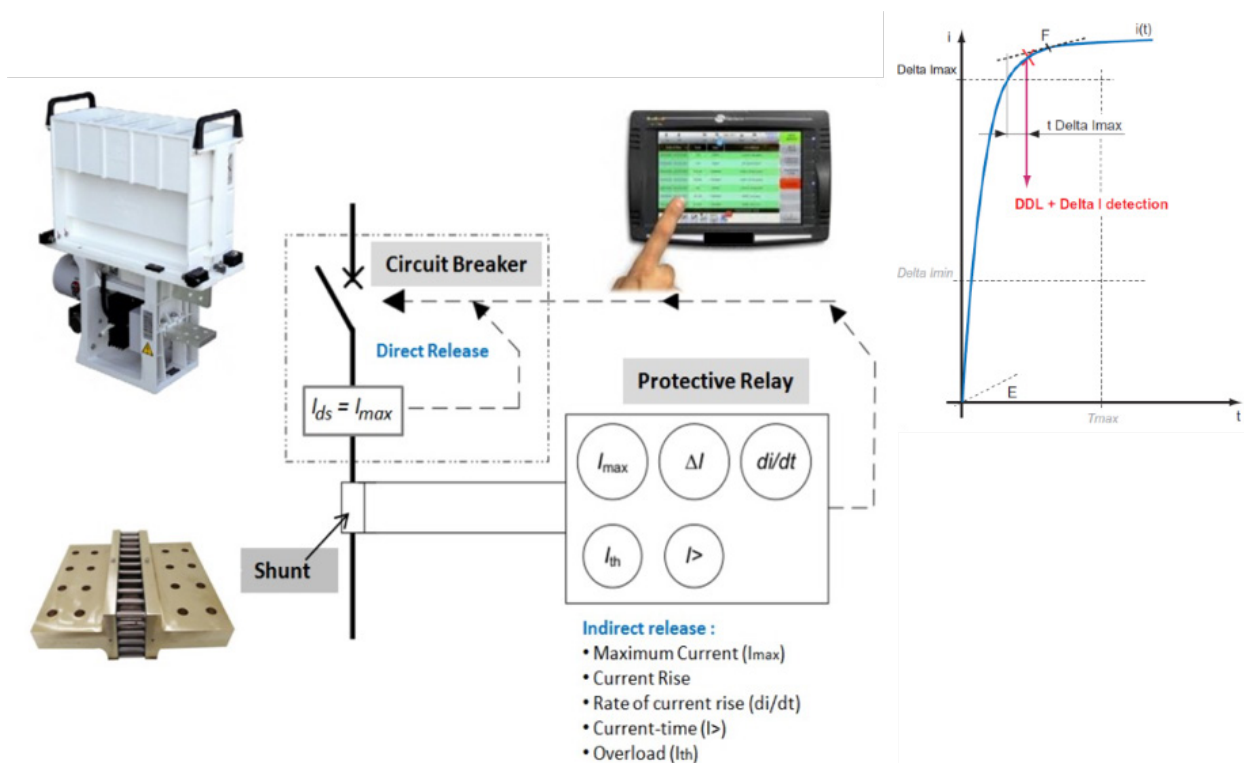
Secondary Injection.
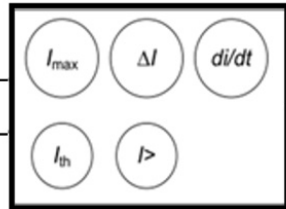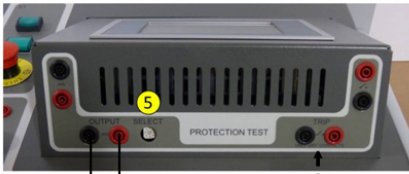
Fig 43: *Connection with PROTECTION TEST module of BALTO Modular.*
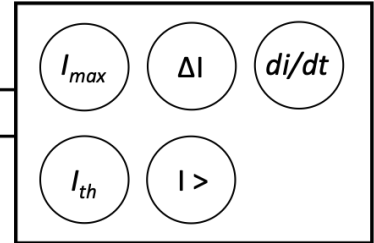
Connection with PROTECTION TEST module of the BALTO COMPACT 4000

11.3   DC Protective Relay Interface.

The PROTECTION TEST module is equipped with outputs for testing DC protective relays.

Output: Source of simulation errors input for DC Protection Relay.

1. **mA:** - 20 mA / +20 mA or +4 mA / +20 mA (1)

2. **mV**: Selection between 60 mV up to 10 VDC (2)

Input - TRIP: Signalling contact from the DC Protection Relay.

3. Trip (3) - Signalling trip contact.

4. Trip (4) - Spare trip contact.

Fig 44: *PROTECTION TEST module of the BALTO Modular*

PROTECTION TEST module of the BALTO COMPACT 4000

The selection of the output level is done with the selector switch 'SELECT'

The different settings are as follows:

Positions	Values
0	-60 mV / 60 mv
1	-90 mV / 90 mV
2	-150 mV / 150 mV
3	-300 mV / 300 mV
4	-500 mV / 500 mV
5	-1 V / 1 V

6	-5 V / 5 V
7	-10 V / 10 V

11.4   Booting up secondary injection

To prepare the BALTO Modular for secondary injection, two methods can be used :

1. Remove all the current generators from the BALTO
2. Remove connectors 2 and 3 as depicted below
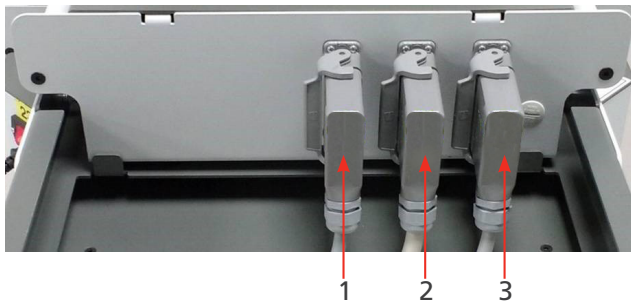
Cable 1 is required to provide the power to the Control Unit.

It is possible to use the Control Unit without a connection to the BALTO Modular. In that case a specific power cable is required (available as an accessory). The cable is depicted below.

To prepare the BALTO Compact for secondary injection, remove the Power Unit (Current Generator) as depicted below.

The start dialog will indicate that the Secondary Injection program is running.

Secondary Injection.
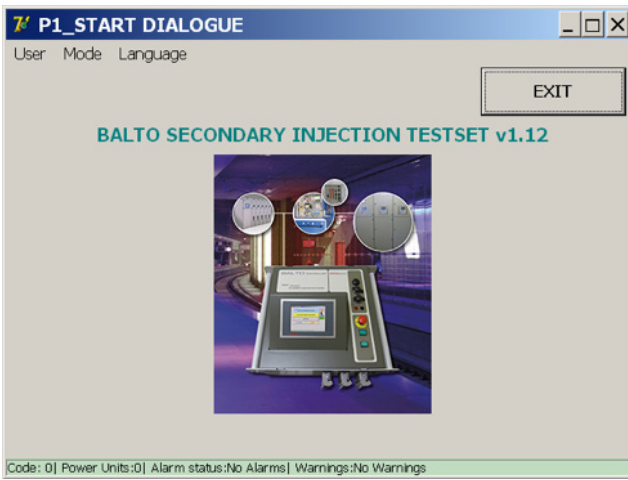
11.5 Main Menu.

From the 'Start Dialog', the application for the test modes will be activated by touching the image.
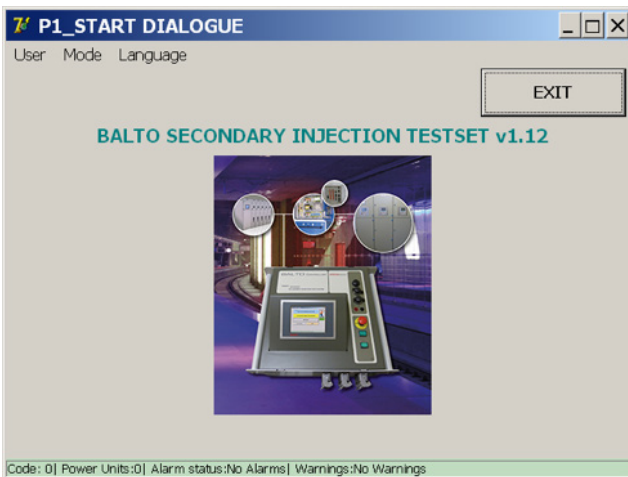
The 'Main Menu' will be displayed …
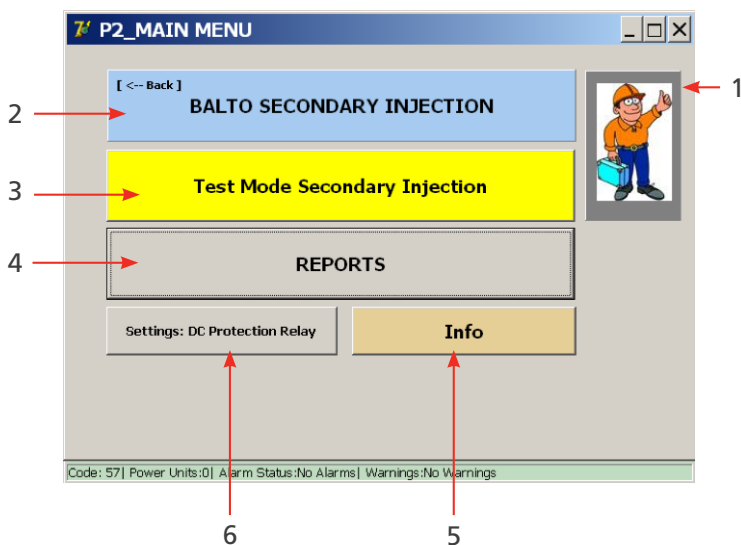
In this Main Menu, several sub-menus can be selected:

Item	Description	Item	Description
1.	Activate Safety Mode	4.	Measurement reports: ■ Displayed in grey: no measurements recorded. ■ Displayed in yellow: contains measurements.
2.	Information about the BALTO, the operator will return to the 'Start Dialog' when selecting this option	5.	'Info' dialog regarding the operating conditions
3.	Access to the various test modes: Quicktest Mode, Auto Mode and Manual Mode	6.	Settings for the DC Protective Relay to be tested

11.5.1   Tuning the BALTO PROTECTION TEST module for a specific relay.

Concerning the configuration off the outputs and feedback, please activate the button 'Settings: DC Protection Relay'.

Current output.
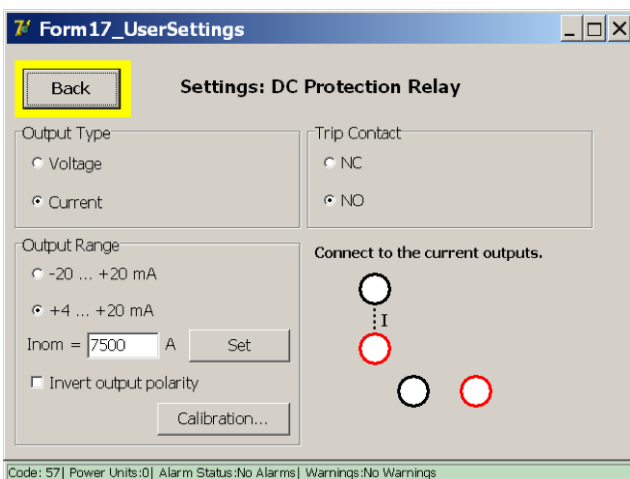
■ Selection of output type (current or voltage).

■ Selection of output range.
Invert output polarity by ticking the check box.

■ Input the value Inom.

The output current from the BALTO PROTECTION TEST module should be in the range expected by the DC Protective Relay.

Example:

Inom = 7.500 A

Output Range			Output Range		
- 20 mA	0	+ 20 mA	+ 4 mA	+ 12 mA	+ 20 mA
- 7.500 A	0	+ 7.500 A	- 7.500 A	0	+ 7.500 A

■ As feedback - trip contact - an auxiliary contact from the DC Protection Relay is utilized, select between:
NC - Normal Closed or NO - Normal Open.

Secondary Injection.

Voltage output.
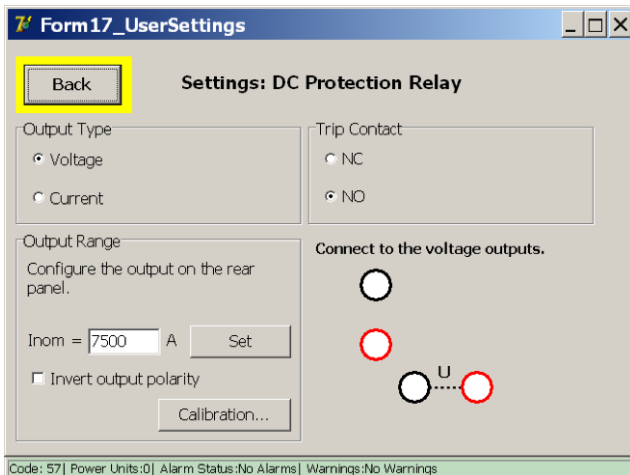
- Selection of output type.
- Selection of output range.
  Invert output polarity by ticking the check box.
- Input the value Inom.

The output voltage from the BALTO PROTECTION TEST module should be in the same range as expected by the DC Protective Relay.

Recalibrate Output.

Before executing tests, it is appropriated to recalibrate the output. By activating the corresponding function, the next dialog will be displayed.
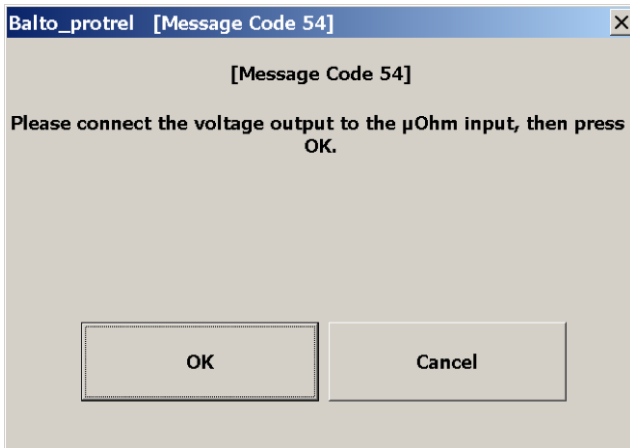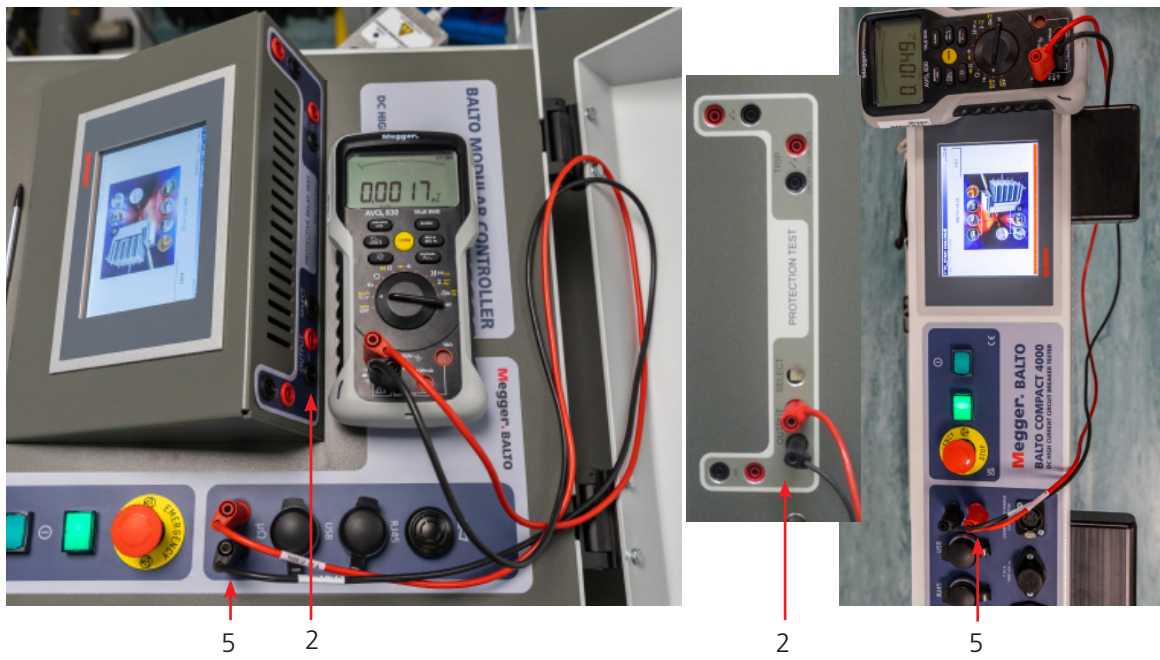
Fig 45: *Connection for recalibrate output.*

Output - mV (2) connect to the External measurement (5), control with a Volt-meter.

Fault message.

Please, check the connections and the polarity.

Calibration result.

Example:

The value of the shunt is 6.000 A / 90 mv and the max value of the expected current is not higher than 7.500 A.

Inom = 7.500 A

- As feedback - trip contact - an auxiliary contact from the DC Protective Relay is utilized, select between:
  NC - Normal Closed, or
  NO - Normal Open.

The connection to the voltage output is automatically done.

- Adjust output range
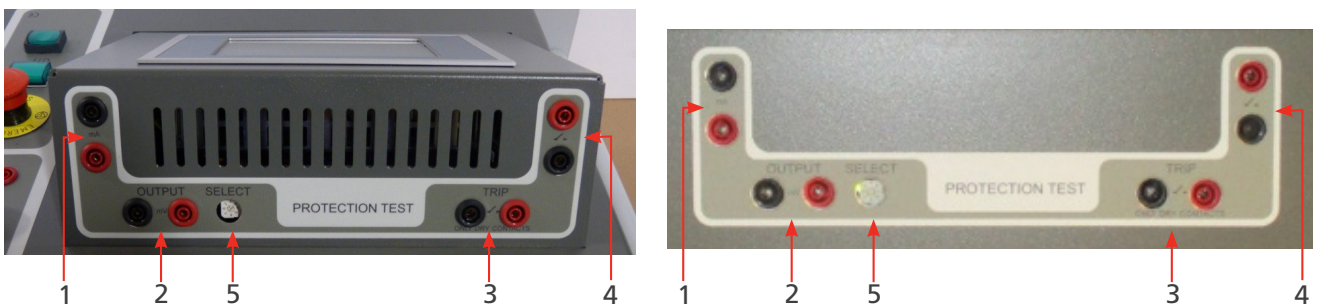
Fig 46: *Adjust output range.*

The selection of the output level is done with the selector switch 'SELECT' (5)

In our example, the selector switch is in position 1 (90 mV).

11.6   Testmodes.

After activating the key 'Test Mode Secondary Injection'
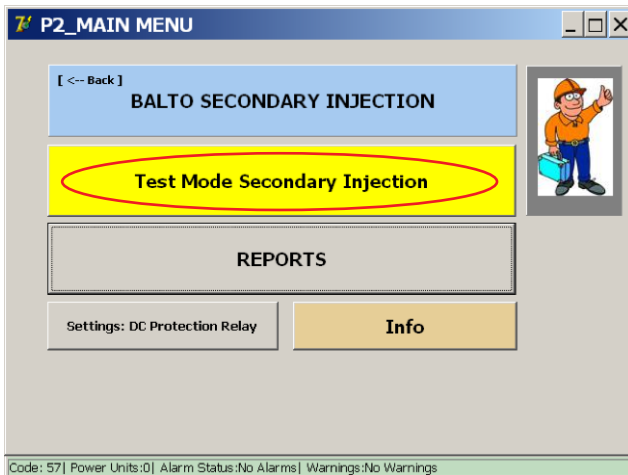
The dialog box 'P3_Selection Testmode' will be displayed:
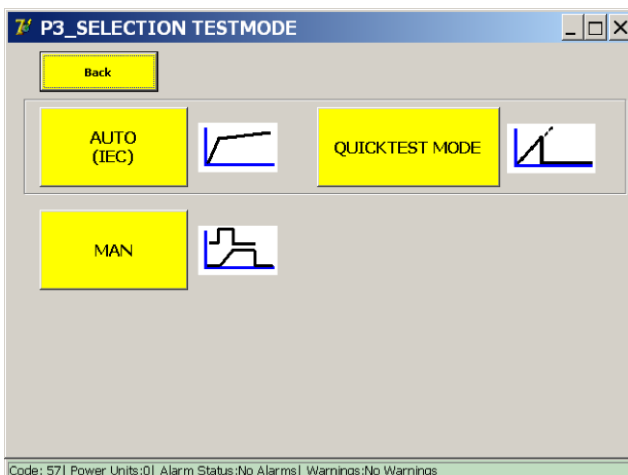
This screen is identical to the screen encountered during primary injections. Most of the tests conducted during primary injection are however less relevant for secondary injection. One can still perform e.g. the Quicktest or IEC test but in-depth testing of the protective relay should be done with the "Protection Relay Test" in Manual mode.

The test capabilities available under "Protection Relay Test" are much more elaborate compared to the primary injection tests.

11.6.1   Manual Mode.

DC Protection Relay Test.
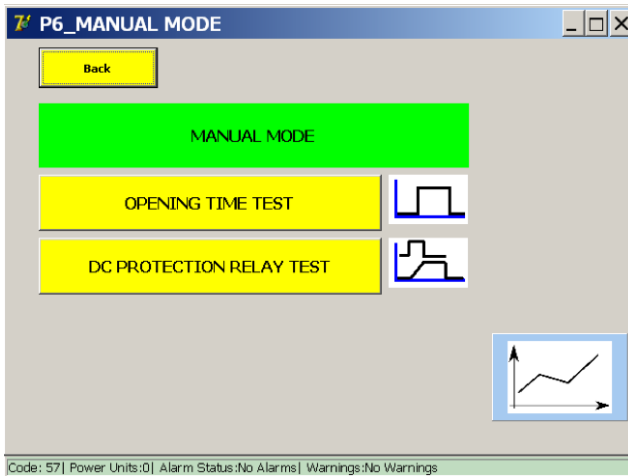
Select in the dialog box 'Manual Mode' the function 'DC Protection Relay Test'. The following dialog will be displayed:
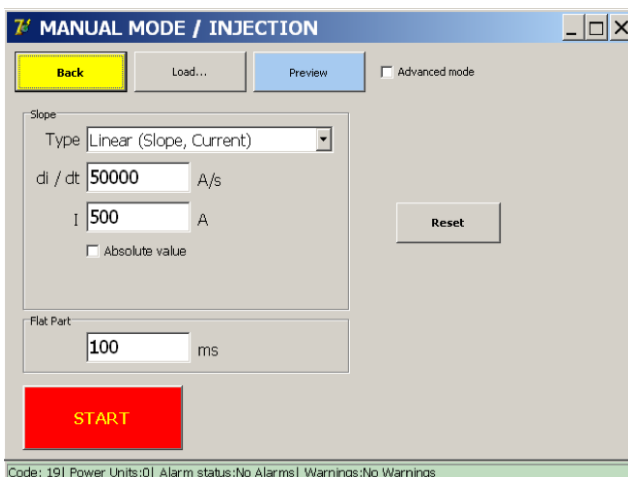
To perform tests, the operator needs to enter various values that correspond to the function of the protective relay that needs to be tested.

Slope types.

Those tests can be configured for a linear or exponential injection.
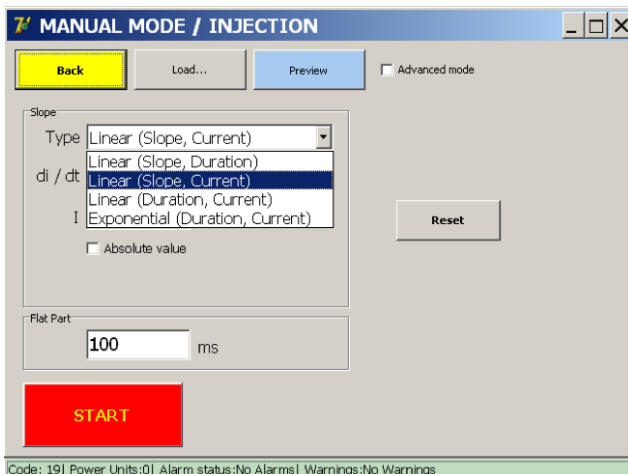
Several types can be selected :

- Linear (Slope, Duration).
  - Input parameters : di/dt - dt
- Linear (Slope, Current).
  - Input parameters : di/dt - I
- Linear (Duration, Current).
  - Input parameters : dt - I
- Exponential (Duration, Current).

Parameters.

The input parameters depend on the selected slope type.

Parameter:	Description:	Unit:
di/dt	The slope used for a linear injection.	A/s
dt	The duration used for a linear injection.	ms
ΔI	The magnitude of the injection.	A
Absolute value	If this is checked, then the current will rise to exactly 'I'. Otherwise, 'I' + the bias current.	
Bias current	The injection starts with a bias current (standard 100 A)	
T	The rate of increase used for an exponential injection. 'tau' is the time it takes to reach 63,2% of 'I'.	ms
Flat Part	The time to hold the final current after the injection.	ms

Principle of measurement.

Linear injections, example :

Example:
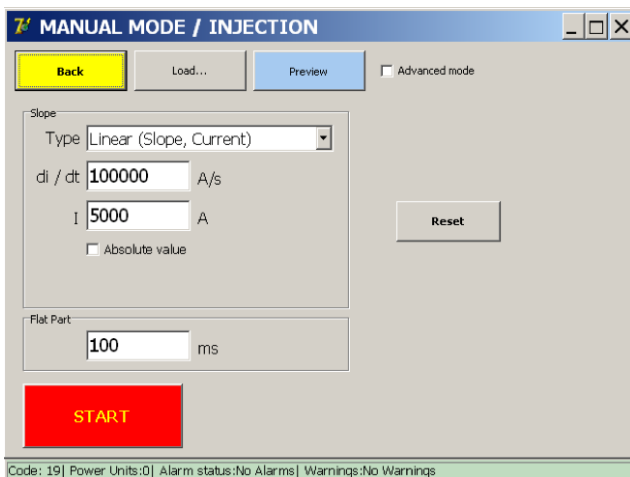
The key 'Preview' from the dialog displays the dialog 'P26_Graph' with a view on the injection graphic.

Secondary Injection.
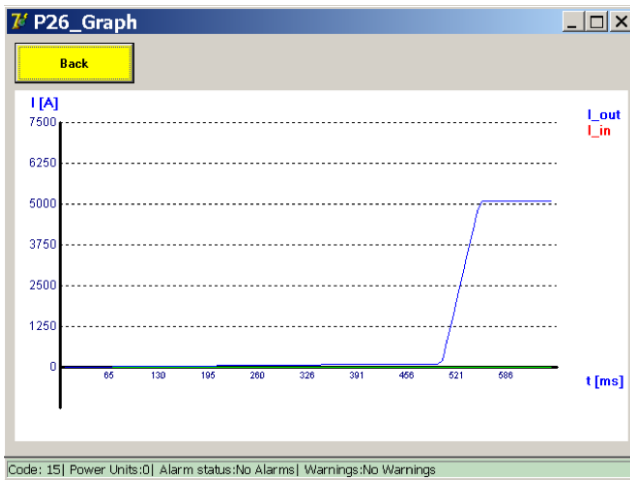
Principle of measurement.

Exponential injections, example :

Exponential injections are configured using Tau and I.

These values can either be entered directly, or their theoretical values can be computed by the BALTO from line characteristics by activating 'Calculate Tau'.

Enter data in this dialogue and active with the button 'Calculate', then 'Apply'.

For an explanation of the parameters, check the description in the primary injection section.

11.6.2 Advanced Mode.

In 'Advanced Mode', the operator has the possibility to combine different curves. When selecting 'Advanced Mode' the following form is displayed:

Adjust Ibias

The bias current can be adjusted as follow:

- Move the scrollbar to the top (1)
- Enter the current I (2)

Advanced Mode adds the following functionality:

- The ability to design an injection with multiple sequenced steps.
- The ability to save a designed injection

Multiple step injections are configured by pressing the 'Add Step' button until the desired number of steps is reached.

The scrollbar is used to switch between steps.

To remove a step, press the 'Remove Step' button. To revert to the initial configuration, which contains the default bias step and an empty step, press 'Reset'.

Secondary Injection.

An example of a multiple step injection can be seen below, using the following input parameters:

Example:
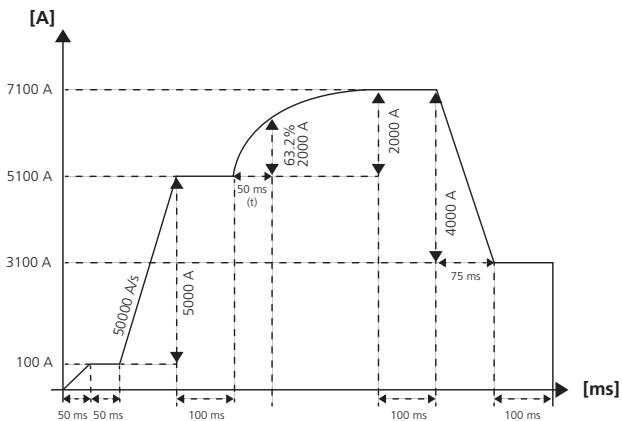
- ◼ Step 1: Linear (default bias)
  - ▪ dt = 50 ms
  - ▪ I = 100 A
  - ▪ flat part = 50 ms
- ◼ Step 2: Linear
  - ▪ di / dt = 50000 A/s
  - ▪ I = 5000 A
  - ▪ flat part = 100 ms
- ◼ Step 3: Exponential
  - ▪ tau = 50 ms
  - ▪ I = 2000 A
  - ▪ flat part = 100 ms
- ◼ Step 4: Linear
  - ▪ dt = 75 ms
  - ▪ I = -4000 A
  - ▪ flat part = 100 ms

Results of advance configuration.

Press the 'Preview' button to get a graphical representation.
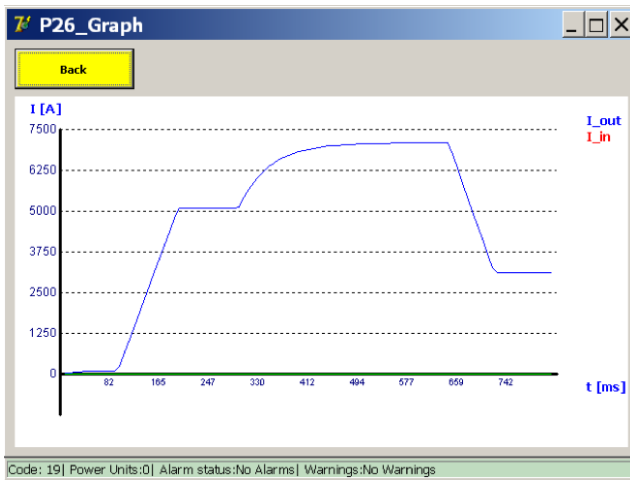
This example contains a negative 'I' value which reduces the output. Negative 'I' values are valid for both linear and exponential steps. Configured injections can be saved as a new pre-configured test by pressing the 'Save As' button. Once a test is named, the 'Save' button can be used to save any changes to the pre-configured test.

Pre-configured tests are saved on the file system and remain present even after a shutdown and reboot of the BALTO System.

Test result.

Test results are displayed in the following dialog:
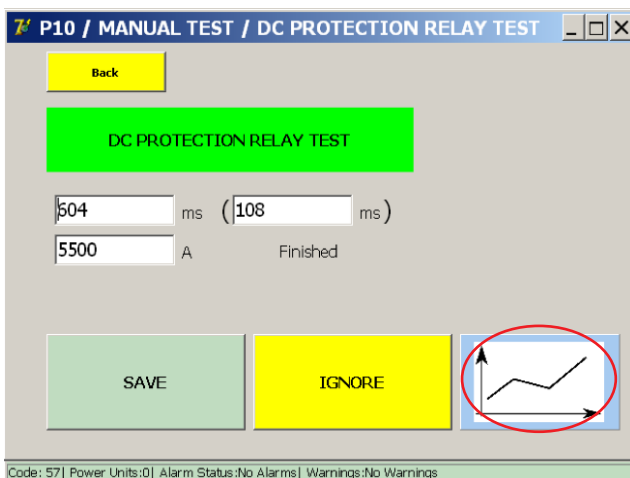
This dialog displays whether the test resulted in a trip.

If so, it displays at what time and current level the trip occurred

The graph key displays the results of the performed measurements.

Secondary Injection.
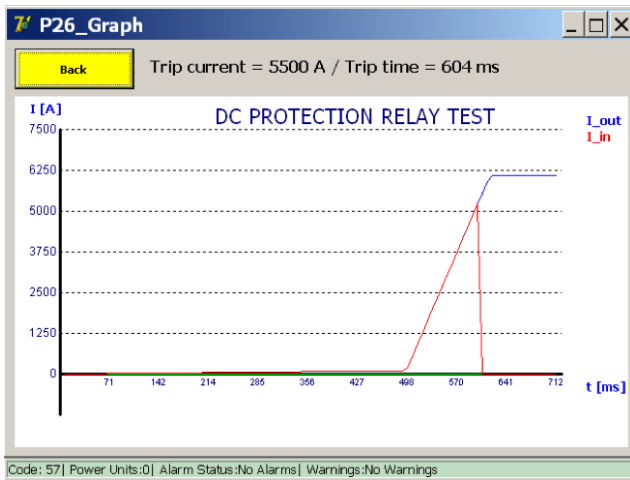
Pre-configured tests.

Previously designed test configurations can be loaded by pressing the 'Load…' button.

Pressing the 'Load…' button presents the following screen :
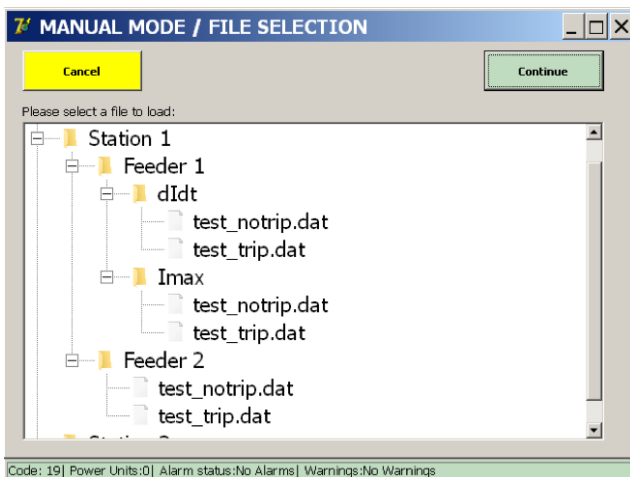
By selecting a test and pressing 'Load Selected', the configuration will be loaded into the test parameters form.

In this example, tests have been pre-configured by an equipment specialist for several feeders and protection functions.

This allows a user to simply select a test and run it, rather than entering the parameters manually each time.

Reports.

From the main menu, activate the sub menu 'Reports'. The report handling is identical to the report section for primary injections.

Info.

From the Main Menu, press the button 'Info' to go to the information sub-menu.

The following screen will be displayed.
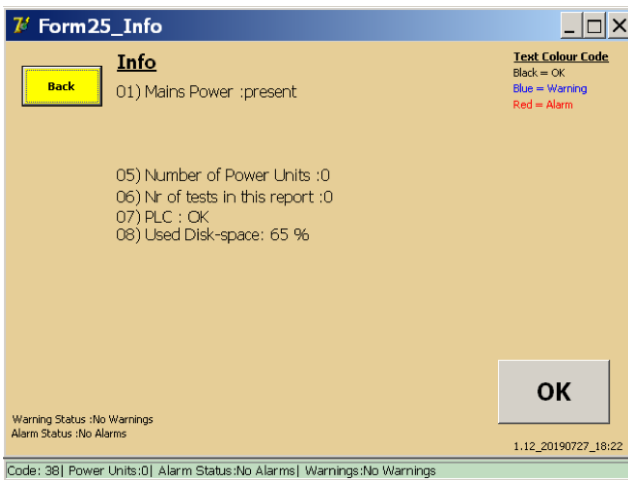
A red message means that there is an active alarm that is blocking any further secondary injections.
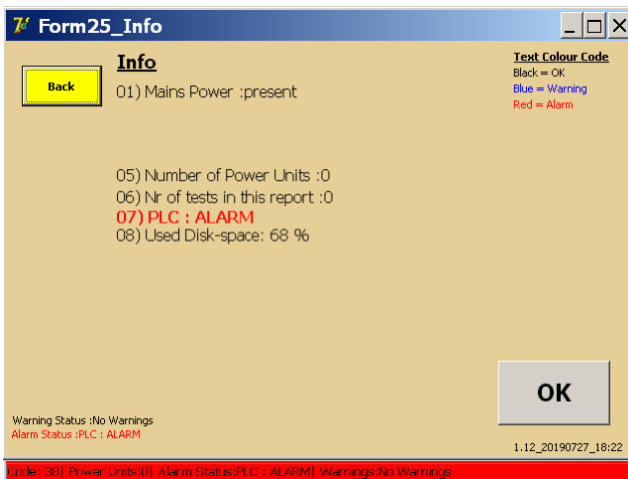
For more information, .

12. Calibration

The BALTO Calibration Tool is available as a separate product and allows the operator to re-calibrate the device. The tool consists of:

- Calibration sensor (LEM 20,000 A / 10 VDC).
- Calibration sensor power supply
  (230 VAC / 50 Hz or 120 VAC / 60 Hz to ±15 VDC).
- Set of connecting cables.

12.1 Preparations

NOTE : It is recommended to charge the BALTO System during 48 hours before starting the calibration procedure.

The BALTO System must be connected to a circuit to perform re-calibration. It is recommended to use a High-speed DC Circuit Breaker with a sufficiently high trip level for this.

To measure the flowing current, the calibration sensor (LEM 20,000 A / 10 VDC) must be inserted into the circuit by running the Power Flex-cables through it, as shown below:

Fig 47: *Sensor for calibration.*

- Ensure the sensor's arrow indicator matches the direction of current (pointing from positive to negative).

Connect the measurement cables to the system µΩ inputs of the Control Panel.

12.1.1 Calibration sets

System calibration is performed separately for each configuration of the DC Current Generators. Each calibration is known as a 'Calibration Set'.

A configuration is defined as the number of connected DC Current Generators. There is a calibration set for one connected DC Current Generator, a set for two connected DC Current Generators, and so on. A BALTO Modular System contains up to 5 calibration sets. The BALTO COMPACT 4000 has only 1 calibration set.

NOTE : It is important to always use the same DC Current Generators - and in the same order - used during calibration for each configuration.

When re-calibrating, it is possible to only re-calibrate a single set. Though, re-calibrating all sets is advised to obtain a complete system re-calibration.

For performing a complete system re-calibration, the following procedure is advised:

- Disconnect all but one DC Current Generator.

- Perform the calibration.

- Add the second DC Current Generator (for a total of two connected DC Current Generators) and perform the second calibration.

- Add the third DC Current Generator (for a total of three connected DC Current Generators) and perform the third calibration.

- Repeat until all configurations have been calibrated.

- Ensure the DC Current Generators are numbered so that they are always connected in the same order.

12.1.2 Precautions

Important information.

CAUTION : It is strongly advised to connect the DC Current Generators to a High-speed DC Circuit Breaker to perform the calibration.

If no High-speed DC Circuit Breaker with a sufficiently high trip level is available, a closed circuit can be created using the Power Flex-cables instead.

CAUTION : The tools for calibration must be removed after calibration has been completed. Specifically:

- Remove the calibration sensor from the circuit.

- Remove the measurement cables from the µΩ input.

12.2 Calibration software

12.2.1 Accessing the application

The operator can access the calibration software from the launcher dialog, which appears on system start-up:
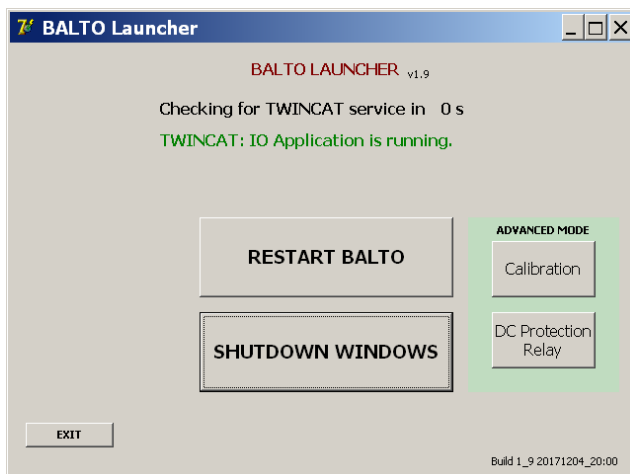
To open the calibration software, press the 'Calibration' button under 'Advanced Mode'.

If the main BALTO application has already started, it must be closed to reach the launcher dialog. Please consult the chapter 'Operation' - section 'Exiting the BALTO application'.

When asked to shut down Windows, press 'No'.

12.2.2 Operation

Access conditions

After launching the calibration software application, the following dialog is displayed:

Calibration
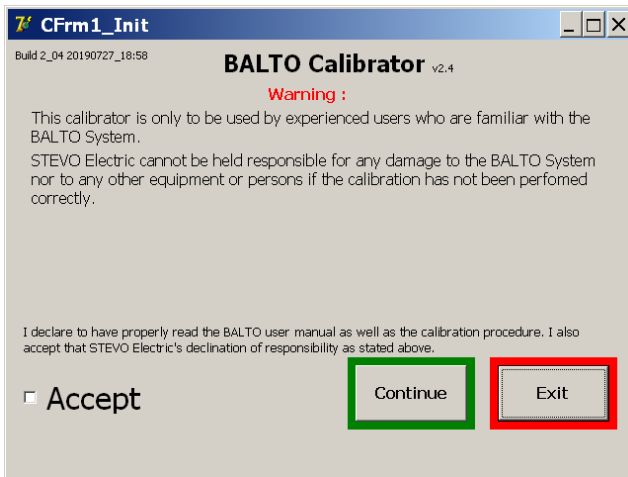
WARNING : The calibration procedure should only be performed by trained personnel.
Megger cannot be held responsible for incorrect use of the device or any property damage and/or injuries caused as a result.

To accept the calibration software conditions, press the 'Accept' checkbox.

The conditions must be accepted to be able to continue.

Password

When pressing 'Continue', the password dialog will be shown:
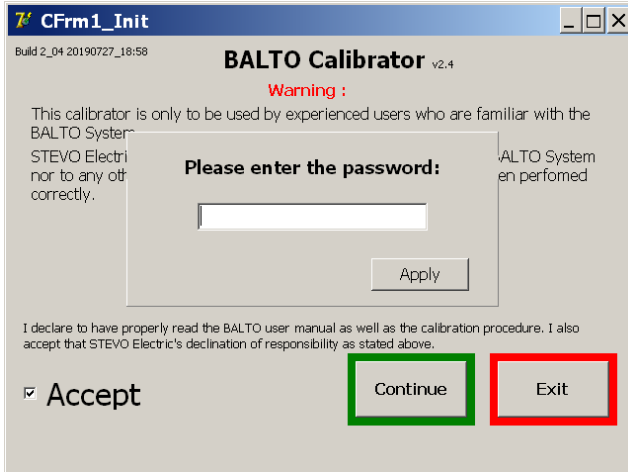
Press the input field to open the virtual keyboard. After entering the password, press OK to confirm the text entry, and 'Apply' to continue.

After the password has been entered, the check status dialog will be shown

Status information

The check status dialog provides an overview of the current calibration and system status.
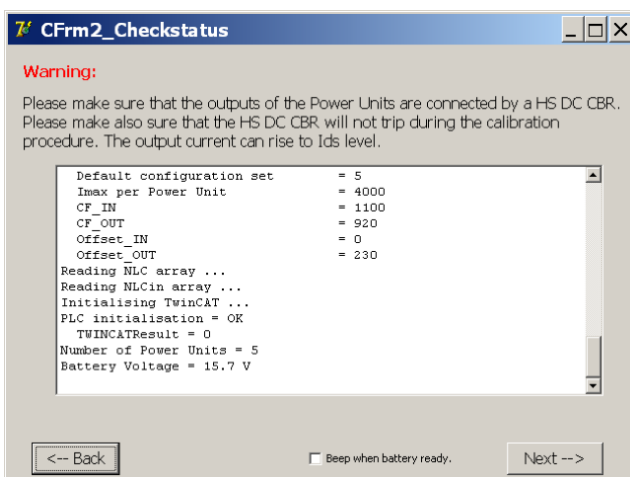
The 'Beep when battery ready' option can be checked to enable an audible beep every time the battery charge indicator turns green and the next injection can be started.

Continue by pressing 'Next'.

Important information

The calibration procedure consists of 6 stages. The progress bar at the bottom of the screen indicates the current stage.

NOTE : The battery voltage and charge current are displayed in the top-right corner of the screen. The colour indicates the battery status:

- Green: battery voltage is normal, fully charged.
- Orange: battery voltage is normal, still charging. (I > 5 A)
- Red: battery voltage is low. (U < 13 V)
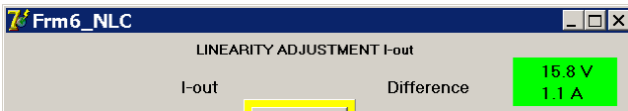
Calibration steps can only be performed when the battery indicator is green.

Exporting calibration reports

The calibration reports are stored in PDF format.

To export the calibration reports, a USB stick can be connected to the USB interface insert on the Control Panel. All calibration reports stored on the system will be automatically copied.

To ensure the latest calibration reports are exported, perform all the required calibrations first and then insert the USB stick.

Example:
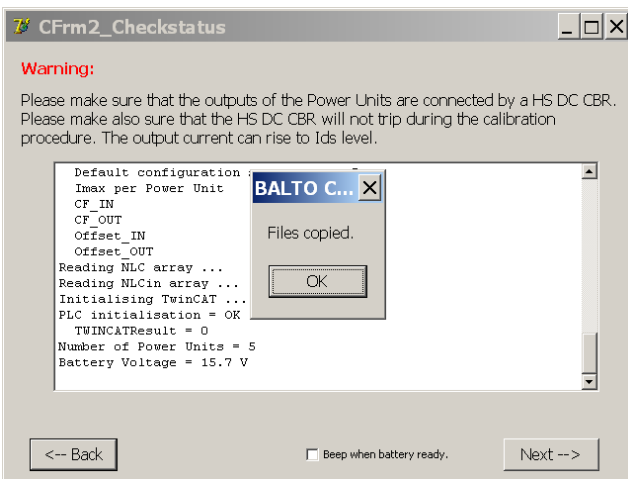
The calibration reports are only created if the operator presses 'Save Report' at the end of the calibration.

NOTE : Please note that the BALTO System only saves the last calibration report for any given calibration set. Any older calibration reports are overwritten.

12.2.3   Step 1/6 – OFFSET CALIBRATION
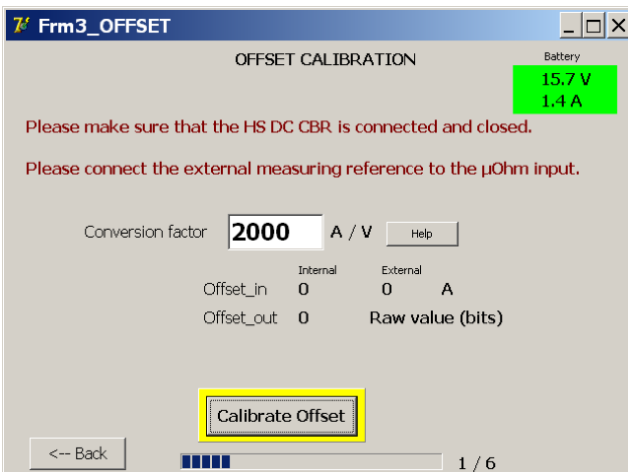
This dialog performs the offset calibration.

If a non-standard calibration sensor is used, please adjust the conversion factor accordingly by pressing the input field.

The default value of 2,000 A/V is correct for the standard calibration tool sensor (LEM 20,000 A / 10 VDC).

CAUTION : The High-speed DC Circuit Breaker must be closed.
Ensure that the trip level is well beyond the range of the calibration tests and avoid opening the device during calibration.

Press 'Calibrate Offset' to perform the calibration.
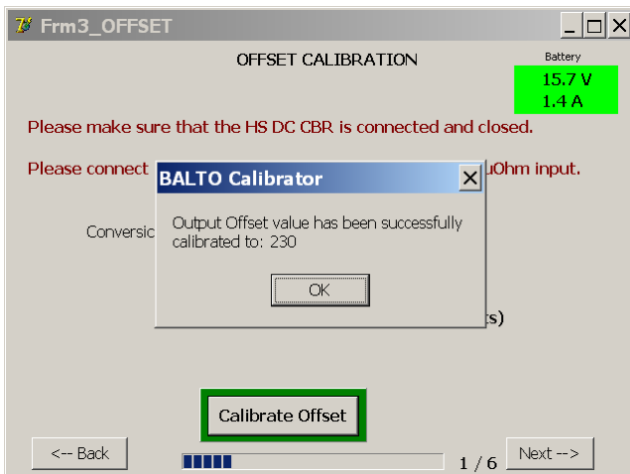
The button will be highlighted in green if the calibration ended successfully. The resulting value is displayed.

Press OK to confirm, and continue by pressing 'Next'.

Error message:

The offset calibration only tests a limited range for the resulting value (0 - 1,500). The nominal value is around 230.

If the offset is not found within this range, the following error dialog is displayed:
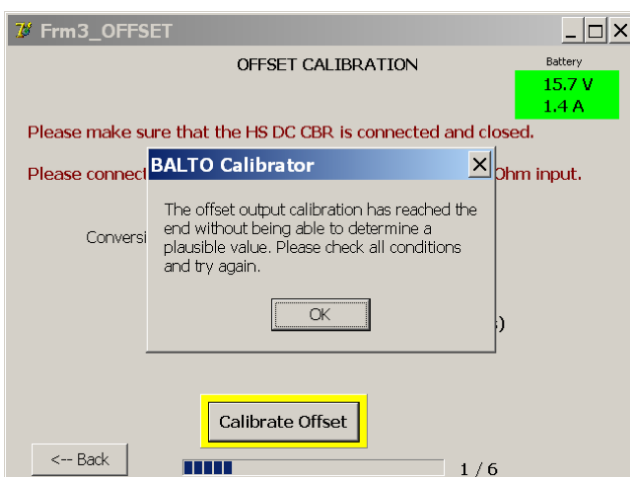
This error means that the maximum offset value has been reached without measuring current from the calibration sensor.

Calibration

Please check the following:

- The calibration sensor is connected properly to the μΩ input. (Mind the polarity.)
- The calibration sensor is included properly in the circuit, and the arrow indicator matches the flow of current. (Pointing from positive to negative.)
- The calibration sensor supply voltages are correct (±15 VDC).
- The calibration sensor output signal reacts to flowing current.
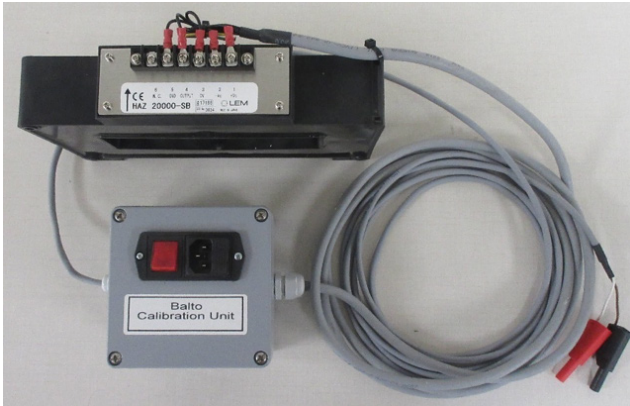
Fig 48: *Sensor for calibration.*

If problems persist, please contact Megger technical assistance.

12.2.4   Step 2/6 - CALIBRATION OF OUTPUT FACTOR

This dialog calibrates the output factor.

The calibration is performed by injecting 80% of the maximum available current.
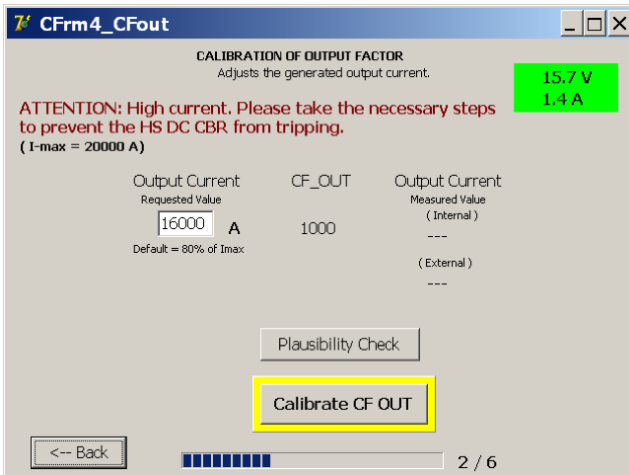
Press 'Calibrate CF OUT' to perform the calibration.

The output factor will be adjusted according to the calibration sensor measurements. When finished, the resulting value is displayed:
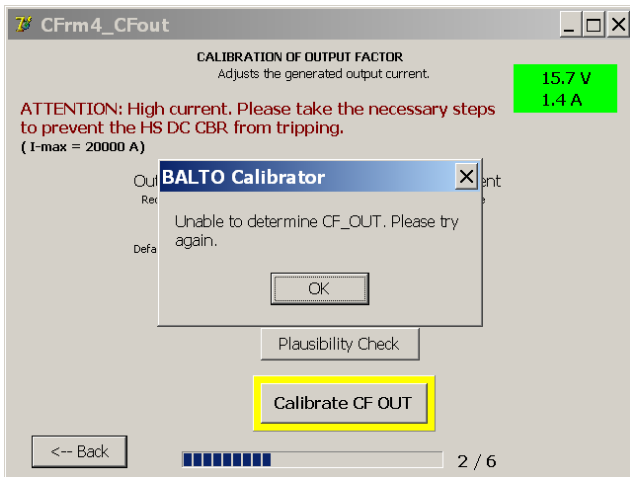
The nominal value is around 940.

Press OK to confirm, and continue by pressing 'Next'.

Error message:

If the output factor cannot be determined within the valid range, the following error dialog is displayed:
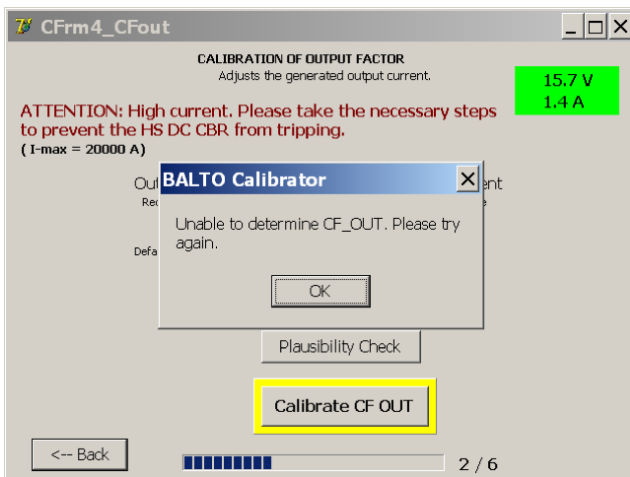
This means the output factor was unable to be determined within the valid range, or a time-out occurred.

Please check the following:

- The calibration sensor is operational and properly connected to the μΩ input.

If problems persist, please contact Megger technical assistance.

12.2.5 Step 3/6 - CALIBRATION OF INPUT FACTOR

This dialog calibrates the internal current measurement factor.

The calibration is performed by injecting 80% of the maximum available current.
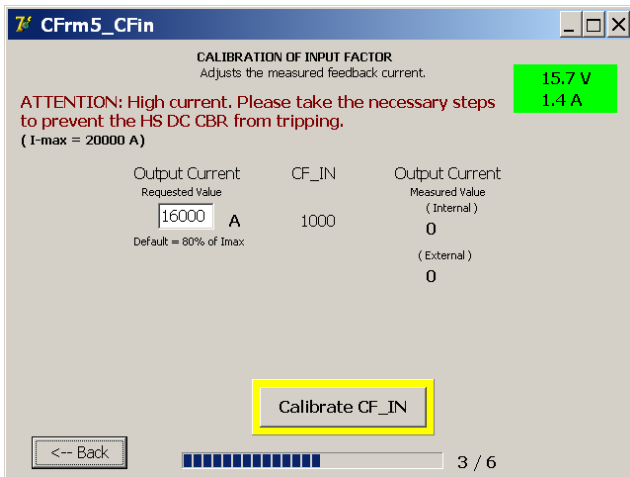
Press 'Calibrate CF IN' to perform the calibration.

The input factor will be adjusted according to the calibration sensor measurements. When finished, the resulting value is displayed:
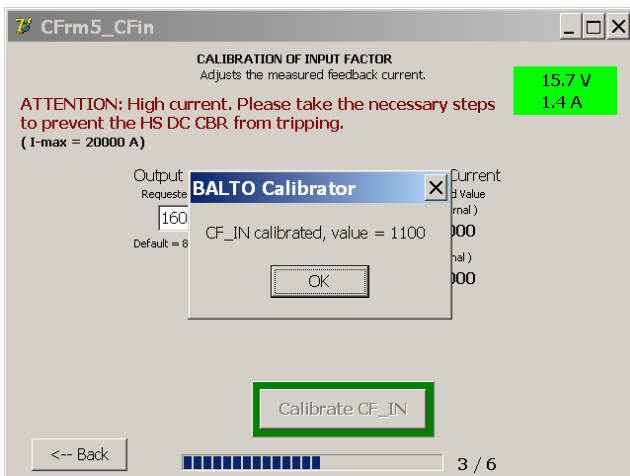
The nominal value is around 1100.

Press OK to confirm, and continue by pressing 'Next'.

Error message:

If the input factor cannot be determined within the valid range, the following error dialog is displayed:
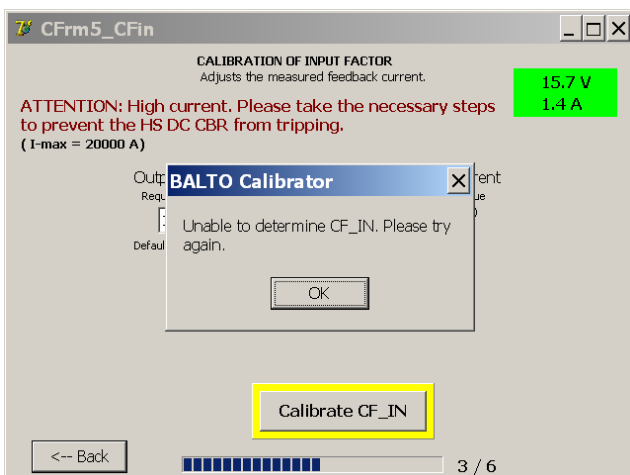
This means the input factor was unable to be determined within the valid range, or a time-out occurred.

Please check the following:

■ The calibration sensor is operational and properly connected to the µΩ input.

If problems persist, please contact Megger technical assistance.

12.2.6   Step 4/6 - LINEARITY ADJUSTMENT I-OUT

This dialog adjusts the linear calibration performed earlier for improved output accuracy.

The adjustments are calibrated using 6 injections at pre-defined points across the current range.

Press the 'Start' button to perform the calibration for a given point. When finished successfully, the button will be highlighted in green and the resulting adjustment is displayed.

Repeat the procedure until all points are calibrated.
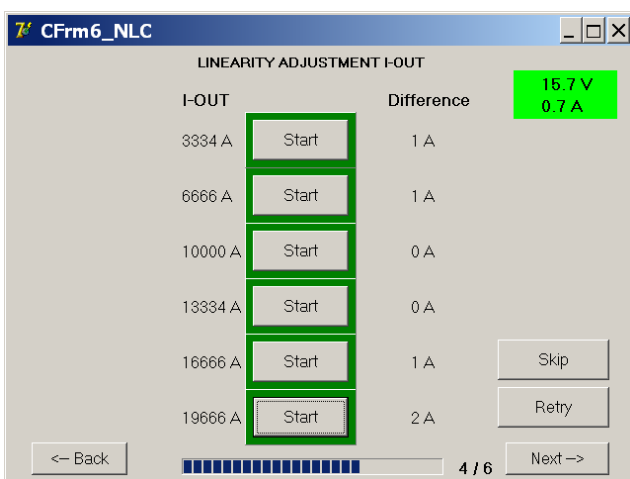
Press 'Next' to continue.

The linearity adjustment can be skipped to perform a faster calibration. However, to obtain maximum accuracy, it is recommended to perform all 6 steps.

12.2.7 Step 5/6 - LINEARITY ADJUSTMENT I-IN

This dialog adjusts the linear calibration performed earlier for improved internal current measurement accuracy.

The adjustments are calibrated using 6 injections at pre-defined points across the current range.

Press the 'Start' button to perform the calibration for a given point. When finished successfully, the button will be highlighted in green and the resulting adjustment is displayed.

Repeat the procedure until all points are calibrated.
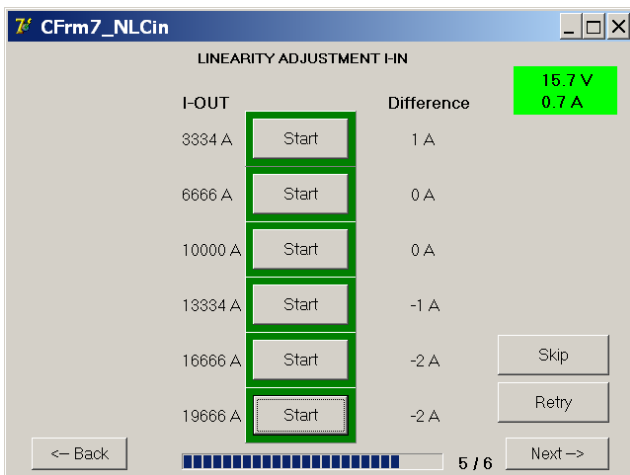
Press 'Next' to continue.

The linearity adjustment can be skipped to perform a faster calibration. However, to obtain maximum accuracy, it is recommended to perform all 6 steps.

12.2.8   Step 6/6 - Verification and application.

The verification dialog allows the operator to test the new calibration before applying it to the BALTO system.
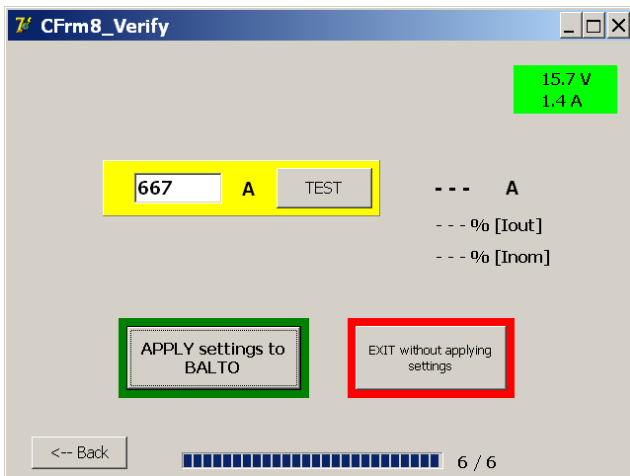
The test current value can be customised by pressing the input field. To perform the injection, press 'Test'.

The internally measured current and its deviation with respect to the chosen output current are displayed once the test finishes:
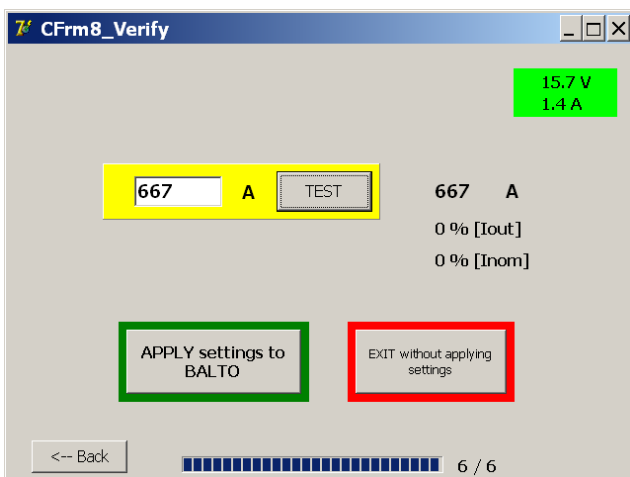
The deviation is displayed as a percentage relative to the output current (Iout) and as a percentage relative to the maximum available current (Inom).

To save and apply the new calibration values, press 'Apply settings to BALTO'.

The following dialog is displayed when the new values have been stored successfully:

Calibration
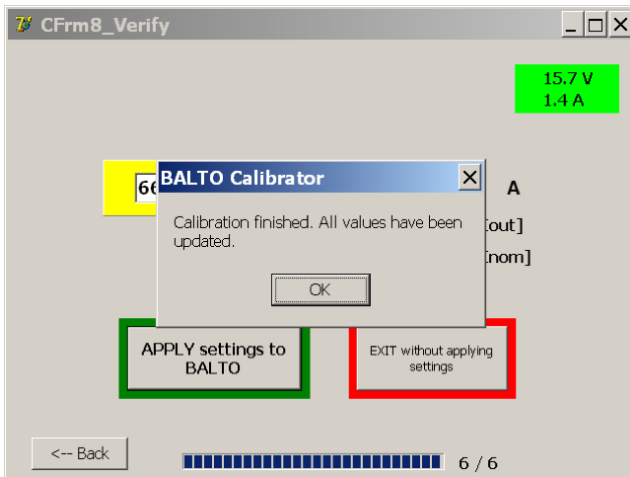
Confirm by pressing OK.

To cancel the calibration, and discard the new calibration values, press 'Exit without applying settings'. The existing system calibration will not be altered:
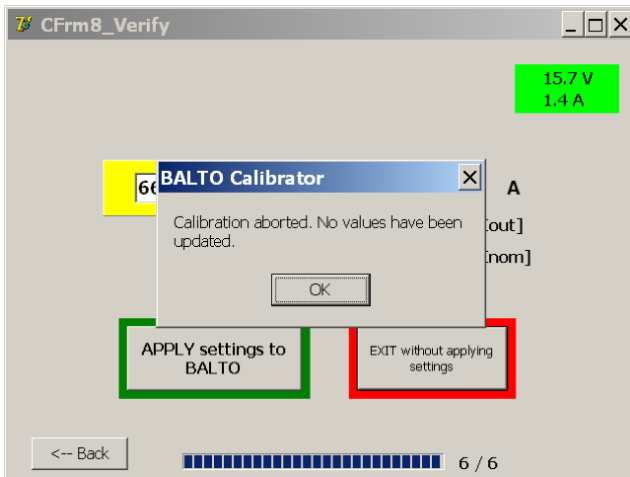
In this case, pressing OK will close the calibration program.

12.2.9   Results.

The final dialog displays the new calibration values that were applied to the system and provides the creation of a report.

The calibration sets overview is displayed at the top of the dialog.
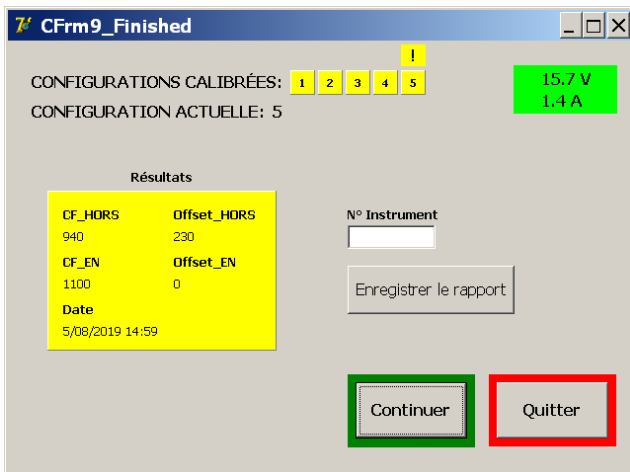
12.2.10   Calibration sets overview.

The calibration sets overview indicates which calibration sets are stored in the system.

(Exclamation mark indicates the standard configuration.)

- ■ The calibration sets completed and stored in the system are highlighted in yellow.
- ■ The calibration sets that have not (yet) been calibrated are shown in grey.

12.2.11   Saving the report.

An instrument number of the used calibration sensor can be entered for reference. Press the input field to open the virtual keyboard. The instrument number is included in the report.

To save the calibration report, press 'Save Report'.

When the report has been saved successfully, the following dialog is displayed:
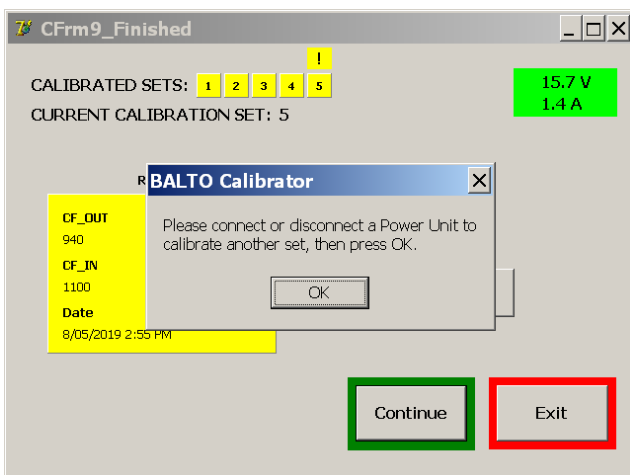
If a USB stick is connected to the system, the report will automatically be copied to the USB stick after saving.

Report example:

An example of the generated calibration report is displayed below:

To perform calibration for another calibration set, press 'Continue'. The following dialog is displayed:
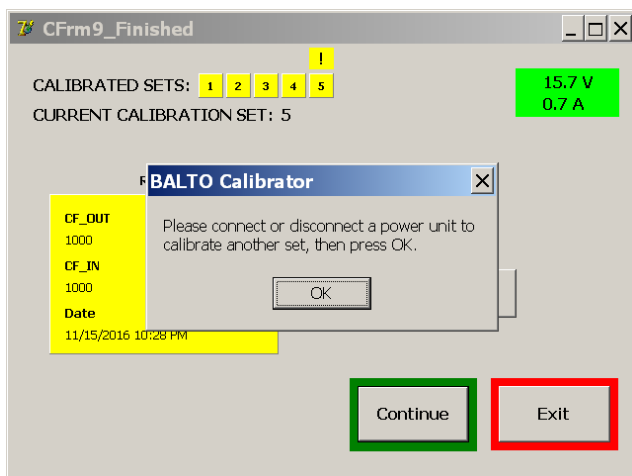
Connect or disconnect a DC Current Generator depending on the next calibration set to be calibrated. Then, press OK to continue.

If no change in the system configuration is detected, an error dialog will be displayed allowing the operator to try again or cancel.

If all calibration sets have been calibrated, exit the calibration program by pressing 'Exit'.

12.3   Message codes.

Messages, warnings and errors displayed in the calibration program are assigned a unique code. A list of message codes is included below.

12.3.1   General messages.

Message no.	Cause:	Action:
1: Battery voltage too low (critical).	Battery voltage < 13 VDC	Please wait for the battery to recharge before performing the calibration step. The battery indicator must be green to continue.
2: Charging Current too high	Charging current > 5 A	Please wait for the battery to recharge before performing the calibration step. The battery indicator must be green to continue.
4: No DC Current Generators available.	No connected DC Current Generators are detected.	Ensure that all DC Current Generators are properly connected.
5: Mains Power missing.	The battery charger is reporting a mains power supply fault.	Ensure that the mains power is functioning normally.
6: Charger error.	The battery charger is reporting a general error.	Ensure that the battery charger is functioning normally.
7: Module temperature too high.	The temperature of a DC Current Generator is too high.	Please wait for the DC Current Generator to cool before proceeding.
8: Ultracapacitor temperature too high.	The temperature of an ultracapacitor is too high.	Please wait for the ultracapacitor to cool before proceeding.
10: Battery voltage low (warning).	Battery voltage < 14.5 VDC	Please wait for the battery to recharge before performing the calibration step. The battery indicator must be green to continue.

12.3.2   Initialisation warnings.

Warning no.	Cause:	Action:
1: Battery voltage critically low.	Battery voltage < 13 VDC	Please wait for the battery to charge fully before starting the calibration. The battery indicator must be green to continue.

12.3.3 Initialisation critical errors.

Error no.	Cause:	Action:
1: Licence is missing.	The BALTO software installation is missing a critical component.	Please contact Megger technical assistance.
2: Calibration values missing.		
3: Registry key 'NLC' not found.		
4: Registry key 'NLCin' not found.	The calibration program is unable to access the system calibration parameters.	Please contact Megger technical assistance.
5: PLC problem detected.	The calibration program is unable to communicate with the TwinCAT I/O service.	Please try restarting the system. If the problem persists, please contact Megger technical assistance.
6: No DC Current Generators connected.	No connected DC Current Generators are detected.	Ensure that all DC Current Generators are properly connected and restart the calibration program.

12.4 Failed calibration messages.

If a step of the calibration process fails, one of the following messages will be displayed:

The offset output calibration has reached the end without being able to determine a plausible value.

Unable to determine CF_OUT.

Unable to determine CF_IN.

Approaching invalid values, procedure stopped for safety reasons.

Cause: The calibration step failed to determine the calibration value.

Action: Please check the following:

- The High-speed DC Circuit Breaker is closed.
- The High-speed DC Circuit Breaker's configured trip level is sufficiently high.
- The calibration sensor is connected properly.

If the problem persists, please contact Megger technical assistance.

13.   BALTOWin.

The BALTOWin software is available as a separate product. It allows the operator to import report files from the BALTO System onto a PC or laptop for further processing.

The BALTOWin installation file is available on a USB stick and can be installed on any Windows system.

13.1   System requirements.

Operating system:	Microsoft Windows 7 or newer
Hardware:	At least one USB port, Ethernet optional
CPU:	1 GHz or faster, 32-bit or 64-bit
Memory:	1 GB or more
Display resolution:	Minimum 800 x 600
Free disk space:	50 MB
Additional software:	Microsoft Excel (optional)

NOTE : To connect to the BALTO System via Ethernet, the IP settings of the PC or laptop must be changed. Alternatively, a USB stick can be used to transfer the report files.

13.1.1   BALTOWin files.

BALTOWin_Setup.exe:	BALTOWin installation file.
BALTOWin Licence.txt:	This file contains the software licence code.

Fig 49: *BALTO Modular and Laptop with BALTOWin.*   *BALTO COMPACT 4000 and Laptop with BALTOWin.*

13.2   Installation.

To start the installation, run the 'BALTOWin_Setup.exe' installation file from the USB stick on the desired system.

The default installation settings should be suitable for a standard system.

After the installation has completed, a shortcut will be placed on the desktop and in the start menu (under 'Megger').

The BALTOWin program will be started automatically.

BALTOWin.

The following window is displayed:
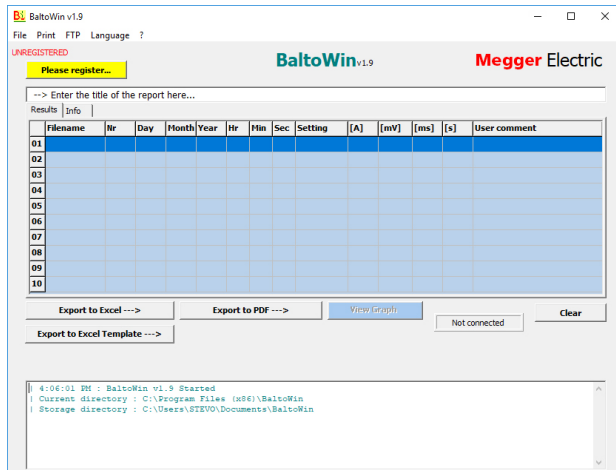
The program can now be registered using the supplied licence code. To do this, click the 'Please register' button.

 NOTE : If the program is not registered, it can only be used for 30 days.

The registration dialog is displayed as follows:

To register, the following information must be entered:

- ■ Licence ID   The licence identifier code.
- ■ Organisation   Enter the name of the organisation. (Optional)
- ■ Registration Code   The licence registration code.

The required licence information can be found in the 'BALTOWin Licence.txt' text file included on the USB stick.

 NOTE : The licence code can be used on multiple systems.

Installing a newer version of BALTOWin can be done without having to uninstall the older version. The installed licence is maintained.

Shortcuts.

The shortcut for opening BALTOWin is available on the desktop as well as in the start menu (under 'Megger').

13.3   Communication.

Communication with the BALTO System is established through the Ethernet interface.

NOTE : **The report files can also be downloaded using a USB stick. In this case, configuring the Ethernet connection is not required.**

13.3.1   PC configuration.

To connect to the BALTO System via Ethernet, the IP settings of the PC or laptop must be changed.

It is recommended for the configuration changes to be made by the system or network administrator.

The procedure on a Windows 10 system is as follows:
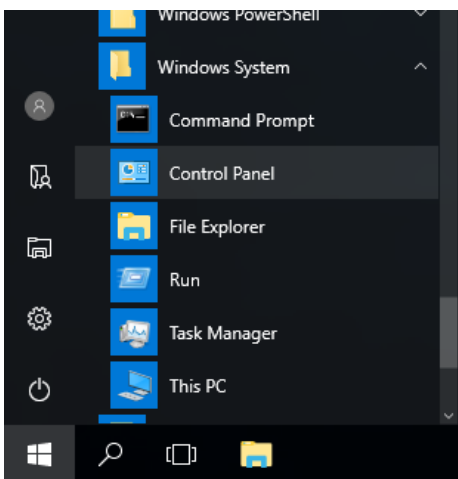
Open the 'Control Panel' from the Start Menu, located under 'Windows System'.
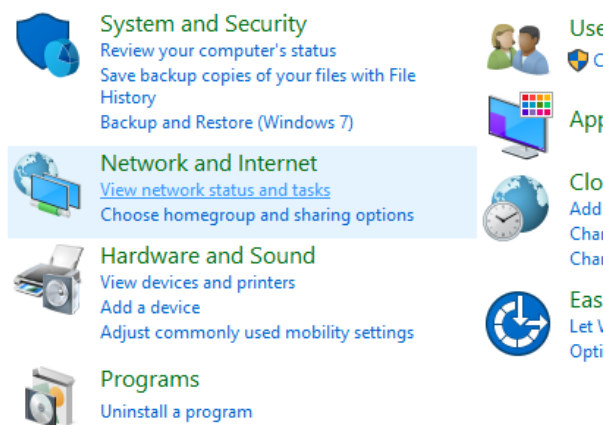
BALTOWin.

Select 'View network status and tasks'.
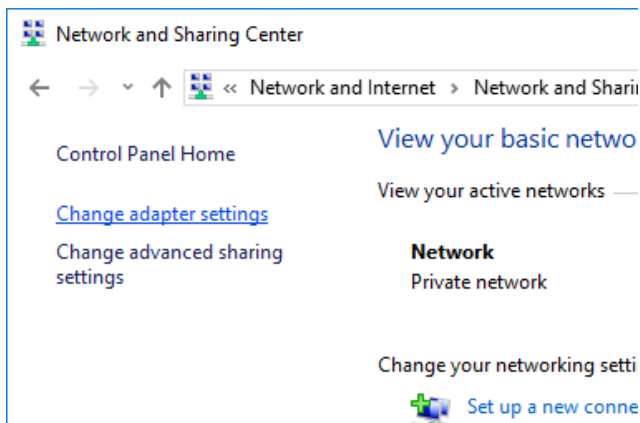
Click 'Change adapter settings'.
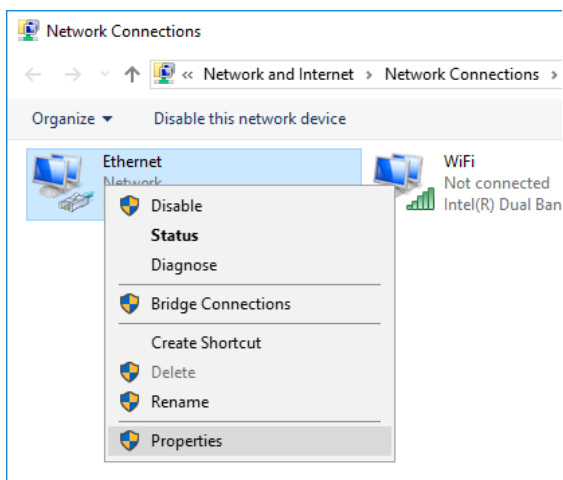
Right-click the 'Ethernet' adapter and select 'Properties'.
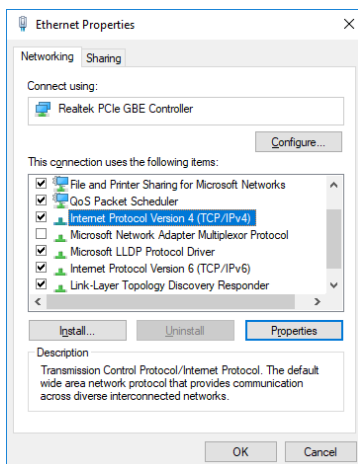
Select 'Internet Protocol Version 4 (TCP/IPv4)' and open 'Properties'.

The following dialog is displayed:
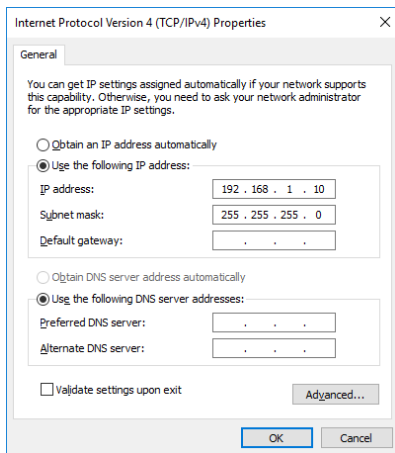
Select 'Use the following IP address'.

Input the data as displayed above.

An 'IP address' of 192.168.1.10 is recommended.

The IP address may be any value in the range 192.168.1.1 to 192.168.1.254, excluding 192.168.1.5 (used by the BALTO System).

The 'Subnet mask' is 255.255.255.0.

The 'Default gateway' can be left blank.

Confirm by clicking 'OK'.

13.3.2   Connecting to the BALTO System.

After configuring the IP settings, the Ethernet connection can be made by connecting the Ethernet cable from the PC or laptop to the BALTO System Ethernet interface - Control Unit position 7.

13.4   Operation.

13.4.1   Starting BALTOWin.

Start the BALTOWin program using the 'BALTOWin' desktop or start menu shortcut.

The following dialog is displayed:
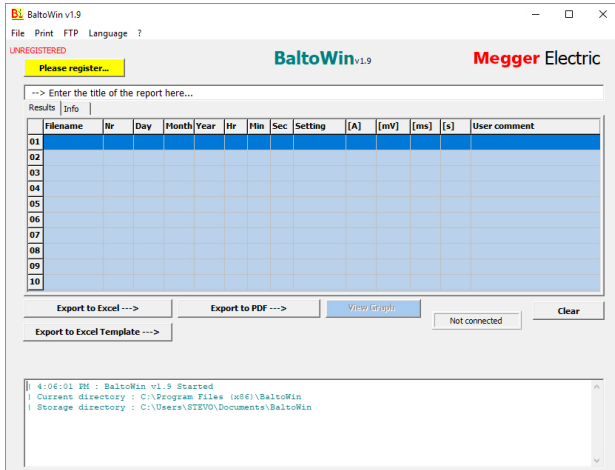
13.4.2 Dialog information.

Menu option - File

Dropdown menu:
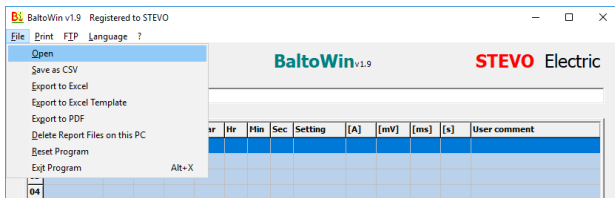
■	'Open'.	Open a report file imported from the BALTO System.
■	'Save as CSV'.	Save a loaded report in CSV text format.
■	'Export to Excel' and 'Export to Excel Template'	Export a loaded report into Microsoft Excel.
■	'Export to PDF'.	Export a loaded report to a PDF file.
■	'Delete report files on this PC'	Delete all local report files imported from the BALTO System.
■	'Reset Program'.	Reinitialises the program.
■	'Exit Program'.	Closes the program.

Menu option - Print
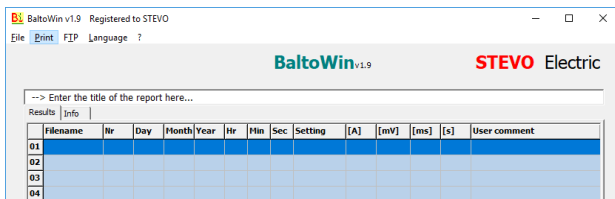
Print a screenshot of the currently displayed measurements.

For printing the complete report, it is recommended to use 'Export to PDF' and printing the PDF file instead.

Menu option - FTP

Dropdown menu:
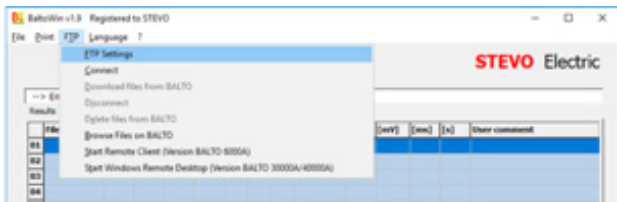
- ■ 'FTP Settings'.   This menu contains the network connection settings.
- ■ 'Connect'.   Establish a network connection with the BALTO System.
- ■ 'Download files from BALTO'   Download all report files from the connected BALTO System.
- ■ 'Disconnect'.   Disconnect from the BALTO System
- ■ 'Delete files on BALTO'   Delete all remote report files from the BALTO System.
- ■ 'Browse files on BALTO'   Open an explorer window to browse the files on the BALTO System.
- ■ 'Start Remote Client (Version   Not used for modern BALTO Systems.
  BALTO 6000A)'
- ■ 'Start Windows Remote   Start Windows Remote Desktop for controlling the BALTO System remotely.
  Desktop'.

Menu option - Language
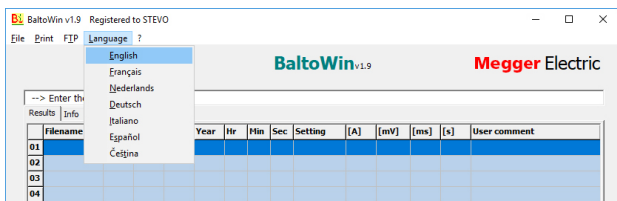
Menu option - ?
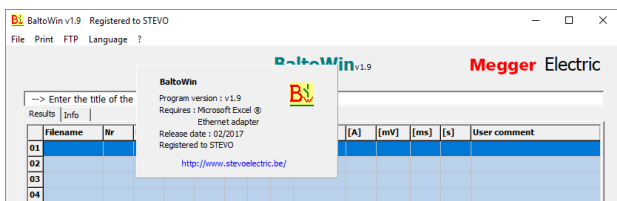
Information regarding the BALTOWin program version.

Report results table.
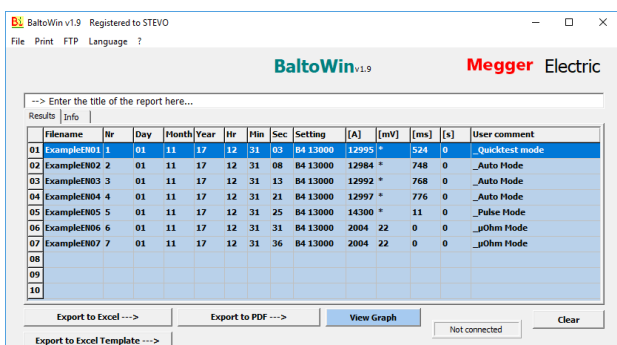
BALTOWin.

Event log.

The event log is also written to the 'BALTOWin.log' text file.

13.5   Downloading.

To connect to the BALTO System, click 'FTP' - 'Connect'.
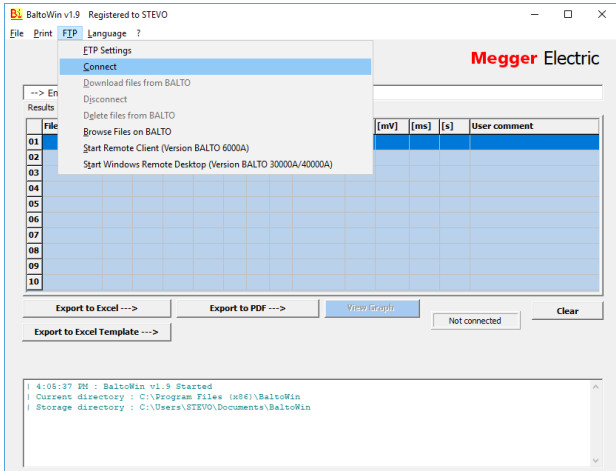
The connection status indicator will indicate whether the connection can be made:
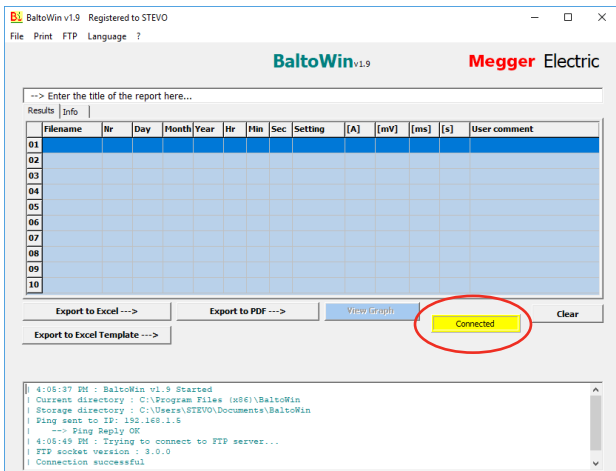
The connection status indicator is highlighted in yellow if the connection has been established successfully.

To begin downloading the report files, click 'FTP' - 'Download files from BALTO'.
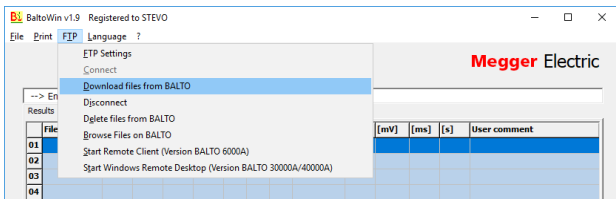
The download progress bar will appear. Downloading reports may take a few minutes depending on the amount of stored reports.
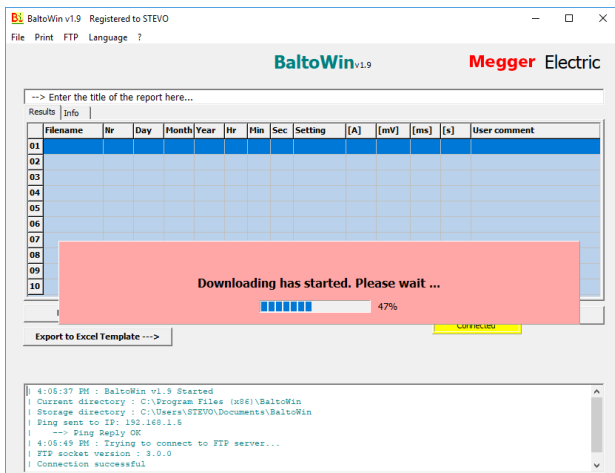
Press OK to confirm the completed download.
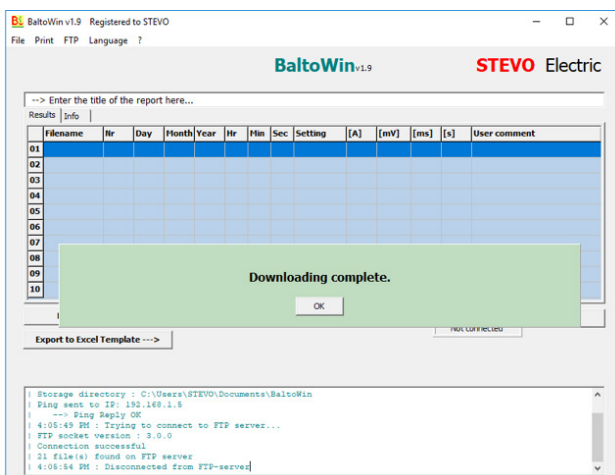
The open dialog will be shown automatically. Select the report file to open from the list of downloaded reports:
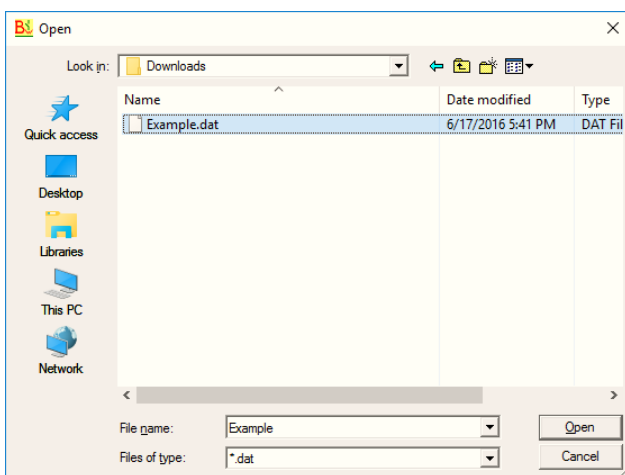
Press 'Open' to open the selected report file.

The report results will be shown in the results table:

BALTOWin.
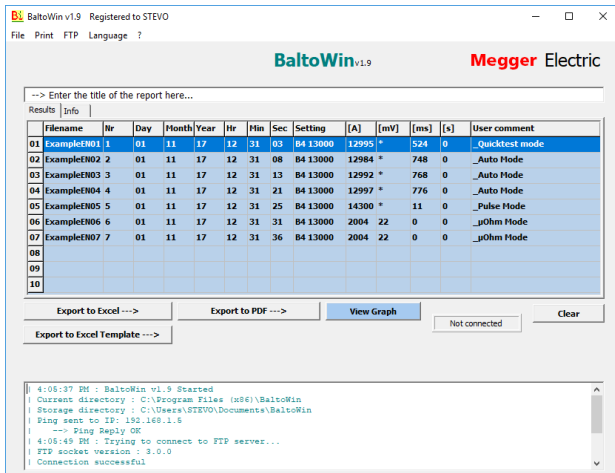
The additional report information is displayed in the 'Info' tab:
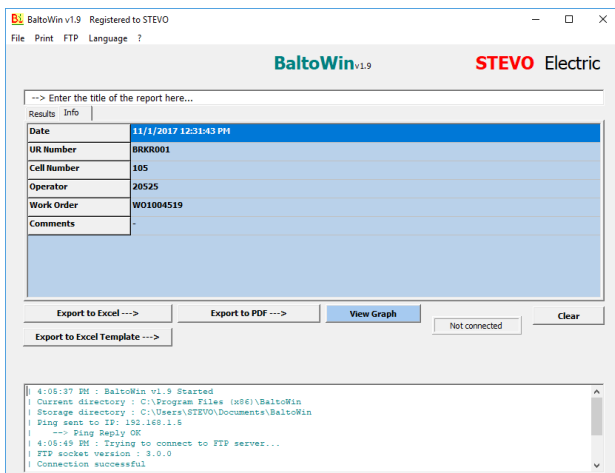
To export the report to a different format, please enter a title for the report in the input field at the top.

To export the report to Microsoft Excel, click the 'Export to Excel' button. This will export the report to a new Excel document using default formatting. Click the 'Export to Excel Template' button to select the Excel document template to use.

Exporting to Excel will only work if Microsoft Excel is installed on the system.

To export the report to PDF, click the 'Export to PDF' button. The PDF file includes the additional report information and the report graphs.

Example PDF report:

C:\Balto\Report\ExampleEN.dat

Example

Date	11/1/2017 12:31:43 PM
UR Number	BRKR001
Cell Number	105
Operator	20525
Work Order	WO1004519
Comments	-

Nr	Day	Month	Year	Hr	Min	Sec	Setting	[A]	[mV]	[ms]	[s]	User comment
1	01	11	17	12	31	03	B4 13000	12995	*	524	0	_Quicktest mode
2	01	11	17	12	31	08	B4 13000	12984	*	748	0	_Auto Mode
3	01	11	17	12	31	13	B4 13000	12992	*	768	0	_Auto Mode
4	01	11	17	12	31	21	B4 13000	12997	*	776	0	_Auto Mode
5	01	11	17	12	31	25	B4 13000	14300	*	11	0	_Pulse Mode
6	01	11	17	12	31	31	B4 13000	2004	22	0	0	_µOhm Mode
7	01	11	17	12	31	36	B4 13000	2004	22	0	0	_µOhm Mode

1/22/2018 3:50:01 PM   Exported report from BaltoWin v1.9

13.5.1 Report graphs.

Report files saved in BALTO software versions 4.08 and newer include the measurement graphs.

If the opened report file includes measurement graphs, the 'View Graph' button is enabled when selecting a measurement.

Click 'View Graph' to open the measurement graph in a new window.

BALTOWin.
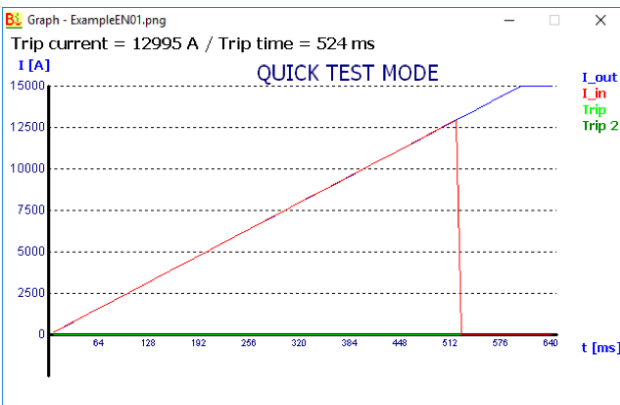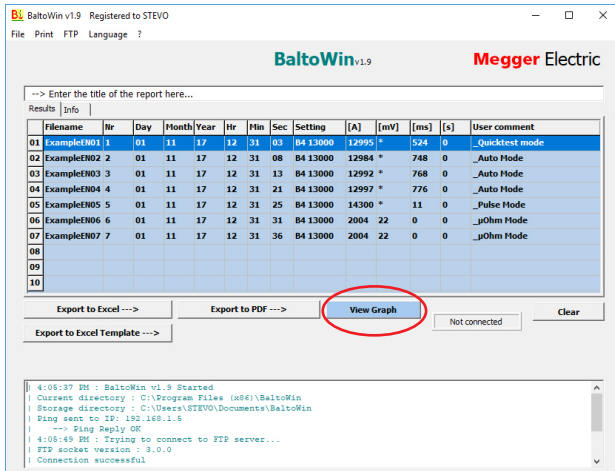
13.5.2 USB downloading.

On the BALTO System.

After performing the measurements and saving the report on the BALTO System, a USB stick can be connected to the USB interface to obtain the report files.

The report files consist of:
- Reports in BALTOWin format.
- Measurement graphs in PNG format.
- Reports in PDF format.

Status messages:

Balto [Message Code 52]

[Message Code 52]

USB Stick already contains a "Report" folder.
Overwrite existing files?

OK   Cancel
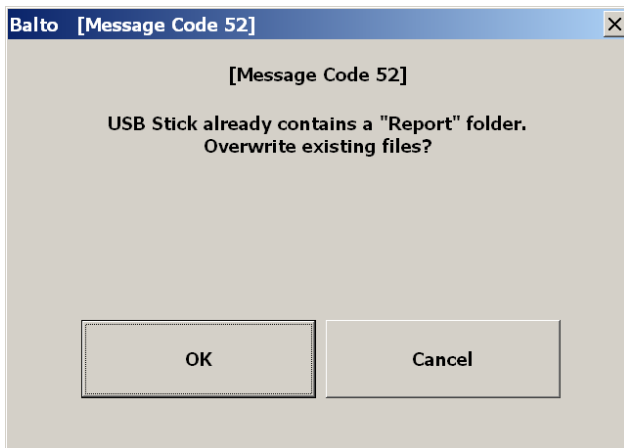
CAUTION : Do not insert the USB stick before performing tests. Only the reports that already exist on the system will be copied.
Insert the USB stick after testing is complete and all reports have been saved successfully.

On the PC or laptop.

Connect the USB stick to a USB port on the PC or laptop.

- ■ Select 'File' - 'Open'.
- ■ Navigate to the USB stick files.
- ■ Open the 'Report' folder.
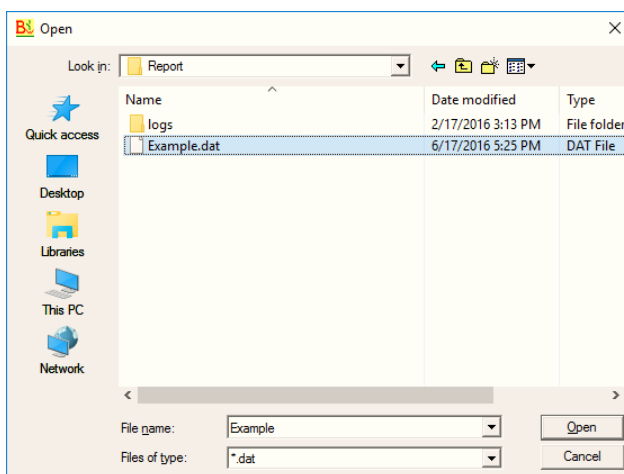
Select the report file to open and click 'Open'.

14. Maintenance

The various system modules require little to no maintenance under normal circumstances, provided the system is handled, transported and stored appropriately.

Check-ups may prove useful if the system is used in harsh conditions or if the system has been in storage for an extended period.

14.1 Junction Connectors

The Power Junction Connectors should be kept clean.

Do not use harsh chemicals for cleaning. Instead, use a damp cloth, and allow the system to dry completely before use. Cleaning off dust can be done using compressed air.

The device must be protected adequately when stored.

14.2 Tyres (BALTO Modular only)

NOTE : The tyre pressure should be checked regularly.

Used tyre pressure: 3 bar (43.5 psi)

14.3 Components

14.3.1 Trained personnel only

DANGER : **Maintenance, and specifically the replacement of components, should only be performed by trained and qualified personnel.**

14.3.2 Battery Chargers.

To ensure reliable operation, regularly check that the cooling fans and vents are free of dust or particle build-up. Dust removal can be done using compressed air.

14.3.3 Ultracapacitors.

DANGER : **During maintenance, never attempt to discharge the ultracapacitors. The ultracapacitors must remain charged to the battery voltage. Appropriate care should be taken when working around the charged ultracapacitors.**

The ultracapacitor terminal connections may need tightening.

Used tightening torque: 20 N·m (14.8 lbf·ft)

14.3.4 Batteries.

The batteries of the BALTO COMPACT 4000 are located in the Main Unit. The batteries of the BALTO Modular are located in the Support Carriage.

Replacing the batteries of the BALTO Compact 4000 can only be performed by a Megger Service Centre. It is sufficient to ship the Main Unit.

The lifetime of the batteries depends on various factors such as usage, grades of depletion, temperatures, etc. When it is noticed that current injections are deteriorating, it is necessary to check and replace the batteries.

Although it is recommended that the replacement of batteries of the BALTO Modular is done in a Megger Service Centre, it can be done by trained personnel. The procedure is as follows :

- Remove the Support Carriage from mains power.
- Remove the DC Current Generators.
- Remove the lever from the Emergency Stop Device.
- Remove the Support Carriage cover plate.
- Remove a connection from every battery row.

NOTE : Care must be taken and proper tools must be used to avoid creating short circuits when manipulating the batteries.
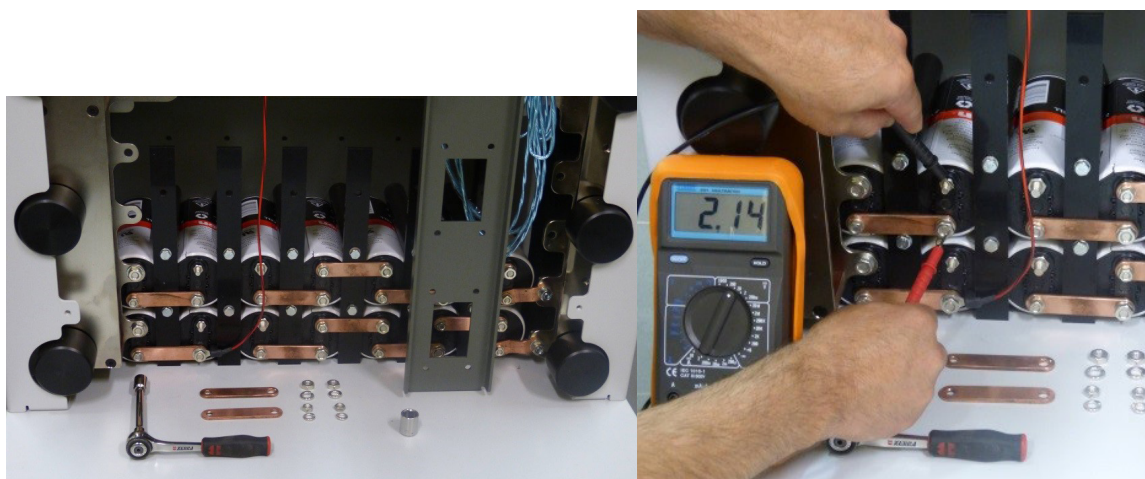
Fig 50: *Support Carriage: Checking the batteries.*

- Check the voltage of every battery cell. A healthy cell will have a voltage of at least 2.0 VDC.

Battery tightening torque: 3.5 N·m (2.6 lbf·ft)

Before reconnecting a battery row, ensure the battery row voltage matches the ultracapacitor voltage. If the ultracapacitor voltage is lower (e.g. after replacing battery cells), the system should be connected to mains power briefly to charge the ultracapacitor voltage to the battery row voltage, to avoid sparks during reconnection.

It is recommended to charge the BALTO System for at least 48 hours a week, even when not in active use. Regular charging will keep the batteries in good health and increases lifespan.
Store the system at appropriate storage temperatures.

14.4 Power Connectors.

The Power Junction Connectors, as well as the power connections on the test object, must be kept clean.

To clean off dust, use compressed air. Do not use harsh chemicals for cleaning.

Abrasive fleece can be used for cleaning the Power Connector contact surface.

Fig 51: *Cleaning the Power Connector.*

The device must be protected adequately when stored.

14.5   Ventilation.

Ensure that the vents are kept clean and free of dust or particle build-up.

14.6   Control Panel.

14.6.1   Screen repairs.

WARNING : Do not open the Control Panel Display. There are no serviceable parts inside.

14.6.2   Screen maintenance.

The display screen exterior can be cleaned using a damp cloth.

Do not use harsh chemicals for cleaning, and avoid using hard or sharp objects.

14.7   Control Electronics.

14.7.1   Embedded PC battery.

The embedded PC uses a battery to back up the date and time. It is advised to replace the battery every five years.

If the battery is no longer functioning properly, time & date may not be correct.

14.7.2   Ventilation.

Ensure that all vents are kept clean and free of dust or particle build-up.
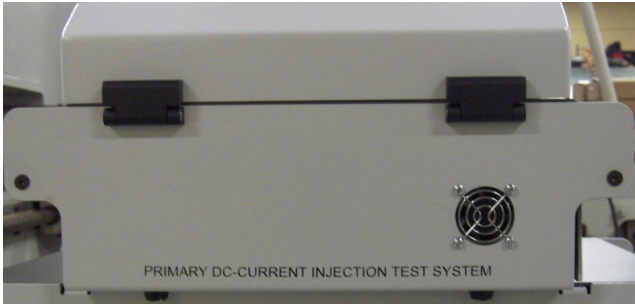
Fig 52: *Control Unit : Vent terminal.*

Fig 53: *Main Unit: Vent.*

Fig 54: *DC Current Generator vents*

15.   Troubleshooting.

This chapter describes a number of problems that may arise during operation of the BALTO System, and how to properly handle or mitigate them.

Furthermore, detailed descriptions of error and warning codes are provided.

15.1   Booting up the BALTO System.

Ensure that the set-up and connection instructions are followed as described in the chapter 'Installation'.

The High-speed DC Circuit Breaker must be in the open position.

> **NOTE :** Depending on the frequency of system usage, it is advised to charge the system during at least a few hours before use. When possible, charging during the entire preceding day is preferred.

15.1.1   Starting procedure.

If the starting procedure succeeds, the starting dialog will be displayed on the screen.

Problems during the starting procedure may cause other dialogs to appear on the screen, providing information regarding the failed starting attempt.

After a successful start, the 'Start Dialog' is displayed as follows:
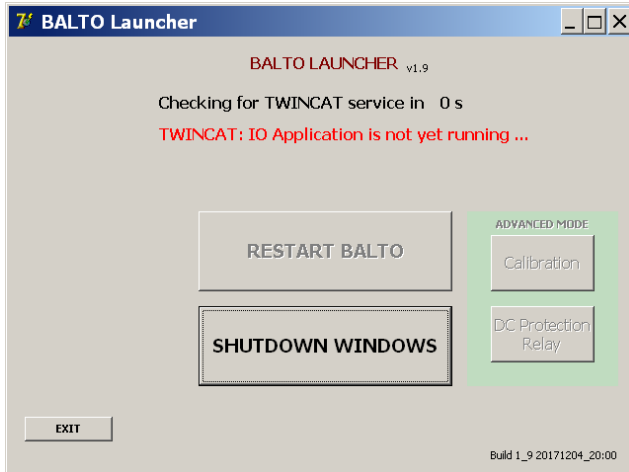
The 'Start Dialog' awaits the starting of the 'TwinCAT' runtime, and automatically starts the main BALTO software.

If the 'TwinCAT' runtime fails to start, the system will shut down after approximately 2 minutes.

If this occurs, please try restarting the system.

> **CAUTION : If start-up issues persist, please contact Megger technical assistance.**

15.2   Info dialog status.

Important information regarding the system status is displayed in the 'Info dialog'.

Info.

Mains Power:	Displays the mains power supply status.
Charger:	Displays the charger general operation and error status.
Battery Voltage:	Displays the battery voltage level. If the voltage is less than 14 VDC, a warning is displayed. If the voltage is less than 12 VDC, an alarm is displayed, and further use is blocked until the battery has recharged.
Charging Current:	Displays the battery charging current. The battery is considered to be fully charged if the charging current drops below 5 A.
Number of Power Units:	Displays the number of connected DC Current Generators.
Warnings Status:	Displays any active warnings.
Alarm Status:	Displays any active alarms.
Number of tests in this report:	The number of test results contained in the current report.
PLC:	Displays the PLC status regarding input/output control. If a PLC error occurs, an alarm is displayed and further use is blocked.
Ultracapacitor temperatures:	Displays the temperature levels of the Ultracapacitors. If the temperature exceeds 45 °C, a warning is displayed. If the temperature exceeds 60 °C, an alarm is displayed, and further use is blocked until the ultracapacitor has cooled. Unused ultracapacitor slots will display a temperature of 0 °C.
Used Disk-space:	Displays the percentage of used disk space on the internal storage. If used disk space exceeds 85%, a warning is displayed. If used disk space exceeds 98%, an alarm is displayed, and further use is blocked until disk space is freed. To free disk space, the stored report files can be deleted. For instructions, please consult the chapter 'Reporting'.
Temperature PU module:	Temperature of the DC Current Generators. If the DC Current Generators are equipped with temperature monitoring, and the temperature exceeds 55 °C, an alarm is displayed, and further use is blocked until cooled.
OK button.	Press the 'OK' button to confirm and dismiss system warnings and alarms.
Software version.	The software version and build date is displayed in the bottom right corner of the 'Info' screen.

Troubleshooting.

Status bar.

Warning status: Displays any active warnings.

Alarm status: Displays any active alarms.
A red status bar indicates that there is an active alarm blocking further use of the BALTO System.
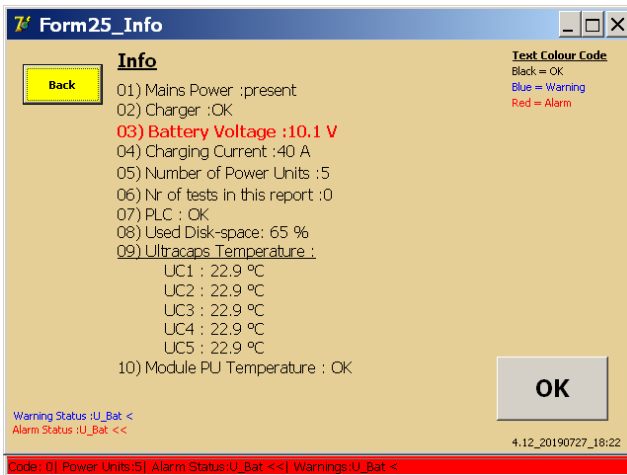
Pressing the 'OK' button confirms the alarm and returns the operator to the testing menus. Operation of the system is blocked and the background colour is changed to red while the alarm persists.
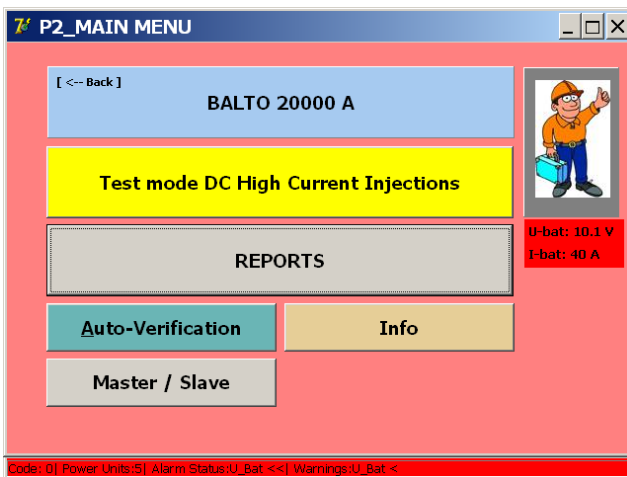
15.3   Emergency Stop Device.

The Emergency Stop Device is operated using the lever.

Before resetting the Emergency Stop Device, the voltage level of the DC Current Generators must be checked. If the voltage no longer matches the system battery voltage, reconnecting the Emergency Stop Device may cause arcing and damage to the contacts.

To check the voltage, remove the DC Current Generators.

- On the rear panel, measure the voltage between the Power Junction Connectors:

Fig 55: *DC Current Generator rear panel.*

The voltage should fall within 13.0 VDC - 15.7 VDC.

- Compare the voltage to the voltage supplied by the energy compartment (Power Connectors) with the Emergency Stop Device back in the working position:

 CAUTION : If the voltages do not match, charge the DC Current Generators using the charging tool.

If the Emergency Stop lever cannot be switched on/off smoothly any longer, or a deterioration of the injections is perceived, the Emergency Stop may be damaged.

 CAUTION : If the Emergency Stop Device has suffered damage, please contact Megger technical assistance before performing any further Current Injections.

15.4   Message codes.

All system messages, errors and warnings are assigned a unique message code.

15.4.1   Operation error codes.

These messages are displayed in a pop-up dialog during operation of the system.

Code no. 1	
Message:	A severe alarm has occurred. No tests will be possible anymore. The 'Info' dialog will be shown.
Cause:	Battery voltage is critically low. No DC Current Generators are connected. PLC error regarding the I/O system. Not enough disk space available. Temperature of the Ultracapacitors is critically high.
Action:	See the 'Info' dialog for a description of the problem. Depending on the problem, the operator may need to wait for the batteries to charge, connect a DC Current Generator, free up disk space, or wait for the ultracapacitors to cool. If a PLC error has occurred, try restarting the system. Contact Megger technical assistance if the problem persists.

Code no. 2	
Message:	No Power Units available. Please connect a Power Unit. Test aborted.
Cause:	The system detects no connected DC Current Generator.
Action:	Ensure a DC Current Generator is properly connected. Contact Megger technical assistance if the problem persists.

Code no. 3	(Reserved for internal use.)
Code no. 4	(Reserved for internal use.)
Code no. 5	(Reserved for internal use.)
Code no. 6	(Reserved for internal use.)

Code no. 7	
Message:	Initialization file not found. Program will be terminated for safety-reasons.
Cause:	Critical components of the software installation are missing.
Action:	Contact Megger technical assistance if the problem persists.

Code no. 8	
Message:	This program is not registered. The program will be terminated.
Cause:	Critical components of the software installation are missing.
Action:	Contact Megger technical assistance if the problem persists.

Code no. 9	
Message:	This program version is too old. This version = … / version of ini-file = … The program will be terminated for security reasons.
Cause:	The software has been downgraded or critical components of the software installation are corrupted.
Action:	Restart the software. Contact Megger technical assistance if the problem persists.

Code no. 10	
Message:	This program version is higher than the version on the ini-file. New parameters will be set to their default values.
Cause:	The software has been upgraded.
Action:	Press OK to confirm.

Code no. 11	
Message:	Ini-file has been updated. The versions are now matching.
Cause:	The software configuration has been upgraded
Action:	Press OK to confirm

Code no. 12	
Message:	Calibration values are missing
Cause:	The system's calibration data is missing.
Action:	If the Calibration Tool is available, a calibration of the system can be performed. For more information, consult the chapter 'Calibration'. Contact Megger technical assistance if the problem persists.

Code no. 13	
Message:	Free disk space has reached the warning level. Please delete old log-files.
Cause:	Too many reports are stored in the BALTO System.
Action:	Clear the stored report files by pressing 'Delete' in the 'Report' dialog. This message does not require immediate action. Contact Megger technical assistance if the problem persists.

Code no. 14	
Message:	** Free disk space has reached the CRITICAL LEVEL ** Please delete old log files as soon as possible.
Cause:	Too many reports are stored in the BALTO System.
Action:	Clear the stored report files by pressing 'Delete' in the 'Report' dialog. This message requires immediate action. Contact Megger technical assistance if the problem persists.

Code no. 15	(Reserved for internal use.)
Code no. 16	(Reserved for internal use.)
Code no. 17	(Reserved for internal use.)

Code no. 18	
Message:	Files copied.
Cause:	The operator has inserted a USB stick. All report files have been transferred to it.
Action:	Press OK to confirm.

Code no. 19	
Message:	USB Stick removed.
Cause:	The USB stick has been disconnected.
Action:	Press OK to confirm.

Code no. 20	
Message:	This Control Unit is configured for … Power Units, but you are using … Power Unit(s). Please check the connections to the HS DC CBR and disconnect the Power Cables from unused Power Units!
Cause:	The number of connected DC Current Generators does not match the default factory configuration.
Action:	If the different number of DC Current Generators is intentional, press OK to confirm. Ensure that unused DC Current Generators are disconnected from the High-speed DC Circuit Breaker.

Code no. 21	
Message:	You have DISCONNECTED some Power Units. Please do not forget to DISCONNECT the corresponding Power Cables at the HS DC CBR side.
Cause:	A DC Current Generator has been disconnected from the system.
Action:	Ensure that any disconnected DC Current Generator is also disconnected from the High-speed DC Circuit Breaker.

Troubleshooting.

Code no. 22	
Message:	You have CONNECTED some additional Power Units. Please do not forget to CONNECT the corresponding Power Cables at the HS DC CBR.
Cause:	A DC Current Generator has been connected to the system.
Action:	Ensure that any connected DC Current Generator is also connected to the High-speed DC Circuit Breaker.
Code no. 23	
Message:	The HS DC CBR is still closed. For safety reasons, this program will not be terminated. Please open the HS DC CBR first before terminating this program.
Cause:	This message is displayed when the operator tries to exit the BALTO software and the High-speed DC Circuit Breaker is still connected and in the closed position.
Action:	Open the High-speed DC Circuit Breaker or disconnect the cables from the High-speed DC Circuit Breaker.
Code no. 24	(Reserved for internal use.)
Code no. 25	
Message:	The maximum number of tests for one report have been reached: Please insert a report name.
Cause:	The saved measurements table has reached the maximum number of lines.
Action:	In the 'Report' dialog, press 'Save' to save the currently saved measurements to a report file. Then, clear the list to begin a new report.
Code no. 26	
Message:	Value of I_ref too high or value of k2 (%) too high. Please reduce either I_ref or k2. Max I_ref Value = …
Cause:	The injection specified by I_ref and k2 exceeds the maximum Current Injection capacity
Action:	Reduce the I_ref value, or Reduce the k2 value.
Code no. 27	
Message:	I-ref Value too high. Max value: …
Action:	Reduce the I-ref value.
Code no. 28	
Message:	Slope speed too slow, please increase the speed to at least … A/s or reduce the current
Action:	Increase the 'Slope' value or decrease the 'Delta I' value.
Code no. 29	
Message:	The value for di/dt should be > 0 ms. Please insert a higher value.
Action:	Increase the 'Delta I' value until the displayed 'dt' is greater than 0 ms.
Code no. 30	
Message:	I-ref Value too high. Max value: …
Action:	Reduce the I-ref value.
Code no. 31	
Message:	Value of measuring current too small. The current must be at least 100 A per Power Unit.
Action:	Increase the I-ref value to at least 100 A per connected DC Current Generator.
Code no. 32	
Message:	I-ref Value too high. Max value: …
Action:	Reduce the I-ref value.
Code no. 33	
Message:	The maximum number of tests for one report has been reached: Please insert a report name to close this form.
Cause:	See code no. 25.
Action:	See code no. 25.

Code no. 34	
Message:	Report "…" saved.
Cause:	The report file has been saved successfully.
Action:	Press OK to confirm.
Code no. 35	(Reserved for internal use.)
Code no. 36	(Reserved for internal use.)
Code no. 37	
Message:	All report-files, logfiles and sample files deleted.
Cause:	The operator has pressed the 'Delete' button in the 'Report' dialog and confirmed the deletion. The stored report files have been deleted.
Action:	Press OK to confirm.
Code no. 38	
Message:	Nothing deleted.
Cause:	The operator has pressed the 'Delete' button in the 'Report' dialog but cancelled the deletion. No files have been deleted.
Action:	Press OK to confirm.
Code no. 39	(Reserved for internal use.)
Code no. 40	
Message:	I-ref Value too high. Max value: …
Action:	Reduce the I-test value.
Code no. 41	
Message:	The Shunt Mode Current should be at least … A per Power Unit. Please set a higher value.
Action:	Increase the I-test value.
Code no. 42	(Reserved for internal use.)
Code no. 43	
Message:	The time for this test is set too high. The time has been automatically reduced to its maximum value.
Cause:	The test time configured in Shunt Mode exceeded the test time limit. The value has been reduced.
Action:	Press OK to confirm.
Code no. 44	(Reserved for internal use.)
Code no. 45	(Reserved for internal use.)
Code no. 46	(Reserved for internal use.)
Code no. 47	(Reserved for internal use.)
Code no. 48	(Reserved for internal use.)
Code no. 49	
Message:	Number of Power Units should be exactly 1.
Cause:	The operator attempted to start 'Auto-Verification', but the number of connected DC Current Generators is zero or more than one.
Action:	Ensure exactly one DC Current Generator is connected to the system to perform 'Auto-Verification'.
Code no. 50	
Message:	Current value too low. Please raise the value of I-ref (min=… A)
Action:	Increase the I_ref value.
Code no. 51	**Reserved for secondary injection**
Message	The system has detected at least one Current Generator.
Action	Open the DC High-Speed Circuit Breaker and remove all Current Generators.

Troubleshooting.

Code no. 52	
Message:	USB Stick already contains a "Report" folder. Overwrite existing files?
Cause:	The operator connected a USB stick that already contains stored reports
Action:	Confirm to begin transferring report files. Reports already on the USB stick using the same report name as reports from the system will be overwritten. Cancel to abort the transfer.

Code no. 53	
Message:	There are unsaved report entries. Are you sure you wish to exit without saving?
Cause:	The software is being closed while there are unsaved measurements in the 'Report' dialog.
Action:	Confirm to discard any unsaved measurements. Cancel to abort the exit procedure.

Code no. 54	Reserved for secondary injection
Message:	Please connect the voltage output to the µOhm input, then press OK. This message is shown before the calibration process is started.
Action:	Once the connection is made, press OK to start the calibration process

Code no. 55	Reserved for secondary injection
Message:	No voltage feedback, please ensure the connection is made. Calibration aborted. This message is shown when no voltage is detected on the µOhm input. The calibration process cannot continue.
Action:	Please ensure the proper connections are made and then try again.

Code no. 56	Reserved for secondary injection
Message:	Calibration in progress…(%d)
Action:	No action required.

Code no. 57	Reserved for secondary injection
Message:	Output offset calibrated to %d. Measured offset : %.3n V This message is shown after the calibration process is completed.
Action:	Press OK to return to the return to the menu

Code no. 200	
Message:	This program will be terminated. Shutdown Windows?
Cause:	The software is being closed.
Action:	Confirm to shut down the system after closing the software. Otherwise, the launcher dialog will be shown.

Code no. 201	
Message:	Are you sure you want to clear the list of tests?
Cause:	The measurements in the 'Report' dialog are being cleared.
Action:	Confirm to clear the measurements table (e.g. for starting a new report). Cancel to retain the stored measurements.

Code no. 203	
Message:	Delete all reports, samples and logfiles from the disk?
Cause:	The operator has pressed 'Delete' in the 'Report' dialog.
Action:	Confirm to delete all report files stored on this system. This cannot be undone. Cancel to abort the deletion procedure.

Code no. 204	
Message:	Invalid password.
Cause:	The operator has entered an invalid password for a password-protected feature.
Action:	Please enter the correct password.

Code no. 205	
Message:	Please fill in the "…" field.

Cause:	The automatic report name feature is enabled and the operator has not filled in the required field.
Action:	Please fill in the required field in the 'Info' tab of the 'Report' dialog. Alternatively, change the automatic report name settings by pressing 'Customise'.

15.4.2 Test result error codes.

The following error codes are related to a performed test and are displayed in the test result dialog.

Troubleshooting.

Code no. 100	
Message:	HS DC CBR is not closed. Test Aborted.
Cause:	The system has detected that the circuit is not closed.
Action:	Please check the circuit and ensure that the High-speed DC Circuit Breaker is closed.

Code no. 101	
Message:	Not tripped / Imax = … A
Cause:	The High-speed DC Circuit Breaker has not tripped during the test.
Action:	If a trip is desired, please try again using a higher test current. The maximum current during this test is displayed as the Imax value. Ensure the setting of the High-speed DC Circuit Breaker is correct.

Code no. 102	
Message:	Battery Overload detected. Test aborted.
Cause:	A battery overload has been detected by the system. This means that the battery voltage has reached 10 V during the measurement or that the measured output current deviated too much from the desired current.

Action:	To avoid battery overloading:
	    Wait for the battery indicator to turn green (battery fully charged) before starting injections.
	    Reduce the impedance of the circuit.
	    Reduce the test current or duration.
	Contact Megger technical assistance if the problem persists.

Code no. 103	
Message:	Tripped too soon / Imax = … A
Cause:	A trip has occurred before the valid measurement range in which a trip is expected.
Action:	Please try reducing the test current. In Auto Mode, the measurement range can also be widened by lowering 'k1'. The measured trip current is displayed as Imax.

Code no.104	(Reserved for secondary injection.)

Code no. 105	
Message:	0 (!) µOhm.
Cause:	The system has measured a voltage drop of 0 mV / resistance of 0 µΩ.
Action:	Please ensure the voltage drop measurement leads are connected properly to the High-speed DC Circuit Breaker and controller µΩ inputs.

Code no. 106	
Message:	HS DC CBR is not open. Test Aborted
Cause:	The system has detected that the circuit is not open
Action:	Please ensure that the High-speed DC Circuit Breaker is open

15.5   Current Injection.

If an alarm occurs that blocks further operation of the system, the 'Info' dialog will be displayed. For a description of the occurred alarm

Operation of the system may be blocked due to the following:

- Emergency Stop Button is active.
  - The emergency stop button is pressed down. Release the button to continue operation of the system.
  - For more information, please consult the chapter 'System Assembly' - section 'Control Unit' - 'Emergency Stop'.
- DC Current Generator temperature.
  - DC Current Generator temperature monitoring is installed and has detected a temperature exceeding 55 °C.
  - Please wait for the DC Current Generator to cool down.
- Battery voltage.
  - If the battery voltage is below 12 VDC, please wait for the battery to recharge.
- PLC error.
  - PLC errors regarding the I/O system will prevent further operation. A system restart may be required.
  - Please contact Megger technical assistance if the problem persists
- Ultracapacitor temperature.
  - An ultracapacitor's temperature has exceeded 60 °C. Please wait for the ultracapacitor to cool down.
- Disk space critically low.
  - The used disk space has exceeded 98%. Please free up disk space by deleting stored report files.
- No DC Current Generator connected.
  - The system has detected no connected DC Current Generator. Connect a DC Current Generator to resume operation.

16. Appendix 1

16.1   Concise technical specifications.

Environment:	
Application field:	Used for testing DC high-speed circuit breakers in various areas including railway (traction, DC power substations, rolling stock) and industries such as mining, marine, etc.
Operating temperature:	0 °C to +55 °C (+32 °F to +131 °F)
Storage & transportation temperature:	-20 °C to +65 °C (-13 °F to +149 °F)
Humidity:	5% to 95% RH, non-condensing
Operating altitude:	≤ 2,000 m
Ingress protection:	IP20
UKCA and CE Marking:	
LVD	EN (IEC) 61010-1; EN (IEC) 61010-2-030
EMC	EN (IEC) 61326-1
Railway Standards:	
Fixed installations - DC switchgear:	IEC 61992-1 Ed.2 - Part 1 IEC 61992-2 Ed.2 - Part 2
Electric equipment for rolling stock:	IEC 60077-1 Part 1 IEC 60077-2 Part 2
General:	
Mains input:	AC 120 V 60 Hz AC 230 V 50 Hz
Power cord:	CEE 7/7 Plug to IEC 60320 C13, 2 m, 10 A, AC 250 V
Duration of primary injection:	2 s to 5 s
Duration of constant current:	60 s maximum
Duration of secondary injection:	0 s to 20 s
Output modes secondary injection - Current:	-20 … +20 mA, 4 … 20 mA
Output modes secondary injection - Voltage	-60 … +60 mV, -10 … +10 V
Maximum output voltage Current Generator:	DC 4.7 V
Maximum current Current Generator:	4,000 A
Accuracy of results:	1.5%
Energy supply:	Batteries and Ultracapacitors
Output voltage:	DC 15.7 V
Earth cable cross-section:	2.5 mm²
Emergency stop lever:	Disconnects DC current generators from energy compartment.
Control Unit:	
Functionality:	HMI (Human Machine Interface) and CPU
Screen Type:	TFT touchscreen
Screen Diagonal:	145 mm (5.7")
Screen Resolution:	640 x 480 pixels

Software:	Primary injection testing and calibration.
Optional:	Secondary injection testing.
On-screen keyboard:	QWERTY, AZERTY
Reporting:	PDF (standard), CSV (standard), XLS (optional).
Communication:	Ethernet 100 base-Tx and USB 2.0
Emergency stop:	Stops all injections immediately.
Interface languages:	English, French, Dutch, German, Spanish, Italian, Chinese, Czech.
Power Cables:	
Length:	2 m (78") or 3 m (118")
Cross-section:	240 mm²
Mass:	4.5 kg (9 lb) for 2 m, 6.8 kg (14 lb) for 3 m
Connectors:	DC current generator side: BALTO proprietary.
BALTO Modular specific	
Current consumption:	AC 120 V 60 Hz: 7.20 A
	AC 230 V 50 Hz: 3.50 A
Dimensions complete system :	1,200 x 645 x 1,005 mm (47.2 x 25.4 x 39.6")
Mass complete system :	249 kg (548 lb) for configuration with five current generators, excluding power cables.
Mass Support Carriage:	110 kg (242 lb) for maximum configuration.
	73 kg (161 lb) for minimum configuration.
Dimensions Control Unit :	230 x 490 x 460 mm (9 x 19.3 x 18.1")
Mass Control Unit :	16.4 kg (36 lb)
Dimensions Current Generator:	155 x 710 x 420 mm (6 x 27.9 x 16.5")
Mass Current Generator:	24.5 kg (54 lb)
Maximum number of DC current generators:	Five (Ten in master/slave configuration.)
Maximum current:	20,000 A (40,000 A in master/slave configuration.)
BALTO COMPACT 4000 specific	
Current consumption:	AC 120 V 60 Hz: 7.20 A
	AC 230 V 50 Hz: 3.50 A
Dimensions complete system:	760 x 730 x 510 mm (30" x 28,7" x 20")
Mass complete system:	76 kg (168 lb)
Dimensions Main Unit:	760 x 660 x 270 mm (30" x 26" x 10,6")
Mass Main Unit :	28 kg (62lb)
Dimensions Current Generator:	700 x 660 x 145 mm (30" x 26" x 5,7")
Mass Current Generator:	28 kg (62 lb)
Maximum number of DC current generators:	One
Maximum current:	4,000A

17. Appendix 2

17.1 References for technical assistance.

Megger: Megger Ltd
          Support / Service
          Archcliffe Road
          Dover, Kent
          CT17 9EN
          United Kingdom
          Phone: +44 (0) 1304 502 101
          DoverSales@megger.com
          www.megger.com

STEVO   STEVO Electric bvba
Electric: Support / Service of legacy systems
          Hamsesteenweg 22/6
          3971 Leopoldsburg-Heppen
          Belgium
          Phone: +32 (0) 11 341 001
          stefaan.volkaert@stevoelectric.be
          www.stevoelectric.be

Beckhoff: Beckhoff Automation GmbH & Co. KG
          Hülshorstweg 20
          33415 Verl
          Germany
          Phone: +49 (0) 5246 963 157
          info@beckhoff.com
          www.beckhoff.com

BENNING: BENNING Elektrotechnik und Elektronik
          GmbH & Co. KG
          Münsterstraße 135-137
          46397 Bocholt
          Germany
          Phone +49 (0) 2871 930
          info@benning.de
          www.benning.de

Maxwell: Maxwell Technologies, Inc.
          3888 Calle Fortunada
          San Diego, CA 92123
          USA
          Phone: +1 858 503 3300
          sales@maxwell.com
          www.maxwell.com

EnerSys: EnerSys
          2366 Bernville Road
          Reading, PA 19605
          USA
          Phone: +1 610 208 1991
          info@enersys.com
          www.enersys.com

18.   Calibration, Repair and Warranty

Megger operate fully traceable calibration and repair facilities to make sure your instrument continues to provide the high standard of performance and workmanship that is expected. These facilities are complemented by a worldwide network of approved repair and calibration companies, which offer excellent in-service care for your Megger products.

For service requirements for Megger instruments contact:

Megger Limited	OR	Megger
Archcliffe Road		Valley Forge Corporate Centre
Dover		2621 Van Buren Avenue
Kent		Norristown
CT17 9EN		PA 19403
U. K.		U. S. A.
Tel: +44 (0) 1304 502 243		Tel: +1 610 676 8579
Fax: +44 (0) 1304 207 342		Fax: +1 610 676 8625

18.1   Return procedure

WARNING : Warning: Remove the battery cells before shipping this instrument.

UK and USA Service Centres

1. When an instrument requires recalibration, or in the event of a repair being necessary, a Returns Authorisation (RA) number must first be obtained from one of the addresses shown above. The following information is to be provided to enable the Service Department to prepare in advance for receipt of your instrument and to provide the best possible service to you:

   ▪ Model (for example, BATL).

   ▪ Serial number (found on the display under settings, device information, or on the rear cover and by the batteries or on the calibration certificate).

   ▪ Reason for return (for example, calibration required, or repair).

   ▪ Details of the fault if the instrument is to be repaired.

2. Make a note of the RA number. A returns label can be emailed or faxed to you if required.

3. Pack the instrument carefully to prevent damage in transit.

4. Before the instrument is sent to Megger, freight paid, make sure that the returns label is attached or that the RA number is clearly marked on the outside of the package and on any correspondence. Copies of the original purchase invoice and packing note should be sent simultaneously by airmail to expedite clearance through customs. In the case of instruments which require repair outside the warranty period, an immediate quotation can be provided when obtaining the RA number.

5. Track the progress on line at www.megger.com.

19. Decommissioning

19.1 WEEE Directive

The crossed out wheeled bin symbol placed on Megger products is a reminder not to dispose of the product at the end of its life with general waste.

Megger is registered in the UK as a Producer of Electrical and Electronic Equipment. The Registration No is WEE/ HE0146QT.

For further information about disposal of the product consult your local Megger company or distributor or visit your local Megger website.

19.2 Battery disposal

The crossed out wheeled bin symbol placed on a battery is a reminder not to dispose of batteries with general waste when they reach the end of their usable life.

For disposal of batteries in other parts of the EU contact your local Megger branch or distributor.

Megger is registered in the UK as a producer of batteries (registration No.: BPRN00142).

For further information see www.megger.com

Megger.

Local Sales office

Megger Limited
Archcliffe Road
Dover
Kent
CT17 9EN
ENGLAND
T. +44 (0)1 304 502101
F. +44 (0)1 304 207342

Manufacturing sites

Megger Limited
Archcliffe Road
Dover
Kent
CT17 9EN
ENGLAND
T. +44 (0)1 304 502101
F. +44 (0)1 304 207342

Megger USA - Dallas
4545 West Davis Street
Dallas TX 75237
USA
T. 800 723 2861 (USA only)
T. +1 214 333 3201
F. +1 214 331 7399
E. USsales@megger.com

Megger GmbH
Obere Zeil 2 61440
Oberursel,
GERMANY
T. +49 06171 92987 0
F. +49 06171 92987 19

Megger AB
Rinkebyvägen 19, Box 724,
SE-182 17
DANDERYD
T. +46 08 510 195 00
E. seinfo@megger.com

Megger USA - Valley Forge
Valley Forge Corporate Center
2621 Van Buren Avenue
Norristown
Pennsylvania, 19403
USA
T. +1 610 676 8500
F. +1 610 676 8610

Megger USA - Fort Collins
4812 McMurry Avenue
Suite 100
Fort Collins CO 80525
USA
T. +1 970 282 1200

This instrument is manufactured in the United Kingdom.

The company reserves the right to change the specification or design without prior notice.

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