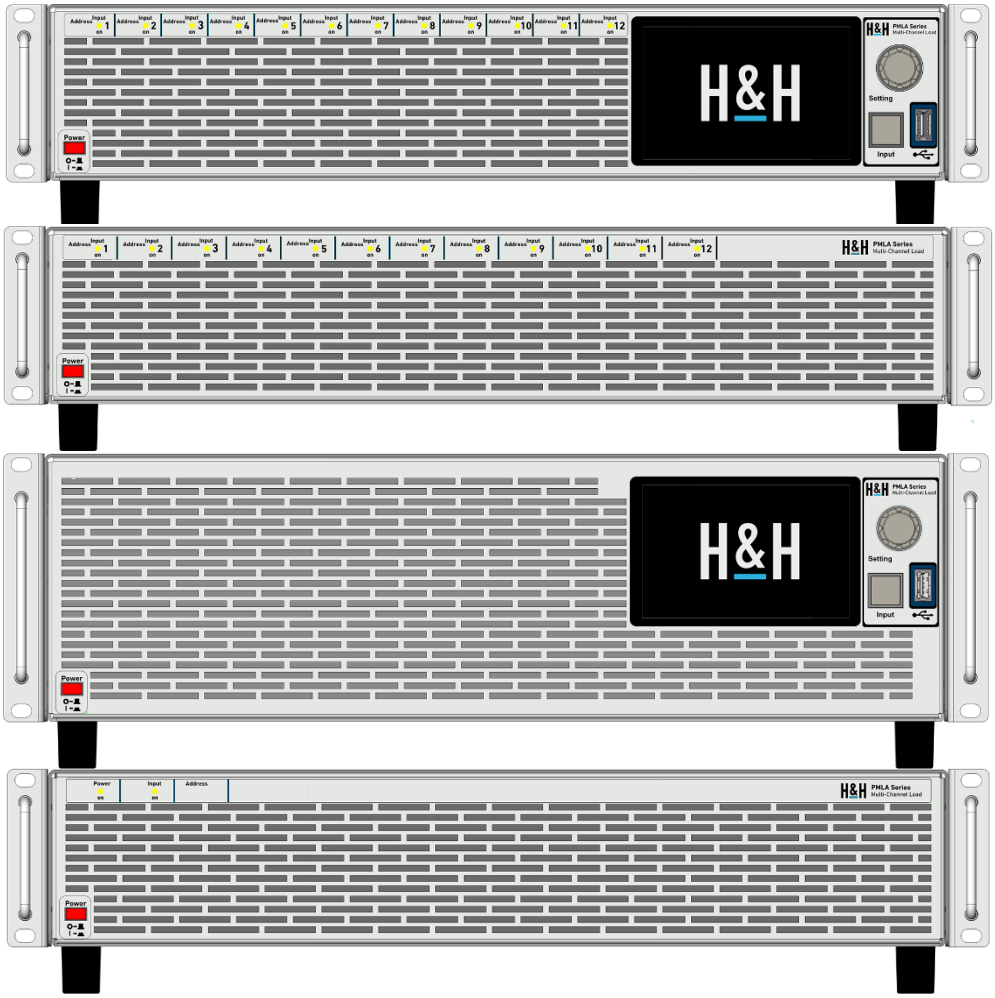

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Table of Contents

1 Introduction and Safety 7
1.1 About This Manual 7
1.2 Description of the Symbols 7
1.3 Terminology and Intended Use 7
1.4 General Information 8
1.4.1 Safety Equipment 8
1.4.2 Unpacking 8
1.4.3 Product Identification 8
1.4.4 Packing 9
1.5 Requirements for the Operator 9
1.6 Operator's Responsibilities 9
1.7 General Safety Instructions 10
1.8 Possible Hazards 11
1.8.1 Electric Shock 11
1.8.2 Burns 11
1.8.3 Injury by Mechanical Effects 11
1.8.4 Effects on Electromedical Devices 12
1.9 Measuring Category 12
1.10 Operating Conditions and Installation of the Device 13
1.10.1 Environment and Emissions 13
1.10.2 Operating Conditions 13
1.10.3 Symbols on the Device 14
1.11 Moving and Relocating 14
1.12 Mains Connection 15
1.13 Switching On the Device 15
1.14 Service and Maintenance 15
1.15 Calibration 16
1.16 Energy Efficiency 16
1.17 Warranty and Repair 16
1.18 Disposal 17
1.19 Abbreviations Used in This Manual 18
2 PMLA Variants 18
2.1 PMLA Standard 19
2.1.1 PMLA Standard Master Front 19
2.1.2 PMLA Standard Master Rear 19
2.1.3 PMLA Standard Slave Front 20
2.1.4 PMLA Standard Slave Rear 20
2.1.5 Module Configuration 20
2.1.6 Labelling of the Channel Numbers and Addresses 21
2.1.7 Modules' Voltage and Current Ranges 22
2.2 PMLA LP 22
2.2.1 PMLA LP Front 22
2.2.2 PMLA LP Rear 23
2.2.3 Module Configuration 23
2.2.4 Load and Sense Labelling 24
2.3 PMLA HP 25
2.3.1 PMLA HP Front 25
2.3.2 PMLA HP Rear 25
2.4 Putting Into Operation 26
2.4.1 Safety Instructions When Connecting the Device Under Test 26
2.4.2 Load and Sense Lines 27
2.4.3 Examples of How to Connect the DUT 27
2.4.4 Input Connector 28
2.4.5 Copper Bars with Safety Cover 30
2.4.6 Permissible Potentials at the Device Terminals 32
2.4.7 Operating Range 32
2.4.8 Protections and Notifications 33

2.5 Connecting System Bus 34
2.6 Channels and Channel Groups 34
3 Basics of Local Operation 37
3.1 Control Elements 37
3.1.1 Touchscreen 37
3.1.2 Key “Input” 37
3.1.3 Rotary Encoder “Setting” 37
3.1.4 Mains Switch 37
3.1.5 USB- Socket 37
3.1.6 Buzzer 38
3.2 Touchscreen Structure 38
3.2.1 Main Section 39
3.2.2 Right Sidebar 40
3.2.3 Status Bar 40
3.2.4 Channel Bar 41
3.3 Main Views 41
3.3.1 Main View with Numeric Measurement Values 41
3.3.2 Main View Yt Graph 42
3.3.3 Function-Specific Main Views 42
3.4 Graphical Control Elements for Navigation 42
3.4.1 Main Menu Icon 42
3.4.2 Main Screen Icon 42
3.4.3 Main View Icon 43
3.4.4 Virtual Keypad Icon 43
3.4.5 OK Icon 43
3.4.6 Esc Icon 43
3.4.7 Shortcut Icon 43
3.5 Graphical Control Elements for Input and Output 44
3.5.1 Measurement Widget 44
3.5.2 Graph Widget 44
3.5.3 Edit Widget 44
3.5.4 Button Widget 45
3.5.5 Checkbox Widget 45
3.5.6 Dropdown Widget 45
3.5.7 Slider Widget 46
3.5.8 Swipelist Widget 46
3.5.9 Simplified Swipelist Widget 46
3.5.10 Progress Bar 46
3.6 Pop-Up Windows 46
3.6.1 Error Window 47
3.6.2 Notification Window 47
3.6.3 Notification Window in Remote Operation 47
3.6.4 Warning Window 48
3.6.5 Help Window 48
3.6.6 Confirmation Window 48
3.6.7 Status Overview 49
3.7 Menu Structure 49
3.8 Help for Dialog and Menu Windows 50
4 Functions 51
4.1 Selecting the Control Source 51
4.2 Basic Operating Modes and Settings 51
4.2.1 Current Mode (CC) 52
4.2.2 Power Mode (CP) 53
4.2.3 Resistance Mode (CR) 54
4.2.4 Voltage Mode (CV) 55
4.2.5 Immediate Settings 55
4.2.6 Triggered Settings 56
4.2.7 Setting Several Channels Simultaneously 56

4.3 Protections and Combined Operating Modes 56
4.3.1 Overcurrent Protection 57
4.3.2 Undervoltage Protection 57
4.4 Regulation Speed 58
4.5 Load Input On-Off 58
4.6 LIST Function 58
4.6.1 Terminology 59
4.6.2 List Set Definition 60
4.6.3 Importing a List File 61
4.6.4 List Execution 63
4.6.5 List Execution by Trigger 63
4.6.6 Data Acquisition by List Function 63
4.6.7 List Example with Data Acquisition 64
4.6.8 General Information for the LIST Function 65
4.7 Internal Data Acquisition (ACQ) 65
4.8 Data Transmission According to IEEE 488.2 - Binary Block Data 65
4.9 Reading Data from Internal Memory 66
4.10 Directory Structure on USB Flash Drive 66
4.11 Discharge Function 67
4.12 Displaying Measurement Data 68
4.13 MPP Tracking 69
4.13.1 Terminology 69
4.13.2 MPPT Function 70
4.14 Watchdog 71
4.15 Fan Speed Control 72
4.16 Trigger Model 72
4.16.1 Trigger Model States 72
4.16.2 Trigger Delay 72
4.17 SyncroLink 73
4.17.1 Functional Principle 73
4.17.2 SyncroLink Delay 75
4.18 Applying Voltage and PWM Operation 75
4.19 Keylock Function 76
4.20 Remote Notification 76
4.20.1 Beeper 76
4.20.2 Notification Window 76
4.21 Configuring Alarm 77
4.22 Save and Recall Device Settings 77
4.22.1 Internal Memory 77
4.22.2 USB Memory 78
4.23 Reset Device Settings 80
4.24 Factory Reset (Preset) 80
4.25 Firmware and User Manual Update 81
4.26 User Manual Download 82
5 Digital Remote Control 83
5.1 Standards 83
5.2 Selecting and Deselecting an Interface 83
5.3 CAN Interface 84
5.3.1 CAN Connector 84
5.3.2 Termination 84
5.3.3 CAN Cable 85
5.3.4 Transmission Rate 85
5.3.5 CAN Address 85
5.3.6 CAN Messages 85
5.4 LAN Interface 86

5.4.1 Ethernet 86
5.4.2 Ethernet Connector 86
5.4.3 Ethernet Cable 86
5.4.4 Transmission Rate 87
5.4.5 Identification 87
5.4.6 TCP/IP 87
5.4.7 TCP Socket 88
5.5 RS-232 Interface 88
5.5.1 RS-232 Cable 88
5.5.2 RS-232 Interface Parameters 89
5.5.3 Data Format at RS-232 Communication 89
5.6 USB Interface 89
5.6.1 USB Cable 89
5.6.2 USB Interface Parameters 89
5.6.3 Data Format at USB Communication 90
5.7 GPIB Interface (Option PMLA02) 90
5.7.1 GPIB Cable 90
5.7.2 GPIB Address 90
5.7.3 Data Format at GPIB Communication 91
5.8 SCPI Command Syntax 91
5.8.1 Header Construction 91
5.8.2 Indentions 91
5.8.3 Selection 92
5.8.4 White Space 92
5.8.5 Long and Short Form, Upper and Lower Case 92
5.8.6 Optional Keywords 92
5.8.7 Parameters 92
5.8.8 Numeric Values 93
5.8.9 Units and Multipliers 93
5.8.10 Numeric and Extreme Values <NRf>|MIN|MAX 94
5.8.11 Boolean Parameters <boolean> 94
5.8.12 Text Parameters 94
5.8.13 Name Parameters <name> 95
5.8.14 String Parameters <string> 95
5.8.15 The Semicolon 95
5.8.16 Queries 96
5.9 Error Queue 96
5.10 Common Commands Description 96
5.10.1 *CLS 96
5.10.2 *ESE <NRf>, *ESE? 96
5.10.3 *ESR? 97
5.10.4 *IDN? 97
5.10.5 *OPC, *OPC? 97
5.10.6 *OPT? 98
5.10.7 *RCL 98
5.10.8 *RST 98
5.10.9 *SAV 99
5.10.10 *SRE <NRf>, *SRE? 100
5.10.11 *STB? 100
5.10.12 *TRG 100
5.10.13 *TST? 100
5.10.14 *WAI 100
5.11 Device-Dependent Commands Description 100

5.11.1 ACQuisition Subsystem ... 101
5.11.2 CHANnel Subsystem ... 102
5.11.3 CURRent Subsystem ... 104
5.11.4 DATA Subsystem ... 105
5.11.5 DISPlay Subsystem ... 106
5.11.6 FORMat Subsystem ... 107
5.11.7 FUNCtion Subsystem ... 108
5.11.8 INPut Subsystem ... 113
5.11.9 LIST Subsystem ... 114
5.11.10 MEASure Subsystem ... 118
5.11.11 POWer Subsystem ... 119
5.11.12 RESistance Subsystem ... 120
5.11.13 SERVice Subsystem ... 121
5.11.14 SETTing Subsystem ... 124
5.11.15 STATus Subsystem ... 125
5.11.16 SYSTem Subsystem ... 132
5.11.17 TRIGger Subsystem, ABORt Subsystem, INITiate Subsystem ... 140
5.11.18 VOLTage Subsystem ... 140
5.12 Common Commands Overview ... 142
5.13 Device-Dependent Commands Overview ... 142
6 External Control by I/O Port ... 151
6.1 PMLA Standard and HP ... 151
6.1.1 I/O Port ... 151
6.1.2 Controllable Functions ... 151
6.1.3 Pin Assignment Standard Variant ... 152
6.1.4 Pin Assignment HP Variant ... 153
6.1.5 Logic Inputs for Load Inputs ... 154
6.1.6 Analog Control Input ... 154
6.1.7 Analog Monitor Outputs ... 154
6.1.8 Connecting to a DAQ System ... 155
6.1.9 Sense Inputs ... 156
6.2 PMLA LP ... 156
7 Analog Master-Slave Mode (Standard and HP Variants) ... 157
7.1 Function ... 157
7.2 Wiring of the Load Channels ... 157
8 Troubleshooting ... 158
8.1 Oscillations ... 158
8.2 Electromagnetic Coupling ... 159
8.3 Distorted Slew Rate in Dynamic Operation ... 159
8.3.1 Causes ... 159
8.3.2 Measuring the Current Slew Rate ... 159
8.4 Distorted Monitor Signals ... 160
8.5 Effects of the Input Capacity ... 160
9 Appendix ... 161
9.1 Error Codes ... 161
9.1.1 Command Errors ... 161
9.1.2 Execution Errors ... 162
9.1.3 Device-Specific Errors ... 163
9.1.4 Query Errors ... 163
9.1.5 Non-standardized Errors ... 164
9.2 Device Parameters ... 165
9.3 Information for Special Models ... 165
9.4 Supplied Accessories ... 166
9.5 Technical Data ... 166
9.6 Declaration of Conformity ... 166
10 Index ... 167

1 Introduction and Safety

1.1 About This Manual

This operating manual describes the functions and operating of series PMLA electronic multi-channel loads from Höcherl & Hackl GmbH (also called H&H in the following). This manual includes the description of the hardware as well as the description of the firmware functions.

Before operating the electronic load you must have carefully read and understood this manual. Follow the instructions in this manual when operating the electronic load.

This user manual must be present near the electronic load at any time. When moving the electronic load the user manual must be brought with it or, respectively, it must be available electronically readable.
H&H reserves the right to make changes or updates in user manuals at any time. The latest versions are provided on the homepage www.hoecherl-hackl.com. The user manuals provided at the homepage are only valid for devices with up-to-date hardware and firmware release. If you need an user manual for a used device ask the H&H support support@hoecherl-hackl.com to provide a manual corresponding to your device (provide serial number).

1.2 Description of the Symbols

Refer to the user manual for specific warning or caution information to avoid personal injury or equipment damage.

This symbol refers to a prohibition.

This symbol refers to a note of the manufacturer, which is useful for operating the device.

1.3 Terminology and Intended Use

The electronic multi-channel load PMLA is a device used as a substitute for a conventional ohmic resistor or, respectively, for several ohmic resistors. Semiconductors transform the electric energy consumed by the electronic load into thermal energy. Fans transport thermal energy and cool the electronic load.
An electronic load is an electric consumer. Therefore, it is not a current or voltage source but a current sink.
The PMLA series electronic loads are suitable for the load of batteries, fuel and solar cells, generators and power supplies. The PMLA series electronic load is designed for DC applications only and must not be connected to AC voltages or to the mains at the DC input terminals.

According to DIN EN 55011, the electronic load of PMLA series is a class A device. This equipment is not intended to be used in domestic areas and cannot provide adequate protection for radio reception in such environments.

The electronic load is not intended for drying objects, animals or human hair by means of the hot exhaust airflow. Do not cover the ventilation slots. The electronic load must not be used as a footstool. Do not step on it and do not use it as a base for other parts.

If the unit is used is some other way than for the intended use the protective functions of the unit can be affected.

1.4 General Information

1.4.1 Safety Equipment

Safety shoes
When unpacking, carrying and relocating
Gloves
When unpacking, carrying and relocating
Hairnet
For long-haired users near the ventilation slots

1.4.2 Unpacking

Accessories

Accessories coming with your electronic load such as mains cable, screws etc. are listed in the separate file TechDat_PMLA_*dn*.PDF (*dn* = device number, see 1.4.3 Product Identification) on the supplied USB flash drive device. It depends on the type of load and on installed options. When unpacking, check if the packing contains all listed accessory parts and inform your supplier if necessary.

Mechanical Check-up

Check the electronic load for mechanical damage and loose parts inside the case immediately after unpacking.

If you recognize any mechanical damage, you must not put the electronic load into operation!

If there is damage because of transportation you must inform the carrier immediately about this fact and write it down on the consignment note. The carrier should countersign the note. Please notice that any complaints later than three days after receiving the goods generally aren't accepted by the carrier. Please also inform the supplier of the electronic load immediately.

1.4.3 Product Identification

The identification label is placed on the bottom of the device.

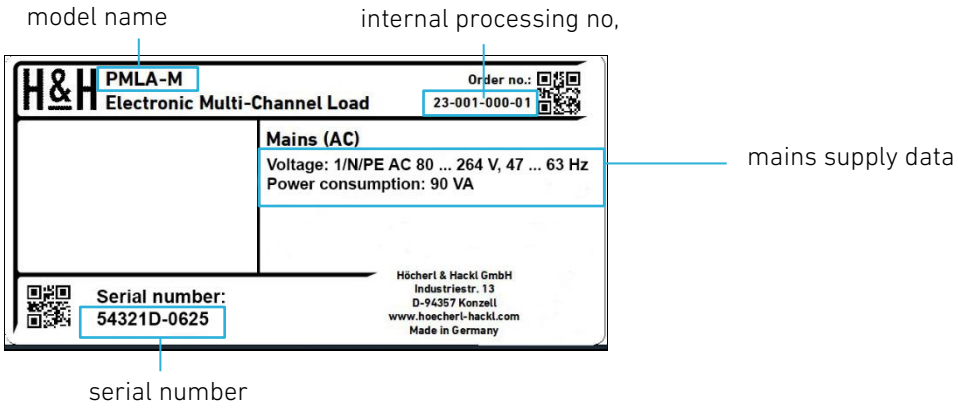


Figure 1.1: ID label

Serial number:

54321D-0525

device number production series date code (month, year)

1.4.4 Packing

H&H recommends to store the original packing and to reuse it when forwarding or returning a device.

You shall recycle materials labelled with the symbol shown on the left. Dispose the packing to the corresponding recycling container according to the national regulations.

You can return the packing to the manufacturer. Please take into account that deliveries are only accepted free of costs.

1.5 Requirements for the Operator

Each person using an electronic load is obligated to the legal job safety regulations and must apply the safety and warning notices in the user manual as well as the safety and accident prevention regulations valid for the given environment.

People using the electronic load

- must be skilled workers who are familiar with the risks during measuring electric magnitudes and have the corresponding qualification
- must not have impaired reaction ability, e.g., due to medication, alcohol, or drugs
- must be informed about the relevant job safety requirements
- must be informed about the responsibilities of maintenance and cleaning of the device
- must have read and understood the General Safety Instructions and the user manual before operating the device
- must use the mandatory safety equipment.

Improper use can cause injury or damage. Any activities should be performed only by persons who have the required training, knowledge and experience.

Skilled personnel are those who, due to their training, knowledge, experience, and familiarity with applicable regulations, are capable of properly performing the assigned work, recognizing potential hazards, and avoiding injury or damage.

Each person using an electronic load must check that the device is in a technically faultless state.

1.6 Operator's Responsibilities

An operator is any natural or legal person who uses the device or making the application available. He is responsible for the safety of the user, staff or third parties.

The device is used in the commercial sector. Therefore, the operator of the device is subject to legal industrial safety obligations. In addition to the warning and safety instructions in this manual the

safety and accident prevention regulations as well as environmental protection rules must be respected.

Particularly, the operator must

- inform itself of the applicable health and safety regulations
- determine other hazards that may arise from the special working conditions at the site of operation in a risk assessment and minimize the hazards
- implement the necessary rules of conduct for using the electronic load on site in operating instructions and
- check regularly throughout the period of use whether the provided user instructions correspond to the current status of the regulations
- adjust the operating instructions, if necessary, to new regulations, standards and operating conditions
- regulate clearly and unambiguously the responsibilities for installation, operation, maintenance and cleaning of the electronic load
- ensure that all employees who are working with the electronic loads have read and understood the user manual and the General Safety Instructions
- provide the required and recommended safety equipment to the employees who are working with the electronic loads
- train the employees working with the electronic loads at regular intervals on how to use the devices and which possible dangers may appear.

Furthermore, the operator must ensure that the device is always in proper technical condition.

1.7 General Safety Instructions

Use the electronic load only under supervision!

If the electronic load does not work properly anymore immediately abort operating the device. Do not try to repair the device on your own. Immediately contact the manufacturer.

All case and chassis parts are connected to the protective earth corresponding to Protection Class 1. For the operation of the devices all protective contact systems have to be correctly established.

DO NOT remove the protective earth connection of the power cable or the internal protective earth connection within the device!

Do not insert any objects into the ventilation slots!

If you assume that safe operating is not possible, you must disconnect the device and secure it against unintentional operation.

This may occur if:

- the device shows visible damage
- there are loose parts inside the device
- smoke is recognized
- the device has been overheated
- liquids have gone into the device
- the device does not work

If you unscrew the device feet, e.g. because a cabinet installation is to be carried out, keep the feet together with the screws and only use the original feet and screws if you want to screw them on again later.
Do not screw the screws into the bottom panel without the corresponding foot!

If you want to open the device remove the mains supply and all other voltage sources before opening the cover.

Checks or repairs with open case or calibration must be carried out by qualified personnel acquainted with the safety regulations.

The safety of a system in which the device is integrated is the responsibility of the system designer.

Also follow the safety instructions when connecting the DUT in chapter 2.4.1 Safety Instructions When Connecting the Device Under Test.

1.8 Possible Hazards

When using this product hazards for persons and property can occur.

1.8.1 Electric Shock

Warning of electric shock caused by dangerous potentials, wrong connection cables, or insufficiently covered input terminals!

Electric shock can lead to serious injury resulting in death: burns, muscle irritation such as muscle cramps, muscle paralysis, cardiac arrhythmias such as ventricular fibrillation, cardiac arrest, respiratory paralysis, neurological injuries, indirectly caused accidents such as falls.

- Install H&H safety cover at the load terminals if dangerous voltages appear!
- Adequately dimension the cross-section of the load cables!

1.8.2 Burns

Warning of burn caused by thermal energy, bad connection cables or bad connection, or reverse polarity, or overvoltage!

Electronic loads produce thermal energy dissipated through the rear panel. Touchable parts in the hot airflow can heat up and cause burns when being touched. Readily combustible solids and liquids which are in the hot air outlet can ignite.
Risk of burn is also given when the device under test is connected with unsuitable cables or when the used cable lugs or plugs are not sufficiently tightened. So, the terminals can heat up and cause burns when touched. Cables held in hands can cause burns.
Untightened terminals can cause electric arcs which can ignite materials in near environment.
Risk of burn is also given when the device under test is connected in reverse polarity or at overvoltage. Reverse polarity and overvoltage cause a short-circuit and therefore uncontrolled current flow! The load circuit of the electronic load is not protected by a fuse.

- Do not put any touchable parts or readily combustible materials in the hot airflow!
- Sufficiently dimension the cross-section of the load lines!
- Fix cable lugs and plugs tightly!
- Take care that the device under test is connected in right polarity!
- NEVER exceed the maximum input voltage!
- Connect an external fuse in the load circuit!

1.8.3 Injury by Mechanical Effects

Warning: Risk of injury due to falling device, pinching, or hair entanglement!

The electronic load can drop or fall and cause injuries such as bruising, bone fractures, skin-abrasion. When carrying or relocating the device fingers can clamp between device bottom and installation surface. Long hair may be sucked in by the rotating fans.

- Follow the notes in 1.11 Moving and Relocating when unpacking, transporting, carrying and moving the device!
- Wear safety shoes and gloves!
- Do not put hands between device bottom and installation surface!
- Wear a hairnet if you have long hair!

1.8.4 Effects on Electromedical Devices

Warning: Risk of interference with electro-medical devices!

Electronic loads can work at very high currents. High currents generate strong magnetic fields, which can have effects on electro-medical devices like pacemakers.

- Persons with electro-medical devices must not be near operating electronic loads.

1.9 Measuring Category

The measuring categories refer to the transients on the mains supply. Transients are short and very fast voltage and current changes which appear periodically or non-periodically. The shorter the distance to the source of the low-voltage installation the higher possible transients can be.

The following applies for electronic DC loads:
The electronic DC load is meant for operating the load inputs at circuits which are not or not directly wired to the mains.

At electronic DC loads no transient overvoltages may occur. Direct operation (without galvanic insulation) of devices under test (DUTs) with measurement category II, III, or IV is not allowed!

The current circuits of a test object are not connected directly to the mains if the test object is operated via an insulating transformer with protection class 2.

Measurement Categories according to IEC 61010-2-30:

Category	Definition
0	Measurements at current circuits not directly connected to the mains: *e.g. airborne supply systems, batteries*
CAT II	Measurements at current circuits electrically directly connected to the low-voltage mains supply: *e.g. household appliance, portable tools*
CAT III	Measurements in the building installation: *e.g. junction box, power switches, mains sockets*
CAT IV	Measurements at the source of the low-voltage installation: *e.g. counters, primary overcurrent protection equipment*

1.10 Operating Conditions and Installation of the Device

1.10.1 Environment and Emissions

The electronic load's noise emission depends on its construction, power, and operating mode. Considering the other noise emissions existing at the workplace, the operator must choose a suitable location for the device corresponding to the requirements of the Workplace Ordinance.

Electronic loads produce heat and heat up the environment. Ensure to maintain the required environmental conditions corresponding to the requirements of the Workplace Ordinance by special measures.

1.10.2 Operating Conditions

The operating conditions are listed in the technical data TechDat_PMLA_*gn*.PDF (*gn* = device number, see 1.4.3 Product Identification) on the supplied USB flash drive.

Warning of voltage flashovers due to condensation!
If the device is operated despite condensation, malfunctions or destruction of the device may occur.

- When stored below the minimum operating temperature, the device must first be brought to the minimum operating temperature before it is powered on!
- Avoid condensation!

The operating of the device has to take place in clean, dry rooms. It shall not be brought into operation in rooms that are contaminated with dust or humidity, under the danger of explosion or aggressive chemical influence. You may use the device only in upright alignment. Ensure that the mains voltage terminal is easily reachable when positioning the device.

Make sure that good air circulation is possible at the front panel and rear panel.

For rack-mounted devices, take care of good air circulation.

Never bring the device into operation when the rear door of the rack is closed! Never operate the device unattended!

Closed rear doors with ventilation slots will reduce the load's power consumption.

At higher environment temperatures take the power derating into account (see technical data).

If the device is used in a manner not specified by the manufacturer, the protection supported by the device may be weakened.

1.10.3 Symbols on the Device

DC current

AC current

DC or AC current

Grounding terminal

Protective Earth terminal

Warning about a dangerous place; read user manual!

Warning about dangerous electrical voltage

Warning about hot surface

1.11 Moving and Relocating

If you want to relocate the electronic load make sure that the power is switched off and all cables are disconnected.

The device is equipped with two handles for lifting and carrying. Always use both handles for carrying.

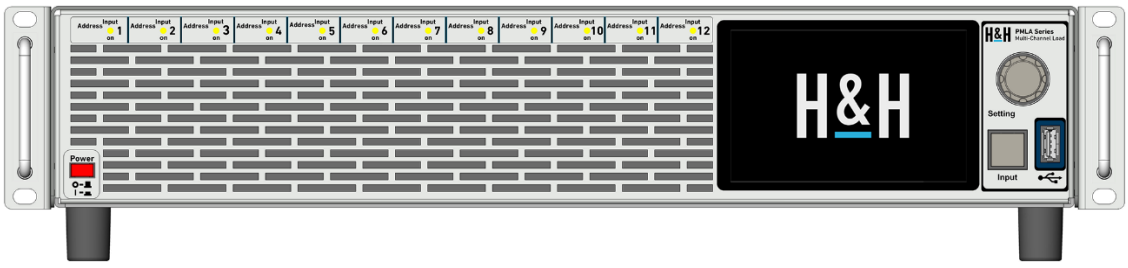


Figure 1.2: Handles for carrying und sliding out of a rack

Make sure to include the user manual when moving the electronic load and keep the manual near the electronic load or, respectively, the manual must be available electronically readable.

1.12 Mains Connection

Before connecting the electronic load to the mains make sure that the mains voltage setting or, respectively, the allowed mains voltage at the device matches the technical characteristics on the mains supply.

The devices are equipped with a wide-ranging power supply. The mains voltage value and frequency range are specified in the technical data and at the ID label, see 1.4.3 Product Identification.

All case and chassis parts are connected to the protective earth corresponding to Safety Class 1. For the operating of the devices all protection contact systems must be correctly established.

Do NOT remove the protective earth connection of the mains cable or the internal protective earth connection within the device.!

Only use a mains cable with sufficient diameter. Detachable mains cables with mains couplings in accordance with IEC 60320 must either meet the requirements of IEC 60799, or they shall be designed at least for a current corresponding to the rated data of the mains connector attached to the mains cable.

1.13 Switching On the Device

When the load is connected to the mains line it can be switched on by pressing the power switch A1 (e.g. see 2.1.1 PMLA Standard Master Front).

If your system consists of a master and one or several slave devices switch on all the slaves first and afterwards switch on the master device.

After switching on the power, the electronic load starts to proceed with an initialization routine. During the initialization no settings can be made. The initialization procedure takes about 5 seconds. After this the electronic load is ready for use.

The default settings after power-on are:

Control Source:	User Interface
Mode:	Current
Setting:	0 A
Input:	Off
Regulation speed:	Fast
Overcurrent Protection:	Maximum
Undervoltage Protection:	0V

1.14 Service and Maintenance

Cleaning the Cooling Paths

For the maintenance of any device it is necessary to clean the cooling paths regularly. Because of the strong forced air-cooling dust will deposit on the cooling fins and fans.

This is noticeable when the device can't take its nominal power anymore and overheating occurs (signalized by the OT LED).

You can clean the cooling fins and the fans with ionized compressed air. To do so, switch off the device and disconnect it from all voltages. Blow through the rear panel onto the cooling fins because especially there dust has settled down.

Cleaning the Case

For cleaning the case put the unit out of operation and disconnect all wires and cables.

Clean the case only with a damp rag. Use only water. For strong dirt you may use a glass cleaner. Take care that no liquids enter the cabinet.

1.15 Calibration

Several important characteristics of the device shall be inspected in regular periods, for example the accurate setting of the current or the accuracy of the displayed measurement values.

When there are noticeable deviations that are not within the specified tolerance range the device should be readjusted.

To do so, you can send the device to H&H where it is checked and calibrated at a fixed price. Before delivery, every new series device is calibrated at H&H. Within the 2-year warranty period, H&H will calibrate a second time free of charge if the device (serial number) has been registered via the H&H website. Use this link to registrate your device:
www.hoecherl-hackl.com/service/device-registration/

Order an RMA number if you want to send the device to H&H for calibration. See 1.17 Warranty and Repair.

For use under laboratory conditions, H&H recommends a calibration interval of 2 years. This is an empirical value that can be used as a guiding value for the first period of use. Depending on the intended purpose, period of use, relevance of the application and ambient conditions, the operator should adjust this interval accordingly.

1.16 Energy Efficiency

Electronic devices consume energy as soon as they are powered on even when they are not in operation. Therefore power off devices which are not in use.

1.17 Warranty and Repair

H&H grants a 24-month warranty with new devices, under the condition that the device wasn't manipulated and the failure has occurred during intended use of the device.

Defects will be eliminated by repair or replacement, if they are registered and accepted by H&H or one of its representatives within 24 months after delivery date (bill of delivery).

Since H&H doesn't know the exact application of the electronic loads nor the physical conditions of the units under test, no warranty for the correct operation of a whole system in the customer's sense can be given.

Damaged devices because of disregarding the technical data are not covered by the warranty, especially in case of exceeding the maximum permissible input voltage and maximum reverse current (see chapter 2.4.8 Protections and).

Worn out parts like fuses, relays and air filters are not subject to the warranty.

Transport damage is not subject to the warranty.

Packed devices from a size of 2 U must be fastened to a pallet! Do not send sensitive measuring devices by parcel service! We recommend that you use the original packaging when sending devices

by forwarding agent. If the original packaging is no longer available, you can request it from H&H at cost price. Please state the exact model of the device.

Location of warranty fulfillment is Konzell, Germany. The buyer is obliged to send the defective goods carriage paid with a precise description of the faults found. For any queries, also state the contact person and telephone number. Unpaid shipments will not be accepted.

In case of warranty repairs at the customer's locations the customer will be charged for the journey expenses.

This is excluded from warranty:

- Damage caused by input voltages higher than 120 % of the nominal voltage
- Damage by overcurrent in reversed polarity
- Input fuses in the load circuit
- Damage of the I/O port by exceeding the electrical specifications
- Modifications made by the customer
- Damage caused by transport
- Damage caused by improper handling (e.g. dropping, entrance of liquids)
- Costs for checking the unit when no failure can be detected

H&H Service Within the Warranty Period

Warranty at H&H:

- Material and working hours are free.
- The repair takes place at H&H.
- Forwarding expenses to H&H must be paid by the customer.
- H&H takes over the costs of the return shipment (standard shipment, no express shipment)

Warranty on site:

- Material and working time on site are free.
- The costs for travelling durations, driven distances and if necessary overnight accommodation are charged.

After expiration of the warranty period

Repair at H&H:

- Material and working time are charged.
- The repair takes place at H&H.
- Forwarding expenses to H&H and the return shipment must be paid by the customer.

Repair on site:

- Material and working time for the repair must be charged.
- The costs for travelling, distance driven and if necessary overnight accommodation have to be charged.

Requesting an RMA Number

When you intend to send the unit back for repair you must request an RMA number (Return Material Authorization) from H&H.
You can do this by phone, e-mail to support@hoecherl-hackl.com or via H&H homepage www.hoecherl-hackl.com.
Note the RMA numbers on your return papers as well as on the packaging of the goods.

1.18 Disposal

Electrical appliances must not be disposed of with household waste. The end user is legally obliged to properly dispose of used appliances. This can be done via community collection points or by returning them to the manufacturer, where they will be disposed of at no charge. Appliances are marked accordingly with the crossed-out dustbin.

1.19 Abbreviations Used in This Manual

This manual uses the following abbreviations:

AI	Analog Interface
CC	Constant current
CP	Constant power
CR	Constant resistance
CV	Constant voltage
DI	Data interface
DUT	Device under test
GND	Ground
MSD	Mass storage device, e.g. USB flash drive
OCP	Overcurrent protection
OPP	Overpower protection
OTP	Overtemperature protection
OV	Overvoltage
RV	Reverse voltage
UI	User interface
UUT	Unit under test
UVP	Undervoltage protection
UV	Undervoltage

2 PMLA Variants

There are 3 PMLA series variants:

- PMLA Standard as master (with touch display and data interfaces) or slave device (without display and data interfaces) for up to 12 load channels per device
- PMLA LP as master device for up to 72 load channels per device with low power
- PMLA HP as slave device for 1 load channel with high power

The three variants can be combined in a system with up to 96 channels. Only one master device may exist in the system (standard or LP variant).

2.1 PMLA Standard

2.1.1 PMLA Standard Master Front

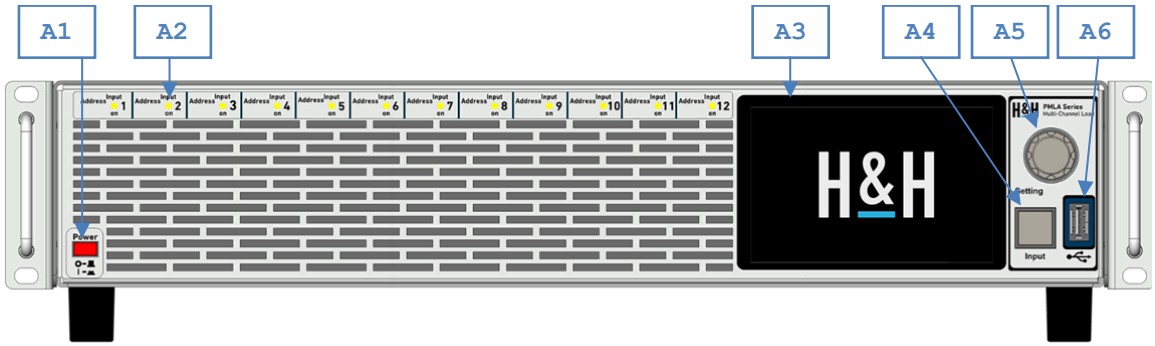


Figure 2.1: Front side PMLA standard master

A1	Mains switch
A2	LEDs for load input state of all channels
A3	Touch display for operating and measurements
A4	Push-button for load input on/off
A5	Rotary encoder for settings
A6	USB flash drive socket

2.1.2 PMLA Standard Master Rear

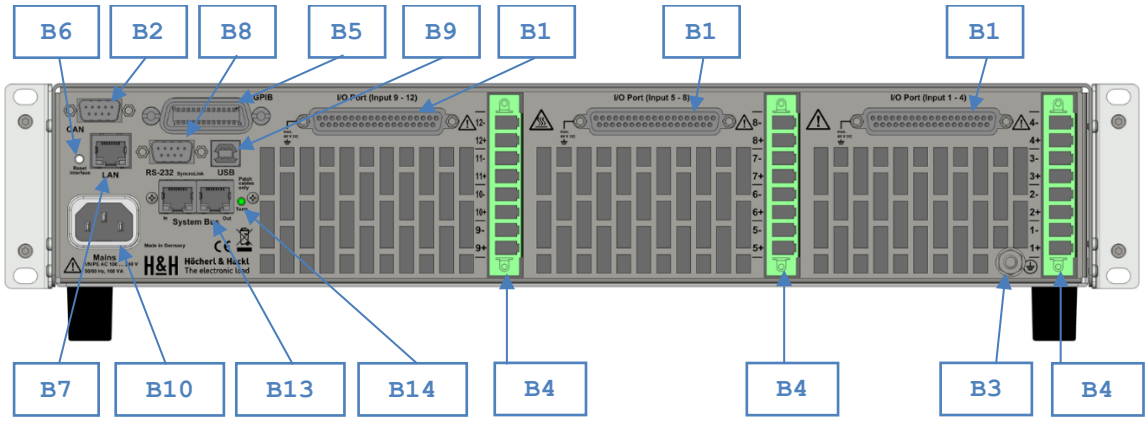


Figure 2.2: Rear side PMLA standard master

B1	I/O Port socket
B2	CAN interface plug
B3	Protective Earth screw
B4	Load terminals
B5	GPIB socket (optional)
B6	Interface reset button
B7	Ethernet socket
B8	RS-232 interface
B9	USB socket
B10	Mains plug
B13	PMLA system bus sockets
B14	LED for system bus termination

2.1.3 PMLA Standard Slave Front

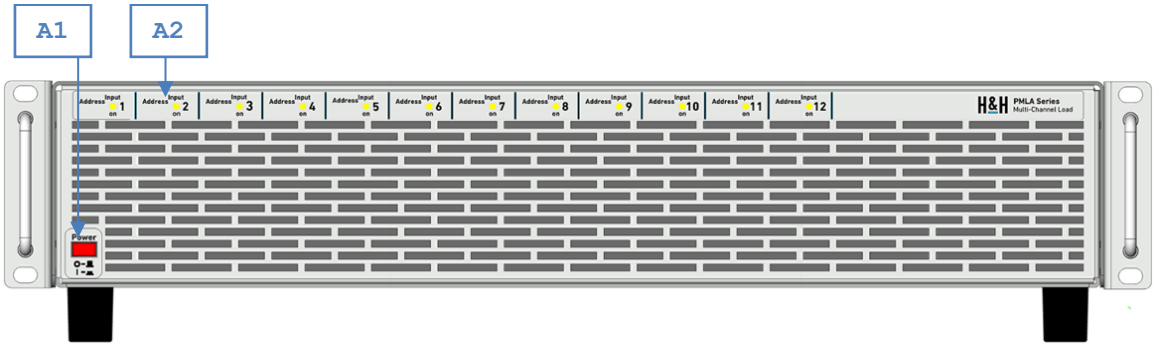


Figure 2.3: Front side PMLA standard slave

A1	Mains switch
A2	LEDs for load input state of all channels

2.1.4 PMLA Standard Slave Rear

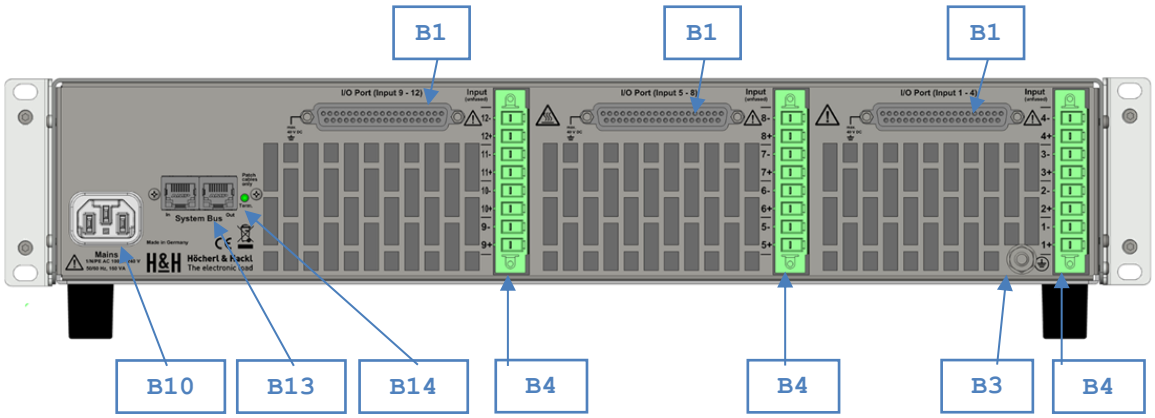


Figure 2.4: Rear side PMLA standard slave

B1	I/O port D-sub socket strip
B3	Protective Earth screw
B4	Load terminals
B10	Mains plug
B13	PMLA system bus sockets
B14	LED for system bus termination

2.1.5 Module Configuration

PMLA standard devices have up to 3 cooling units, each with 4 slots for load modules. Each slot accommodates one load module with 150 W. Modules with higher power ratings occupy several slots:

Power	No. of occupied slots
150 W	1
300 W	2
450 W	3
600 W	4

A load module cannot be split across several cooling units.

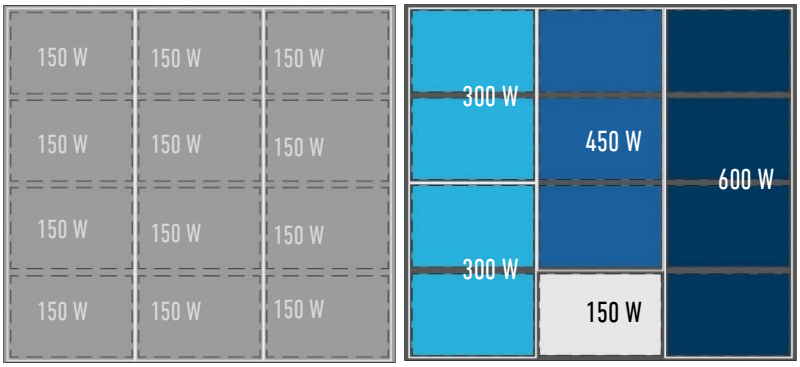


Figure 2.5 left: 3 cooling units with 4 module slots each, right: 5 channels with mixed power ratings

2.1.6 Labelling of the Channel Numbers and Addresses

There is a difference between the number of the physical channel input (hard-wired slot in the device, labelled "Input" at the front and rear panel) and the address of the channel (labelled "Address" at the front panel) with which it is selected and programmed.

In the housing there are max. 12 inputs for load modules available. They are marked with the labels "Input 1" to "Input 12" A2.

The related terminals on the rear panel B4 are also marked with "Input 1" to "Input 12".

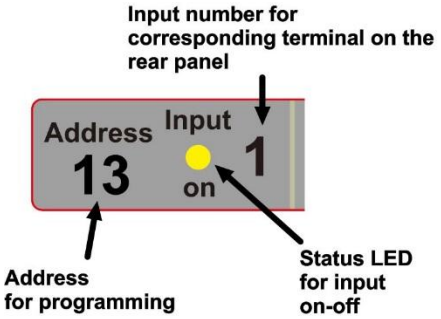


Figure 2.6 Address and input numbers

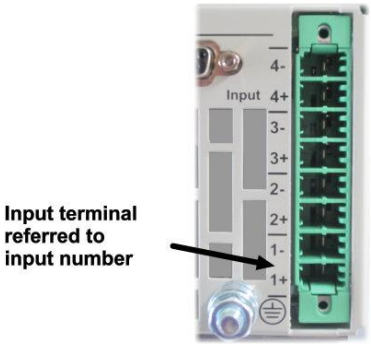


Figure 2.7 Input terminal

At systems with one or more Slave devices the input numbers repeat at each housing since they are always numbered from 1 to 12. The addresses of the channels are normally consecutively numbered from 1 to 96.

Load modules with higher power than 150 W occupy several inputs. Therefore, on the front panel several inputs are marked with the same address number.

Power	Number of input terminals
150 W	1
300 W	2
450 W	3
600 W	4

2.1.7 Modules' Voltage and Current Ranges

The voltage and current ranges of the individual channels can be viewed via the user interface in the menu:
Main Menu -> Tech. Data

2.2 PMLA LP

2.2.1 PMLA LP Front

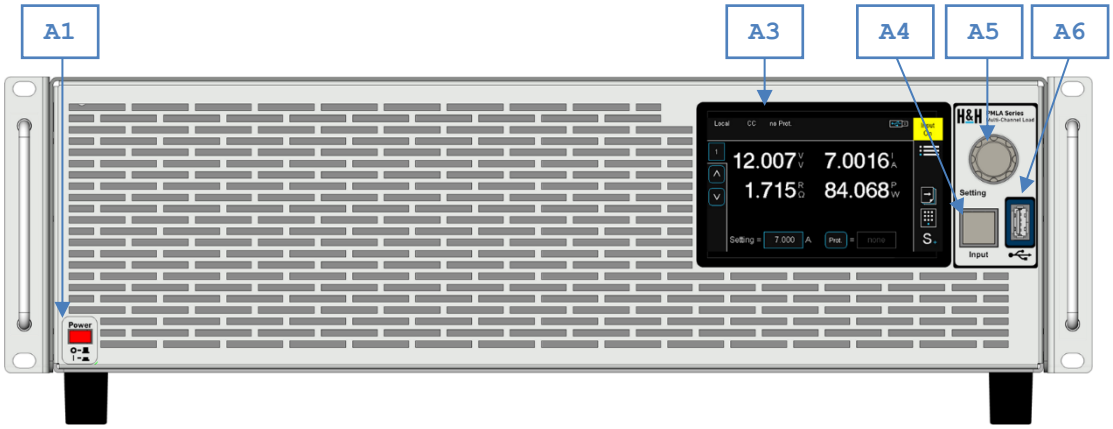


Figure 2.8: Front side PMLA LP

A1	Mains switch
A3	Touch display for operating and measurements
A4	Push-button for load input on/off
A5	Rotary encoder for settings
A6	USB flash drive socket

2.2.2 PMLA LP Rear

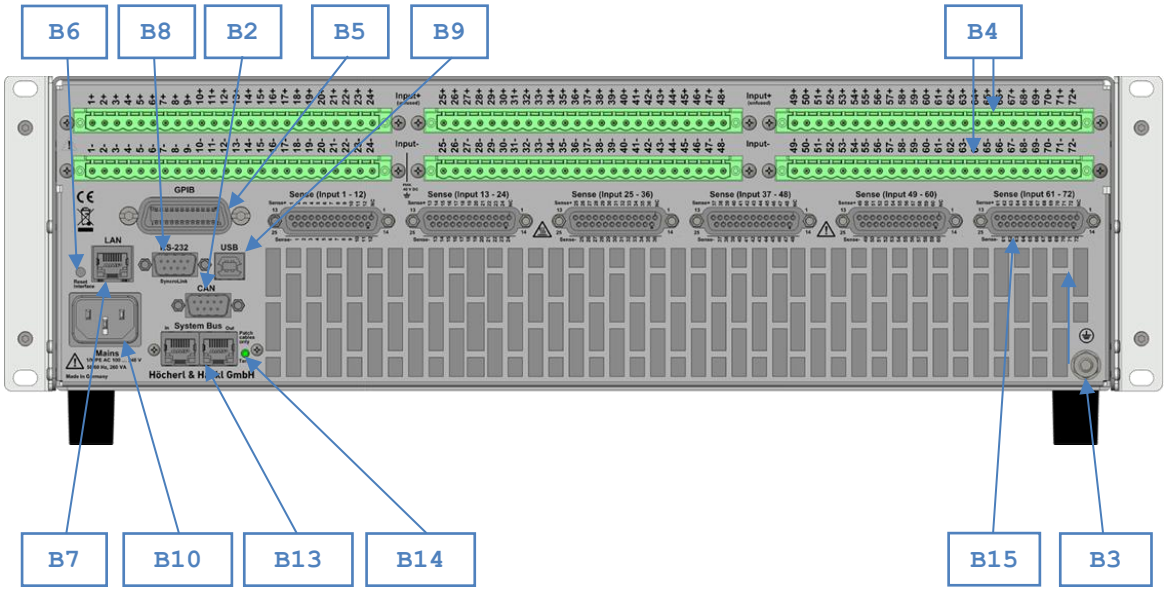


Figure 2.9: Rear side PMLA LP

B2	CAN interface plug
B3	Protective Earth screw
B4	Load terminals
B5	GPIB socket (optional)
B6	Interface reset button
B7	Ethernet socket
B8	RS-232 interface
B9	USB socket
B10	Mains plug
B13	PMLA system bus sockets
B14	LED for system bus termination
B15	Sense terminals (12 channels per D-sub socket)

2.2.3 Module Configuration

PMLA LP devices have up to 3 cooling units, each with 24 slots for load modules. Each slot accommodates one load module with 30 W. Modules with higher power ratings occupy several slots:

Power	No. of occupied slots
30 W	1
60 W	2
90 W	3
120 W	4

A load module cannot be split across several cooling units.

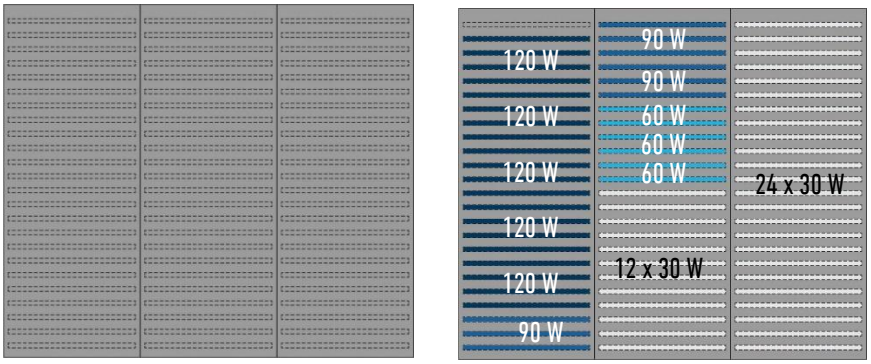


Figure 2.10: left: 3 cooling units with 24 module slots each, right: 47 channels with mixed power ratings

2.2.4 Load and Sense Labelling

Unlike the standard versions, the input and address numbers are not labeled on the front panel.

The modules' load inputs are led out to a maximum of three pairs of terminal strips at the rear panel. The positive load inputs are connected to the upper terminal strip and the negative load inputs to the lower terminal strip.

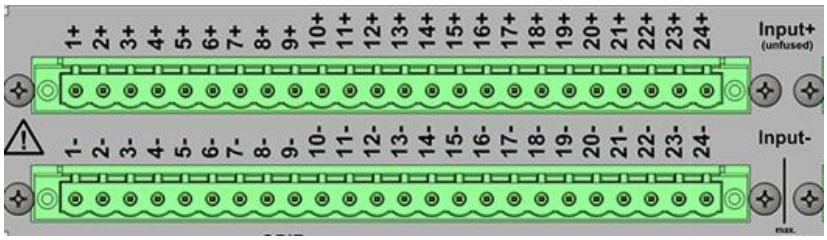


Figure 2.11: Positive and negative load terminals for Input 1 ... 24

The sense connections are located on up to 6 D-Sub sockets on the rear panel. Each socket strip has 12 sense pairs for the corresponding load inputs. The positive sense inputs are connected to the upper row and the negative sense inputs to the lower row.

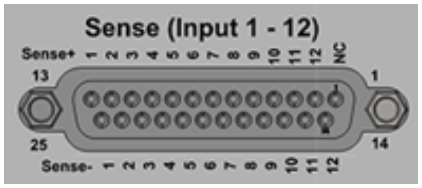


Figure 2.12: Sense terminals

2.3 PMLA HP

2.3.1 PMLA HP Front

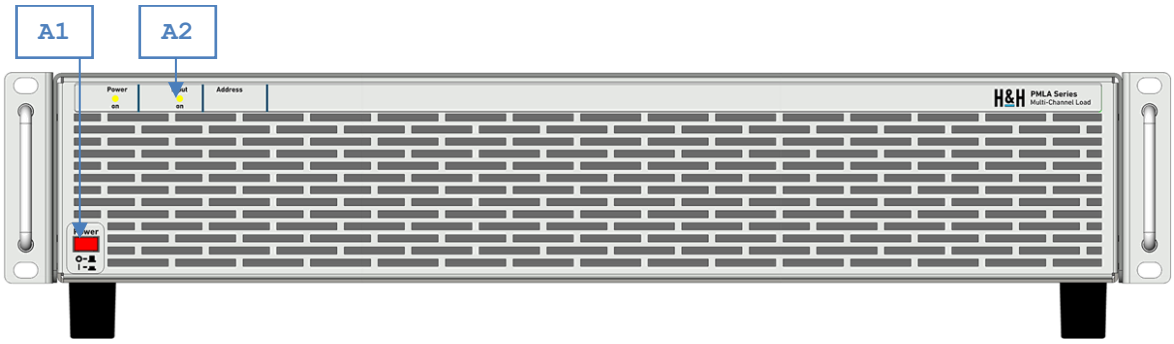


Figure 2.13: Front side of PMLA HP unit

A1 Mains switch
A2 LEDs for load input state of channel

2.3.2 PMLA HP Rear

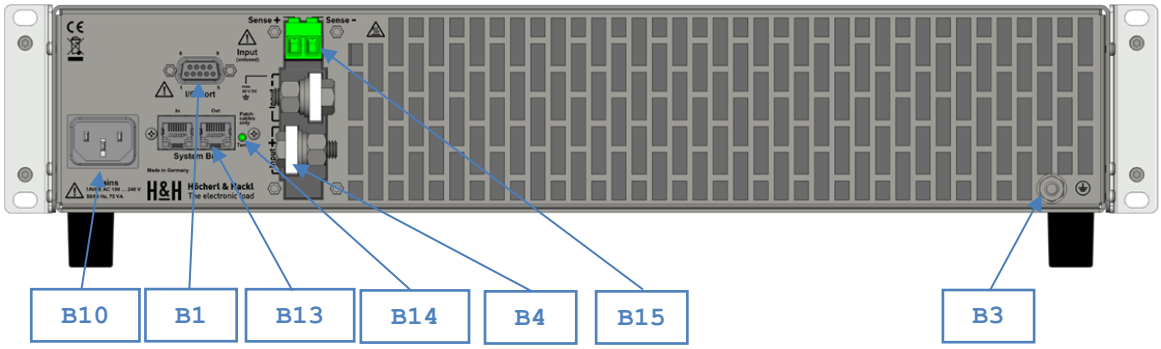


Figure 2.14: Rear side of PMLA HP unit

B1 I/O port D-sub socket strip
B3 Protective Earth screw
B4 Load input terminals
B10 Mains plug
B13 LED for system bus termination
B14 PMLA system bus sockets
B15 Sense terminals

The PMLA HP variant is always only one load channel with only one load input **B4** and one pair of sense terminals **B15**.
The HP variant is used to expand the system with a powerful channel and cannot be operated independently without a master unit.

2.4 Putting Into Operation

2.4.1 Safety Instructions When Connecting the Device Under Test

Provide a touch protection at any terminals with dangerous voltages!
You may realize the touch protection by installing the electronic load in other casings, racks, etc.

The maximum permissible voltages for touch protection are
for AC voltage: 30 V_{eff} / 42.4 V_p
for DC voltage: 60 V

The load circuits do **NOT have a fuse**. Connect a fuse suitable for your application between device under test and the electronic load's Input+ terminal!
If the potential on Input- of the electronic load against PE is increased, also connect a fuse in the positive output branch of the source which increases the potential!

When the device is used with dangerous voltage use a second measuring equipment to get reliable information about the level of the connected voltage.

The maximum voltage between the negative load inputs and device case is given in the technical data.

Switch on the power by pressing the electronic load's mains switch **A1** before connecting the input voltage to be loaded!

Switch off the concerning load input before connecting the unit under test! The display must show "Input Off" or the "Input" LED (not available on LP version) must be off!

The maximum input voltage defined in the technical data may NOT be exceeded, not even for a short time, neither at the load lines nor at the sense lines! **Overvoltage causes a short-circuit without any current limitation!**

Ensure the right polarity when connecting the device under test to the electronic load's input terminals! **Reverse polarity causes a short-circuit without any current limitation!**

The rear Protective Earth terminal **B3** must always be connected to the whole system's Protective Earth potential. Use a wire with at least 4 mm^2 for standard and HP variants and 10 mm^2 for LP variants.

The negative input terminals (Input -) are galvanically connected to GND of the I/O port. Thereby dangerous active voltages may appear at the I/O port if the negative input potential is shifted against PE.

Do NOT connect several electronic loads in series to increase the maximum tolerable input voltage!

Only choose cables with sufficient diameter and electric strength for the connection. Consider increased currents in case of fault of the device or the unit under test.

2.4.2 Load and Sense Lines

The DUTs are to be connected to the load terminal strips (standard and LP) or copper bars (HP) labelled by "Input" at the rear panel of the electronic load. These are the power leading inputs.

All PMLA variants offer sense lines for all load channels.

- Standard: I/O-Port D-sub socket strip **B1**, see 6.1.3 Pin Assignment and 6.1.9 Sense Inputs for pin assignment
- LP: Sense D-sub socket strip **B15**
- HP: Phoenix Contact double-pole plug **B15**

If the sense terminals are not connected the load measures the voltage automatically at the input terminals.

The sense lines have influence on all device functions the input voltage is essential for:

- Voltage measurement and display
- CV operating mode
- CR operating mode
- CP operating mode

The voltage measurement accuracies specified in the technical data only apply when the sense lines are connected.

If a device is not equipped with all load modules, the corresponding pins of the free modules are not assigned. If a load module occupies several slots (standard and LP variant) the corresponding input pins are connected in parallel. In this case, the sense lines are only available at the sense pins of the corresponding lowest slot number.

Twist the load lines to minimize the inductance. Twist also the sense lines, but do NOT twist the sense lines with the load lines to prevent coupling from the load lines.

The connection cables should not be longer than 3 m.

The sense terminals are connected internally via a PTC resistor to the corresponding load inputs and are protected against reverse polarity.

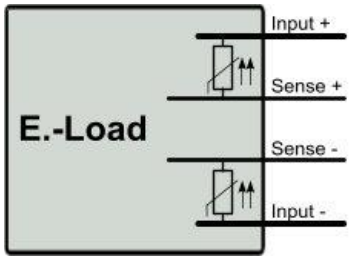


Figure 2.15: Internal connection of the sense lines

2.4.3 Examples of How to Connect the DUT

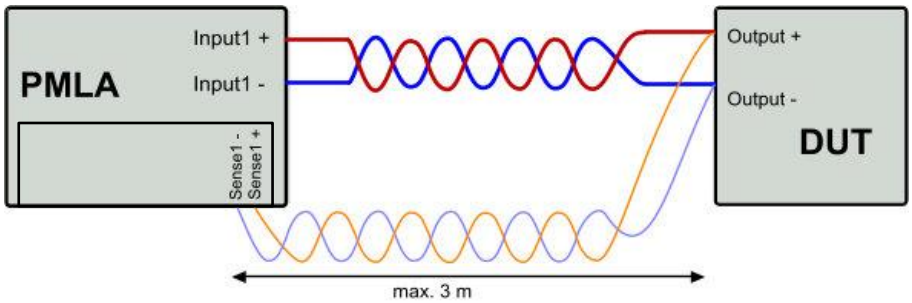


Figure 2.16: Wiring example for a single voltage

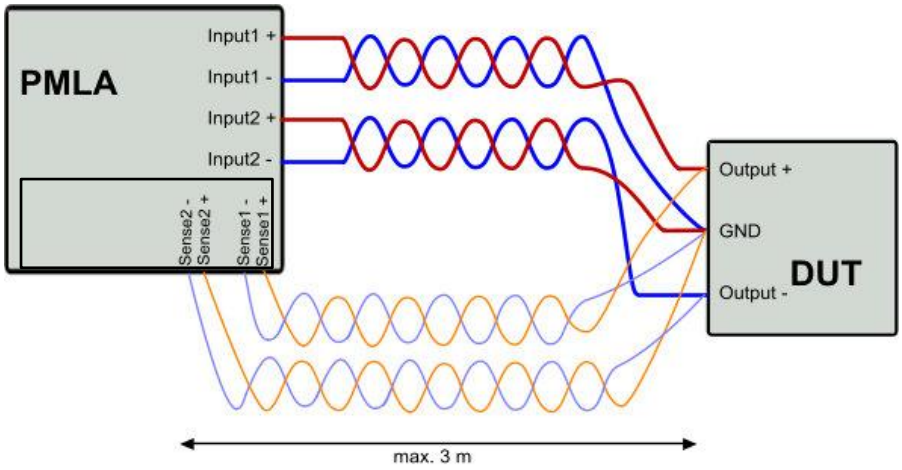


Figure 2.17: Wiring example for a bipolar voltage

2.4.4 Input Connector

In the standard version, the input connector is implemented as an 8-pole screw terminal block for up to 4 channels, which can be plugged into the device for quick connection. In the LP version, a pair of 24-pole screw terminal blocks are used for up to 24 channels.

To prevent a mix-up of the input connectors when plugging the mating connectors use the supplied coding pins. Slide 8 coding pins per connector couple into the notches in a way that each mating connector can only match with the corresponding input connector (see Figure 2.18).

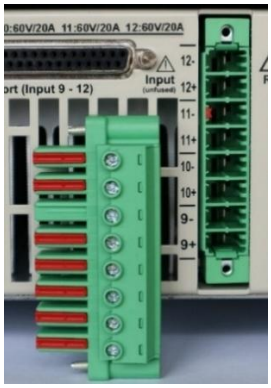


Figure 2.18: Connector coding example with standard device

If there is another PMLA device in the system, insert the coding pins in a way that for instance the left mating connector of device 1 cannot be plugged into the left input connector of device 2.

A set of mating connectors with corresponding coding pins is included with the device. Spare parts can be obtained from H&H or directly from the manufacturer Phoenix Contact.

	Standard	LP variant
Mating connector		
H&H name	PH8/7.62-BU43	PH24/5.08BU12
H&H order no.	63-000-001-23	63-000-003-23
Phoenix order no.	1777891	1898800
Coding pins		
H&H name	CP-PC RD	CP-MSTB
H&H order no.	63-000-002-23	63-000-004-23
Phoenix order no.	1701967	1734634

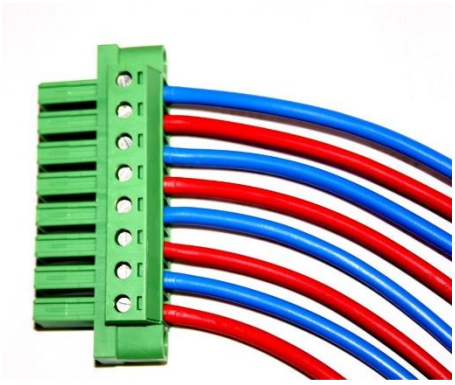


Figure 2.19: Input mating connector with standard device

Figure 2.20: Input with mating connector with standard device

The diameter capacity is up to 6 mm^2 for standard devices and 2.5 mm^2 for LP variants. The assignment of the channel to the corresponding terminal is indicated at the rear panel (see Figure 2.7 and Figure 2.11).

Example:
Input1+: Channel 1 Load Input +
Input1-: Channel 2 Load Input -
etc.

For modules that occupy multiple slots, multiple poles are led out in parallel as inputs. The labeling is then, e.g., for a standard device (LP variants are not labeled):
Input1-Input4: 60V/80A

In this case the input terminals of Input 1, Input 2, Input 3, Input 4 must be connected in parallel to carry the maximum current of 80 A.

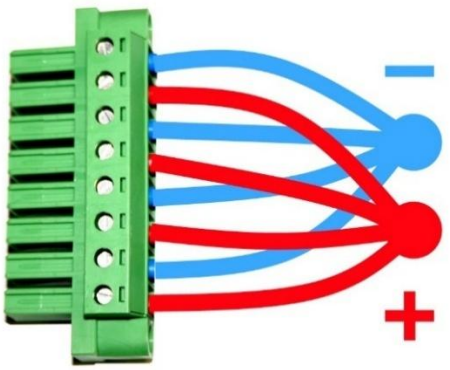


Figure 2.21: Parallel connection of Input1 to Input4

The current capacity of each input pin is 30 A for standard devices and 12 A for LP variants. Switch at least as many contacts in parallel so that the maximum current carrying capacity per contact is not exceeded. The corresponding inputs are also connected internally.

Do not connect the load lines in parallel at the connector's entry side but lead single load lines of the same diameter and length to the DUT and connect it there at its output. This achieves equal current distribution across the entire connector and prevents single pin overload.

2.4.5 Copper Bars with Safety Cover

In the HP variant, the load terminals are designed as copper bars. The safety cover supplied serves as touch protection and must be fitted before the electronic load is operated . Safety covers can be reordered from H&H.

2.4.5.1 Assembling Load Lines and Safety Cover

1. Disconnect load and sense lines from all voltage sources!
   Remove all cables and lines from the electronic load!

2. To ensure the appropriate safety distances, connect load lines with the supplied screws and washers to the copper bars so that they run straight on from the copper bars, corresponding to Figure 2.22.

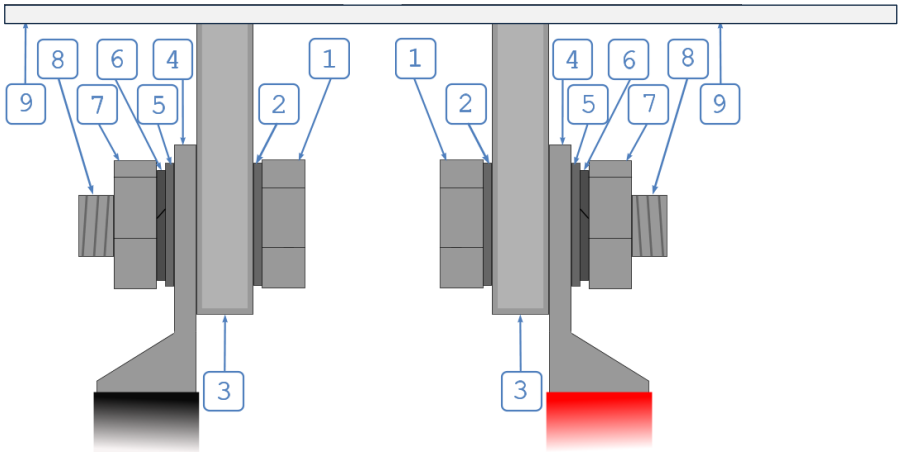


Figure 2.22: Screw and washer assembly on copper bars

1 screw head
2 washer
3 power bar
4 cable lug
5 washer
6 spring washer
7 nut
8 screw thread
9 rear panel

The following **numbers** refer to Figure 2.22.

3. Use a knife or side cutter to open the cable grommets 6 until the load cables fit through. For thick load cables, omit the cable grommets if necessary, ensuring that there is no more than 2 mm space between the cable and the cover! Proceed in the same way with the cable grommets for the sense lines 2.

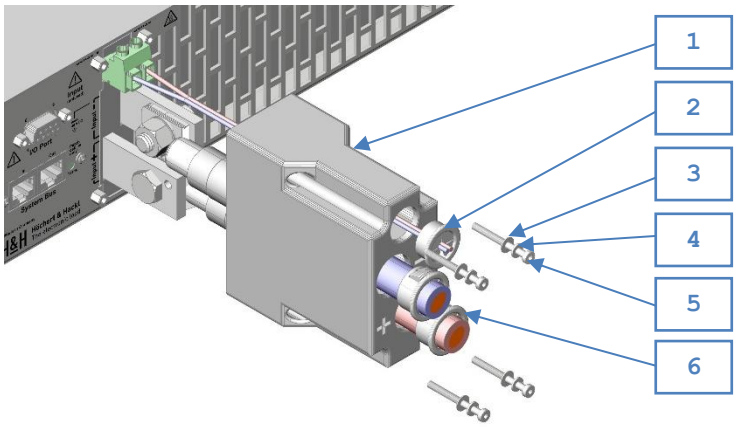


Figure 2.23: Safety cover SAB-PLI-2CUH

1 1 pc. housing
2 1 pc. cable grommet sense
3 4 pc. washer
4 4 pc. spring washer
5 4 pc. hexagon socket cylinder head screw M3x30
6 2 pc. cable grommet load

4. Insert the loose ends of the load cables as shown in Figure 2.23 first through the corresponding holes in the housing 1 and then through the cable grommets 6. Pay attention to the right polarity!

5. Connect the sense lines to the sense terminals. Insert the loose ends through the upper opening in the housing 1 and then through the cable grommet 2. Screw the housing to the rear panel using the screws and washers 8 9 10. Push the cable grommets over the wires and press them into the housing openings.

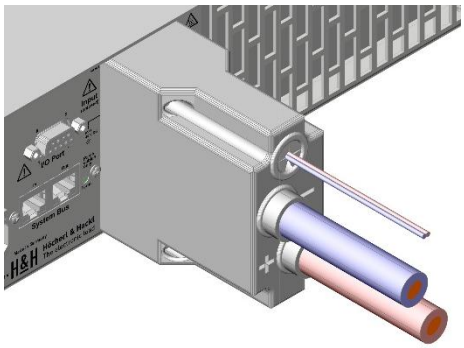


Figure 2.24: Completely mounted safety cover

2.4.5.2 Removing Load Lines and Safety Cover

1. Disconnect load and sense lines from all voltage sources!
   Remove all cables and lines from the electronic load!

2. After that, unscrew the safety cover from the electronic load and remove load and/or sense lines.

2.4.6 Permissible Potentials at the Device Terminals

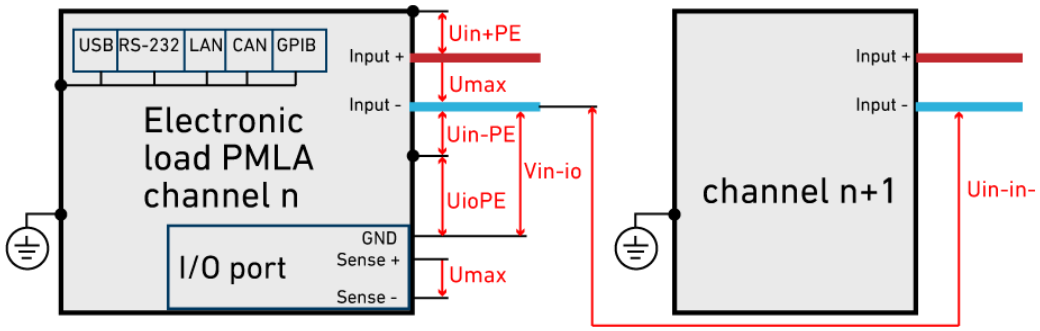


Figure 2.25: Voltages at the load modules

The maximum permissible potentials/voltages are defined in the technical data. These voltages must never be exceeded – even not in an error case!

Voltage potentials at the Data Interfaces

All data interfaces (USB, RS-232, LAN, CAN and GPIB) are connected to the Protective Earth terminal.

Protective Earth terminal:

Keep the rear Protective Earth terminal B3 always connected to the whole system's Protective Earth potential!

2.4.7 Operating Range

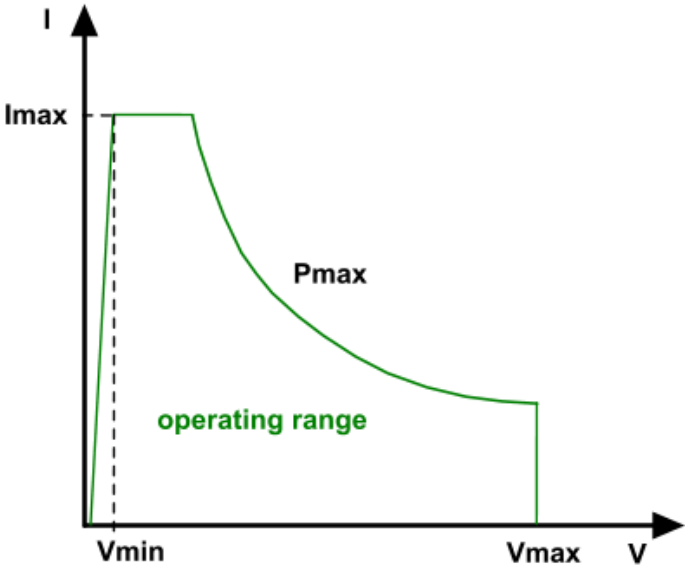


Figure 2.26: Operating range

The operating range of each channel depends on the minimum and maximum input voltage, the maximum current and the maximum power consumption. The corresponding limit numbers can be found in the technical Data listed in the file TechDat_PMLA_*dn*.PDF (*dn* = device number, see 1.4.3 Product Identification) on the supplied USB flash drive device.

With reduced load current also voltages below the minimum input voltage can be loaded.

2.4.8 Protections and Notifications

Overcurrent Protection OCP

At the operating modes voltage, power and resistance a current protection can occur at each channel. The function of adjustable overcurrent protection is described in 4.3.1 Overcurrent Protection.

Overvoltage Indication OV

When a voltage higher than 105 % of the nominal voltage is applied to a channel's input the device indicates this by displaying "OV" if the concerning channel is focused.

The maximum input voltage of a load module defined in the technical data may NOT be exceeded, even not for a short time! **Overvoltage causes a short-circuit without any current limitation!**

The load circuit does **NOT have a fuse**! Connect a fuse suitable for your application between device under test and the electronic load's Input+ terminal as shown in Figure 2.27!

Undervoltage Indication UV

If the concerning channel is focused the electronic load indicates a "UV" error if the input voltage is too low for the electronic load to keep the desired current.

Undervoltage Protection UVP

At the operating modes current, power and resistance a voltage protection can occur at each channel. The function of adjustable undervoltage protection is described in 4.3.2 Undervoltage Protection.

Reverse Voltage Indication RV

If an input voltage of < -0.5 V is recognized the electronic load will display "RV" if the concerning channel is focused.

When the DUT is connected in reverse polarity it is short-circuited by a built-in diode, even when the electronic load is switched off. If the reverse current is not limited the load channel concerned can be damaged when it exceeds the specifications!

The load circuit does **NOT have a fuse**! Connect a diode or a fuse suitable for your application between device under test and the electronic load's Input+ terminal as shown in Figure 2.27!

Damage to the electronic load caused by reversed polarity is not covered by warranty!

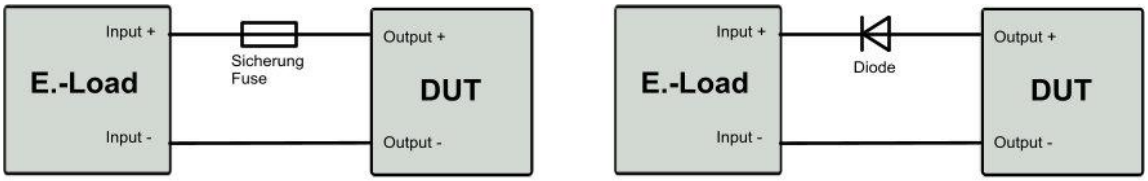


Figure 2.27: Reverse voltage protection by fuse (left) or diode (right)

Overpower Protection OPP

To protect the built-in power stage the power protection monitors the consumed power and limits the current in a way that approx. 110 % of the allowed power is possible.

If the overpower protection is active the electronic load will display "OPP" if the concerning channel is focused.

Overtemperature Protection OTP

To protect the power stage of the electronic load semiconductor temperature sensors are provided which permanently monitor the temperature. If a channel's temperature exceeds a permissible maximum, the current will be turned off.
After the power stage has cooled down, the current is reactivated automatically.

In case of overtemperature the electronic load indicates "OTP" if the concerning channel is focused.

2.5 Connecting System Bus

For assembling a multi-channel load system multiple PMLA slave devices can be connected to a PMLA master device. A master device can control up to 96 channels (including the channels within the master device, see Figure 2.28).

1. Connect the System Bus Out **B13** of the master device to the System Bus In of the slave device using an Ethernet patch cable.
2. Leave the System Bus In of the master device unconnected.
3. If additional slave devices are to be integrated into the system, connect System Bus In of each slave device to System Bus Out of the previous device using Ethernet patch cables.
4. Leave the System Bus Out of the last slave device unconnected.
5. Switch on all slave devices.
6. Switch on the master device.
7. Check termination: LED **B14** must be lit.

The patch cables should be as short as possible. The ideal length is 25 cm.

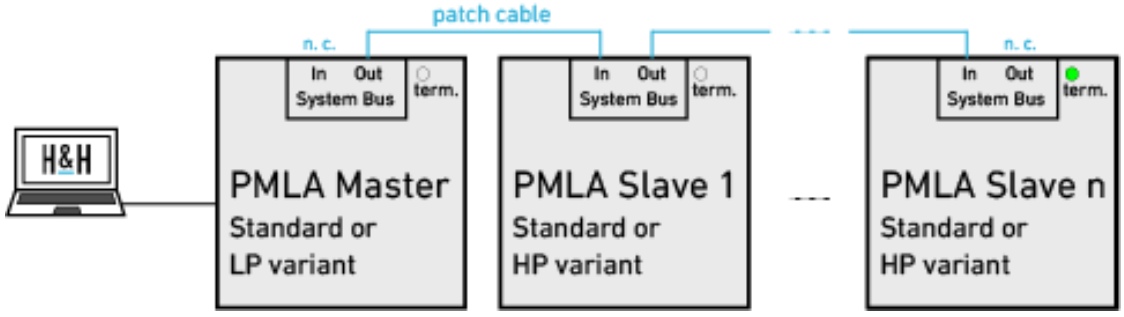


Figure 2.28: PMLA System bus wiring

Do not connect two Master devices to a system! This could cause damage to one of the devices.

2.6 Channels and Channel Groups

A channel represents the smallest unit in a system (single device or combination of devices), which can be selected by the data interface or focused via the user interface with the help of a unique address. These units can be assigned to different channel groups.

Terminology and Explanations

Channel, Address
The address of a channel must be unique and within the range from 1 to 99.
A reset or preset to factory settings have no influence on the address of a channel.
The address of a channel can be changed via the user interface or via a data interface.

Channel Group
Channel groups are used for the efficient and simultaneous setting of nominal values of several channels. 10 channel groups with the numbers 1 to 10 are available, whereby any subset of the available channels can be assigned to a channel group. Channel group 10 contains all available channels of the system by default and cannot be changed.
A channel can be assigned to several (also all) groups.
A reset has no effect on the channels of a group.
Channel groups can only be configured via a data interface.

Selection (operation via data interface)
The selection determines which channel or which channel group will get the following channel specific commands and queries received from a data interface.
The command “CHANnel[:SELect]” serves for channel selection, the command “CHANnel:GROup[:SELect] for channel group selection. If a channel group is selected, no channel specific queries can be executed (no automatic aggregation of query results).
The selection of a channel group invalidates the previous selection of a single channel. Conversely, the selection of a single channel also invalidates the previous selection of a group.
After powering on or resetting the Master device the channel with the lowest address in the system is selected.

Focus of a channel (operation via user interface)
The focus determines which channel status and measurement data will be displayed at the user interface and which channel will execute the channel specific commands and queries via the user interface. After powering the master device, the channel with the lowest address in the system is focused.
A reset has no effect on the focus.
A channel may be focused on the user interface independently of the selection of a different channel or channel group by the data interface.
See 3.2 Touchscreen Structure

Names
User-defined names with a length of up to 12 characters can be assigned for channels and channel groups. These names can consist of upper and lower case letters from the Latin alphabet, Arabian numerals and the underscore "_", but must not begin with a digit. Lowercase letters are implicitly converted to uppercase letters.
User-defined names can be used when selecting a channel or channel group (instead of the channel number or group number).
A reset has no effect on the names of channels and channel groups.
Channel and group names can be assigned and queried exclusively via a data interface. Names of individual channels are also shown on the user interface.

Programming Example:
Several channels simulate different consumers in the vehicle and are assigned corresponding names. The channels are assigned to a group called Interior or a group called Lights. Then all interior channels are switched on and later all lights channels.

INIT ROUTINE	CHAN:NAME 1,"WIN_LIFTER" CHAN:NAME 2,"VENTILATION" CHAN:NAME 5,"SEATHEATER1" CHAN:NAME 6,"SEATHEATER2" CHAN:NAME 9,"BRAKELIGHTS" CHAN:NAME 10,"HIGHBEAM" CHAN:NAME 11,"TAILLIGHT"	Assign names for channels 1, 2, 5, 6, 9, 10, 11
	CHAN:GRO:NAME 1,"INTERIOR" CHAN:GRO INTERIOR CHAN:GRO:MEMB 1,2,5,6	Assign name Interior for group 1 Select group Interior Assign channels to group Interior
	CHAN:GRO:NAME 2,"LIGHTS" CHAN:GRO LIGHTS CHAN:GRO:MEMB 9,10,11	Assign name Light to group 2 Select group lights Assign channels to group Lights

	CHAN:GRO INTERIOR INP ON … CHAN:GRO LIGHTS INP ON	Select group Interior All channels of Interior group input on … Select group Lights All channels of Lights group input on

In the programming example above, we assign names and use them to select the channel groups, in order to make the relationships clearer. To save data transmission bandwidth in a test stand software, we recommend working with names when communicating with the operator, but with numbers when communicating between the control computer and the electronic load.

Local operation:
Channel bar (see 3.2 Touchscreen Structure) or
Main Menu -> Channel -> Focus
Dropdown widget "New focus": select new focused address or name.

Main Menu -> Channel -> Address
Edit widget „Available channels": enter channel address to be modified.
Edit widget „New channel address": enter new channel address. Press "Change" button.

Digital remote operation:
See 5.11.2 CHANnel Subsystem

3 Basics of Local Operation

PMLA Standard Master and PMLA LP devices can be operated via a user interface on the front panel.

3.1 Control Elements

3.1.1 Touchscreen

The graphical touchscreen A3 is the core element of the user interface and is used for easy device operation. It is used to display measurement and setting values, navigate through menus, and configure the device and its functions.

3.1.2 Key “Input”

The "Input" key A4 activates or deactivates the load input of the focused channel. The load input state toggles with each keystroke between “ON” and “OFF”.

3.1.3 Rotary Encoder “Setting”

The rotary encoder A5 is used to change numerical values in edit widgets. Turn clockwise to increase the decimal digit marked by a blinking cursor. Turning counterclockwise decrements the decimal digit. Pressing the rotary encoder moves the blinking cursor one decimal place to the left.

3.1.4 Mains Switch

Use the mains switch A1 to switch the electronic load on and off. In pushed position (I) the power is switched on. In released position (O) the power is switched off.

3.1.5 USB- Socket

3.1.5.1 USB Flash Drive

The USB socket A6 (USB embedded host interface) is used to communicate with FAT16 and FAT32 formatted USB flash drives (mass storage devices). A connected and properly enumerated USB flash drive is indicated by a USB symbol in the status bar.

The USB interface is used for the following functions:

- measurement data logging
- importing setting values for executing a load profile
- exporting measurement data from the internal memory
- exporting/importing device settings
- exporting/importing the user manual from/to the internal memory
- updating the firmware

The following USB flash drives were tested:

- Intenso Alu Line 4GB USB2.0 FAT32
- Intenso Alu Line 32GB USB2.0 FAT32
- Intenso Speed Line 8GB USB3.0 FAT32
- Intenso Ultra Line 32GB USB3.0 FAT32
- Sandisk Ultra USB 3.0 64 GB
- Transcend Jetflash 700 USB 3.1 64 GB
- Verbatim Onestripe USB 3.0 128 GB

Only FAT16 and FAT32 formatted USB flash drives can be used. exFat and NTSF formatted USB flash drives are not compatible. Windows only allows formatting USB flash drives of 64 GB or larger as NTFS or exFAT. Therefore, use a suitable formatting tool.

Other USB flash drives should also be compatible, but H&H cannot guarantee this.

3.1.5.2 USB Mouse

For easier operation of the device in laboratory environments, a wired standard mouse can be connected to the USB socket A6 (USB embedded host interface). Pressing the left mouse button corresponds to a normal touch event. If an Edit Widget (see 3.5.3) is focused, the marked decimal place can be changed with the mouse wheel. Pressing the mouse wheel moves the blinking cursor one position to the left. The mouse wheel thus has the same function as the Rotary Encoder "Setting" (see 3.1.3).

When using a mouse, it is no longer possible to connect a USB flash drive. The USB interface does not support a USB hub.

3.1.6 Buzzer

The buzzer is used for acoustic signalling of

- an error event (a short beep is generated for each event)
- an alarm for critical system states (partially adjustable)
- an encoder input (adjustable)

3.2 Touchscreen Structure

The touchscreen serves for the interaction with the user and is divided into 4 sections.

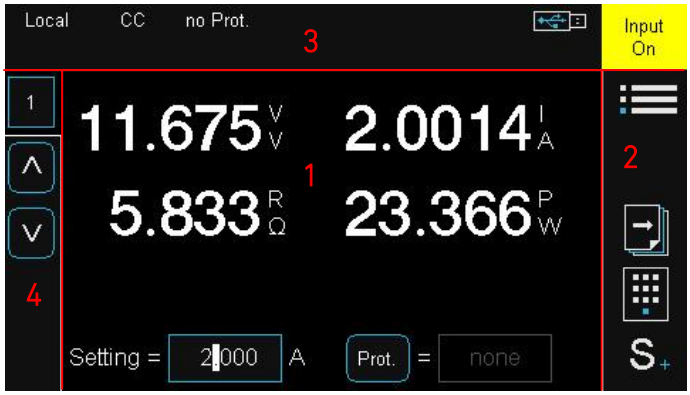


Figure 3.1: Touchscreen division

1. main section

2. right sidebar
3. status bar
1. channel bar

In addition, pop-up windows are displayed on the touch screen for specific events to provide the user with additional information. A detailed description of these pop-up windows can be found in the chapter 3.6 Pop-Up Windows.

3.2.1 Main Section

This section displays the various main, menu and dialog windows.

3.2.1.1 Main Window

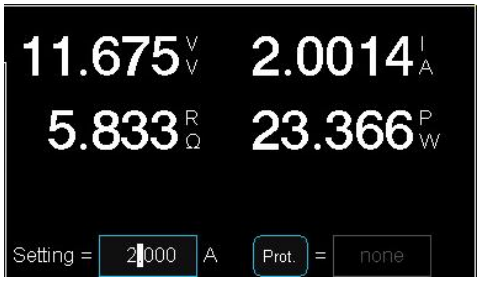


Figure 3.2: Main window

Depending on the view selected, the main window displays different measurement values and allows important setting values to be changed, which take effect immediately.

The main window is shown when the electronic load is switched on and can be accessed from any menu or dialog window by pressing the following button:

A detailed description of the individual views can be found in the chapter 3.3 Main Views.

3.2.1.2 Menu Window

Figure 3.3: Menu window

A menu window allows you to open another menu or dialog window. Each menu window contains menu items in the form of icons that can be selected by touching them on the touchscreen. If there are more than 8 menu items, the menu can be scrolled with vertical swipe movements.

Pressing the "Esc" button closes the current menu window and switches to the previous menu or main window.

A detailed description of the individual menu items can be found in the chapter 3.7 Menu Structure.

3.2.1.3 Dialog Window

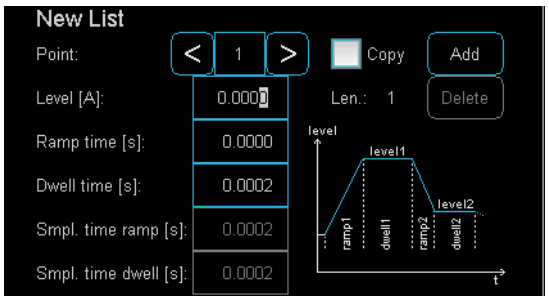


Figure 3.4: Dialog screen

Dialog windows allow you to view and adjust setting values for functions using various graphical control elements.

You can exit the dialog window using the 'OK' or 'Esc' buttons. 'OK' applies the changes, while 'Esc' discards them.

A detailed description of the graphical control elements can be found in chapter 3.5 Graphical Control Elements.

3.2.2 Right Sidebar

Figure 3.5: Right sidebar

This sidebar displays important buttons for navigation and quick device operation (e. g. menu, virtual keyboard etc.).

The symbols of this sidebar are described in the chapter 3.4 Graphical Control Elements for Navigation.

3.2.3 Status Bar

Figure 3.6: Status bar

In this bar, operation states and status signals are displayed independent of menu and dialog windows. Examples:

- control source (Local, RS-232, USB, CAN, LAN, GPIB)
- activation state of the load input (On, Off)
- operating mode of regulation (CC, CV, CR, CP)
- activation status of the external control via the I/O port (external)
- operation, questionable, function and service status
- status of the error queue (ERR)

- system unit mode (Master, Slave)
- control of a function by the UI ( )
- activated key lock (or)
- enumerated USB flash drive ( )

Detailed description of displayed status signals see 5.11.15 STATus Subsystem

By touching the status bar, the status window opens, in which all active status signals are listed in a table (see 3.6.7 Status Overview).

3.2.4 Channel Bar

Figure 3.7: Channel bar

The channel address of the focused channel is displayed in the channel bar. The desired channel number can be entered numerically or incremented or decremented using the two buttons.

3.3 Main Views

The main views are usually displayed during the loading of a device under test. They provide an overview of important measurement values and their history and allow the entry of setting values.

3.3.1 Main View with Numeric Measurement Values

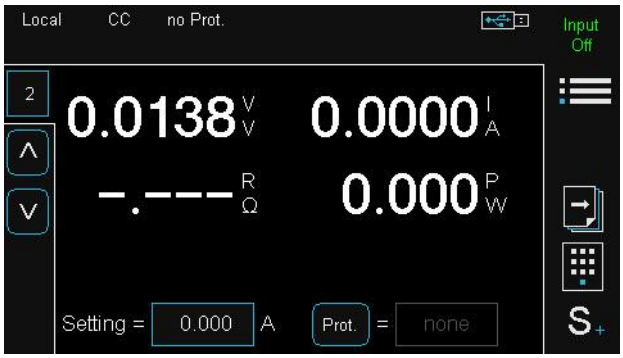


Figure 3.8: Main view

In this main view, the following measurement values are displayed:

- input voltage (in volts)
- input current (in amps)
- input resistance (in ohms)
- input power (in watts)

Furthermore, the setting values for the regulation and the current or voltage limitation during the load can also be changed here. The changes to these values are applied immediately.

3.3.2 Main View Yt Graph

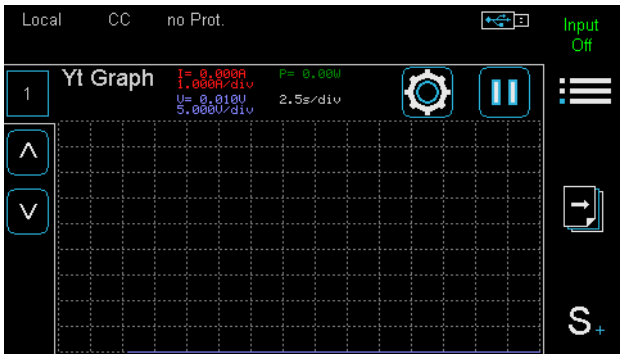


Figure 3.9: Yt graph

This main view shows the timeline of measured current, voltage, and power signals. The properties of the graphs displayed can be adjusted in a pop-up window by tapping the gear icon. The pause button in the upper right corner pauses the updating of this display. Pressing this button again continues the measurement recording without interruption.

3.3.3 Function-Specific Main Views

There are function-specific main views for important functions, which display important measurement and status values and allow important setting values to be changed when the function is activated. The changes of these values are applied immediately.

Depending on the function, its execution can be started with the shortcut combination S+ -> Start and ended with S+ -> Stop (see 3.4.7 Shortcut Icon).

3.4 Graphical Control Elements for Navigation

Graphical control elements for navigation are displayed in the right sidebar depending on the window displayed in the main area. They allow you to navigate between the main, menu, and dialog windows.

3.4.1 Main Menu Icon

This icon is displayed with active main windows and allows to open the main menu.

3.4.2 Main Screen Icon

This icon is displayed with most menu and dialog windows and allows to switch directly to the main window. Changes in dialog windows are discarded.

3.4.3 Main View Icon

This page turn icon is displayed if several main views are available and a switch of these views is possible (see 3.3 Main Views).

3.4.4 Virtual Keypad Icon

This icon is displayed whenever a numeric edit widget is in editing mode. It allows the direct input of a numeric decimal or floating point value. The virtual keypad also opens by double-touching the edit widget.

3.4.5 OK Icon

This icon is mainly displayed with dialog windows in which changes to setting values are possible. After pressing this icon, the changes are applied and the previous window is displayed.

3.4.6 Esc Icon

This icon is mainly displayed with menu and dialog windows and is used to exit the currently displayed window. Changes in dialog windows are discarded.

3.4.7 Shortcut Icon

Figure 3.10: Shortcut symbol (left) and shortcut list

The shortcut icon is displayed with main, menu and dialog windows. It opens a window with shortcuts that allows to quickly select important functions and dialog windows.

- Display of error queue entries
- Display of help for the current dialog or menu window

- Key lock for local operation
- Exit remote control mode and switch to local operation
- Start a pre-configured function
- Stop a running function
- Activate all load inputs
- Deactivate all load inputs
- Call the Function menu
- Call the "Save/Recall" dialog window
- Call the "Mode" menu window
- Create a screenshot on a connected USB stick

3.5 Graphical Control Elements for Input and Output

Graphical control elements for input and output appear in the main and dialog windows and are used for interaction with the device. They are identified by blue frames, blue sub-areas or blue nuances in a symbol.

3.5.1 Measurement Widget

The measurement widget displays a formatted measurement value. In most cases, the corresponding symbol (upper) with the unit (lower) is displayed next to the value.

3.5.2 Graph Widget

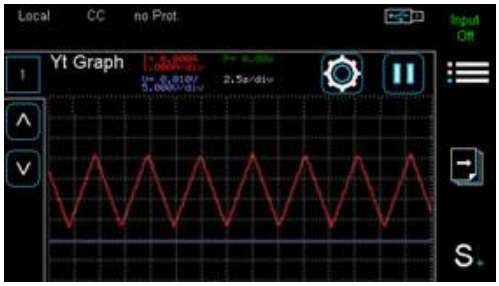
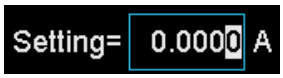


Figure 3.11: Graph widget

The graph widget visually displays a Yt or XY diagram, for example to show the time course of a measurement signal.

3.5.3 Edit Widget



This element is used to enter or change numerical values. It is displayed as a rectangular blue frame with a numeric value. The edit widget can be operated in two different ways.

Rotary encoder:

An edit widget can be set to editing mode by touching it. The editing mode is indicated by a blinking cursor at the decimal digit touched. This decimal digit can now be changed by turning the rotary encoder. In the event of an overflow or underflow, the adjacent decimal digit is incremented or decremented. Pressing the rotary encoder moves the cursor one digit to the left. Now the value of this digit can be changed, etc.

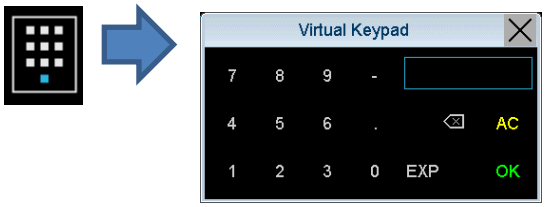


Figure 3.12: Keypad icon and virtual keypad

Virtual keypad:
When an edit widget is in editing mode, a keypad icon appears on the right sidebar. Touching this icon opens the virtual keyboard. This keyboard can be used to enter a numeric value directly. The 'AC' button clears the entire input. "OK" accepts the input, "Esc" rejects it.

You can also open the virtual keypad by double-tapping the corresponding edit widget.

3.5.4 Button Widget

The button widget is operated by touch. It is marked by a rounded blue frame with text. After releasing the button, the corresponding action is executed.

3.5.5 Checkbox Widget

The checkbox widget is operated by touch. This causes the check mark, which represents the state of the checkbox to be shown or hidden.

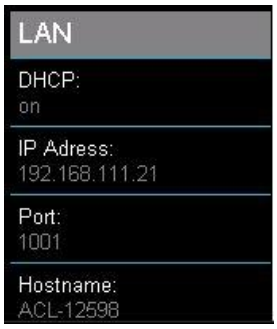
3.5.6 Dropdown Widget

The dropdown widget is operated by touch. It is marked by a rounded blue frame and a small triangle. After touching the dropdown widget, a selection list with predefined entries is opened. If there are many entries in the selection list, the list can be scrolled by a swipe gesture. The selected list entry has a blue font color and is marked with a blue rectangle. By pressing on an entry it is taken over and the selection list collapses.

3.5.7 Slider Widget

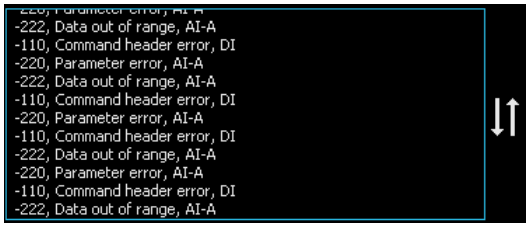
The slider widget can be operated by a touch, swipe.

3.5.8 Swipelist Widget



The swipelist widget is used to display "read only" information. The swipelist widget can be scrolled vertically by a swipe gesture.

3.5.9 Simplified Swipelist Widget



The simplified swipelist widget is used to display "read only" information. If there are many list entries, two arrows appear to the right hand side of the simplified swipelist widget in order to indicate that the list can be scrolled vertically by a swipe gesture.

3.5.10 Progress Bar

The progress bar is used to visually display the progress of a time-limited action. In addition, the percentage progress is displayed as a decimal number on the progress bar.

3.6 Pop-Up Windows

Pop-up windows are displayed above the currently displayed main, menu or dialog window. They are used to display information for the user (e.g. about errors) or to prompt the user to confirm an action.

3.6.1 Error Window

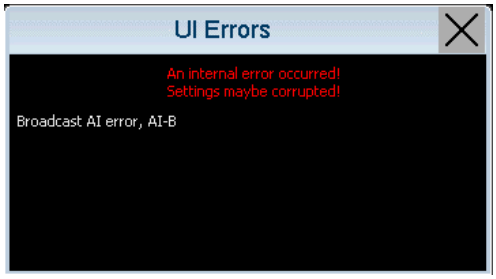


Figure 3.13: Error window

This window is displayed if an unexpected error or an error during local operation occurred. The errors are displayed in plain text.

This window can be closed by pressing the "X" or "Esc" button.

3.6.2 Notification Window

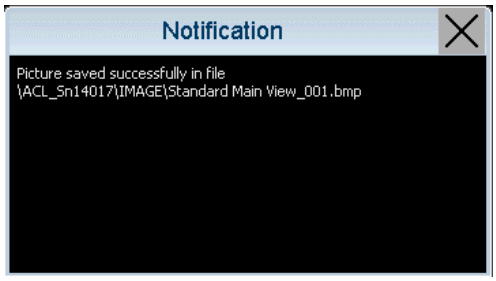


Figure 3.14: Notification window

This window is displayed to inform the user about events, e.g. when a USB flash drive has been detected.

The window is closed after a short display period or can be closed earlier by pressing the "X" or "Esc" buttons.

3.6.3 Notification Window in Remote Operation

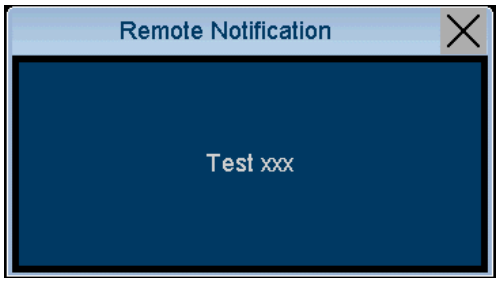


Figure 3.15: Notification window in remote operation

This window is displayed if a text has been sent to the device with the SCPI command DISP:TEXT via one of the digital data interfaces.

The window is displayed until it is removed by pressing the "X" button, redrawing the displayed screen or by the SCPI command DISP:TEXT with an empty string.

3.6.4 Warning Window

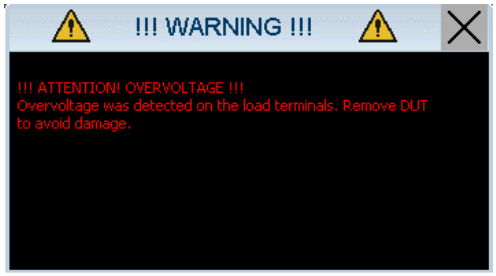


Figure 3.16: Warning window

This window is displayed to inform the user about dangerous system conditions that can damage the load and pose a risk of injury to users (e.g. inadmissible overvoltage at load input).

The window is permanently displayed as long as the dangerous system condition is present. This warning cannot be closed during this time. After the dangerous system condition no longer exists, the warning remains displayed until the user actively closes it with the "Esc" key.

3.6.5 Help Window

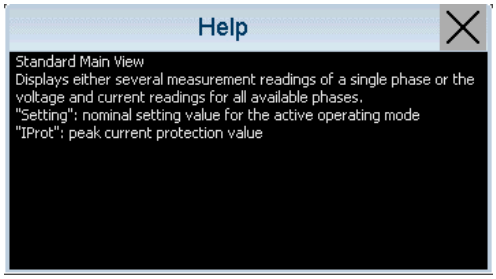


Figure 3.17: Help window

This window appears after selecting S+ -> Help. It contains a short explanation of the displayed menu or dialog window.

3.6.6 Confirmation Window

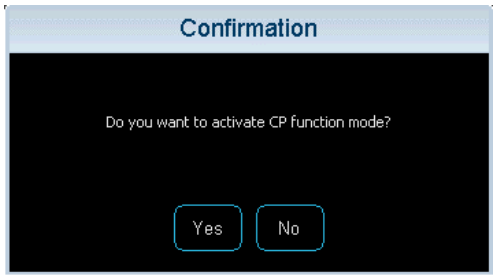


Figure 3.18: Confirmation window

This window is displayed to ask the user whether to proceed with the next action.

3.6.7 Status Overview

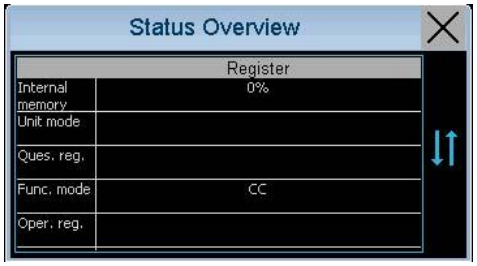


Figure 3.19: Status overview

This window is displayed after touching the status bar. It contains an indication of the current fill level of the internal measurement data memory and an overview of all active status signals.

A detailed description of the displayed status signals can be found in 5.11.15 STATus Subsystem.

3.7 Menu Structure

	Main Menu (Level 1)	Menu (Level 2)	Menu (Level 3)	Menu (Level 4)
Main Menu	Channel Menu	Focus		
		Address		
		Info		
	Settings menu	Basic settings menu	Mode menu	CC (Constant Current)
				CP (Constant Power)
				CR (Constant Resistance)
				CV (Constant Voltage)
			External control	
			Protection	
			Speed	
		Function menu	List	New list
				Edit list
				Import list from USB
				List settings
			Discharge	Initialize
			MPPT	
		Cooling		
		Acquisition		
		Save/Recall	Import from USB flash drive	
		Reset		
	Data menu	Export		
		USB info		
	Errors			
	Configuration menu	Power-on		
		Communication menu	RS-232	
			USB VCP	
			LAN	LAN Configuration
				LAN Status
			CAN	
			GPIB[1)]	
		User interface menu	Display	
			Help language	
			Tips and tricks	
		Alarms		
		Buzzer		
		Time and date		
		Factory settings		
	Service menu	Firmware update		
		User manual export		
		Calibration	Calibration	
			Calibration signal name	
		Parameter menu	View parameter	
			Edit user parameter	
			Edit calibration parameter	
		Power stage temperature		
		H&H Service		
	Technical data			
	Contact			

[1)] "GPIB" is only displayed if the optional GPIB interface is installed.

3.8 Help for Dialog and Menu Windows

For an explanation of the individual dialog and menu windows there is a device-internal help system (see 3.6.5 Help Window).

4 Functions

This chapter describes the functions of the electronic load. After each function description we describe how each function can be executed via the following control types:

- Local operation
- Digital remote control
- Analog remote control

Local Operation
The local operation is performed via the user interface on the front panel of the device (see 3 Basics of Local Operation).
At the user interface, special functions are arranged in the menu "Function" $f(x)$. These functions are each defined in a separate dialog. Starting and stopping is done with the shortcut S+ -> Start or S+ -> Stop. Starting a special function will terminate any other function currently running.

Digital Remote Control
The digital remote control is done by one of the data interfaces on the rear side of the device (see 5 Digital Remote Control). Local operation and digital remote control are mutually exclusive: after switching on the device, local operation is automatically activated, after receiving a SCPI command via one of the data interfaces, the device automatically switches to digital remote control.

External Control
External control is done by the optional I/O port on the rear side of the device (see 6 External Control by I/O Port). The external control is independent of the local operation and digital remote control and is configured via the menu *Main Menu -> Settings -> Basic settings -> Ext. control* or the corresponding SCPI commands. Specific setting values (e.g. setting value for output state) can be controlled by analog and digital input signals.

4.1 Selecting the Control Source

Control of the electronic load can come from several control sources:

- User Interface (locally from the front panel)
- Data Interface
- I/O Port (not with LP variants)

The electronic load will change to "Remote" state as soon as a command is received from one of the data interfaces, independent of the selected channel. Settings being made by any of the control sources are not deleted when changing to a different control source.

Local operation:
Main Menu -> Settings -> Basic Settings -> Ext. control

Digital remote operation:
See 5.11.14 SETTing Subsystem

4.2 Basic Operating Modes and Settings

Each channel of the electronic load offers four basic operating modes:

- Current mode
- Voltage mode
- Resistance mode
- Power mode

The active operating mode of regulation is specified by the basic operating mode or an active function (e.g. list function). If the load input is switched on without activated functions or if a function is deactivated when the load input is switched on, the basic operating mode is used.

When changing the mode, the previously set nominal value of the chosen mode is activated again. The load input is not deactivated when changing the mode, not even temporarily.

Warning of undefined settings while operating mode change! Changing the operating mode can cause dangerous settings which can damage or destroy the DUT.

Switch off the input before changing the mode and switch it on again after the mode change has been performed.

4.2.1 Current Mode (CC)

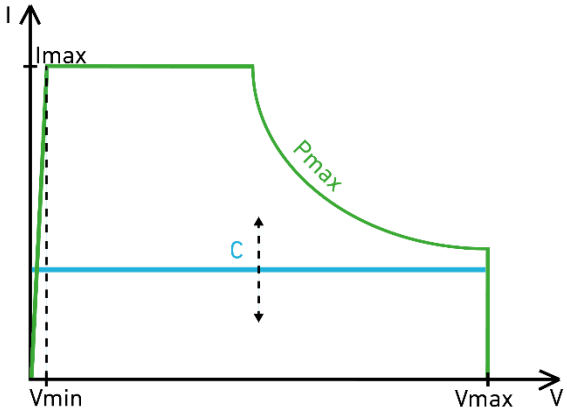


Figure 4.1: Current (CC) mode

The set current is independent of the input voltage. Current regulation ensures that changes in the input voltage do not affect the load current.

Sources with a regulated current output cannot be operated in current mode. A physical quantity can be regulated only once, either at the source or at the sink.

Local operation:
Main Menu -> Settings -> Basic Settings -> Mode -> Constant current
Edit widget "Setting": enter setting value for the input current.
Confirm with "OK".

Digital remote operation:
See 5.11.3 CURRent Subsystem, 5.11.7 FUNCtion Subsystem

External control:
See 6 External Control by I/O Port

4.2.2 Power Mode (CP)

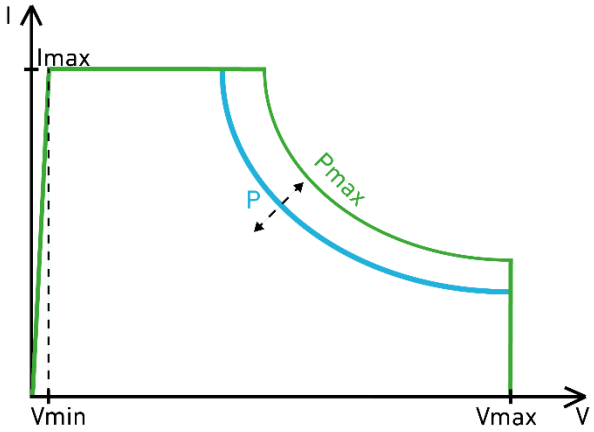


Figure 4.2: Power (CP) mode

In power mode, the electronic load controls the set power in software by using a PI controller. The required current is calculated based on the measured input voltage and applied accordingly.

The software controller operates with a sampling interval of 100 µs. The control parameters are stored in non-volatile memory for each load channel and can be modified locally or by digital remote control. There is a pair of parameters for slow regulation speed and one for fast regulation speed.

Parameter no. 10: Kp_Power_Fast
Parameter no. 11: Ki_Power_Fast
Parameter no. 12: Kp_Power_Slow
Parameter no. 13: Ki_Power_Slow

Control parameter Kp
This parameter determines the control constant for the proportional part of the PI controller. This parameter has the standard value 0 and therefore deactivates the proportional part of the software-based PI controller. If you increase this value to accelerate the controller then you must ensure stable operation under all operating conditions.

Control parameter Ki
This parameter determines the control constant for the integral part of the PI controller. This parameter may be varied depending on the source's internal resistance. If you increase this value to accelerate the controller then you must ensure stable operation under all operating conditions.

See also 9.2 Device Parameters.

Sources with controlled output current (e.g. by a current limitation) cannot be loaded in power mode if the required current exceeds the source's current limit.

Local operation:
Main Menu -> Settings -> Basic Settings -> Mode -> Constant power
Edit widget "Setting": enter setting value for the input power.
Confirm with "OK".

Digital remote operation:
See 5.11.7 FUNCtion Subsystem, 5.11.11 POWer Subsystem, 5.11.13 SERVice Subsystem

External control:
See 6 External Control by I/O Port

4.2.3 Resistance Mode (CR)

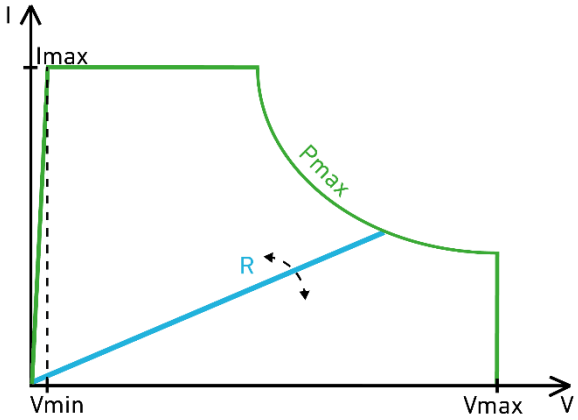


Figure 4.3: Resistance (CR) mode

In resistance mode the electronic load controls the set resistance in software by using a PI controller. The required current is calculated based on the measured input voltage and applied accordingly. The current follows to Ohm's Law and changes linearly with the input voltage.

In contrast to a real ohmic resistance the current of the electronic load can only respond to voltage changes with a limited regulation speed.

The software controller operates with a sampling interval of 100 µs. The control parameters are stored in non-volatile memory for each load channel and can be modified locally or by digital remote control. There is a pair of parameters for slow regulation speed and one for fast regulation speed.

Parameter no. 14: Kp_Resistance_Fast
Parameter no. 15: Ki_Resistance_Fast
Parameter no. 16: Kp_Resistance_Slow
Parameter no. 17: Ki_Resistance_Slow

Control parameter Kp
This parameter determines the control constant for the proportional part of the PI controller. This parameter has the standard value 0 and therefore deactivates the proportional part of the software-based PI controller. If you increase this value to accelerate the controller then you must ensure stable operation under all operating conditions.

Control parameter Ki
This parameter determines the control constant for the integral part of the PI controller. This parameter can be changed depending on the source's internal resistance. If you increase this value to accelerate the controller then you must ensure stable operation under all operating conditions.

See also 9.2 Device Parameters.

Sources with controlled output current (e.g. by a current limitation) cannot be loaded in resistance mode if the required current exceeds the source's current limit.

Local operation:
Main Menu -> Settings -> Basic Settings -> Mode -> Constant resistance
Edit widget "Setting": enter setting value for the input resistance.
Confirm with "OK".

Digital remote operation:
See 5.11.7 FUNCtion Subsystem, 5.11.12 RESistance Subsystem, 5.11.13 SERVice Subsystem

External control:
See 6 External Control by I/O Port

4.2.4 Voltage Mode (CV)

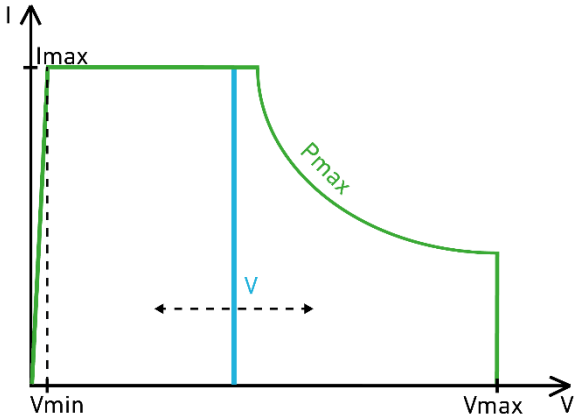


Figure 4.4: Voltage (CV) mode

In voltage mode the electronic load consumes current until the desired voltage is established by the DUT's internal impedance or its current limit.

For dynamic settings in constant voltage mode high current transients can occur which cannot be absorbed by the load when there is some capacitance in the DUT´s output. Then the electronic load may trigger its current protection and the regulated waveform will differ from the specified waveform.

Since an electronic load can only consume current, it can only control the falling edges of voltage waveforms. The rising edges depend on the characteristics of the DUT. The properties of the DUT are responsible for the rising edges.

To ensure stable operation the minimum load current in voltage mode should not be less than 10 % of the current range of the electronic load. If oscillations should occur the system may be stabilized by changing the regulation speed (see chapter 4.4 Regulation Speed).

Local operation:
Main Menu -> Settings -> Basic Settings -> Mode -> Constant voltage
Edit widget "Setting": enter setting value for the input voltage.
Confirm with "OK".

Digital remote operation:
See 5.11.7 FUNCtion Subsystem, 5.11.18 VOLTage Subsystem, 5.11.13 SERVice Subsystem

External control:
See 6 External Control by I/O Port

4.2.5 Immediate Settings

In each basic operating mode a corresponding setting value can be programmed. When changing the operating mode its associated setting value is set automatically. If a setting value is set for an operating mode currently not active the concerning setting is saved by the load and set when this operating mode is set next time.

If no setting value has been programmed for an operating mode the electronic load uses default values when this mode is set. Default values are always chosen to cause minimum possible load current.

Local operation:
Main Menu -> Settings -> Basic Settings -> Mode -> <mode>
Edit widget "Setting": enter setting value for the controlled input level.
Confirm with "OK".

Digital remote operation:
5.11.3 CURRent Subsystem, 5.11.11 POWer Subsystem, 5.11.12 RESistance Subsystem, 5.11.18 VOLTage Subsystem

External control:
See 6 External Control by I/O Port

4.2.6 Triggered Settings

In digital remote control mode, each operating mode supports both an immediate setting value and a triggered setting value. The triggered setting value for the active mode is applied immediately when a trigger occurs. For inactive modes, the triggered setting value replaces the immediate current value and becomes active once that mode is activated. After a triggered setting value has been used, further triggers have no effect until a new triggered setting value is programmed.

After a reset, an ABORt command, or after triggering, all triggered setting values follow the immediate setting values until new triggered values are explicitly programmed.

Digital remote operation:
5.11.3 CURRent Subsystem, 5.11.11 POWer Subsystem, 5.11.12 RESistance Subsystem, 5.11.18 VOLTage Subsystem

4.2.7 Setting Several Channels Simultaneously

To change the setting value for multiple channels simultaneously via a trigger, the new value must be defined as the triggered setting for each channel. When the trigger event occurs (using `*TRG`), all channels apply the triggered setting value regardless of their current operating mode.

Programming Example:

`*RST`	Reset (all channels)
`CHAN 1`	select channel 1
`CURR 5.6;INP ON`	set 5,6 A immediately
`CURR:TRIG 13.3`	set 13,3 A at trigger
`CHAN 2`	select channel 2
`FUNC:MODE VOLT`	CV mode
`VOLT 30;INP ON`	set 30 V immediately
`VOLT:TRIG 11.5`	set 11,5 V at trigger
`CHAN 3`	channel 3 as channel 2
`FUNC:MODE VOLT`	
`VOLT 30;INP ON`	
`VOLT:TRIG 11.5`	
`INIT`	wait for trigger (all channels)
`*TRG`	set trigger (all channels)

See also 4.16 Trigger Model, example.

4.3 Protections and Combined Operating Modes

An adjustable overcurrent protection and an adjustable undervoltage protection ensure that so-called combined operating modes exist in addition to the basic operating modes:
CC+CV, CP+CV, CR+CV, CP+CC, CR+CC, CV+CC

You can select either an overcurrent protection or an undervoltage protection. After power-on the protections are switched off by default.

4.3.1 Overcurrent Protection

Each channel has an adjustable overcurrent protection. After power-on, if overcurrent protection is enabled, it defaults to the channel's maximum current limit, allowing unrestricted operation.

The overcurrent protection is active in all operating modes and ensures the current does not exceed the configured limit. When active, "OCP" is displayed on the user interface if the corresponding channel is focused. Overcurrent protection is automatically deactivated when undervoltage protection is enabled.

Local operation:
Main Menu -> Settings -> Basic Settings -> Protection
Dropdown widget "Voltage protection": select "Current".
In the "Current protection" edit widget, adjust the setting value for the current limitation. Confirm with "OK".

Digital remote operation:
See 5.11.3 CURRent Subsystem

4.3.2 Undervoltage Protection

Each channel has an adjustable undervoltage protection. After power-on, if undervoltage protection is enabled, it defaults to the minimum voltage threshold to allow unrestricted operation. It is active in all operating modes and permits current flow only if the input voltage exceeds the defined threshold. When undervoltage protection is active, the user interface displays "UVP" if the corresponding channel is focused.

Depending on the selected regulation speed the undervoltage protection is performed in two different modes automatically:

- regulating (at slow control speed)
- switching (at fast control speed)

The regulating mode is used, for example, to realize the CC-CV transition during battery discharge. It is implemented as a PI controller and cannot prevent the voltage from briefly falling below the defined threshold in the event of a sudden voltage drop – for example, when testing the current limit of a power supply while the electronic load is operating in constant current mode.

The switching mode operates as a comparator function. If the input voltage drops below the threshold, the current is switched off abruptly. This may cause the voltage to rise again due to load removal, triggering the current to switch on again. This can lead to oscillations around the switching point. The switching mode is intended to minimize the delay between applying the input voltage and the start of current flow.

Local operation:
Main Menu -> Settings -> Basic Settings -> Protection
Dropdown widget "Voltage protection": select "Voltage".
Adjust the setting value for undervoltage protection in the "Voltage protection" edit widget. Confirm with "OK".

Digital remote operation:
See 5.11.18 VOLTage Subsystem

4.4 Regulation Speed

For some DUTs or when using long load cables, it can be required to change the regulation speed of the electronic load to achieve a stable operation. For this the regulation speed of each channel can be individually changed.

After powering the unit, the "Fast" regulation speed is selected by default. "Slow" is intended for use with long load cables or for DUTs with control characteristics incompatible to the load.

In power mode and resistance mode you can adjust the control parameters Kp and Ki to the requirements of the UUT (see 4.2.2 Power Mode and 4.2.3 Resistance Mode).

The regulation speeds (rise times) are defined in the technical data.

Local operation:
Main Menu -> Settings -> Basic Settings -> Speed
Dropdown widget "Regulation speed": select regulation speed.
Confirm with "OK".

Digital remote operation:
See 5.11.7 FUNCtion Subsystem

4.5 Load Input On-Off

You can switch the focused channel's load input off and on by pressing **A4**. When the input is switched on the corresponding LED "Input" **A2** lights up and the connected DUT is loaded. When the input is switched off the corresponding LED "Input" is off and the input resistance of the device is high impedance.

In voltage mode the current will be started with a "soft start" when the input is switched on. It can take several milliseconds until the desired setting is achieved.

Local operation:
Button **A4**

Digital remote operation:
See 5.11.8 INPut Subsystem

External control:
See 6 External Control by I/O Port

4.6 LIST Function

Each channel of the electronic load can generate dynamic load profiles using LIST mode, both in local operation and via digital remote control. This function is available in all operating modes.

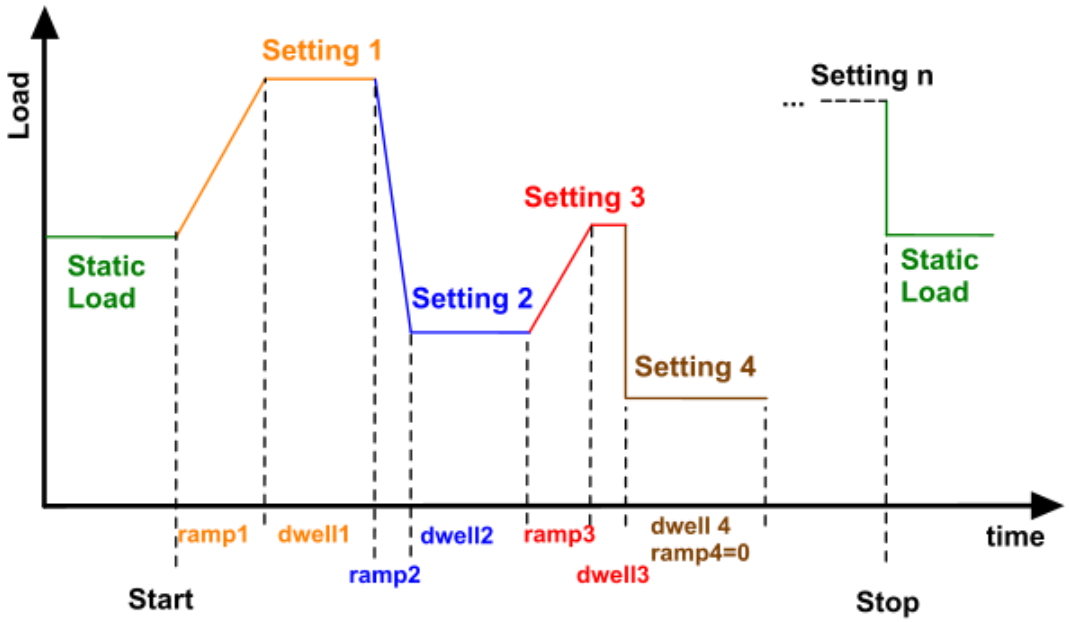


Figure 4.5: Load profile with n LIST elements

4.6.1 Terminology

Load profile
A load profile consists of a consecutively chained set of setting values building a continuous function (current, power, resistance, voltage).

Setting list
This list is used to define a load profile and contains the setting values for the corresponding operating mode. A value in this list represents the setting value being controlled during the corresponding dwell time (see below).
The list length is set to 0 at reset.

List Mode
The list mode defines the operating mode (current, power, resistance, voltage) in which the list shall be executed. The list mode selects the corresponding setting list.
A reset sets the list mode to Current.

List of ramp times
This list is used to define a load profile. A value in this list represents the duration of the rise or fall time to the next setting value of the list.
The list length is set to 0 at reset.

List of dwell times
This list is used to define a load profile. A value in this list represents the duration of which the corresponding setting value is kept.
The list length is set to 0 at reset.

List of sample times in ramps
This list is used to define sample intervals for the corresponding ramps of a load profile. The list for sample times does not need to be defined if the data acquisition is not activated. The list length is set to 0 at reset.

List of sample times in dwells
This list is used to define sample intervals for the corresponding dwells of a load profile. The list for sample times needs does not need to be defined if the data acquisition is not activated. The list length is set to 0 at reset.

List set
A list set consists of the lists defining a load profile (settings, ramp times, dwell times). The elements with matching index in the single lists define a section of the load profile.
In a valid list set the length of all lists are > 0 and identical, e. g. all lists contain equal numbers of elements.
The length of all lists in the list set is set to 0 at reset. This makes the list set invalid and the list cannot be executed.

List count
The list count defines the number of list iterations after a start condition.
The list count is set to 1 at reset.

Measurement data point
A measurement data point is a set of three measurement values consisting of timestamp, voltage value and current value. When reading data points these three values are separated from each other by a comma followed by a space character.

4.6.2 List Set Definition

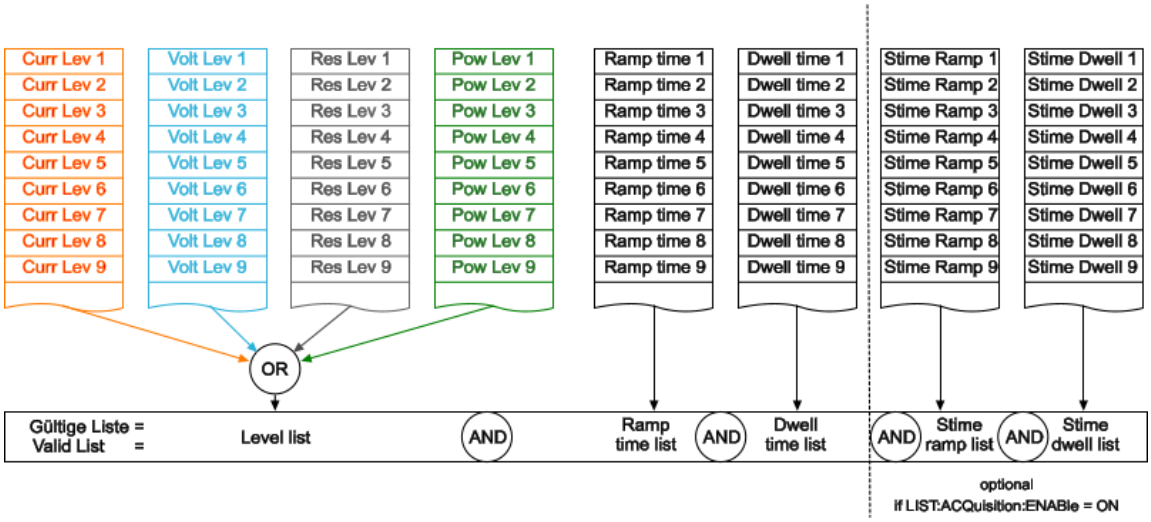


Figure 4.6: LIST memory usage

Figure 4.6 shows the internal memory usage of lists in PMLA series loads. A valid list set consists of three lists with equal length. The "Level list" is chosen according to the operating mode of the list function. The lists for the ramp times and dwell times are used commonly in every operating mode. This means that the user may need to update the ramp time and dwell time lists when changing the list mode.

If data acquisition is enabled during list execution the behavior of the sample time lists (“Stim ramp” and “Stim dwell”) is analog to the lists for ramp times and dwell times.

Local operation:
Main Menu -> Settings -> Function -> List
Button "New": press to switch to the "Initialize New List" dialog window.
Dropdown widget "List mode": select list mode.
If voltage and current are to be recorded synchronously during list execution, activate the "Data acquisition" checkbox.
Confirm with “OK”.
In the following dialog window "New List": define setting values for level, ramp time, dwell time and if necessary, sample times of the first list section.
Increment the value for "Point" and repeat the process for all list sections.
Single list points can be inserted after the currently displayed list point with the "Add" button. With the "Delete" button the displayed list point is removed.

Confirm with “OK”.

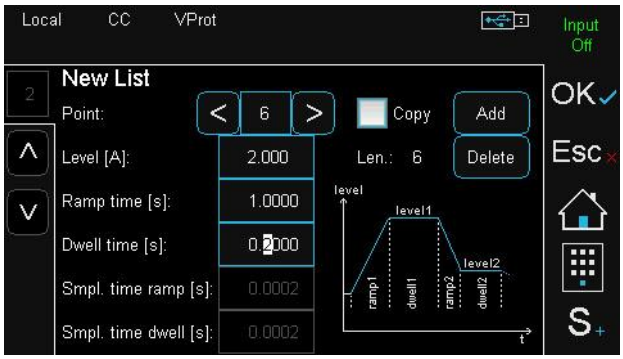


Figure 4.7: Dialog window for definition of a load profile

If required, edit further setpoints for the list function in the "List" dialog box using the "Enter" button.

If a valid list has been defined, the list function is activated (but not yet started) and the function sign $f(x)$ is displayed in the status bar.

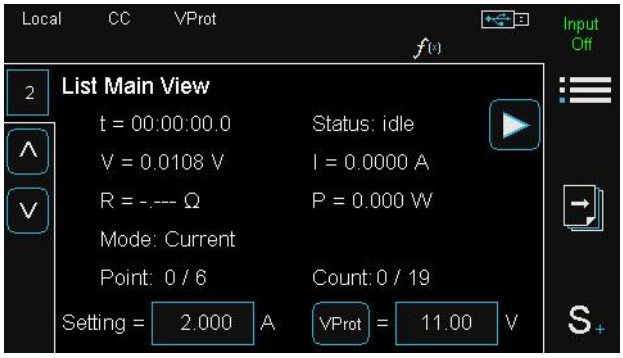


Figure 4.8: Main view of list function

Digital remote operation:
See 5.11.9 LIST Subsystem

4.6.3 Importing a List File

In addition to manually creating or programming the list function using SCPI commands, an import function for list files is available. The required file can be created on a PC using the PMLA tool and transferred to a USB flash drive. List files with the extension *.lst must be located in the subdirectory “LIST” in the root directory of the USB flash drive. Using the dialog “Import list from USB”, the prepared file can then be loaded into the electronic load. Structure of a valid list file:

```
[LIST_MODE]\n
VOLT\n
\n
[LIST_COUNT]\n
6\n
\n
[LIST_ACQ]\n
On\n
\n
;comment
[LIST_VALUES]\n
1.234, 2.566, 2.854, 0.001,
0.01;comment\n
2.168, 3.987, 3.1, 0.02, 0.003\n
;comment\n
5.78, 6.77, 9.6, 0.01, 0.1\n
\n
```

A valid list file must contain the following elements:

- Tag "[LIST_MODE]"
- Operating mode following the tag "[LIST_MODE]"
- Tag "[LIST_COUNT]"
- Number of list repetitions following the tag "[LIST_COUNT]"
- Tag "[LIST_ACQ]"
- Activation state of synchronous data acquisition following the tag "[LIST_ACQ]"
- Tag "[LIST_VALUES]"
- List values following the tag "[LIST_VALUES]"

Furthermore, each line must be terminated with a linefeed ('LF' or '0x0A' or '\n'). The data section is concluded with an additional blank line.

LIST_MODE:
Operating mode in which the list function is executed. Valid identifiers for the operating mode are: CURR, CURRENT, VOLT, VOLTAGE, POW, POWER, RES and RESISTANCE (case insensitive).

LIST_COUNT:
The value for the number of list repetitions must be a positive value between 1 and 4E9. Infinite list execution can be achieved by using the value 9.9E37.

LIST_ACQ:
The synchronous data acquisition can be activated with "1" or "ON" and deactivated with "0" or "OFF". If the data acquisition is enabled 5 settings for each list point are expected: desired level value, ramp time, dwell time, sample time for ramp time and sample time for dwell time. If the data acquisition is disabled only the settings for the desired level value, ramp time and dwell time are required.

LIST_VALUES:
The list values of the individual points are arranged according to the following scheme:
Level value in A, V, W or Ω, ramp time in s, dwell time in s[, sampling time ramp in s, sampling time dwell in s]

e.g. 1.234, 2.566, 2.854, 0.001, 0.0002

List values must be entered in a valid IEEE 754 floating-point format using the respective base unit (A, V, Ω, s). Values may also be provided in exponential notation. Commas serve as separators between the individual values of a list point. A blank line must follow the list entries.

A semicolon denotes a comment. Comments may appear in a separate line or at the end of a line. Characters between the semicolon and the next linefeed are ignored.

Messages after loading the list file:

List imported successfully (x steps)	The list (x points) was successfully imported.
Line x; Invalid char. or separator missing	Line x contains an invalid character or the separator is missing.
Line x; Blank line missing	Blank line missing in line x.
LIST_MODE tag not found	The "[LIST_MODE]" tag was not found.
LIST_MODE value not found	No valid operating mode was found for LIST_MODE.
LIST_COUNT tag not found	The "[LIST_COUNT]" tag was not found.
LIST_COUNT value not found	No valid value for the number of list repetitions was found.
LIST_ACQ tag not found	The "[LIST_ACQ]" tag was not found.
LIST_ACQ state not found	No valid value for the data acquisition state was found.
LIST_VALUES tag not found	The "[LIST_VALUES]" tag was not found.
LIST_VALUES data not found	No valid LIST_VALUES data was found.
Line x; LIST_VALUES data missing	At least one required parameter for the list point in line x is missing.

Line x; Value out of range	A list value in line x is outside the valid range.
SBP data error	An error occurred while querying minimum and maximum parameter limits.
Sample time values missing	Sampling times for ramp and dwell are missing (displayed only when LIST_ACQ is enabled).
Line x; Too long data string, end missing	The length of line x exceeds 70 characters.
List exceeds max. length	The maximum list length has been exceeded (see technical data).
Could not open file	The list file could not be opened.
Could not close file	The list file could not be closed.
Could not open directory	The LIST directory could not be opened.
USB flash drive not found	The USB flash drive could not be detected.

4.6.4 List Execution

To execute the list function, a valid list set must reside in the device (s. 3.3.2 Structure of a Valid List Set). The list function can be started with the corresponding SCPI command, or the key sequence "Shortcut" -> "Start" or a trigger event. The device automatically switches to the list mode in which the function is to be executed.
During a running list the FUNC bit in the Operation Status Register is set.

If the load input is switched off during list execution, the list function is paused and resumes when the input is switched on again. After the list has finished or been aborted, the device returns to the previously set operating mode and corresponding setting value. The load input remains active after the list execution.

Local operation:
Shortcut S+ -> Start
The list execution is started as soon as the shortcut sequence is pressed. The list mode selected is automatically set. When a list is running the FUNC bit in the operation status is set and LIST is displayed in the status bar.

Shortcut S+ -> Stop
List execution is stopped and the load input is switched off. After the set list count has expired or the list is aborted, the device sets the previously set basic operating mode with the corresponding setting.

Digital remote operation:
See 5.11.9 LIST Subsystem

4.6.5 List Execution by Trigger

If the list execution shall be started or stopped by a trigger event the processing of trigger events by the list function must be activated.

Digital remote operation:
See 5.11.9 LIST Subsystem, 5.11.17 TRIGger Subsystem, ABORt Subsystem, INITiate Subsystem

4.6.6 Data Acquisition by List Function

The electronic load can store measurement data points at defined sampling rates. A corresponding sampling rate is defined for each list segment. If data acquisition is enabled voltage and current are measured synchronously and saved with a relative timestamp.

Data acquisition during execution of the list function must be explicitly enabled. Data acquisition is disabled at reset.

A data point consists of a relative timestamp, voltage and current value. If the end of the available data memory is reached the electronic load overwrites the oldest data with new data according to the ring buffer principle. This is indicated by setting the MEM status in the Questionable Status Register and displaying it in the status bar of the user interface. This status is kept until either a data point is read, all data points are deleted, or the list function is restarted.

To avoid an overflow of the measurement data memory, data points should be continuously read from the memory during very long measurements. The data points saved can be read from the electronic load as one single data point or in blocks of with up to 100 data points per query.

Local operation:
See 4.6.2 List Set Definition

Digital remote operation:
See 5.11.4 DATA Subsystem, 5.11.9 LIST Subsystem

4.6.7 List Example with Data Acquisition

Programming Example: load profile with two current levels (50 A, 20 A) and enabled data acquisition:

```
CURR 10;INP ON
LIST:MODE CURR
LIST:CURR 60,20
LIST:RTIM .025,.005
LIST:DWEL .01,.02
LIST:STIM:RTIM .005,.0025
LIST:STIM:DWEL .001,.01
LIST:COUN 10
LIST:ACQ ON
LIST:STAT ON
```

This example generates a load current according to the schematic shown in Figure 4.9. The green marks are measuring points.

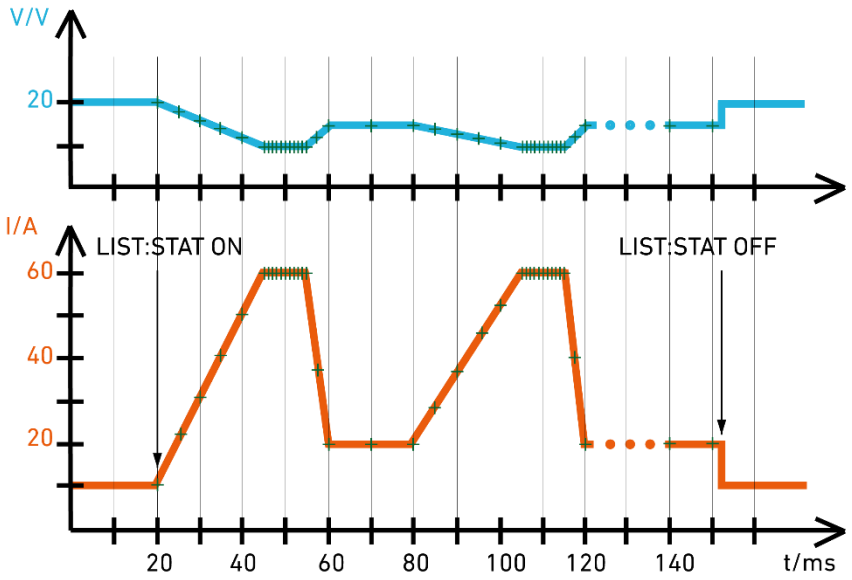


Figure 4.9: Example of a list with synchronous data acquisition

4.6.8 General Information for the LIST Function

The usable time settings may be limited by the rise and fall time of the particular model (see technical data).

There is a separate setting list for every list mode. The lists for the ramp and dwell times are shared for all list modes.

The list mode cannot be changed while a list is running. If you attempt to change the list mode while a list is executed, the load will generate a Settings Conflict Error (see 9.1Error Codes).
The list function cannot be executed while an internal data acquisition function is executed.

4.7 Internal Data Acquisition (ACQ)

In digital remote operation, all channels of the electronic load can independently acquire measurement data points synchronously with a defined sampling rate. The data is stored in internal memory.

A data point consists of a relative timestamp, voltage and current.

If the end of the available data memory is reached the electronic load either stops data acquisition or overwrites the oldest data with the new data, according to the ring buffer principle. Overwriting is enabled by activating continuous data acquisition.

The stored data can be read only when data acquisition is stopped. In remote operation the data can be read by the commands of the DATA subsystem. Data is always read in chronological order, even if the ring buffer has overrun.

The data acquisition cannot be executed while a list function is executed.

A reset deletes all measurement data.

Local operation:
Main Menu -> Settings -> Acquisition
Checkbox “Enable state”: activate data acquisition.
Edit widget “Sample rate [s]”: edit sample rate.
The acquisition is immediately activated when the dialog window is exited by “OK” and started by switching the input on.

Digital remote operation:
See 5.11.1 ACQuisition Subsystem, 5.11.4 DATA Subsystem

4.8 Data Transmission According to IEEE 488.2 - Binary Block Data

Data transmission in accordance with the IEEE 488.2 standard enables the transfer of measurement data in a defined binary block format. This method ensures more efficient and faster transmission of large amounts of data.

Binary block data transfer is used exclusively for reading measurement data. Using the SCPI command `DATA:REM?` measured values can be retrieved in a compact binary format, significantly reducing the transmission time compared to ASCII data.

1	2	3	4	5
‘#‘	number of elements that follow (ASCII) <nonzero digit>	number of bytes that follow (ASCII) <digit(s)>	binary data (non-ASCII) <8 bit data bytes>	termination character

Example:
#3144<data>NL
start character
3 number of subsequent digits
144 number of data bytes to be transmitted
<data> binary block data in IEEE 754 format
NL termination character

To activate the binary block data transfer, the SCPI command `FORM:DATA REAL,32` is used. This configures the data transfer in IEEE 754 format, enabling precise and fast transmission of floating-point numbers.

The byte order can be switched between little endian and big endian using the `FORM:BORD NORM|SWAP` command.

Binary block data transmission in accordance with IEEE 488.2 can only be used via RS-232, USB and LAN communication interfaces. Use via GPIB and CAN is not supported.

Digital remote operation:
See 5.11.4 DATA Subsystem, 5.11.6 FORMat Subsystem

4.9 Reading Data from Internal Memory

The data buffered in the internal device memory (s. 4.6.6 Data Acquisition by List Function or4.7 Internal Data Acquisition (ACQ)) are read as follows.

Local operation:
Main Menu -> Data -> Export
Edit widget "DUT directory": A directory with the defined number ist created on the flash drive device in which the read data are stored.
"start" button: start data reading.

Digital remote operation:
See 5.11.4 DATA Subsystem.

4.10 Directory Structure on USB Flash Drive

Some functions of the electronic load can save measurement data or results to an attached USB flash drive (e.g. data acquisition). The generated files are saved on the USB flash drive with the following directory structure:

Export/Import of device settings:
The electronic load can export the active setting values to an attached USB flash drive. Additionally, these files can also be imported into the load. The "settings" files must be saved in the subdirectory "SETTINGS" of the root directory.

Export of measurement data and measurement results:
A directory named according to the device series and device number is created in the root directory of the USB flash drive. To assign the exported files to a specific device under test, the user can enter a DUT number in the corresponding dialog windows. A "DUTxx" directory (xx = DUT number) is then created based on the entered DUT number. Inside each DUT directory, further subdirectories are

created based on the export functions executed. Measurement data and measurement results are saved in these subdirectories.

4.11 Discharge Function

To test energy storage devices such as batteries, ultracaps and capacitors each channel can discharge a connected DUT and provide the values of the consumed amount of charge and energy.

This function is available in local operation and by digital remote control. In local operation you are guided by the menu in a way that the device requests important setting values such as current and voltage protection values.

You can start the discharging function when the function is activated, and the load setting is pre-defined by switching the load input on. At local operation you must have activated at least one stop condition.

During the running discharge function the electronic load accumulates the consumed charge in Ah and energy in Wh. The user interface displays these values for voltage and current and the elapsed time.

The DUT connected to the load input is loaded with the given setting until one of the activated stop conditions will be fulfilled.

Discharge mode

The discharge function is basically possible in any operating mode. In local operation the following operating modes for discharging are available:

- Current mode
- Power mode
- Resistance mode
- dynamic discharging in List mode

Enter the setting value corresponding to the chosen operating mode directly in the “Level” window. It is editable even later during a running static discharge function.

Dynamic Discharging

The discharge function offers the possibility to discharge a DUT in a controlled manner with the aid of a dynamic load profile. For this application case, a valid load profile must first be created using the List function (see 4.6 LIST Function). Afterwards, the "List" entry can be selected in the "Discharge Mode" dialog window. After starting the discharge function with the key sequence Shortcut -> Start, the list and discharge function are executed simultaneously.

In digital remote control, the list and discharge function must be started separately.

IUa Discharging, CC+CV Discharging

A special kind of discharging is CC+CV or IUa discharging. The DUT is firstly discharged with constant current until a defined voltage (setting value of voltage protection level) is reached. At this point the electronic load implicitly switches to voltage mode, which means the defined voltage is kept constant **until** the measured current falls below the current stop condition value (see below). When the current stop condition is fulfilled, the electronic load switches the load input off and the test is finished.

To realize an IVa discharging set the value of the minimum voltage as setting value for the voltage protection and activate and set the current stop condition.

Stop Conditions

You can activate the following stop conditions independently from each other:

- Charge

- Energy
- Time
- Current
- Voltage

In digital remote operation, the stop conditions are also variable while a discharge is running.

The stop conditions are monitored for exceeding (charge, energy, time) or falling below (current, voltage) the preset limits. That means for example, the discharging is stopped if the accumulated charge is higher or equal to the preset stop condition or if the measured voltage is lower or equal to the preset stop condition.

If one of the activated stop conditions is reached the electronic load switches the input off and deactivates the discharge function.

Static Measurement Data Acquisition

With digital remote control, static measurement data acquisition can be activated for storage of measurement data (see 4.7 Internal Data Acquisition (ACQ)).

Local operation:
Main Menu -> Settings -> Function -> Discharge
"Initialize function": Press "Enter".
In the following "Discharge Stop Conditions" dialog, activate and define at least one shutdown criterion. Confirm with "OK".
In the following "Discharge Mode and Protection" dialog, edit the setting values for operating mode, level and protections. Confirm with "OK".
In the following dialog "Discharge" finish the configuration of the function with "OK".
In the function-specific main view "Discharge Main View", start the discharge function by Shortcut S+ -> Start discharge function.

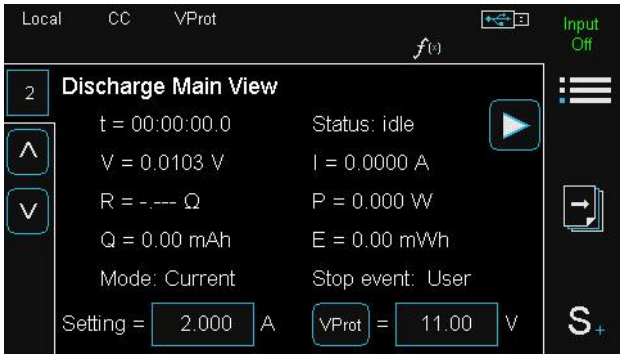


Figure 4.10: Main view of discharge function

Digital remote operation:
See 5.11.7 FUNCtion Subsystem: commands FUNCtion:DISCharge

4.12 Displaying Measurement Data

There are different types of measured value or measured data display in local operation.

In addition to the measured value display in numeric format, the Yt graph shows the time course of voltage, current and/or power. The Yt graph is displayed by touching the page turn icon in the main view.
See chapter 3.3 Main Views.

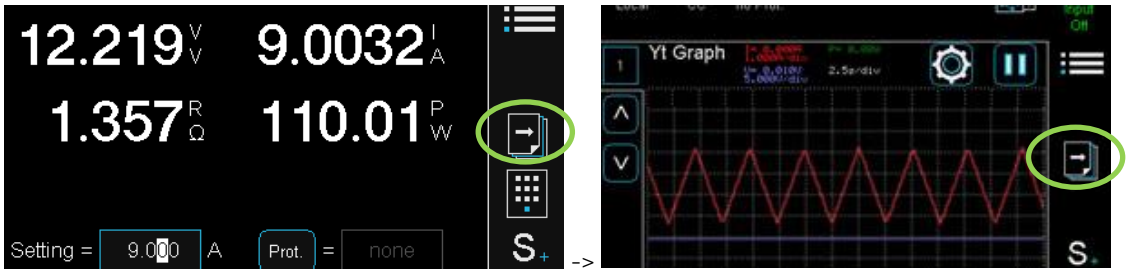


Figure 4.11: Main views of the measurement readings

Local operation:
Main view -> Page turn icon

4.13 MPP Tracking

The Maximum Power Point Tracking (MPPT) function enables testing of solar or photovoltaic modules. A load channel determines the maximum power point of the connected DUT by continuously adjusting the voltage setting value in voltage mode.

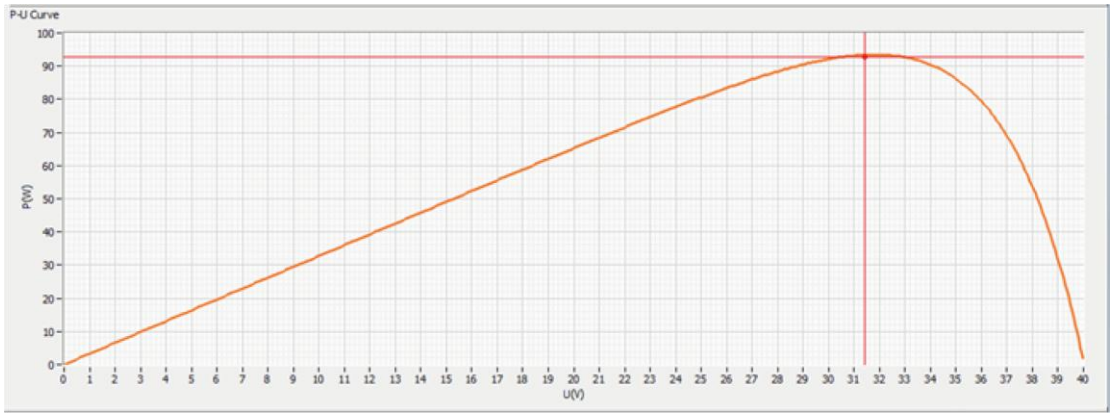


Figure 4.12: Power-Voltage characteristic with MPP

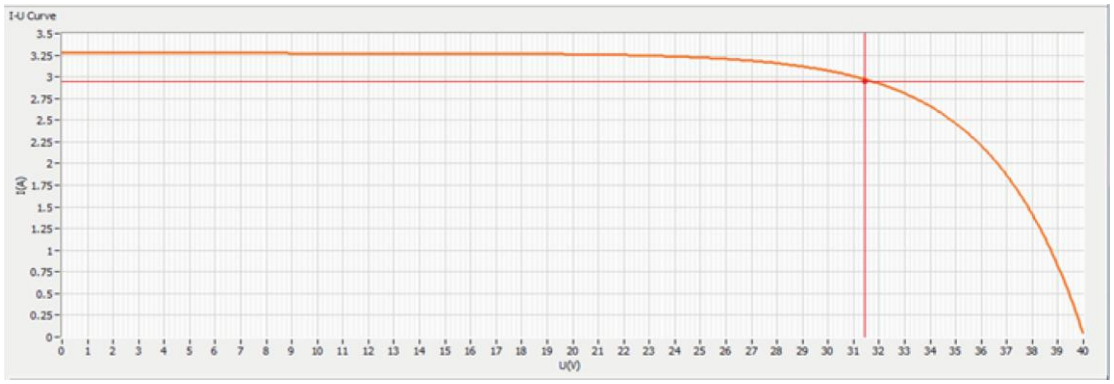


Figure 4.13: Current-voltage characteristic with MPP

4.13.1 Terminology

MPP
The MPP (Maximum Power Point) is the operating point at which the device under test (solar/PV module) supplies the most power. The latest found/regulated MPP is displayed at the user interface and can be queried via a data interface.

Sweep
The MPPT sweep function measures the open-circuit voltage Voc of the device under test, measures the V/I characteristic and determines the global MPP on its basis.

Sweep time
The sweep time determines how long a single sweep takes. It is set via the user interface or a data interface.

Sweep period
The sweep period determines the time interval at which a sweep is performed. It is set via the user interface or a data interface.

Sweep direction
The sweep direction determines whether the voltage is reduced from the open-circuit voltage Voc of the device under test to 0 Volts (direction "down") or whether the voltage is increased from 0 Volts to the open-circuit voltage Voc (direction "up"). The sweep direction can be set via the user interface or a data interface.

Sweep measurement data
The measured sweep measurement data represents the V/I characteristic of the device under test with 100 points. They are composed as follows:
<Volt_0>,<Curr_0>,<Volt_1>,<Curr_1>,...,<Volt_99>,<Curr_99>
The sweep measurement data can be queried via a data interface. The number of measuring points of the last sweep can also be queried via a data interface. If the number is equal to 0, no sweep has been performed yet.

Cumulated energy
Energy in Wh, which has been drawn from the solar module since the MPPT function was activated. When the MPPT function is activated, the energy in Wh is cumulated starting at 0 until execution is deactivated. If the load input is switched off while MPPT is running, the cumulation pauses until the input is switched on again. The value is retained even after deactivation of the function until the MPPT function is restarted.
The energy value is displayed at the user interface in the MPPT Main View and can be queried via a data interface.

Control accuracy ΔP
Control accuracy determines the accuracy with which the MPP is regulated. Starting with the MPP of the last sweep, the voltage is varied in one direction until the power is reduced ΔP · MPP. Then the direction of the voltage variation is reversed until a power maximum is found again and this then decreases by ΔP · MPP and so on.
The MPP control accuracy is stored as a non-volatile device parameter (see 9.2 Device Parameters). This parameter is set to the default value when the device is reset to factory settings (Factory Reset or SYSTem:PRESet).

Minimum voltage
The minimum voltage determines the minimum open-circuit voltage at which the device under test can be swept and tracked.
The minimum voltage is stored as a non-volatile device parameter. See 9.2 Device Parameters. This parameter is set to the default value when the device is reset to factory settings (Factory Reset or SYSTem:PRESet).

4.13.2 MPPT Function

The function consists of the two sub-functions sweeping and tracking, which alternate continuously in an adjustable interval (sweep period). A sweep can also be forced via a data interface if the electronic load does not already carry out a sweep at this moment.

To start the MPP regulation the MPPT function must be enabled and the load input must be switched on. If the measured open-circuit voltage is higher than the minimum voltage, the electronic load performs a sweep and then regulates the MPP found.

The V/I characteristic is displayed together with the V/P characteristic in the function graph of the user interface.

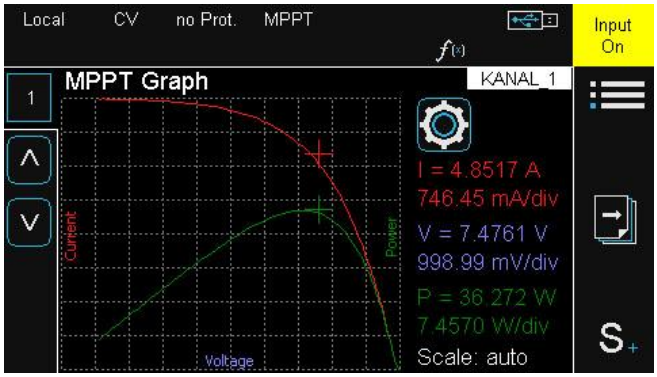


Figure 4.14: V/I and V/P characteristics

Local operation:
Main Menu -> Settings -> Functions-> MPPT
Define setting values for sweep duration, sweep period and sweep direction. Confirm with "OK".

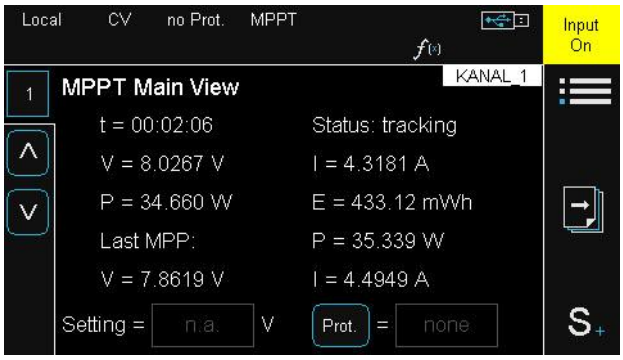


Figure 4.15: Main view of MPPT function

Digital remote operation:
See 5.11.7 FUNCtion Subsystem

4.14 Watchdog

Each channel has got a watchdog function which deactivates the load input if the previously programmed watchdog delay expires without the watchdog being reset.

The watchdog delay is set to a defined time by a SCPI command. Another SCPI command activates the watchdog. A control program must ensure that the command to reset the watchdog is continuously sent to the electronic load before the watchdog delay expires.

When the watchdog is reset the time restarts downcounting from the programmed delay value. If the delay expires without a watchdog reset command the electronic load deactivates the load input and sets WDP status. To be able to reactivate the input the watchdog must be deactivated.

The watchdog has no influence on the nominal setting of the input state.

Digital remote operation:
See 5.11.8 INPut Subsystem

4.15 Fan Speed Control

The devices have an automatic fan speed control. The speed of the fans depends on the temperature of the power stage of the hottest channel. It is switched in two steps.

In some applications it may be advantageous to keep the temperature of the power stage as low as possible. For this purpose, the fan speed control can be switched from "Automatic" to "Full" for maximum cooling power.

Local operation:
Main Menu -> Settings -> Cooling

Digital remote operation:
See 5.11.16 SYSTem Subsystem

4.16 Trigger Model

At digital remote control, several trigger actions can be triggered by a trigger event:

- Set triggered setting values of all operating modes
- Set activation state of load input, list function and data acquisition

4.16.1 Trigger Model States

There is a system specific trigger model integrated in the electronic load (see Figure 4.16) where the following states are possible:

- IDLE: The trigger model is in idle state. The electronic load does not wait for any trigger. Trigger events in idle state cause an error. Idle state is set by the ABORt command or by a reset command.
- INITIATED: In INITIATED state the device waits for a trigger event.
- ACTION: The trigger actions are executed. Afterwards, the IDLE state will become active if a single trigger was initiated. If the trigger system has been continuously initiated the INITIATED state will be active when the execution is finished.

4.16.2 Trigger Delay

A trigger delay can be defined for the transition from INITIATED to ACTION state. ACTION state is entered after this trigger delay.

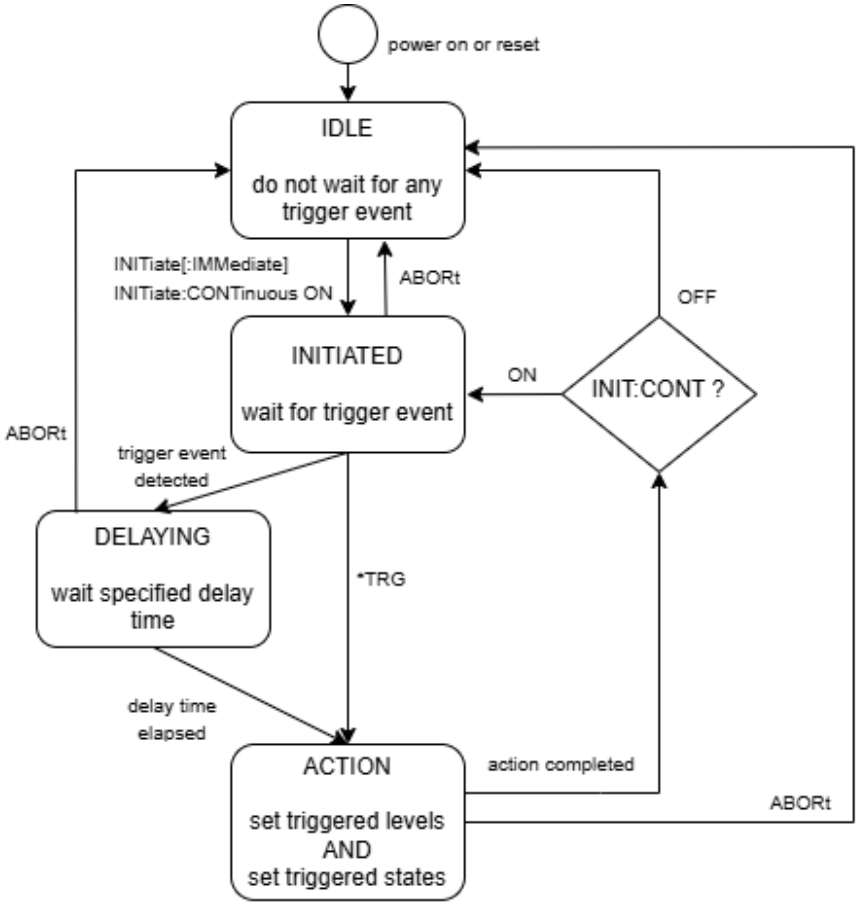


Figure 4.16: Trigger model

The latency time (delay time) from getting a trigger command (*TRG) to the trigger action is defined in the technical data.

Digital remote operation:
See 5.10.12 *TRG, 5.11.17 TRIGger Subsystem, ABORt Subsystem, INITiate Subsystem

4.17 SyncroLink

4.17.1 Functional Principle

The SyncroLink function enables the synchronization of multiple electronic loads (across series) using a trigger signal to ensure simultaneous operation of the devices. It offers precise synchronization and deterministic behavior, making it ideal for applications where multiple loads need to be controlled synchronously, e.g., in test setups involving multiple PMLA series load channels.

The SyncroLink uses the physical RS-232 interface to transmit the synchronization signal.
One device acts as the SyncroLink master, which generates the synchronization signal, while the other devices act as SyncroLink slaves and receive the signal. A special SyncroLink cable, which is connected via the RS-232 ports of all devices, determines which device is the SyncroLink master or slave. See Figure 4.18.
All devices in the SyncroLink network must initially be configured via a different data interface (e.g. LAN or USB).

Configuration example for activating the load input:
Configure the RS-232 interface:
Local operation:
Main Menu -> Configuration -> Communication -> RS-232 Configuration
Dropdown widget "Mode": select "SyncroLink". Confirm with "OK".

Digital remote control:
`SYST:COMM:SER:MODE SLIN`
This setting becomes active after a restart and is retained permanently

Activate SyncroLink:
Digital remote control: `SYST:SLIN ON`
Activation of the triggered load input: `INP:TRIG ON`
Initialize trigger system continuously: `INIT:CONT ON`
Only to SyncroLink master: `*TRG` (synchronization signal generation)

The synchronization signal is then distributed from the master device to all connected slave devices via the SyncroLink cable.

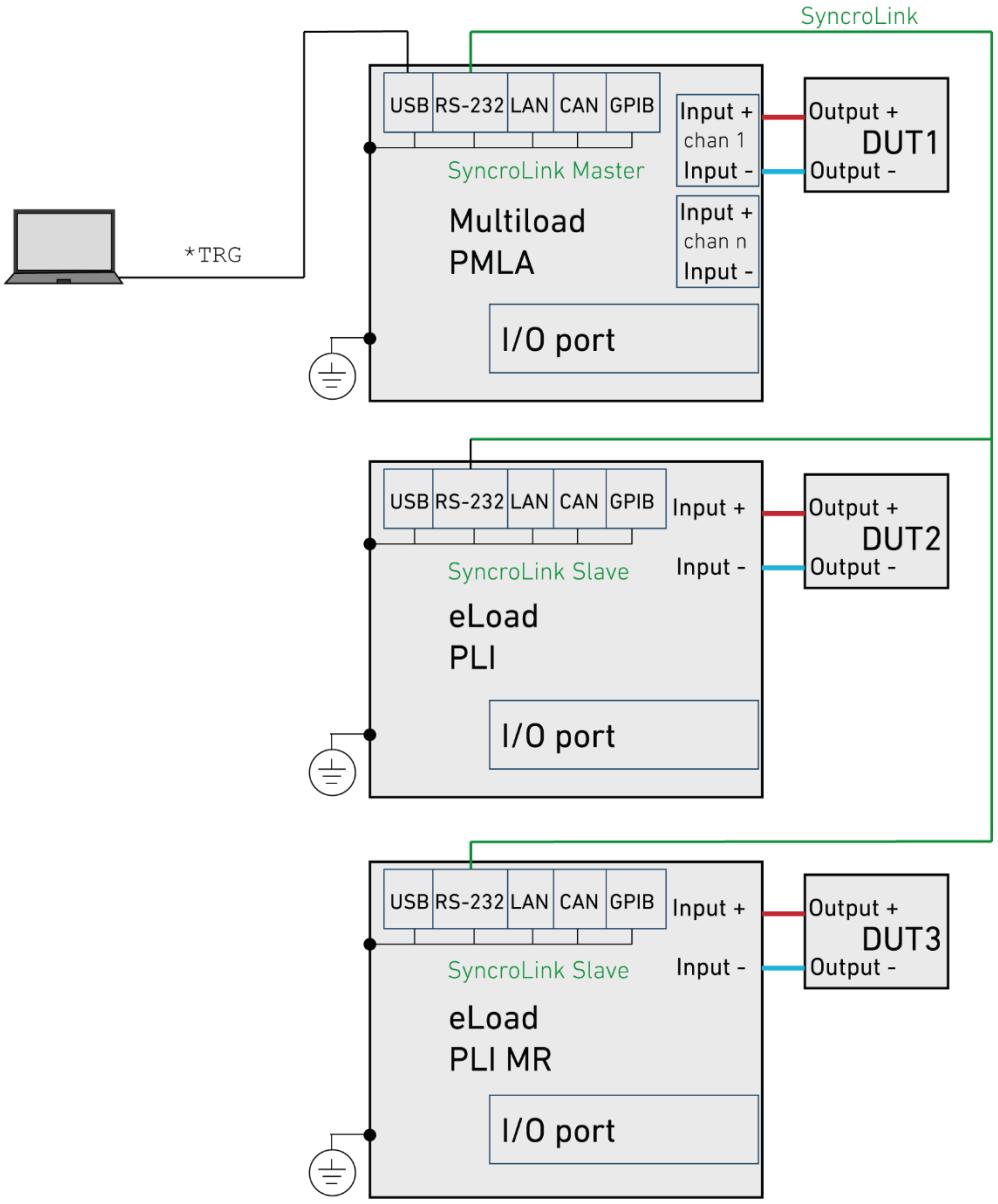


Figure 4.17: Connecting multiple devices with SyncroLink

Advantages

- High synchronicity: the SyncroLink function offers synchronization with a delay of typically less than 300 µs.
- Deterministic behavior: the load input is executed in a predictable time frame.
- No I/O port required: uses the RS-232 interface as the physical transmission medium, the I/O port is not required.
- Galvanic isolation of the devices

Pin Assignment SyncroLink Cable:

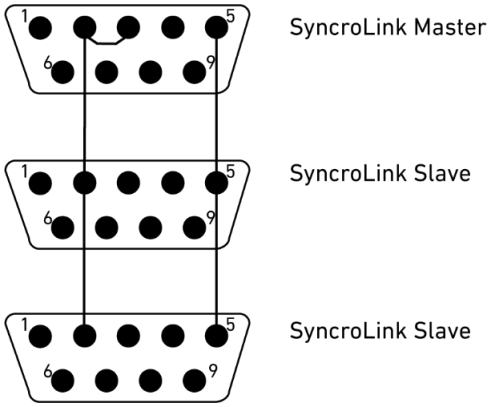


Figure 4.18: SyncroLink cable wiring

4.17.2 SyncroLink Delay

The PMLA multi-channel load series processes trigger signals differently than other H&H loads, resulting in varying response times. In mixed systems that include PMLA devices, these differences can be compensated by setting a delay time of 450 µs on the PMLA units. This ensures that all devices operate with only minimal offset

Command to all PMLA devices:
`SYST:SLIN:DEL 0.00045`

Digital remote operation:
See 5.11.16 SYSTem Subsystem

Find detailed explanation in Application Note 21 on the H&H website:
https://www.hoecherl-hackl.com/download/10805/

4.18 Applying Voltage and PWM Operation

Electronic H&H Loads are well suited to be operated with PWM volta-ges or in cases of input voltage steps.

To avoid inrush current peaks when the input voltage is applied or at the rising edge of the PWM voltage, the undervoltage protection of the electronic load should be adapted to the value of the input voltage. In other words, set the undervoltage protection to a value greater than 0 V and lower than the input voltage.

To achieve the shortest possible dead time until the load current flows, set the fast regulation speed (see 4.3.2 Undervoltage Protection, 4.4 Regulation Speed).

Find detailed explanation in Application Note 7 on the H&H website:
www.hoecherl-hackl.com/download/1259/

4.19 Keylock Function

To avoid accidental or unauthorised local operating, the keylock can be activated.

The keylock function can be activated and deactivated locally by the key sequence Shortcut -> Lock or remotely by the SCPI command SYSTem:KLOCk ON|OFF.

If the keylock is locally activated the main menu displays a padlock symbol with 'L' attribute for "Local". The 'L' attributed keylock can be deactivated locally (another Shortcut-Lock) or remotely.

If the keylock is remotely activated the main menu displays a padlock symbol with 'R' attribute for "Remote". The 'R' attributed keylock can be deactivated only remotely by the SCPI command SYSTem:KLOCk OFF.
The remote attribute overwrites the local attribute.

Local operation:
Shortcut S+ -> Lock
Shortcut S+ -> Unlock

Digital remote operation:
See 5.11.16 SYSTem Subsystem

4.20 Remote Notification

To alert the operator to a specific situation, a control unit can give acoustic and/or visual notifications via one of the data interfaces of the device.

4.20.1 Beeper

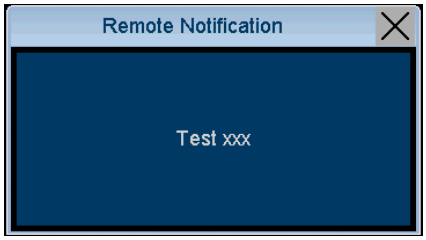
With the command SYSTem:BEEP, an acoustic warning signal with a specifiable duration is output on the buzzer.

Digital remote operation:
See 5.11.16 SYSTem Subsystem

4.20.2 Notification Window

The DISPlay:TEXT command displays a specific message text in a notification window on the display of the user interface.

If an empty string ("") is transmitted, the notification window is closed again. The operator can also acknowledge and close the notification window.



Digital remote operation:
See 5.11.5 DISPlay Subsystem

4.21 Configuring Alarm

If safety-critical conditions occur, the electronic load issues acoustic and visual notifications.

For overtemperature and overpower conditions, an acoustic signal can be enabled (default: disabled). In the event of overvoltage or reverse polarity of the input voltage, a notification window appears in addition to the acoustic alarm, which the user must actively acknowledge (default: enabled).

For special applications where the electronic load is intended to operate near the threshold of critical states, the OV, RV, and OTP/OPP alarms can be individually enabled or disabled.

The setting "OTP, OPP (only acoustic)" activates the acoustic alarm signal for temperature and power protection. No notification window is displayed for the OTP and OPP device statuses.

Overvoltage or reverse polarity of the input voltage causes a short circuit without any current protection! This can destroy the electronic load and the test object!

- Make sure that the load current is limited by a fuse in the load circuit!
- Reactivate the messages as soon as the application with deactivated alarms is finished!

Local operation:
Main Menu -> Configuration -> Alarms
Checkbox "OV (Overvoltage)": When checked, acoustic and visual warnings are active in the case of overvoltage at the load input.
Checkbox "RV (Reverse Voltage)": When checked, acoustic and visual warnings are active in the case of reverse polarity of the input voltage. Checkbox "OTP, OPP": When checked, the acoustic warning at overtemperature or overpower is active.

4.22 Save and Recall Device Settings

4.22.1 Internal Memory

The currently active device settings can be internally saved in one of 10 non-volatile settings memories (0 to 9) from which the settings may be recalled at a later time. The user can choose one of 10 memory positions: Memory position 0 to 9.

This function does not only apply to the selected channel but to all channels in the system.

The following settings are saved and restored when using the memory function:

- Activation state of the data acquisition
- Activation state of the continuous data acquisition
- Sample time of the data acquisition
- Setting value for the current in CC mode
- Current protection value

- Activation status for the dischare function
- Setting values for the stop criteria of the dischare function
- Activation states of the stop criteria
- Activation status for the MPPT function
- Execution direction of the sweep function
- Execution time of the sweep function
- Execution interval of the sweep function
- Operating mode
- Regulation speed
- Kind of protection (overcurrent or undervoltage protection)
- Activation state of protection
- Activation state of the load input
- Activation state of the discharge function
- Activation state of all stop conditions of the discharge function
- Values of all stop conditions of the discharge function
- Activation state of the MPPT function
- Sweep direction of the MPPT function
- Sweep time of the MPPT function
- Sweep period of the MPPT function
- Activation state of list mode
- List count
- List mode
- Current list
- Power list
- Resistance list
- Voltage list
- Dwell list
- Ramp time list
- Setting value for the power in CP mode
- Setting value for the resistance in CR mode
- Control source for input and setting value
- Cooling mode
- Trigger delay time
- Setting value for the voltage in CV mode
- Undervoltage protection value

If you try to recall a settings position which previously has not been saved the load will generate a "Memory use error".

Local operation:
Main Menu -> Settings -> Save-Recall
In addition, one of the 10 memory positions can be selected via the user interface for loading settings at power-up:
Main Menu -> Configuration -> Power-on

Digital remote operation:
See 5.10.7 *RCL, 5.10.9 *SAV

4.22.2 USB Memory

The active system settings (i.e., all installed load channels) can also be exported to and imported from a connected USB flash drive. This allows, for example, settings for different test tasks to be saved and managed. Furthermore, in a possible support case, the export of the settings can facilitate troubleshooting.

o export the current system settings, the user can choose from 100 storage numbers. The settings are saved in the "Settings" directory of the attached USB flash drive. For each storage number a corresponding subfolder is created, which contains the setting files of the available load channels.

Subfolder naming scheme:
PMLA_xx (xx = storage number)

Setting file naming scheme::
PMLA_Chan_xx.set (xx = channel number)

For importing settings, you can choose from the existing subfolders of the storage numbers in the "Settings" directory.

Structure of a valid setting file:

```
MA30-04C60, 1.0, 2015-01-01 00:00:09
;FW versions: AI1.3.1, DI1.3.0, UI1.3.3

[ACQ]
[:STAT]
1
[:STIM]
0.00215
[END_ACQ]

[CURR]
[:LEV:IMM]
2.158
[:PROT:LEV]
10
…
[END_CURR]

[FUNC]
[:MODE]
CURR
…
[END_FUNC]

[LIST]
[:CURR]
3.2588, 6.2411, 3.58712, 4.547212, …
…
[END_LIST]

[END_FILE]
```

A valid setting file must contain the following elements:

- Headline with model name and version of the setting file
- Subsystem start tags (e.g. [ACQ])
- Subsystem end tags (e.g. [END_ACQ])
- Command tags (e.g. [:TRIG:ENAB])
- Setting values after the command tag
- File end tag

Each line must be terminated with a line feed ('LF' or '0x0A' or '\n', respectively).

Blank lines are allowed (Exception: A blank line for list values (LIST:CURR:LEV) means that there is no list data available).

A comment is marked by a semicolon. Comments can occur in a separate line or at the end of a line. Characters between a semicolon and the next line feed are ignored.

The following messages can occur after loading the setting file:

- Settings imported successfully: The system setting files were successfully imported.

- Could not open file: The setting file could not be opened.
- Could not close file: The setting file could not be closed.
- Could not open directory: The directory SETTINGS could not be opened.
- USB flash drive not found: No USB flash drive found.
- Device mismatch error: The setting file and the target device do not match.
- Document version error: The major version of the setting file does not match with the firmware version of the user interface.
- Document version warning: The minor version of the setting file does not match with the firmware version -> maybe not all settings from the file were successfully loaded.
- Unknown tag error: An unknown tag was read from the setting file.
- Read line error: An error occurred during reading a line from the setting file.
- Value error: A setting value is out of the valid range.
- Reset error: An error occurred during the reset operation at the beginning of the import function.
- Error detected: An unspecified error occurred.

Local operation:
Main Menu -> Settings -> Save-Recall

4.23 Reset Device Settings

At device reset the device applies the default reset settings.

This function does not only apply to the selected channel but to all channels in the system.

By pressing the rear "Reset Interface" button B6 only the following data interfaces are restarted without changing settings as addresses, baud rates etc.:
- RS-232
- LAN
- USB (VCP)
- CAN

Local operation:
Main Menu -> Settings -> Reset

Digital remote operation:
See 5.10.8 *RST

4.24 Factory Reset (Preset)

At factory reset (preset) all device and interface settings like address and baudrate saved in the electronic load's non-volatile memory are set to factory default settings.

The Preset function is executed by the SYSTem:PRESet command via a data interface.

Factory default settings RS-232
Mode: SCPI
Baud rate: 115200
Parity: None
Stop bits: 1
Factory default settings USB VCP
Baud rate: 115200
Parity: None
Stop bits: 1

Factory default settings LAN
DHCP: On
Port: 1001
Factory default settings GPIB
GPIB-Address: 7
Factory default settings CAN
Address: 1
Baud rate: 1000000
Termination: Off

Reset interface settings will become active after power-cycling the electronic load.

Local operation:
Main Menu -> Configuration -> Factory Settings

Digital remote operation:
See 5.11.16 SYSTem Subsystem

4.25 Firmware and User Manual Update

The PMLA series devices offer the possibility to update the firmware of all microcontroller-controlled modules. This can only happen in cooperation with H&H since only the manufacturer knows the compatibility between hardware and firmware as well as between the modules themselves.

To execute a firmware update you will need a FAT16 or FAT32-formatted USB mass storage device (MSD). Copy the hex file(s) and the corresponding user manual (PDF format) you get from a H&H support engineer to this USB mass storage device.

There is a corresponding hex file for each of the following modules which the electronic load validates because of the file name.

Module	File name
Analog Interface AI	PMLA_AI_*xx_yy_zz*.hex
Data Interface DI	PMLA_DI_*xx_yy_zz*.hex
User Interface UI	PMLA_UI_*xx_yy_zz*.hex

xx_yy_zz represents the firmware version number here.

The required files must be located directly to the USB flash drive's root directory. Moreover, only ONE hex file per module may be present in the root directory, otherwise the error message "multiple files" will appear. If the electronic load doesn't detect any file with the required file name for a module, "n.a." will appear in the concerning row.
The device cannot be operated during the firmware update.

Local operation:
Main Menu -> Service -> Firmware/User manual update
Plug the USB flash drive into the USB socket A5 on the front panel of the device. When the load has detected the storage device, use the appropriate check boxes to select the module(s) whose firmware should be updated. Follow the same procedure with the user manual. Start the update of all selected components with "OK". The selected components will be updated automatically one after the other.

The update process varies slightly for the different microcontroller modules.

For the update of the Analog Interfaces you can define a subset of channels for the update. The concerning AIs are then automatically updated one after the other. Two progress bars show the progress for the currently updated channel and for the whole update progress.
When the user interface is updated the bootloader output is shown on the display while the procedure is running. The UI restarts automatically after the update process.

Slave units can be only updated via the Master unit.

After you have updated the firmware of all desired components you must power-cycle the device with a 5 second break.

4.26 User Manual Download

The user manual is stored in an internal memory of the device and can be exported to an attached USB flash drive.

Local operation:
Main Menu -> Service -> User Manual
Attach the USB flash drive to the USB socket **A6** on the front panel. When the load has detected the flash drive, press the Export button. The progress of the export is displayed graphically with a progress bar. The manual is copied to the root directory of the USB flash drive as a PDF file.

5 Digital Remote Control

The electronic load provides the following standard data interfaces:

- LAN (Ethernet)
- RS-232
- USB (VCP)
- CAN

As an option:

- GPIB (Option PMLA02)

Besides the local operation, all device functions are controllable remotely. Only the CAN interface has a reduced command set with respect to the other interfaces.

Standard Settings
The standard interface settings are listed in chapter 4.24 Factory Reset (Preset).

5.1 Standards

For data transmission, the bus interfaces GPIB, LAN, RS-232 and USB implement the following standards:
IEEE 488.1-1987
IEEE 488.2-1992
SCPI Specification 1999.0
IEEE Std 1174-2000 for Performance Class 1
Universal Serial Bus Specification 2.0, Full Speed

5.2 Selecting and Deselecting an Interface

An interface is automatically selected when a valid command is received. When the load receives a query that triggers a response, the reply is sent back via the same interface the query was received from.

As soon as the electronic load receives a valid command through one of the data interfaces, it switches to remote state. This is indicated by the "Local" label in the upper-left corner of the user interface being replaced with the name of the active interface (e.g. RS232). A short "Notification" window is also briefly displayed.

An interface is deselected if a valid command is received from another interface, provided all pending queries have been answered.

Any user input on the front panel (except "Shortcut" -> "Local" shortcut) will be ignored in remote state. This is signalized by temporarily fading over a "Notification" window at the user interface when you press any key.

You can set the electronic load back to local mode by pressing the key sequence "Shortcut" -> "Local" or by sending the SCPI command SYSTem:LOCal.

Simultaneous communication over multiple interfaces is not permitted; commands must not be sent to more than one interface at the same time. However, different interfaces may be used sequentially.

If this confinement is not followed commands sent to the load may be lost.

5.3 CAN Interface

The CAN interface conforms to the CAN 2.0A standard with 11 bit identifier.

Only the most essential functions of the electronic load required for automated testing can be controlled via the CAN interface.:

- Channel selection
- Set and query setting and triggered value for the current in the operating mode constant current
- Set and query setting and triggered value for the resistance in the operating mode constant resistance
- Set and query setting and triggered value for the power in the operating mode constant power
- Set and query setting and triggered value for the voltage in the operating mode constant voltage
- Set and query protection value for overcurrent in all operating modes
- Set and query protection value for undervoltage in all operating modes
- Set and query operating mode
- Set and query load input state
- Set and query triggered input state
- Common Commands for reset, trigger, status and settings memory
- Query measurement values
- Query status values
- Query value for currently possible peak power
- Set and query cooling mode
- Query number of errors in the error queue
- Query last error in the error queue

5.3.1 CAN Connector

The master device must be connected with a CAN communication network via the 9 pin D-Sub male connector on its rear side. The CAN connector has the following pin assignment:

Pin 1	Not connected
Pin 2	CAN_L
Pin 3	GND
Pin 4	Not connected
Pin 5	Not connected
Pin 6	GND
Pin 7	CAN_H
Pin 8	Not connected
Pin 9	Not connected

5.3.2 Termination

A CAN communication bus (ISO 11898-2) must be terminated with 120 Ω resistors at both ends to ensure proper communication. Without proper termination, disruptive signal reflections may occur on the communication bus.
The electronic load's CAN interface includes a switchable termination resistor with 120 Ω which can be enabled or disabled using the SCPI command SYSTem:COMMunicate:CAN:TERMination[:STATe].

If the internal termination resistor is enabled, an external termination resistor in the D-sub connector is no longer necessary.

A reset does not affect the activation state of the termination resistor. The factory reset setting of the termination resistor is OFF.

5.3.3 CAN Cable

The maximum dimension of a CAN communication bus and thereby the cable length of a point-to-point connection is primarily depending on the transmission rate.
The following table shows the theoretically possible cable length at the given transmission rates:

Transmission Rate	Cable Length
1 Mbit/s	40 m
500 Kbit/s	110 m
250 Kbit/s	240 m
125 Kbit/s	500 m

5.3.4 Transmission Rate

The transmission rate of the CAN interface can be configured using the SCPI command:
SYSTem:COMMunicate:CAN:BAUD

All devices connected to a shared CAN bus must be configured with the same transmission rate! After changing the transmission rate, the electronic load must be power-cycled for the new setting to take effect.

5.3.5 CAN Address

The device-specific CAN address can be configured using the SCPI command:
SYSTem:COMMunicate:CAN:ADDRess

The identifiers of the two CAN messages the electronic load uses for communication via CAN interface are derived from this address:
0x100 + CAN Address: ID of request message
0x300 + CAN Address: ID of response message

Each device connected to a common CAN bus must be configured with a unique address. After changing the CAN address, the electronic load must be restarted (power-cycled) for the new value to take effect..

5.3.6 CAN Messages

Request message:
This message is sent to the electronic load to execute a specific function. It contains a 16-bit multiplexer value that specifies either a command or a query, along with any associated parameter values.

Response message:
A response message is sent by the electronic load after processing a request. It includes the 16-bit multiplexer value of the original request, an execution status, and the response value (if applicable).

Every request message receives a corresponding response message from the electronic load. The message structure is defined in a CAN symbol file (.sym, PEAK-System format) or a CAN database file (.dbc, Vector Informatik format). These files can be used with PCAN-Explorer (PEAK-System) or CANoe (Vector Informatik) to control the electronic load via the CAN interface. Both files are available from H&H upon request.

5.4 LAN Interface

The integrated LAN interface allows the exchange of SCPI commands and queries to configure and control the electronic load via a TCP/IP socket connection within a local network.
Before using the LAN interface, its configuration values can be set either locally via the user interface or remotely via another SCPI-capable interface (GPIB, RS-232, USB), using the commands described below.

Find detailed explanation about configuring the LAN interface in Application Note 19 on the H&H website:
www.hoecherl-hackl.com/download/9118/

5.4.1 Ethernet

The Ethernet interface is conform to the Ethernet standard IEEE 802.3 (100BASE-TX, 10BASE-T).

5.4.2 Ethernet Connector

The electronic load can be connected to the LAN via the rear RJ-45 plug (8P8C modular plug).
Pin assignment:

Pin 1	Tx+
Pin 2	Tx-
Pin 3	Rx+
Pin 4	not connected
Pin 5	not connected
Pin 6	Rx-
Pin 7	not connected
Pin 8	not connected

The RJ-45 connector has got two LEDs showing the status of the Ethernet connection:

Left green LED:
This LED permanently lights up at a valid connection and flashs when a transmission is in progress (sending or receiving data).
Right yellow LED:
This LED indicates either the connection speed or also data activity, depending on the device type.

5.4.3 Ethernet Cable

To connect the electronic load to the LAN, use a shielded or unshielded twisted-pair cable of category 3 or 5. The cable length must not exceed 100 meters, regardless of shielding.

5.4.4 Transmission Rate

The Ethernet transmission rate is 10 Mbit/s or 100 Mbit/s and cannot be configured by the user. It is automatically negotiated by the switch or router the electronic load is connected to.

5.4.5 Identification

The electronic load can be uniquely identified in the network segment by its globally unique MAC (Ethernet) address. This address can be queried using the SCPI command:
SYSTem:COMMunicate:LAN:MAC[:ADDRess]?
The MAC address cannot be changed by the user.

5.4.6 TCP/IP

To communicate via LAN, the electronic load requires a valid IP configuration consisting of an IP address and a subnet mask. This configuration can be assigned automatically via DHCP (Dynamic Host Configuration Protocol) if a DHCP server is available in the network.

Since the dynamically assigned values (especially the IP address) may change over time, it is recommended to use static configuration values for long-term automated control over LAN. In this case, contact your network administrator to obtain appropriate static settings for TCP/IP communication.

Automatic Configuration of Network Parameters

To enable automatic configuration via DHCP, activate the DHCP client function using the SCPI command:
SYSTem:COMMunicate:LAN:DHCP[:STATe] ON

After enabling the DHCP client, the electronic load must be restarted (power-cycled) for the new setting to take effect.

The DHCP server assigns the IP address, subnet mask, and the IP addresses for the DNS and gateway servers. The current configuration values can be queried using the following SCPI commands:
SYSTem:COMMunicate:LAN:DNS[:ADDRess]?
SYSTem:COMMunicate:LAN:GATeway[:ADDRess]?
SYSTem:COMMunicate:LAN:IP[:ADDRess]?
SYSTem:COMMunicate:LAN:SUBNet[:MASK]?

If the DHCP server has not yet fully processed the configuration then the queried addresses or masks may have the value "0:0:0:0".

Contact your network administrator if the DHCP server will not configure the LAN parameters within 60 s.

Manual Configuration of the Network Parameters

To configure the network parameters manually, disable the DHCP client function using the SCPI command:
SYSTem:COMMunicate:LAN:DHCP[:STATe] OFF

After disabling DHCP, the electronic load must be restarted (power-cycled) for the change to take effect.

The static configuration values for the electronic load's IP address, the network's subnet mask and the IP addresses of the DNS and Gateway server can be set with the SCPI commands

SYSTem:COMMunicate:LAN:IP[:ADDRess]
SYSTem:COMMunicate:LAN:SUBNet[:MASK]
SYSTem:COMMunicate:LAN:DNS[:ADDRess]
SYSTem:COMMunicate:LAN:GATeway[:ADDRess]

Consult your network administrator to agree configuration values for the network parameters. Invalid configuration values may disturb the network!

After changing any communication parameter, the electronic load must be restarted for the new value(s) to take effect.

Identification

The electronic load can also be identified in the LAN by its hostname. The hostname can be queried using the SCPI command:
SYSTem:COMMunicate:LAN:HOSTname?
The Host Name cannot be modified.

5.4.7 TCP Socket

To exchange SCPI commands and queries, a TCP connection must be established to the built-in TCP socket of the electronic load. This can be done using a terminal program or a custom application.
The port number of the TCP socket can be queried using the SCPI command:
SYSTem:COMMunicate:LAN:PORT?
The default port number is 1001.

5.5 RS-232 Interface

The RS-232 interface allows programming the electronic load in standard programming language SCPI (Standard Commands for Programmable Instruments).
It realizes the requirements of the IEEE 1174-2000 Standard for Performance Class 1.

The electronic load's RS-232 port is a standard D-sub 9-pin male connector.

5.5.1 RS-232 Cable

For RS-232 communication a standard Nullmodem cable with RTS-CTS handshake or a cable with the following pin assignment must be used (sockets in wiring view):

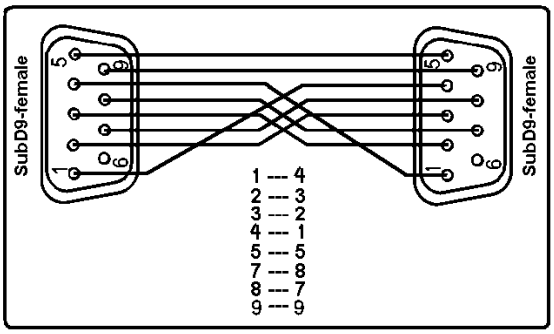


Figure 5.1: Pin assignment RS-232 cable

The RxD and TxD lines (pin 2 and 3) are crossed-over, i.e. pin 2 of the left socket is wired to pin 3 of the right socket and pin 3 of the left socket is wired to pin 2 of the right socket.

Also the RTS and CTS lines (pin 7 and 8) as well as the DCD and DTR lines (pin 1 and 4) are wired crossed-over.
Pin 5 and pin 9 are straightly connected from the left to the right connector.

5.5.2 RS-232 Interface Parameters

The RS-232 interface parameters can be configured with the SCPI commands
SYSTem:COMMunicate:SERial:BAUD
SYSTem:COMMunicate:SERial:PARity
SYSTem:COMMunicate:SERial:SBITs

After changing any communication parameter, the electronic load must be restarted for the new value(s) to take effect.

5.5.3 Data Format at RS-232 Communication

The electronic load's RS-232 interface expects the <line feed> character (10 dec.) as string termination.

When sending data the load also uses the <line feed> character (10 dec.) as termination.

5.6 USB Interface

The USB interface realizes a Virtual COM Port (VCP) and allows programming the electronic load in standard programming language SCPI (Standard Commands for Programmable Instruments).
It realizes the requirements of the IEEE 1174-2000 Standard for Performance Class 1.

After connecting the electronic load with a computer via a USB cable the load can be accessed via a virtual serial terminal which is equivalent to RS-232.

Download the concerning USB VCP driver from the homepage of the USB chip manufacturer FTDI:
http://www.ftdichip.com/Drivers/VCP.htm

5.6.1 USB Cable

Use a standard USB 2.0 cable of type A/B to control the electronic load via USB. The cable is not included in the scope of delivery.

5.6.2 USB Interface Parameters

The USB interface parameters can be configured with the SCPI commands
SYSTem:COMMunicate:VCP:BAUD
SYSTem:COMMunicate:VCP:PARity
SYSTem:COMMunicate:VCP:SBITs

After changing any communication parameter, the electronic load must be restarted for the new value(s) to take effect.

5.6.3 Data Format at USB Communication

The electronic load's USB interface expects the <line feed> character (10 dec.) as string termination.

When sending data the load also uses the <line feed> character (10 dec.) as termination.

5.7 GPIB Interface (Option PMLA02)

The optional GPIB interface allows programming the electronic load in standard programming language SCPI (Standard Commands for Programmable Instruments).
It is aligned on the requirements of the IEEE 488.2 standard.

The GPIB interface implements the following standardized functions:

Source handshake SH1
Acceptor handshake AH1
Talker T6
Listener L4
Service request SR1
Remote local RL1
Device clear DC1
Device trigger DT1
Electrical interface E1

The following functions are not implemented:
Parallel poll PP0
Controller C0

5.7.1 GPIB Cable

H&H recommends to use double-shielded standard cables which are not included in the scope of delivery. You can buy such GPIB cables from many instrument manufacturers.

If several GPIB instruments are within one GPIB system the total length of all GPIB cables must must not exceed 2 m times the number of connected instruments – up to a total of 20 m.

No more than 15 devices may be connected to a GPIB bus, with at least two-thirds of the connected devices powered on.

5.7.2 GPIB Address

The setting of the GPIB address is configured with the command
SYSTem:COMMunicate:GPIB:ADDRess.

The default factory setting for the GPIB address of any electronic load from H&H is 7.

After editing the GPIB address, you must cycle the power to apply the new value.

5.7.3 Data Format at GPIB Communication

The electronic load's GPIB interface expects the <line feed> character (10 dec.) or the EOI line with the last data character or the EOI line with the <LineFeed> character as end of string identification when receiving data.

When sending data via the GPIB bus the load uses the <line feed> character (10 dec.) with asserted EOI line as termination.

The output buffer for SCPI responses of the GPIB interface has got 15,000 bytes.

5.8 SCPI Command Syntax

The SCPI Standard (Standard Commands for Programmable Instruments) includes a standardized command set for programming devices, independent of device type and manufacturer. In this way the device dependent commands are unified.

Basically there are two groups of SCPI commands:

- Common commands
- Device-dependent commands

Common Commands are device independent commands that are defined in the standard IEEE 488.2. They include an asterisk (*) and three letters with optional parameter.
Query commands are built by appending a question mark.

Device-dependent commands have a structured syntax which is described in the following sections.

5.8.1 Header Construction

The device dependent commands are hierarchically structured. A command contains a so-called header as well as one or more parameters, separated by a white space from the header.

The header contains one or more keywords separated by a colon (:).

5.8.2 Indentions

The levels of the command hierarchy are identified by indention to the right. The deeper the level, the more it is indented to the right.

Example: Command System CURRent

```
CURRent
  [:LEVel]
     [:IMMediate] <num>
     [:IMMediate]?
     [:IMMediate]?
      :TRIGgered <num>
   :PROT
     [:LEVel] <num>
     [:LEVel]?
```

5.8.3 Selection

For some commands there are several certain parameters possible. These keywords are shown in the command syntax within one line, separated through a vertical bar (|).
In a command string only one of the alternative keywords may be specified.

Example: Command System FUNCtion

```
FUNCtion
  [:SPEed] FAST|SLOW
  [:SPEed]?
```

5.8.4 White Space

"White Space" includes all characters with ASCII code from 0 to 9 dec. and from 11 to 32 dec. The line feed character (10dec) is not part of white space. It determines the termination.

White Space is used to separate parameters from the header. Several white space characters may be combined.

5.8.5 Long and Short Form, Upper and Lower Case

Keywords are provided in long and short format (if the word contains more than four characters). Both formats are allowed. All other abbreviations are not supported and result in a syntax error.

This manual shows the short form in upper case, to allow a distinction. The remaining string, that builds in combination with the short form the long form, is appended to the short form.

The device itself doesn't distinguish between upper case and lower case letters.

For example, to program a current protection of 5A there are several methods:
`CURRENT:PROT 5`
`curr:protection 5`
`Curr:PRot 5`
but not: `CURR:PROTECT 5`

For minimum transmission times you should use the short form.

5.8.6 Optional Keywords

In some command systems it is possible to optionally use certain keywords in the header, to guarantee SCPI conformity. These words are marked using brackets ([]).

Note that the command string can be considerably shortened by omitting the optional keywords.

Example: Load Current 10 A
`CURRent[:LEVel][:IMMediate] 10`
can be reduced to:
`CURR 10`

5.8.7 Parameters

For most commands parameters have to be appended to the header (separated through white space). Depending on the recognized header the device expects a certain parameter type: Numeric, Boolean, String

If a command needs several parameters they are separated by comma (,).

Example:
```
LIST:CURR 5.5,44,83.2
```

5.8.8 Numeric Values

Numeric values may be sent to the electronic load in every decimal format specified in IEEE488.2 standard (chapter 7.7.2).

<NR1> Decimal integer value (e.g. 132)

<NR2> Floating point value (e.g. 132.0)

<NR3> Value in exponential format (e.g. +1.320000E+02)

<NRf> Flexible numeric representation
<NR1>|<NR2>|<NR3>

The decimal separator is the dot (.), no comma! In the syntax the variable <NRf> (flexible numeric representation) is used for numerical values received by the load.

Example (Resistance 0.558 Ohms):
```
RESistance 55.8E-2
RES .558
```

5.8.9 Units and Multipliers

For most numerical values the unit may be specified (suffix).
In front of the unit a multiplier can be set.

Common multipliers for electronic loads are:

Mnemonic	Definition	Multiplier
M	Milli	0.001
K	Kilo	1000

For the physical dimension the following units are supported for electronic loads:

Dimension	Unit	Description
Current	A	Amp
	MA	Milliamp
	KA	Kiloampere
Resistance	OHM	Ohm
	KOHM	Kiloohm
Power	W	Watt
	MW	Milliwatt
	KW	Kilowatt
Voltage	V	Volt
	MV	Millivolt
Time	S	Second
	MS	Millisecond

Example (Load Current 520 mA):
```
CURRENT 520MA
CURR:IMM 0.52
CURR 520E-3
```

5.8.10 Numeric and Extreme Values <NRf>|MIN|MAX

For most commands that use a numeric value as parameter, the text parameters MIN and MAX can be specified. MIN describes the lowest possible value for a parameter (mostly 0). MAX describes the highest possible value for a parameter.

Example: Set maximal current
```
CURR MAX
```

MIN and MAX must not be followed by a suffix.

The minimum and maximum value of a numeric parameter can be determined by a query. To do so, a white space as well as MIN or MAX are appended after the question mark.

Example: Determining the maximal load current:
```
CURR? MAX    may return:
+3.000000E+01
```

5.8.11 Boolean Parameters <boolean>

Some commands need a Boolean parameter, for example to switch the device input:
```
INPut ON
```

Boolean parameters can take two logic values. The logic state "FALSE" is represented by the parameter OFF or the numeric value 0. The logic state "TRUE" is represented by the parameter ON or 1.

For programming a Boolean parameter, it doesn't matter whether the numeric form or the text form is used. In general, numbers are rounded by the electronic load. If the rounded number is higher than 0 a logic TRUE will be generated.

The command
```
INPut ON        has the same result as
INPut 1         or
INPut 34.8
```

For the query of Boolean states, the Boolean numeric values 0 or 1 are always returned.

Example:
```
INPut?        (Response: 1)
```

5.8.12 Text Parameters

Text parameter obey the syntactic rules for keywords and provide a short and a long form. The separation from the header is realized by a white space.

Example:
```
FUNC:MODE VOLT
```

For the query of text parameters the short form is returned.

Example:
```
FUNC:MODE?      Result (e.g.): VOLT
```

5.8.13 Name Parameters <name>

Name parameters are special text parameters, which were definied earlier by the user, such as channel or group names. In contrast to the text parameters, no short form is supported.

Example:
`CHANnel:FOCus INDI_1R`

5.8.14 String Parameters <string>

String parameters are used to define/pass IP addresses or network masks and to define channel or group names.

These parameters are always enclosed in quotation marks (""). Length and allowed composition depend on the command header.

Example:
`CHANnel:NAME 1,"INDI_1R"`

5.8.15 The Semicolon

There are several possibilities to combine commands in one command string.

A semicolon (;) at the end of the first command returns to the last colon (:), and another command of the same hierarchical level of a command system can be appended.

Example:
The two single commands
`CURR:IMM 10` and
`CURR:PROT 15`
can be combined to one string:
`CURR:IMM 10;PROT 15`

The highest hierarchical level is reached by appending a colon to the semicolon (;:).

Example:
`CURR:LEV:IMM 10;PROT 15;:INP ON`

If the first command has got only one hierarchical level, the colon behind the semicolon can be omitted, because one semicolon switches back to the highest hierarchical level in such a case.

Example:
`CURR 15;:INP ON` has the same result as
`CURR 15;INP ON`

But for
`FUNC:MODE RES;:INP ON`
the characters ;: must be specified.

When the end of a character string is reached the SCPI parser automatically changes to the highest hierarchical level.
The string terminator is always the linefeed character (10 dec.).

5.8.16 Queries

For most commands there is a corresponding query, that returns the actual setting value. For the query a question mark (?) is appended to the header.

Example: Determine the actual setting value for the load current
`CURR?`
Result (e.g.) `+1.000000E+01`

The numeric value that is sent from the device is presented in the exponential format with sign, one digit before the comma, as default six digits after the comma, exponent, sign, two exponent digits. The device never sends units appended to the numeric values.

To determine the minimum or maximum allowed setting value for the corresponding command append a white space and MIN or MAX after the question mark. The response is a numeric value without unit.

Example: Determination of the maximum current
`CURRent? MAX`
Result e.g.: `+1.200000E+02`

5.9 Error Queue

If the electronic load receives an invalid command or a command would cause a conflict with the present state the load enters an error in the error queue. Thereby a short beep sounds.

See SYSTem:ERRor command in 5.11.16 SYSTem Subsystem and 9.1 Error Codes

5.10 Common Commands Description

<system specific>

Common Commands are defined in the IEEE488.2 standard. They begin with an * and three characters for a command or three characters and a question mark ('?') for a query.

Common Commands are system specific, i.e. they always affect the whole system, not only the currently selected load channel.

5.10.1 *CLS

Clears the following Status Registers:

- Questionable Status Event Register
- Operation Status Event Register
- Standard Event Status Register
- Status Byte Register
- Error queue

5.10.2 *ESE <NRf>, *ESE?

Sets the value of the Standard Event Status Enable Register.

Parameter: 0 ... 255

The numeric parameter specifies the new value for the register and is implicitly rounded to the next decimal integer value.

Query: *ESE?
Queries the value of the Standard Event Status Enable Register as decimal integer value.

See also 5.11.15 STATus Subsystem.

5.10.3 *ESR?

Queries the value of the Standard Event Status Register as decimal integer value. This query resets the register value to 0.

See also 5.11.15 STATus Subsystem.

5.10.4 *IDN?

Queries the channel independent identification data of the electronic load.

The returned ID string contains the following data:
Manufacturer, device type, serial number, firmware revision of Data Interface and user interface.

The identification data of the selected channel are queried by the command
`CHANnel:ID?`

See also 5.11.2 CHANnel Subsystem

5.10.5 *OPC, *OPC?

Set the Operation Complete Bit (Bit 0) in the Standard Event Status Register if all commands have been executed.

Query: *OPC?
Queries the execution state of all preceding commands. If all commands are executed the numeric value 1 is returned as decimal integer value.

5.10.6 *OPT?

Queries the options installed in the electronic load.

A string is returned which consists of concatenated part strings, separated by comma.

Position 0: “CAN”
Position 1: "GPIB”
Position 2: reserved
Position 3: reserved
Position 4: reserved
Position 5: reserved
Position 6: reserved
Position 7: reserved

If an option is available in the electronic load the corresponding part string is set to the scheduled position in the response string. If the option is not available, the corresponding part string will get the character ‘0’.

The CAN interface is now standard in the PMLA D series (previously optional), but for compatibility reasons, bit 1 remains assigned to CAN.

Example
*OPT?
Response string if no option is available:
CAN,0
Response string in GPIB option is availabe:

5.10.7 *RCL

Recalls the settings of all channels from the desired settings memory and activates it.

Parameter: 0 ... 9

The numeric parameter is implicitly rounded to the next integer value and specifies the memory number being recalled.
See 4.22 Save and Recall Device Settings

5.10.8 *RST

Resets all channels of the electronic load to power-on state. The following default settings are set at reset as well as at power-on:

ABORt
ACQuisition OFF
ACQuisition:CONTinuous OFF
ACQuisition:TRIGgered OFF
ACQuisition:STIMe MIN
CHANnel MIN
CURRent MIN
CURRent:PROTection MAX
CURRent:TRIGgered MIN
FORMat:BORDer NORM
FORMat:DATA ASCii,7
FORMat:SREGister ASCii

FUNCtion:DISCharge OFF
FUNCtion:DISCharge:STOP:CHARge 0
FUNCtion:DISCharge:STOP:CURRent 0
FUNCtion:DISCharge:STOP:ENERgy 0
FUNCtion:DISCharge:STOP:TIME 1
FUNCtion:DISCharge:STOP:VOLTage 0
FUNCtion:DISCharge:STOP:ENABle CHARge,OFF
FUNCtion:DISCharge:STOP:ENABle CURRent,OFF
FUNCtion:DISCharge:STOP:ENABle ENERgy,OFF
FUNCtion:DISCharge:STOP:ENABle TIME,OFF
FUNCtion:DISCharge:STOP:ENABle VOLTage OFF
FUNCtion:MODE CURRent
FUNCtion:MPPT OFF
FUNCtion:MPPT:SWEep:DIRection DOWN
FUNCtion:MPPT:SWEep:TIME 1.0
FUNCtion:MPPT:SWEep:PERiod MIN
FUNCtion:PROTection OFF
FUNCtion:PROTection:MODE CURRent
FUNCtion:SPEed FAST
INITiate:CONTinuous OFF
INPut OFF
INPut:TRIGgered OFF
LIST OFF
LIST:ACQuisition OFF
LIST:TRIGgered OFF
LIST:COUNt MIN
LIST:CURRent <undefined>
LIST:DWELl <undefined>
LIST:MODE CURRent
LIST:POWer <undefined>
LIST:RESistance <undefined>
LIST:RTIMe <undefined>
LIST:STIMe:RTIMe <undefined>
LIST:STIMe:VOLTage <undefined>
LIST:VOLTage <undefined>
POWer MIN
POWer:TRIGgered MIN
RESistance MAX
RESistance:TRIGgered MAX
SETTing:EXTernal OFF
SETTing:EXTernal:ENABle INPut, OFF
SETTing:EXTernal:ENABle ILEVel, OFF
SYSTem:COOLing AUTO
SYSTem:SLINk OFF
SYSTem:SLINk:DELay 0
TRIGger:DELay 0
VOLTage MAX
VOLTage:PROTection MIN
VOLTage:TRIGgered MAX

5.10.9 *SAV

Saves the active settings of all channels to a defined settings memory.

Parameter: 0 ... 9

The numeric parameter is implicitly rounded to the next integer value and specifies the memory number.
See 4.22 Save and Recall Device Settings

5.10.10 *SRE <NRf>, *SRE?

Sets the value of the Service Request Enable Register.

Parameter: 0 ... 255
The numeric parameter specifies the new value for the register and is implicitly rounded to the next decimal integer value.

Query: *SRE?
Queries the value of the Service Request Enable Register as decimal integer value.

See also 5.11.15 STATus Subsystem.

5.10.11 *STB?

Queries the value of the Status Byte Register as decimal integer value.

See also 5.11.15 STATus Subsystem.

5.10.12 *TRG

Produces a trigger for all actions.

5.10.13 *TST?

Starts the self test in the electronic load and returns the test result.
If the returned value is 0 no errors occurred during the self test. Otherwise a SCPI-defined error code is returned.

5.10.14 *WAI

Blocks the processing of subsequent commands as long as precedent commands have been completely precessed.

5.11 Device-Dependent Commands Description

This chapter describes the device-dependent SCPI commands of the electronic load. You shall be familiar with the basic SCPI syntax rules described in chapter 5.8.

At the beginning of each subsystem there is an information if the subsystem's commands affect only the selected channel (*<channel specific>*) or the whole system (*<system specific>*).

The commands are described by the following definitions:

Syntax
Syntax definitions are always given in long form with optional keywords.

Parameters
Most commands need one or more parameters. For some commands the valid range of a command depends on the model type of the electronic load, i.e. current, voltage, resistance, power range. The actual lowest or highest possible values of parameters can be determined by querying the parameter and appending MIN or MAX to the query command, for example `CURR? MAX`

Unit
If a unit specifier is allowed after the parameter it is given with possible multipliers, if available. E.g. A|MA.

**RST Value*
When a command's setting value is changed by the Reset command the *RST value is defined. This is also the power-on value.

Examples
Examples are always defined in short form without optional keywords.

Query Syntax
Most commands have a corresponding query which returns the concerning setting value.

Returned Value
The query's parameter type is defined in the description.

In chapter 0 and 5.13 all commands are listet in alphabetic order.

5.11.1 ACQuisition Subsystem

<channel specific>

ACQuisition

This command sets the activation state of the data acquisition.

The parameter OFF or 0 deactivates data acquisition, parameter ON or 1 activates it.

Syntax	ACQuisition[:STATe] <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	ACQ ON
Query Syntax	ACQuisition[:STATe]?
Return Value	0|1

ACQuisition:TRIGgered

This command sets the trigger state for the data acquisition.

The parameter OFF or 0 deactivates the data acquisition when a trigger event occurs, the parameter ON or 1 activates the data acquisition when a trigger event occurs.

Syntax	ACQuisition[:STATe]:TRIGgered <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	ACQ:TRIG ON
Query Syntax	ACQuisition[:STATe]:TRIGgered?
Return Value	0|1

ACQuisition:CONTinuous

This command sets the activation state of the continuous data acquisition.

At activated continuous data acquisition the oldest data are overwritten when the data memory is full (ring buffer).
If the continuous data acquisition is deactivated no further data is saved when the data memory is full and data acquisition is automatically stopped.

The parameter OFF or 0 deactivates continuous data acquisition, parameter ON or 1 activates it.

Syntax	ACQuisition:CONTinuous <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	ACQ:CONT ON
Query Syntax	ACQuisition:CONTinuous?
Return Value	0|1

ACQuisition:STIMe

This command sets the sample time for the data acquisition.

The numeric parameter specifies the sample time in the base unit seconds.

Syntax	ACQuisition:STIMe <NRf>
Parameter	1E-03 ... 100|MIN|MAX
Unit	S|MS
**RST Value*	0.001
Example	ACQ:STIM 0.5
Query Syntax	ACQuisition:STIM? [MIN|MAX]
Return Value	<NR3>

5.11.2 CHANnel Subsystem

<channel specific>, <system specific>

To understand the terminology and functions of the CHANnel subsystem see chapter 2.6 Channels and Channel Groups.
The CHANnel subsystem is used to identify, select and configure the single channels in a multi-channel system by their addresses.
The CHANnel subsystem also provides commands for defining channel groups, channel names and group names. If a predefined group is addressed, all channels of the group execute the corresponding commands simultaneously.

If a channel group is selected, no channel specific queries can be executed.

CHANnel

This command selects a specific channel. If a channel is selected it will execute all following commands until a different channel will be selected.

The numeric parameter specifies the address of the channel to be selected. The alternative parameter <name> specifies the previously defined name of the channel to be selected.

The <min> value corresponds to the lowest address, the <max> value corresponds to the highest address available in the system.

Syntax	CHANnel[:SELect] <NRf>|<name>
Parameter	<min> ... <max>
Example	CHAN 2
Query Syntax	CHANnel? [MIN|MAX]
Return Value	<NR1>

CHANnel:ADDRess

This command sets a new address for the currently selected channel. The new address is immediately set and is kept non-volatilely even if the power is cycled.

The numeric parameter specifies the new address. The query with a trailing MIN attribute will result in the value for the lowest possible address, the query with a trailing MAX attribute will result in the value for the highest possible address.

Syntax	CHANnel:ADDRess <NRf>
Parameter	1 ... 98
Example	CHAN:ADDR 2
Query Syntax	CHANnel:ADDRess? [MIN|MAX]
Return Value	<NR1>

CHANnel:CATalog?

This query returns the addresses of all load channels available in the system, comma-separated in ascending order.

Query Syntax	CHANnel:CATalog?
Return Value	<NR1>{,<NR1>...}
Return Example	1,2,3,4,5,6,7,8,9,10,11,12

CHANnel:COUNt?

This query supplies the number of load channels in the system.

The query with a trailing MIN attribute will result in the value for the lowest possible number of channels, the query with a trailing MAX attribute will result in the value for the theoretically highest possible address in the system. See the number of maximum channels in the technical data to get the practicable number of channels.

Query Syntax	CHANnel:COUNt? [MIN|MAX]
Return Value	<NR1>
Return Example	12

CHANnel:FOCus

This command focuses the specified channel, i.e. the setting, measurement and status values of the specified channel are displayed at the user interface of the master device.

The numeric parameter specifies the address of the channel to be focused. The alternative parameter <name> specifies the previously defined name of the channel to be selected.

The <min> value corresponds to the lowest address, the <max> value corresponds to the highest address available in the system.

Syntax	CHANnel:FOCus <NRf>|<name>
Parameter	<min> ... <max>
Example	CHAN:FOC 2
Query Syntax	CHANnel:FOCus? [MIN|MAX]
Return Value	<NR1>

CHANnel:GROup

This command selects the specified channel group.

The numeric parameter specifies the group number. The alternative parameter <name> specifies the previously defined name of the group to be selected.
The group number 10 selects all available channels of the system.

Syntax	CHANnel:GROup[:SELect] <NRf>|<name>
Parameter	1 ... 10
Example	CHAN:GRO 2

Query Syntax	CHANnel:GROup[:SELect]? [MIN|MAX]
Return Value	<NR1>

CHANnel:GROup:MEMBers

This command sets the channels of the currently selected channel group in the non-volatile memory. This command is not available for the group with the number 10.

A numeric parameter specifies the number of an available channel.

If a channel is to be removed from a group, the command must be sent again, but only with the channels that remain in the group. To resolve a group, no parameter is specified.

Syntax	CHANnel:GROup:MEMBers <NRf>{,<NRf>}
Parameter	<min> ... <max>{,<min> ... <max>}
Example	CHAN:GRO:MEMB 2,4,9
Query Syntax	CHANnel:GROup:MEMBers?
Return Value	<NR1>{,<NR1>}

CHANnel:GROup:NAME

This command sets the name of the specified channel group.

The first numeric parameter specifies the group number. The second parameter specifies the group name to be set (e.g. "GROUP_1").

Syntax	CHANnel:GROup:NAME <NRf>,<string>
Parameter1	1 ... 10
Parameter2	<string>
Example	CHAN:GRO:NAME 1,“GROUP_1“
Query Syntax	CHANnel:GROup:NAME? <NRf>
Return Value	<string>

CHANnel:ID?

This query returns the identification data of the selected channel.

The returned ID string contains the following data: manufacturer, channel type, module number, firmware revision of the channel

Query Syntax	CHANnel:ID?
Return Value	<name>,<name>,<name>,<name>

CHANnel:NAME

This command sets the name of the specified channel.

The first numeric parameter specifies the channel number. The second parameter specifies the channel name to be set (e.g. "WIPER_FRONT").

Syntax	CHANnel:NAME <NRf>,<string>
Parameter1	<min> ... <max>
Parameter2	<string>
Example	CHAN:NAME 1,“WIPER_FRONT“
Query Syntax	CHANnel:NAME? <NRf>
Return Value	<string>

5.11.3 CURRent Subsystem

<channel specific>

CURRent

This command sets the setting value for the regulated input current in current operating mode.

The numeric parameter specifies the current in the base unit amps. The parameter MIN sets the lowest admissible value for the current, the parameter MAX sets the highest admissible value for the current.

The <max> value corresponds to the current range and is specified in the technical data.

Syntax	CURRent[:LEVel][:IMMediate] <NRf>|MIN|MAX
Parameter	0 ... <max>|MIN|MAX
Unit	A|MA
**RST Value*	0
Example	CURR 12.5
Query Syntax	CURRent[:LEVel][:IMMediate]? [MIN|MAX]
Return Value	<NR3>

CURRent:PROTection

This command sets the value for the input current protection in all operating modes.

The numeric parameter specifies the current in the base unit amps. The parameter MIN sets the lowest admissible value for the current, the parameter MAX sets the highest admissible value for the current.

The <max> value corresponds to the current range and is specified in the technical data.

Syntax	CURRent:PROTection[:LEVel] <NRf>|MIN|MAX
Parameter	0 ... <max>|MIN|MAX
Unit	A|MA
**RST Value*	MAX
Example	CURR:PROT 6.5
Query Syntax	CURRent[:PROTection][:LEVel]? [MIN|MAX]
Return Value	<NR3>

CURRent:TRIGgered

This command sets the triggered value for the regulated input current in current operating mode.

The numeric parameter specifies the current in the base unit amps. The parameter MIN sets the lowest admissible value for the current, the parameter MAX sets the highest admissible value for the current.

The <max> value corresponds to the current range and is specified in the technical data.

Syntax	CURRent[:LEVel]:TRIGgered <NRf>|MIN|MAX
Parameter	0 ... <max>|MIN|MAX
Unit	A|MA
**RST Value*	0
Example	CURR:TRIG 18.5
Query Syntax	CURRent[:LEVel]:TRIGgered? [MIN|MAX]
Return Value	<NR3>

5.11.4 DATA Subsystem

<channel specific>

The DATA subsystem is available to read measurement data points saved in the electronic load.

A measurement data point consists of a sequence of <NRf> values in the order timestamp_x, voltage_x, current_x. The returned measurement data points are concatenated as follows:

timestamp_1, voltage_1, current_1, timestamp_2, voltage_2, current_2, ... timestamp_n, voltage_n, current_n.
In ASCII format all values are separated from each other by a comma followed by a space character.
In REAL format data are transferred in IEEE 754 fprmat.
See 4.8 Data Transmission According to IEEE 488.2 - Binary Block Data, 5.11.6 FORMat Subsystem.

DATA:POINts?

This command reads the number of measurement data points currently saved in the electronic load.

Query Syntax	DATA:POINts? [VMEM]
Return Value	<NR1>

DATA:REMove?

This command reads the number of measurement data points specified by the parameter saved in the electronic load.

Only a limited amount of measurement data points may be read in one query. If more data points are available than readable in one read cycle you must split the available data points into several read cycles.

The parameter of the read command must not be greater than the number of the saved data points.

Measurement data point reading is not possible while a data acquisitionis running.

Query Syntax	DATA:REMove? <NRf>
Parameter	1 ... 100
Return Value	<NR3>{,<NR3>}
Example	DATA:POIN? *// Response: 324*
	DATA:REM? 100
	DATA:REM? 100
	DATA:REM? 100
	DATA:REM? 24

5.11.5 DISPlay Subsystem

<system specific>

DISPlay:TEXT

This command displays or queries the specified string in a notification window at the user interface.

The parameter specifies the string with a maximum length of 32 characters. If the string is empty (""), the notification window is closed.

The notification window with the notification text can be confirmed and closed by the operator. With the query DISPlay:TEXT? you can determine whether the notification window with the message text is still visible. The query returns either the displayed text or an empty string ("") if no notification window is displayed.

Syntax	DISPlay:TEXT <string>
Parameter	<string>
Example	DISP:TEXT "Function cancelled"
Query Syntax	DISPlay:TEXT?
Return Value	<string>

5.11.6 FORMat Subsystem

<system specific>

FORMat

This command sets the data format for decimal values queried by SCPI commands.

The first parameter defines that values shall be returned as ASCII characters or in IEEE 754 format, see 4.8 Data Transmission According to IEEE 488.2 - Binary Block Data.
The second parameter defines the number of significant digits of a queried value.

The data format and the number of significant digits are volatile, i.e. they are reset to their default values after switching off and on.

Syntax	FORMat[:DATA] ASCii,<NRf>
Parameter1	ASCii|REAL
Parameter2	1 ... 7|32
**RST Value*	7
Example	FORM REAL,32
Query Syntax	FORMat[:DATA]?
Return Value	ASC|REAL,<NR1>

FORMat:BORDer

This command sets the byte sequence for queried measurement data in REAL format.

If the NORM parameter is transferred, the measurement data is transferred in little endian format (LSBF).

If the SWAP parameter is transferred, the measurement data is transferred in big endian format (MSBF).

Syntax	FORMat:BORDer <order>
Parameter1	NORMal|SWAPped
Default Value	NORMal
Example	FORM:BORD NORM
Query Syntax	FORMat:BORDer?
Return Value	NORM|SWAP

FORMat:SREGister

This command sets the data format for queried SCPI Status register values.

When parameter ASCii is programmed the queried register values will be returned as ASCII strings in decimal format corresponding to IEEE 488.2 standard.

When parameter HEXadecimal is programmed the queried register values will be returned in hexadecimal format corresponding to IEEE 488.2 standard. The electronic load will set the prefix "#H" with each returned register value.

When parameter OCTal is programmed the queried register values will be returned in octal format corresponding to IEEE 488.2 standard. The electronic load will set the prefix "#Q" with each returned register value.

Syntax	FORMat:SREGister <format>
Parameter1	ASCii|HEXadecimal|OCTal
**RST Value*	ASCii
Example	FORM:SREG ASC
Query Syntax	FORMat:SREGister?
Return Value	ASC|HEX|OCT

5.11.7 FUNCtion Subsystem

<channel specific>

FUNCtion:DISCharge

The command group FUNCtion:DISCharge configures and controls the electronic load's discharge function.
The command FUNCtion:DISCharge[:STATe] sets the activation state for the discharge function.

The parameter OFF or 0 deactivates the discharge function, the parameter ON or 1 activates the discharge function.

Syntax	FUNCtion:DISCharge[:STATe] <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	FUNC:DISC ON
Query Syntax	FUNCtion:DISCharge[:STATe]?
Return Value	0|1

FUNCtion:DISCharge:CHARge?

This command queries the charge in Ah having taken from the DUT since the discharge was started.

Query Syntax	FUNCtion:DISCharge:CHARge?
Return Value	<NR3>

FUNCtion:DISCharge:ENERgy?

This command queries the energy in Wh having taken from the DUT since the discharge was started.

Query Syntax	FUNCtion:DISCharge:ENERgy?
Return Value	<NR3>

FUNCtion:DISCharge:STOP:CHARge

This command sets the value for the amount of charge at which the discharging is deactivated, and the input is switched off. The stop condition is activated by the FUNCtion:DISCharge:STOP:ENABle command.

The numeric parameter specifies the charge in ampere hours. The parameter MIN sets the lowest possible value for the charge, the parameter MAX sets the highest possible value for the charge.

Syntax	FUNCtion:DISCharge:STOP:CHARge <NRf>
Parameter	0 ... 999999.9|MIN|MAX
Unit	AH|MAH|KAH
**RST Value*	0
Example	FUNC:DISC:STOP:CHAR 1.2
Query Syntax	FUNCtion:DISCharge:STOP:CHARge? [MIN|MAX]
Return Value	<NR3>

FUNCtion:DISCharge:STOP:CURRent

This command sets the value for the minimum current at which the discharging is deactivated, and the input is switched off. The stop condition is activated by the FUNCtion:DISCharge:STOP:ENABle command.

The numeric parameter specifies the current in amps. The parameter MIN sets the lowest possible value for the current, the parameter MAX sets the highest possible value for the current.

The <max> value is given in the technical data.

Syntax	FUNCtion:DISCharge:STOP:CURRent [:LEVel] <NRf>

Parameter	0 ... <max>|MIN|MAX
Unit	A|MA|KA
**RST Value*	0
Example	FUNC:DISC:STOP:CURR 1.2
Query Syntax	FUNCtion:DISCharge:STOP:CURRent [:LEVel]? [MIN|MAX]
Return Value	<NR3>

FUNCtion:DISCharge:STOP:ENABle

This command sets the enable state of the specified condition for stopping the discharge (stop condition).

The first parameter specifies the stop condition:
CHARge: stop if defined charge is accumulated
CURRent: stop if defined minimum current is reached
ENERgy: stop if defined energy is accumulated
TIME: stop if defined discharge time has expired
VOLTage: stop if defined minimum voltage is reached

The second parameter specifies the activation state of the stop condition:
0|OFF: The condition cannot stop the discharge.
1|ON: The condition can stop the discharge.

Syntax	FUNCtion:DISCharge:STOP:ENABle <signal>,<boolean>
Parameter1	CHARge|CURRent|ENERgy|TIME|VOLTage
Parameter2	0|OFF|1|ON
**RST Value*	Alle OFF
Example	FUNC:DISC:STOP:ENAB CHAR,ON
Query Syntax	FUNCtion:DISCharge:STOP:ENABle? <signal>
Return Value	0|1

FUNCtion:DISCharge:STOP:ENERgy

This command sets the value for the amount of energy at which the discharging is deactivated, and the input is switched off. The stop condition is activated by the FUNCtion:DISCharge:STOP:ENABle command.

The numeric parameter specifies the energy in watt hours. The parameter MIN sets the lowest possible value for the energy, the parameter MAX sets the highest possible value for the energy.

Syntax	FUNCtion:DISCharge:STOP:ENERgy <NRf>
Parameter	0 ... 999999.9|MIN|MAX
Unit	WH|MWH|KWH
**RST Value*	0
Example	FUNC:DISC:STOP:ENER 10.56
Query Syntax	FUNCtion:DISCharge:STOP:ENERgy? [MIN|MAX]
Return Value	<NR3>

FUNCtion:DISCharge:STOP:EVENt?

This query reads the event which has stopped the discharge function.

The return value can be one out of the following:
NONE: no stop event occured
CHAR: defined charge accumulated
CURR: defined minimum current reached
ENER: defined energy accumulated
TIME: defined discharge time elapsed

VOLT: defined minimum voltage reached

Query Syntax	FUNCtion:DISCharge:STOP:EVENt?
Return Value	NONE|CHAR|CURR|ENER|TIME|VOLT

FUNCtion:DISCharge:STOP:TIME

This command sets the value for the time duration after which the discharge will be deactivated, and the input will be switched off. The stop condition is activated by the FUNCtion:DISCharge:STOP:ENABle command.

The numeric parameter specifies the time in seconds. The parameter MIN sets the lowest possible value for the time, the parameter MAX sets the highest possible value for the time.

Syntax	FUNCtion:DISCharge:STOP:TIME <NRf>
Parameter	1 ... 999999|MIN|MAX
Unit	S|MS
**RST Value*	1
Example	FUNC:DISC:STOP:TIME 18000
Query Syntax	FUNCtion:DISCharge:STOP:TIME? [MIN|MAX]
Return Value	<NR3>

FUNCtion:DISCharge:STOP:VOLTage

This command sets the value for the minimum voltage after which the discharge will be deactivated and the input will be switched off. The stop condition is activated by the FUNCtion:DISCharge:STOP:ENABle command.

The numeric parameter specifies the voltage in volts. The parameter MIN sets the lowest possible value for the voltage, the parameter MAX sets the highest possible value for the voltage.

The <max> value is given in the technical data.

Syntax	FUNCtion:DISCharge:STOP:VOLTage [:LEVel] <NRf>
Parameter	0 ... <max>|MIN|MAX
Unit	V|MV
**RST Value*	0
Example	FUNC:DISC:STOP:VOLT 1.253
Query Syntax	FUNCtion:DISCharge:STOP:VOLTage[:LEVel]? [MIN|MAX]
Return Value	<NR3>

FUNCtion:DISCharge:TIME?

This command reads the time in seconds having elapsed since the discharge function was started.

Abfragesyntax	FUNCtion:DISCharge:TIME?
Return Value	<NR3>

FUNCtion:MODE

This command sets the operating mode for the regulation.

The parameter CURRent activates current mode.
The parameter RESistance activates resistance mode.
The parameter VOLTage activates voltage mode.
The parameter POWer activates power mode.

Syntax	FUNCtion|MODE <mode>
Parameter	CURRent|RESistance|VOLTage|POWer
**RST Value*	CURRent
Example	FUNC:MODE VOLT
Query Syntax	FUNCtion:MODE?

Return Value	CURR|RES|VOLT|POW

FUNCtion:MPPT

This command sets the activation state of the MPP Tracking function.

The parameter OFF or 0 deactivates the MPPT function, the parameter ON or 1 activates the function.

Syntax	FUNCtion:MPPT[:STATe] <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	FUNC:MPPT ON
Query Syntax	FUNCtion:MPPT[:STATe]?
Return Value	0|1

FUNCtion:MPPT:ENERgy?

This command queries the energy in Wh accumulated while an MPP Tracking function is running.

Query Syntax	FUNCtion:MPPT:ENERgy?
Return Value	<NR3>

FUNCtion:MPPT:MPP?

This command queries the latest found and controlled MPP.
The return value is a tuple consisting of the following values:
Vmpp, Impp, Pmpp

Query Syntax	FUNCtion:MPPT:MPP?
Return Value	<NR3>,<NR3>,<NR3>

FUNCtion:MPPT:SWEep

This command triggers an immediate sweep if no sweep is already running.

Syntax	FUNCtion:MPPT:SWEep[:IMMediate]
Example	FUNC:MPPT:SWE

FUNCtion:MPPT:SWEep:DATA?

This command queries the acquired measurement data of the latest sweep.

The returned measurement data consist of 100 voltage-current couples which are composed as follows:
<Volt_0>,<Curr_0>,....,<Volt_99>,<Curr_99>

Abfragesyntax	FUNCtion:MPPT:SWEep:DATA?
Return Value	<NR3>{,<NR3>}

FUNCtion:MPPT:SWEep:DATA:POINts?

This command queries the number of measurement data points of the latest sweep.

If no sweep has been performed the number of measurement data points is 0, otherwise always 100.

Query Syntax	FUNCtion:MPPT:SWEep:DATA:POINts?
Return Value	<NR3>

FUNCtion:MPPT:SWEep:DIRection

This command sets the sweep direction of the MPP Tracking function.

The text parameter specifies the sweep direction:
DOWN: from Voc to 0 V
UP: from 0 V to Voc

Syntax	FUNCtion:MPPT:SWEep:DIRection DOWN|UP
Parameter	DOWN|UP

**RST Value*	DOWN
Example	FUNC:MPPT:SWE:DIR UP
Query Syntax	FUNCtion:MPPT:SWEep:DIRection?
Return Value	<NR3>

FUNCtion:MPPT:SWEep:PERiod

This command sets the sweep period of the MPP Tracking function.

The numeric parameter specifies the sweep period in seconds. The parameter MIN sets the lowest possible value for the time, the parameter MAX sets the highest possible value for the time.

Syntax	FUNCtion:MPPT:SWEep:PERiod <NRf>
Parameter	10 ... 3600
**RST Value*	10
Example	FUNC:MPPT:SWE:PER 60
Query Syntax	FUNCtion:MPPT:SWEep:PERiod? [MIN|MAX]
Return Value	<NR3>

FUNCtion:MPPT:SWEep:TIME

This command sets the sweep time of the MPP Tracking function.

The numeric parameter specifies the sweep time in seconds. The parameter MIN sets the lowest possible value for the time, the parameter MAX sets the highest possible value for the time.

Syntax	FUNCtion:MPPT:SWEep:TIME <NRf>
Parameter	0.1 ... 5
**RST Value*	1
Example	FUNC:MPPT:SWE:TIME 60
Query Syntax	FUNCtion:MPPT:SWEep:TIME? [MIN|MAX]
Return Value	<NR3>

FUNCtion:MPPT:TIME?

This command queries the time elapsed since the MPPT function was activated.

The value returned is in seconds.

Query Syntax	FUNCtion:MPPT:TIME?
Example	FUNC:MPPT:TIME?
Return Value	<NR3>

FUNCtion:PROTection

This command sets the activation state of the current or voltage protection function.

The parameter OFF or 0 deactivates the protection function, the parameter ON or 1 activates the protection function.

Syntax	FUNCtion:PROTection[:STATe] <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	FUNC:PROT ON
Query Syntax	FUNCtion:PROTection[:STATe]?
Return Value	0|1

FUNCtion:PROTection:MODE

This command sets the mode of protection.

The parameter CURRent selects overcurrent protection.
The parameter VOLTage selects undervoltage protection.

Syntax	FUNCtion:PROTection:MODE <mode>
Parameter	CURRent|VOLTage

**RST Value*	CURRent
Example	FUNC:PROT:MODE VOLT
Query Syntax	FUNCtion:PROTection:MODE?
Return Value	CURR|VOLT

FUNCtion:SPEed

This command sets the regulation speed for the hardware-based regulation.

The parameter may have one of the following values:
SLOW: low regulation speed
FAST: high regulation speed

Syntax	FUNCtion:SPEed <speed>
Parameter	SLOW|FAST
**RST Value*	FAST
Example	FUNC:SPE SLOW
Query Syntax	FUNCtion:SPEed?
Return Value	SLOW|FAST

5.11.8 INPut Subsystem

<channel specific>

INPut

This command sets the state of the load input.

The parameter OFF or 0 deactivates the input, the parameter ON or 1 activates the input.

The query always returns the requested state. That means if the electronic load has received the INPut ON command it responds with 1 to a query even if the actual state is off because of an independent state such as overtemperature protection. The actual input state is determined by reading the Operation Status Register.

Syntax	INPut[:STATe] <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	INP ON
Query Syntax	INPut[:STATe]?
Return Value	0|1

INPut:TRIGgered

This command sets the trigger state for the load input.

The parameter OFF or 0 deactivates the input when a trigger event occurs, the parameter ON or 1 activates the load input when a trigger event occurs.

Syntax	INPut[:STATe]:TRIGgered <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	INP:TRIG ON
Query Syntax	INPut[:STATe]:TRIGgered?
Return Value	0|1

INPut:WDOG

This command sets the activation state of the watchdog.

The parameter OFF or 0 deactivates the watchdog, the parameter ON or 1 activates the watchdog.

The watchdog is deactivated for all channels when the electronic load is powered on. A device reset does not change the activation state.

Syntax	INPut:WDOG[:STATe] <boolean>
Parameter	0|OFF|1|ON
Example	INP:WDOG ON
Query Syntax	INPut:WDOG[:STATe]?
Return Value	0|1

INPut:WDOG:DELay

This command sets the watchdog delay time.

The numeric parameter specifies the delay in seconds. The numeric value is implicitly rounded to the next integer value. The parameter MIN sets the lowest possible value, the parameter MAX sets the highest possible value.

The delay time is 60 s for all channels after the electronic load is powered on. A device reset does not change the delay time.

INPut:WDOG:RESet

This command resets the watchdog.

This command has no query form.

Syntax	INPut:WDOG:RESet
Example	INP:WDOG:RES

5.11.9 LIST Subsystem

<channel specific>

LIST

This command sets the activation state of a list.

The parameter ON or 1 activates the list execution, the parameter OFF or 0 deactivates the list execution.

Syntax	LIST[:STATe] <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	LIST ON
Query Syntax	LIST[:STATe]?
Return Value	0|1

LIST:ACQuisition

This command sets the activation state for synchronous data acquisition when a list is executed.

The parameter ON or 1 activates data acquisition, the parameter OFF or 0 deactivates it.

Syntax	LIST:ACQuisition[:ENABle] <boolean>
Parameter	0|OFF|1|ON
Example	LIST:ACQ ON
Query Syntax	LIST:ACQuisition[:ENABle]?
Return Value	0|1
Reset Value	OFF

LIST:COUNt

This command specifies how often a list shall be processed after it is activated.

The numeric parameter value specifies the number of iterations and is implicitly rounded to the next integer value. The parameter MIN sets the lowest possible value, the parameter MAX sets the highest possible value. A higher value than the MAX value or the numeric value vor infinity (9.9E37) causes a continuous execution of the list as long as it will be stopped by the command LIST:STATe OFF.

Syntax	LIST:COUNt <NRf>
Parameter	1 ... 999|MIN|MAX
**RST Value*	1
Example	LIST:COUN 23
Query Syntax	LIST:COUNt? [MIN|MAX]
Return Value	<NR3>

LIST:CURRent

This command sets the setting values for a current list.

A numeric parameter specifies the current in amps. The maximum number of parameter values (settings) is 100.

Syntax	LIST:CURRent[:LEVel] <NRf>{,<NRf>}
Parameter	<NRf>{,<NRf>}
Unit	A|MA
**RST Value*	Invalid list
Example	LIST:CURR 12.75,56.2,0
Query Syntax	LIST:CURRent[:LEVel]?
Return Value	<NR3>{,<NR3>}

LIST:CURRent:POINts?

This query reads the number of settings in the current list.

When the optional parameter MIN is appended the lowest possible number is queried. When the optional parameter MAX is appended the highest possible number is queried.

Abfragesyntax	LIST:CURR[:LEVel]:POINts? [MIN|MAX]
Return Value	<NR1>

LIST:DWELl

This command sets the dwell values in a list.

A numeric parameter specifies the dwell time in seconds. The maximum number of parameter values is 100.

Syntax	LIST:DWELl <NRf>{,<NRf>}
Parameter	0.0002 ... 1000.0{,0.0002 ... 1000.0}
Unit	S|MS
**RST Value*	Invalid list
Example	LIST:DWEL 5.5E-3,0.01,1.02
Query Syntax	LIST:DWELl?
Return Value	<NR3>{,<NR3>}

LIST:DWELl:POINts?

This query reads the number of dwell times in the present list.

When the optional parameter MIN is appended the lowest possible number is queried. When the optional parameter MAX is appended the highest possible number is queried.

Query Syntax	LIST:DWELl:POINts? [MIN|MAX]
Return Value	<NR1>

LIST:MODE

This command sets the operating mode for the LIST function. It selects the corresponding setting list.

Syntax	LIST:MODE <mode>
Parameter	CURRent|POWer|RESistance|VOLTage
**RST Value*	CURRent
Example	LIST:MODE VOLT
Query Syntax	LIST:MODE?
Return Value	CURR|POW|RES|VOLT

LIST:POINts?

This command queries the number of list points executed since the list was activated.

Query Syntax	LIST:POINts?
Return Value	<NR1>

LIST:POWer

This command sets the setting values in a power list.

A numeric parameter specifies the power in watts. The maximum number of parameter values is 100.

Syntax	LIST:POWer[:LEVel] <NRf>{,<NRf>}
Parameter	<NRf>{,<NRf>}
Unit	W|MW|KW
**RST Value*	Invalid list
Example	LIST:POW 50,8.5,26.8
Query Syntax	LIST:POWer[:LEVel]?
Return Value	<NR3>{,<NR3>}

LIST:POWer:POINts?

This query reads the number of settings in the power list.

When the optional parameter MIN is appended the lowest possible number is queried. When the optional parameter MAX is appended the highest possible number is queried.

Query Syntax	LIST:POWer[:LEVel]:POINts? [MIN|MAX]
Return Value	<NR1>

LIST:RESistance

This command sets the setting values in a resistance list.

A numeric parameter specifies the resistance in ohms. The maximum number of parameter values is 100.

Syntax	LIST:RESistance[:LEVel] <NRf>{,<NRf>}
Parameter	<NRf>{,<NRf>}
Unit	OHM|KOHM
**RST Value*	Invalid list
Example	LIST:RES 5.0,0.85,2.667E-2
Query Syntax	LIST:RESistance[:LEVel]?
Return Value	<NR3>{,<NR3>}

LIST:RESistance:POINts?

This query reads the number of settings in the resistance list.

When the optional parameter MIN is appended the lowest possible number is queried. When the optional parameter MAX is appended the highest possible number is queried.

Query Syntax	LIST:RESistance[:LEVel]:POINts? [MIN|MAX]
Return Value	<NR1>

LIST: RTIMe

This command sets the ramp values in a list.

A numeric parameter specifies the ramp time in seconds. The maximum number of parameter values is 100.

Syntax	LIST:RTIMe <NRf>{,<NRf>}
Parameter	0.0 ... 1000.0{,0.0 ... 1000.0}
Unit	S|MS
**RST Value*	Invalid list
Example	LIST:RTIMe 5.5E-3,0.01,1.02
Query Syntax	LIST:RTIMe?
Return Value	<NR3>{,<NR3>}

LIST:RTIMe:POINts?

This query reads the number of ramp times in the present list.

When the optional parameter MIN is appended the lowest possible number is queried. When the optional parameter MAX is appended the highest possible number is queried.

Query Syntax	LIST:RTIMe:POINts? [MIN|MAX]
Return Value	<NR1>

LIST:STIMe:DWELl

This command sets the setting values in the list for sample times during dwell times.

A numeric parameter specifies the sample time in seconds. The maximum number of parameter values is 300.

Syntax	LIST:STIMe:DWELl <NRf>{,<NRf>}
Parameter	2E-04 ... 1E+03{,2E-04 ... 1E+03}
Unit	S
Example	LIST:STIM:DWEL 1E-3,0.01,0.05
Query Syntax	LIST:STIMe:DWELl?
Return Value	<NR3>{,<NR3>}
Reset Value	Empty list

LIST:STIMe:DWELl:POINts?

This query reads the number of setting values in the list for sample times during dwell times.

When the optional parameter MIN is appended the lowest possible number is queried. When the optional parameter MAX is appended the highest possible number is queried.

Query Syntax	LIST:STIMe:DWELl:POINts? [MIN|MAX]
Return Value	<NR1>

LIST:STIMe:RTIMe

This command sets the setting values in the list for sample times during ramp times.

A numeric parameter specifies the sample time in seconds. The maximum number of parameter values is 300.

Syntax	LIST:STIMe:RTIMe <NRf>{,<NRf>}
Parameter	2E-04 ... 1E+03{,2E-04 ... 1E+03}
Unit	S
Example	LIST:STIM:RTIM 1E-3,0.01,0.05
Query Syntax	LIST:STIMe:RTIMe?
Return Value	<NR3>{,<NR3>}
Reset Value	Empty list

LIST:STIMe:RTIMe:POINts?

This query reads the number of setting values in the list for sample times during ramp times.

When the optional parameter MIN is appended the lowest possible number is queried. When the optional parameter MAX is appended the highest possible number is queried.

Query Syntax	LIST:STIMe:RTIMe:POINts? [MIN|MAX]
Return Value	<NR1>

LIST:TIME?

This command queries the time elapsed since the list function was activated.

The value returned is in seconds.

Query Syntax	LIST:TIME?
Return Value	<NR3>

LIST:TRIGgered

This command sets the trigger state for the list execution.

The parameter OFF or 0 deactivates the list execution when a trigger event occurs, the parameter ON or 1 activates the list execution when a trigger event occurs.

Syntax	LIST[:STATe]:TRIGgered <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	LIST:TRIG ON
Query Syntax	LIST[:STATe]:TRIGgered?
Return Value	0|1

LIST:VOLTage

This command sets the setting values in a voltage list.

A numeric parameter specifies the voltage in volts. The maximum number of parameter values is 100.

Syntax	LIST:VOLTage[:LEVel] <NRf>{,<NRf>}
Parameter	<NRf>{,<NRf>}
Unit	V|MV
**RST Value*	Invalid list
Example	LIST:VOLT 12.75,56.2,0
Query Syntax	LIST:VOLTage[:LEVel]?
Return Value	<NR3>{,<NR3>}

LIST:VOLTage:POINts?

This query reads the number of settings in the voltage list.

When the optional parameter MIN is appended the lowest possible number is queried. When the optional parameter MAX is appended the highest possible number is queried.

Query Syntax	LIST:VOLTage[:LEVel]:POINts? [MIN|MAX]
Return Value	<NR1>

5.11.10 MEASure Subsystem

<channel specific>

MEASure:CURRent?

This query reads the latest measured value of the load current.

The returned value of the current is in amps.

Query Syntax	MEASure:CURRent?

Return Value <NR3>

MEASure:POWer?

This query reads the latest value of the power, calculated of measured current and voltage.

The returned value of the power is in watts.

Query Syntax MEASure:POWer?
Return Value <NR3>

MEASure:RESistance?

This query reads the latest value of the resistance, calculated of measured current and voltage.

The returned value of the resistance is in ohms.

Query Syntax MEASure:RESistance?
Return Value <NR3>

MEASure:TEMPerature?

This query reads the latest value of the measured power stage temperature.

The returned value of the temperature is in degree celsius.

Query Syntax MEASure:TEMPerature?
Return Value <NR3>

MEASure:VOLTage?

This query reads the latest value of the measured input voltage.

The returned value of the voltage is in volts.

Query Syntax MEASure:VOLTage?
Return Value <NR3>

MEASure:VOLTage:EXTernal?

This query returns the latest measurement value for the voltage for the voltage at the analog control input LEVEL+ respective to LEVEL- at the I/O port.

PMLA LP variants do not have analog control inputs and generate an execution error when this command is received.

The returned value of the voltage is in volts.

Query Syntax MEASure:VOLTage:EXTernal?
Return Value <NR3>

5.11.11 POWer Subsystem

<channel specific>

POWer

This command sets the setting value for the regulated power in power operating mode.

The numeric parameter specifies the power in the base unit watts. The parameter MIN sets the lowest admissible value for the power, the parameter MAX sets the highest admissible value for the power.

The <max> and MAX value correspond to the maximum short-time power which is specified in the technical data.

Syntax POWer[:LEVel][:IMMediate] <NRf>|MIN|MAX

Parameter	0 ... <max>|MIN|MAX
Unit	W|KW|MW
**RST Value*	0
Example	POW 57.88
Query Syntax	POWer[:LEVel][:IMMediate]? [MIN|MAX]
Return Value	<NR3>

POWer:TRIGgered

This command sets the value for the regulated power in power operating mode.

The numeric parameter specifies the power in the base unit watts. The parameter MIN sets the lowest admissible value for the power, the parameter MAX sets the highest admissible value for the power.

The <max> and MAX value correspond to the maximum short-time power which is specified in the technical data.

Syntax	POWer[:LEVel]:TRIGgered <NRf>|MIN|MAX
Parameter	0 ... <max>|MIN|MAX
Unit	W|KW|MW
**RST Value*	0
Example	POW:TRIG 2.3E3
Query Syntax	POWer[:LEVel]:TRIGgered? [MIN|MAX]
Return Value	<NR3>

POWer:PEAK?

This query reads the currently possible peak power which depends on the power stage temperature.

The returned value for the peak power has the unit watts.

Query Syntax	POWer:PEAK?
Return Value	<NR3>

5.11.12 RESistance Subsystem

<channel specific>

RESistance

This command sets the setting value for the regulated resistance in resistance operating mode.

The numeric parameter specifies the resistance in the base unit ohms. The parameter MIN sets the lowest admissible value for the resistance, the parameter MAX sets the highest admissible value for the resistance.

<min> and MIN values are the lowest possible setting values, <max> and MAX values are the highest possible setting values. They are specified in the technical data.

Syntax	RESistance[:LEVel][:IMMediate] <NRf>|MIN|MAX
Parameter	<min> ... <max>|MIN|MAX
Unit	OHM|KOHM
**RST Value*	MAX
Example	RES 3.77
Query Syntax	RESistance[:LEVel][:IMMediate]? [MIN|MAX]
Return Value	<NR3>

RESistance:TRIGgered

This command sets the value for the regulated resistance in constant resistance operating mode.

The numeric parameter specifies the resistance in the base unit ohms. The parameter MIN sets the lowest admissible value for the resistance, the parameter MAX sets the highest admissible value for the resistance.

The values for <min> and <max> and MIN and MAX, respectively, are specified in the technical data.

Syntax	RESistance[:LEVel]:TRIGgered <NRf>|MIN|MAX
Parameter	<min> ... <max>|MIN|MAX
Unit	OHM|KOHM
**RST Value*	MAX
Example	RES:TRIG 0.91
Query Syntax	RESistance[:LEVel]:TRIGgered? [MIN|MAX]
Return Value	<NR3>

5.11.13 SERVice Subsystem

<channel specific>

SERVice:CALibration

This command sets the activation state for the adjusting mode of the selected channel.

The first parameter specifies the state: the parameter ON or 1 activates calibration mode, the parameter OFF or 0 deactivates calibration mode. The second parameter specifies the password to activate adjustment mode. It can be left blank for deactivating the calibration mode.

The query command reads only the activation state of calibration mode. When the numeric value 0 is returned the calibration mode is deactivated, when 1 is returned the calibration mode is activated.

This command is only provided for qualified personnel familiar with the calibration procedure for H&H electronic loads. Therefore, it is password-protected.
Misuse of this command may lead to malfunction of the electronic load and make it unusable!

Syntax	SERVice:CALibration[:STATe] <boolean> [,<code>]
Parameter1	0|OFF|1|ON
Parameter2	<code>
**RST Value*	OFF
Example	SERV:CAL OFF
Query Syntax	SERVice:CALibration[:STATe]?
Return Value	0|1

SERVice:CALibration:EXTernal:HIGH

This command sets the reference value of the upper adjustment point for adjusting the external measurement path. The command is only valid if calibration state is active and therefore intended to be used only by qualified service personnel.

The numeric parameter specifies the reference value at the adjustment point. The reference value is in volts.

This command has no query form.

Syntax	SERVice:CALibration: EXTernal:HIGH <NRf>
Parameter	0 ... <max>
Example	SERV:CAL:EXT:HIGH 18.5

SERVice:CALibration:EXTernal:LOW

This command sets the reference value of the lower adjustment point for adjusting the external measurement path. The command is only valid if calibration state is active and therefore intended to be used only by qualified service personnel.

The numeric parameter specifies the reference value at the adjustment point. The reference value is in volts.

This command has no query form.

Syntax	SERVice:CALibration: EXTernal:LOW <NRf>
Parameter	0 ... <max>
Example	SERV:CAL:EXT:LOW 1.5

SERVice:CALibration:LEVel:HIGH

This command sets the reference value of the upper adjustment point for adjusting the setting value of the actively controlled input value. The command is only valid if calibration state is active and therefore intended to be used only by qualified service personnel.

The numeric parameter specifies the reference value at the adjustment point.

This command has no query form.

Syntax	SERVice:CALibration:LEVel:HIGH <NRf>
Parameter	0 ... <max>
Example	SERV:CAL:LEV:HIGH 18.5

SERVice:CALibration:LEVel:LOW

This command sets the reference value of the lower adjustment point for adjusting the setting value of the actively controlled value. The command is only valid if calibration state is active and therefore intended to be used only by qualified service personnel.

The numeric parameter specifies the reference value at the adjustment point.

This command has no query form.

Syntax	SERVice:CALibration:LEVel:LOW <NRf>
Parameter	0 ... <max>
Example	SERV:CAL:LEV:LOW 1.5

SERVice:CALibration:MEASure:HIGH

This command sets the reference value of the upper adjustment point for adjusting the measurement value of the actively controlled input value. The command is only valid if calibration state is active and therefore intended to be used only by qualified service personnel.

The numeric parameter specifies the reference value at the adjustment point.

This command has no query form.

Syntax	SERVice:CALibration:MEASure:HIGH <NRf>
Parameter	0 ... <max>
Example	SERV:CAL:MEAS:HIGH 18.5

SERVice:CALibration:MEASure:LOW

This command sets the reference value of the lower adjustment point for adjusting the measurement value of the actively controlled value. The command is only valid if calibration state is active and therefore intended to be used only by qualified service personnel.

The numeric parameter specifies the reference value at the adjustment point.

This command has no query form.

Syntax	SERVice:CALibration:MEASure:LOW <NRf>
Parameter	0 ... <max>
Example	SERV:CAL:MEAS:LOW 1.5

SERVice:CALibration:PROTection:HIGH

This command sets the reference value of the upper adjustment point for adjusting the protection value of the actively controlled value. The command is only valid if calibration state is active and therefore intended to be used only by qualified service personnel.

The numeric parameter specifies the reference value at the adjustment point.

This command has no query form.

Syntax	SERVice:CALibration:PROTection:HIGH <NRf>
Parameter	0 ... <max>
Example	SERV:CAL:PROT:HIGH 18.5

SERVice:CALibration:PROTection:LOW

This command sets the reference value of the lower adjustment point for adjusting the protection value of the actively controlled value. The command is only valid if calibration state is active and therefore intended to be used only by qualified service personnel.

The numeric parameter specifies the reference value at the adjustment point.

This command has no query form.

Syntax	SERVice:CALibration:PROTection:LOW <NRf>
Parameter	0 ... <max>
Example	SERV:CAL:PROT:LOW 1.5

SERVice:PRODuction

This command sets the activation state for the production mode of the selected channel.

The first parameter specifies the new state: the parameter ON or 1 activates production mode, the parameter OFF or 0 deactivates production mode. The second parameter specifies the password to activate the production mode. It can be left blank for deactivating the production mode.

The query command reads only the activation state of production mode. If the numeric value 0 is returned the production mode is deactivated, when 1 is returned the production mode is activated.

This command is only provided for qualified personnel familiar with the production procedure for H&H electronic loads. Therefore, it is password-protected.
Misuse of this command may lead to malfunction of the electronic load and make it unusable!

Syntax	SERVice:PRODuction[:STATe] <boolean> [,<code>]
Parameter1	0|OFF|1|ON
Parameter2	<code>
**RST Value*	OFF
Example	SERV:PROD OFF
Query Syntax	SERVice:PRODuction[:STATe]?
Return Value	0|1

SERVice:STRing

This command sets the specified string parameter with the specified character string in the non-volatile memory of the load.

The first numeric parameter specifies the string number. The second parameter specifies the character string to be set.

This command is only provided for qualified personnel familiar with the production procedure for H&H electronic loads. Therefore, it is password-protected and only allowed in production state.
Misuse of this command may lead to malfunction of the electronic load and make it unusable!

Syntax	SERVice[:PARameter]:STRing <NRf>, <string>

Parameter1	0 ... 19
Parameter2	<string>
Example	SERV:STR 8,"Abc123"
Query Syntax	SERVice[:PARameter]:STRing? <NRf>
Return Value	<string>

SERVice:VALue

This command sets the specified system parameter with the specified value in the non-volatile memory.

The first numeric parameter specifies the system parameter number. The second numeric parameter specifies the parameter value to be set.

This command is – except a small, unprotected range - mainly provided for qualified personnel familiar with the production procedure for H&H electronic loads. Therefore, a certain parameter range is password-protected and only writable in production or calibration state, respectively.
Misuse of this command may lead to malfunction of the electronic load and make it unusable!

See also 5.11.16 SYSTem Subsystem (SYSTem:PRESet command).

Syntax	SERVice[:PARameter]:VALue <NRf>,<NRf>
Parameter1	0 ... 101
Parameter2	<NRf>
Example	SERV:VAL 7,0.8
Query Syntax	SERVice[:PARameter]:VALue? <NRf>
Return Value	<NR3>

5.11.14 SETTing Subsystem

<channel specific>

SETTing:EXTernal

This command sets the activation state for external control via the I/O port.

PMLA LP variants do not have I/O ports and generate an execution error when this command is received.

The parameter ON or 1 activates external control, the parameter OFF or 0 deactivates external control.

The desired external controllable signals must be enabled by the command SETTing:EXTernal:ENABle.

Syntax	SETTing:EXTernal[:STATe] <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	SETT:EXT ON
Query Syntax	SETTing:EXTernal[:STATe]?
Return Value	0|1

SETTing:EXTernal:ENABle

This command sets the activation state for the specified external signal.

PMLA LP variants do not have I/O ports and generate an execution error when this command is received.

The first parameter specifies the external signal:
INPut: activation state of load input
ILEVel: immediate level (setting value)

The second parameter specifies the activation state:
0|OFF: the external signal is not activated.

1|ON: the external signal is activated.

Syntax	SETTing:EXTernal:ENABle <signal>, <boolean>
Parameter1	INPut|ILEVel
Parameter2	0|OFF|1|ON
**RST Value*	All OFF
Example	SETT:EXT:ENAB INP,ON
Query Syntax	SETTing:EXTernal:ENABle? <signal>
Return Value	0|1

5.11.15 STATus Subsystem

<channel specific>, <system spezific>

The STATus subsystem determines the status of the single load channels as well as of the system status and serves for configuration of the summary state in the Status Byte.

The content of a status register is represented by a decimal number that is built of the values of the set bits:

Bit	Value	Bit	Value
0	1	8	256
1	2	9	512
2	4	10	1024
3	8	11	2048
4	16	12	4096
5	32	13	8192
6	64	14	16384
7	128	15	32768

After activating the electronic load all bits of all status registers are FALSE – except Bit 7 (PON) in the Standard Event Register (see following sections).

The status model contains the following groups:

- Channel Questionable Status
- Channel Operation Status
- System Questionable Status
- System Operation Status
- Standard Event Status
- Status Byte

The Questionable, Condition and Standard Event Status groups are built of

- Condition Register (only Questionable and Operation Status)
- Event Register
- Enable Register

Condition Register
Represents the status of functions and errors. The bit state of a Condition Register is not changed by reading it. A state/error is active if the corresponding bit is set. If a state is no longer active the bit in the corresponding Condition Register is reset.

Event Register
Saves information about occurred events and errors. Every bit of an Event Register corresponds to a bit in the Condition Register (for Questionable Status and Operation Status) or directly to special events (Standard Event Status).

A bit in the Event Register is set when the corresponding event has become active. The event is set until the corresponding Event Register has been read. After reading the Event Registers all bits are reset to 0.

Enable Register

Determines which bits of the corresponding Event Registers are logically ORed to a resulting sum bit. The Enable Register acts as filter for the corresponding Event Register.
The bit state of an Enable Register is not changed by reading it.

PMLA Channel and System Status Model

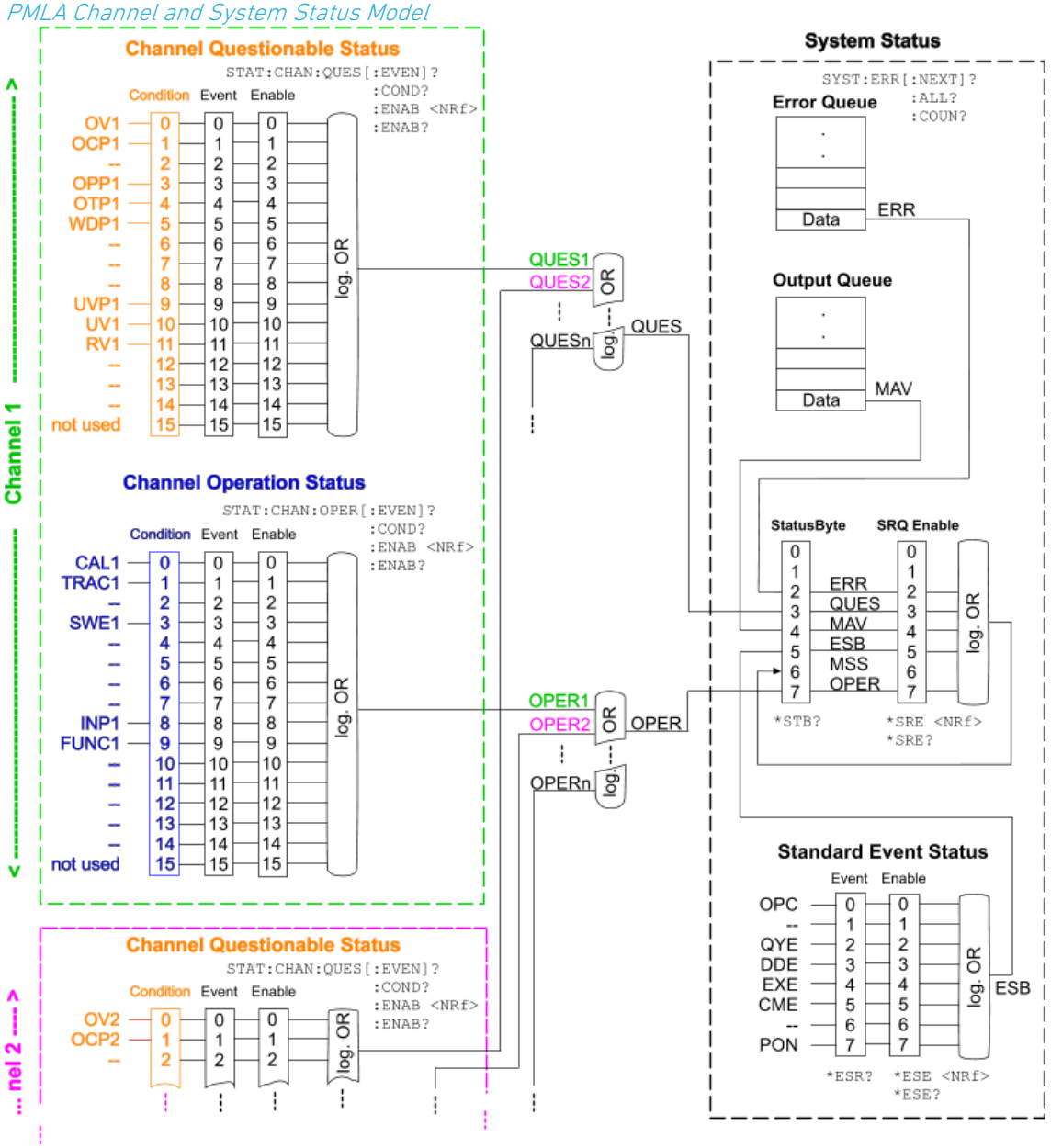


Figure 5.2: PMLA Channel and System Status Model

Channel Operation Status

The Channel Operation Status Registers provide information about the operating state of the selected channel.

These registers can be configured and read by the
STATus:CHANnel:OPERation
command group (see below).

Bit	Wert	Description
0 CAL	1	A calibration procedure is active.
1 TRAC	2	MPP tracking is active.
3 SWE	8	MPP sweeping is active.
8 INP	256	The load input is on. This is the actual state, i. e. if a protection unit is active (e.g. OTP) the input is switched off even when the activation state is on (INPut ON).
9 FUNC	512	One of the functions ACQ, LIST, MPPT or DISC is active.

The channel specific Channel Operation Status OPER1 to OPERn (n = 1 ... 99) are logically ored to the sum bit OPER which is part of the Status Byte Register.

Channel Questionable Status

The Channel Questionable Status Registers inform you about particular error or overload states of the selected channel.

These registers can be configured and read by the
`STATus:CHANnel:QUEStionable`
command group (see below).

Bit	Wert	Description
0 OV	1	Overvoltage indication. OV is displayed on the user interface.
1 OCP	2	Overcurrent protection. OCP is displayed on the user interface.
3 OPP	8	Overpower protection. OPP is displayed on the user interface.
4 OTP	16	Overtemperature protection. OTP is displayed on the user interface.
5 WDP	32	Watchdog. WDP is displayed on the user interface.
9 UVP	512	Undervoltage protection. Is set when the input voltage falls below the programmed voltage protection value. UVP is displayed on the user interface
10 UV	1024	Undervoltage. Is set when the input voltage is not high enough to control the desired load setting. UV is displayed on the user interface.
11 RV	2048	Reverse Voltage. Is set when the voltage at the input terminals is lower than about -0.5 V. RV is displayed on the user interface.

The channel specific Channel Questionable Status QUES1 to QUESn (n = 1 ... 99) are logically ored to the sum bit QUES which is part of the Status Byte Register.

Standard Event Status

The system specific Standard Event Status Register contains information about the standard events defined in the standard IEEE 488.2.
It is read by the *ESR? Common Command (see 5.9.3).

The command `*ESE <NRf>` (see 5.9.2) sets the bit pattern determined by the decimal parameter in the Standard Event Status Enable Register. This method determines which bits from the Standard

Event Register are relevant for the interpretation of the ESB sum bit. The Enable Register is read by the `*ESE?` query.

Bit	Value	Description
0 OPC	1	Operation Complete. The device has executed all pending commands. For the electronic loads this bit is always TRUE, because the commands are executed serially and not in overlapped mode.
2 QYE	4	Query Error. Errors in the range from –400 to –499 can set this bit.
3 DDE	8	Device Dependent Error. Errors in the range from –399 to –300 can set this bit.
4 EXE	16	Execution Error. Errors in the range from –299 to –200 can set this bit.
5 CME	32	Command Error. Errors in the range from –199 to –100 can set this bit.
7 PON	128	Power On. Indicates that the load has been switched off and on since the last register value reading or, respectively, a mains power failure has occurred.

Status Byte

In the Status Byte Register the Status Events of all Status Registers as well as the sum bits for the system specific QUES and OPER status are combined.
The Status Byte is read with the `*STB?` Common Command (see 5.10.11 *STB?).

Bit	Value	Description
2 ERR	4	Error. An error is in the error queue.
3 QUES	8	Questionable. An enabled Questionable Event has occurred.
4 MAV	16	Message Available.
5 ESB	32	Event Status Bit. An enabled Standard Event has occurred.
6 MSS	64	Master Summary Status.
7 OPER	128	Operation. An enabled Operation Event has occurred.

System Operation Status

The single channel specific Channel Operation Status Condition bits of all load channels are logically ored to a sum bit which is part of the System Operation Status Condition Register.

The System Operation Status Condition and Event Register can be read by the commands
`STATus:OPERation[:EVENt]?`
`STATus:OPERation:CONDition?`

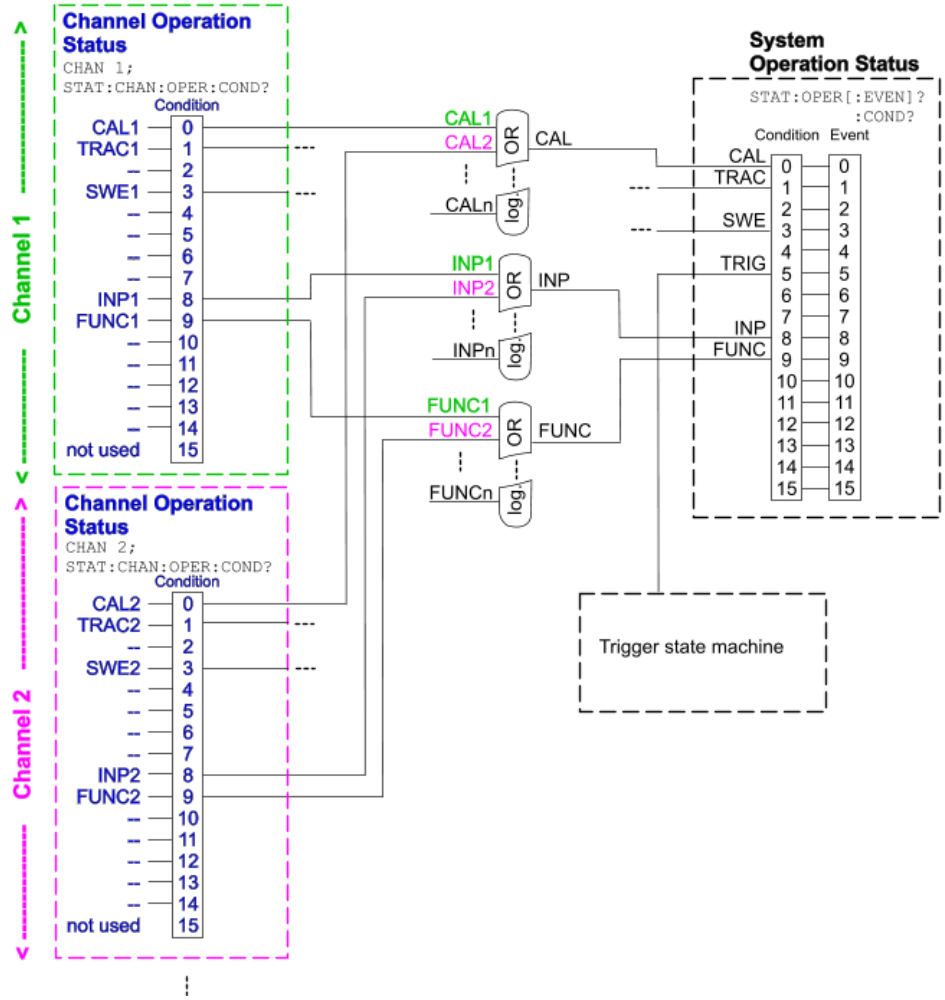


Figure 5.3: Figure 5.4: System Operation Status generation

System Questionable Status

The single channel specific Channel Questionable Status Condition bits of all load channels are logically ored to a sum bit which is part of the System Questionable Status Condition Register.

The System Questionable Status Condition and Event Register can be read by the commands
`STATus:QUEStionable[:EVENt]?`
`STATus:QUEStionable:CONDition?`

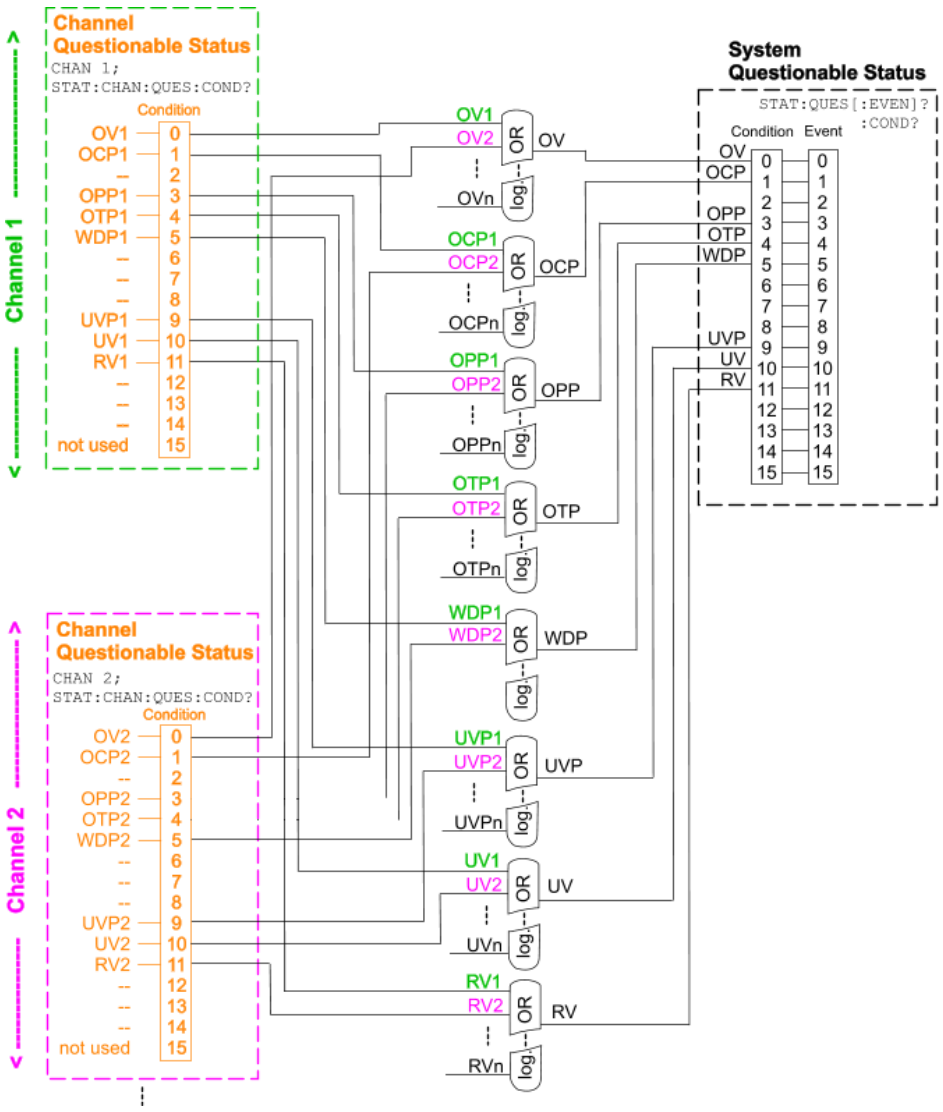


Figure 5.5: System Questionable Status generation

STATus:CHANnel:OPERation?

This query reads the value of the channel specific Operation Status Event Register of the currently selected load channel.

The register value is reset to 0 after this query.

Query Syntax	STATus:CHANnel:OPER[:EVENt]?
Return Value	<NR1>

STATus:CHANnel:OPERation:CONDition?

This query reads the value of the channel specific Operation Status Condition Register of the currently selected channel.

Query Syntax	STATus:CHANnel:OPERation:CONDition?
Return Value	<NR1>

STATus:CHANnel:OPERation:ENABle

This command sets the bit combination for the channel specific Operation Status Enable Register of the currently selected load channel defined by the decimal parameter value.

The numeric parameter specifies the new value for the register.
The register value is retained after reset (*RST).

Syntax	STATus:CHANnel:OPERation:ENABle <NRf>
Parameter	0 ... 32767
Example	STAT:CHAN:OPER:ENAB 16
Query Syntax	STATus:CHANnel:OPERation:ENABle?
Return Value	<NR1>

STATus:CHANnel:PRESet

This command sets the channel specific SCPI Status Enable Registers of the currently selected load channel to defined values.

Channel Operation Status Enable: register value 0
Channel Questionable Status Enable: register value 0

This command has no query form.

Syntax	STATus:CHANnel:PRESet
Example	STAT:CHAN:PRES

STATus:CHANnel:QUEStionable?

This query reads the value of the channel specific Questionable Status Event Register of the currently selected load channel.

The register value is reset to 0 after this query.

Query Syntax	STATus:CHANnel:QUEStionable[:EVENt]?
Return Value	<NR1>

STATus:CHANnel:QUEStionable:CONDition?

This query reads the value of the channel specific Questionable Status Condition Register of the currently selected load channel.

Query Syntax	STATus:CHANnel:QUEStionable:CONDition?
Return Value	<NR1>

STATus:CHANnel:QUEStionable:ENABle

This command sets the value for the channel specific Questionable Status Enable Register of the currently selected load channel.

The numeric parameter specifies the new value for the register.
The register value is retained after reset (*RST).

Syntax	STATus:CHANnel:QUEStionable:ENABle <NRf>
Parameter	0 ... 32767
Example	STAT:CHAN:QUES:ENAB 16
Query Syntax	STATus:CHANnel:QUEStionable:ENABle?
Return Value	<NR1>

STATus:OPERation?

This query reads the value of the System Operation Status Event Register.

The register value is reset to 0 after this query.

Query Syntax	STATus:OPER[:EVENt]?
Return Value	<NR1>

STATus:OPERation:CONDition?

This query reads the value of the System Operation Status Condition Register.

Query Syntax	STATus:OPERation:CONDition?
Return Value	<NR1>

STATus:PRESet

This command sets all SCPI Status Enable Registers of the whole system to defined values.

all Channel Operation Status Enable Registers: 0
all Channel Questionable Status Enable Registers: 0
SRQ Enable Register: 0
Standard Event Status Enable Register: 0

This command has no query form.

Syntax	STATus:PRESet
Example	STAT:PRES

STATus:QUEStionable?

This query reads the value of the System Questionable Status Event Register.

The register value is reset to 0 after this query.

Query Syntax	STATus:QUEStionable[:EVENt]?
Return Value	<NR1>

STATus:QUEStionable:CONDition?

This query reads the value of the System Questionable Status Condition Register.

Query Syntax	STATus:QUEStionable:CONDition?
Return Value	<NR1>

5.11.16 SYSTem Subsystem

<system specific>

SYSTem:BEEP

This command activates the electronic load's buzzer for the specified duration.

The numeric parameter specifies the duration in seconds (range from 0.1 to 2.0 s). The parameter MIN activates the buzzer for the shortest possible duration, the parameter MAX activates the buzzer for the longest possible duration.

Syntax	SYSTem:BEEP <NRf>|MIN|MAX
Parameter	0.1 ... 2.0
Example	SYST:BEEP 0.8

SYSTem:COMMunicate:CAN:ADDRess

This command sets the address for the CAN interface.

The numeric parameter specifies the new address for the CAN interface. The parameter MIN sets the lowest possible address, the parameter MAX sets the highest possible address.

Syntax	SYSTem:COMMunicate:CAN:ADDRess <NRf>
Parameter	1 ... 127|MIN|MAX
Example	SYST:COMM:CAN:ADDR 4
Query Syntax	SYSTem:COMMunicate:CAN:ADDRess? [MIN|MAX]
Return Value	<NR1>

SYSTem:COMMunicate:CAN:BAUD

This command sets the baud rate for the CAN interface.

The numeric parameter specifies the baud rate in bits/second. The parameter MIN sets the lowest admissible baud rate, the parameter MAX sets the highest admissible baud rate.

Syntax	SYSTem:COMMunicate:CAN:BAUD <NRf>
Parameter	125000|250000|500000|1000000|MIN|MAX
Unit	Bits/s
Example	SYST:COMM:CAN:BAUD 500000
Query Syntax	SYSTem:COMMunicate:CAN:BAUD? [MIN|MAX]
Return Value	<NR1>

SYSTem:COMMunicate:CAN:TERMination

This command sets the activation state for the termination resistor of the CAN bus.

The parameter OFF or 0 deactivates the termination resistor, the parameter ON or 1 activates the termination resistor.

Syntax	SYSTem:COMMunicate:CAN:TERMination[:STATe] <boolean>
Parameter	0|OFF|1|ON
Example	SYST:COMM:CAN:TERM ON
Query Syntax	SYSTem:COMMunicate:CAN:TERMination[:STATe]?
Return Value	0|1

SYSTem:COMMunicate:GPIB:ADDRess

This command sets the address for the GPIB interface.

The numeric parameter specifies the new address for the GPIB interface. The parameter MIN sets the lowest possible address, the parameter MAX sets the highest possible address.

Syntax	SYSTem:COMMunicate:GPIB:ADDRess <NRf>
Parameter	1 ... 30|MIN|MAX
Example	SYST:COMM:GPIB:ADDR 12
Query Syntax	SYSTem:COMMunicate:GPIB:ADDRess? [MIN|MAX]
Return Value	<NR1>

SYSTem:COMMunicate:LAN:DHCP

This command activates/deactivates the use of the Dynamic Host Configuration Protocol (DHCP).

The parameter OFF or 0 deactivates DHCP, the parameter ON or 1 activates DHCP.

Syntax	SYSTem:COMMunicate:LAN:DHCP[:STATe] <boolean>
Parameter	0|OFF|1|ON
Example	SYST:COMM:LAN:DHCP ON
Abfragesyntax	SYSTem:COMMunication:LAN:DHCP[:STATe]?
Return Value	0|1

SYSTem:COMMunicate:LAN:DNS

This command sets the static IP address of the server for the Domain Name System (DNS).

The parameter specifies the IP address in dot notation ("XXX.XXX.XXX.XXX"). 0 to 255 is allowed for XXX.

The query command reads the configured DNS address by appending the keyword STATic. It reads the actually used DNS address by appending the keyword ACTual or appending no keyword.

Syntax	SYSTem:COMMunicate:LAN:DNS[:ADDRess] <string>
Parameter	<string>
Example	SYST:COMM:LAN:DNS "192.168.0.253"
Query Syntax	SYSTem:COMMunication:LAN:DNS[:ADDRess]? [ACTual|STATic]
Return Value	<string>

SYSTem:COMMunicate:LAN:GATeway

This command sets the static IP address of the Gateway.

The parameter specifies the IP address in dot notation (“XXX.XXX.XXX.XXX”). 0 to 255 is allowed for XXX.

The query command reads the configured Gateway address by appending the keyword STATic. It reads the actually used Gateway address by appending the keyword ACTual or appending no keyword.

Syntax	SYSTem:COMMunicate:LAN:GATeway[:ADDRess] <string>
Parameter	<string>
Example	SYST:COMM:LAN:GAT "192.168.0.254"
Query Syntax	SYSTem:COMMunicate:LAN:GATeway[:ADDRess]? [ACTual|STATic]
Return Value	<string>

SYSTem:COMMunicate:LAN:HOSTname?

This query reads the host name of the electronic load.

The host name is returned as a character string.

Query Syntax	SYSTem:COMMunicate:LAN:HOSTname?
Return Value	<string>

SYSTem:COMMunicate:LAN:IP

This command sets the static IP address of the LAN interface.

The parameter specifies the IP address in dot notation (“XXX.XXX.XXX.XXX”). 0 to 255 is allowed for XXX.

The query command reads the configured IP address by appending the keyword STATic. It reads the actually used IP address by appending the keyword ACTual or appending no keyword.

Syntax	SYSTem:COMMunicate:LAN:IP[:ADDRess] <string>
Parameter	<string>
Example	SYST:COMM:LAN:IP "192.168.0.1"
Query Syntax	SYSTem:COMMunicate:LAN:IP[:ADDRess]? [ACTual|STATic]
Return Value	<string>

SYSTem:COMMunicate:LAN:MAC?

This query reads the Media Access Control (MAC) address of the Ethernet interface.
This 48 bit address is unique worldwide and may not be changed.

The MAC address is returned in the form "XX:XX:XX:XX:XX:XX" where XX is a hexadecimal value between 0x00 and 0xFF.

Query Syntax	SYSTem:COMMunicate:LAN:MAC[:ADDRess]?
Return Value	<string>

SYSTem:COMMunicate:LAN:PORT

This command sets the TCP port number of the LAN interface.

Syntax	SYSTem:COMMunicate:LAN:PORT <NRf>
Parameter	0 ... 65535
Example	SYST:COMM:LAN:PORT 1001
Query Syntax	SYSTem:COMMunicate:LAN:PORT?
Return Value	<NR1>

SYSTem:COMMunicate:LAN:SUBNet

This command sets the subnet mask of the LAN interface.

The parameter specifies the subnet mask in dot notation (“XXX.XXX.XXX.XXX”). 0 to 255 is allowed for XXX.

The query command reads the configured subnet mask by appending the keyword STATic. It reads the actually used subnet mask by appending the keyword ACTual or appending no keyword.

Syntax	SYSTem:COMMunicate:LAN:SUBNet[:MASK] <string>
Parameter	<string>
Example	SYST:COMM:LAN:SUBN "255.255.255.0"
Query Syntax	SYSTem:COMMunicate:LAN:SUBNet[:MASK]? [ACTual|STATic]
Return Value	<string>

SYSTem:COMMunicate:SERial:BAUD

This command sets the baud rate for the RS-232 interface.

The numeric parameter specifies the baud rate in bits/second. The parameter MIN sets the lowest admissible baud rate, the parameter MAX sets the highest admissible baud rate.

Syntax	SYSTem:COMMunicate:SERial:BAUD <NRf>
Parameter	1200|2400|4800|9600|19200|38400|57600|115200|250000|MIN|MAX
Example	SYST:COMM:SER:BAUD 57600
Query Syntax	SYSTem:COMMunicate:SERial:BAUD? [MIN|MAX]
Return Value	<NR1>

SYSTem:COMMunicate:SERial:BITS?

This query reads the number of data bits transmitted with each character via RS-232 interface.

The optional parameter MIN queries the lowest bit number, the parameter MAX queries the highest bit number.

Query Syntax	SYSTem:COMMunicate:SERial:BITS? [MIN|MAX]
Return Value	<NR1>

SYSTem:COMMunicate:SERial:MODE

This command sets the baud rate for the RS-232 interface.

The parameter can have the following values:
SCPI: interface is used for communication with SCPI protocol.
SLINk: interface is used as SyncroLink for synchronizing multiple devices.

A reset has no effect on the configured mode.

Syntax	SYSTem:COMMunicate:SERial:MODE <NRf>
Parameter	[SCPI|SLINk]
Example	SYST:COMM:SER:MODE SLIN
Query Syntax	SYSTem:COMMunicate:SERial:MODE?
Return Value	SCPI|SLINk

SYSTem:COMMunicate:SERial:PARity

This command sets the parity of each character transmitted via RS-232 interface.

The parameter can have one of the following values:
EVEN: the parity of each character is even.
NONE: the parity is neither checked nor generated
ODD: the parity of each character is odd

Syntax	SYSTem:COMMunicate:SERial:PARity <parity>
Parameter	EVEN|NONE|ODD
Example	SYST:COMM:SER:PAR EVEN
Query Syntax	SYSTem:COMMunicate:SERial:PARity?
Return Value	EVEN|NONE|ODD

SYSTem:COMMunicate:SERial:SBITs

This command sets the number of stop bits for each character transferred via RS-232 interface.

The numeric parameter specifies the number of stop bits per data byte.

Syntax	SYSTem:COMMunicate:SERial:SBITs <NRf>
Parameter	1 ... 2|MIN|MAX
Example	SYST:COMM:SER:SBIT 2
Query Syntax	SYSTem:COMMunicate:SERial:SBITs? [MIN|MAX]
Return Value	1|2

SYSTem:COMMunicate:VCP:BAUD

This command sets the baud rate for the USB VCP (Virtual COM Port) interface.

The numeric parameter specifies the baud rate in bits/second. The parameter MIN sets the lowest admissible baud rate, the parameter MAX sets the highest admissible baud rate.

Syntax	SYSTem:COMMunicate:VCP:BAUD<NRf>
Parameter	1200|2400|4800|9600|19200|38400|57600|115200|250000|500000|MIN|MAX
Example	SYST:COMM:VCP:BAUD 115200
Query Syntax	SYSTem:COMMunicate:VCP:BAUD? [MIN|MAX]
Return Value	<NR1>

SYSTem:COMMunicate:VCP:BITS?

This query reads the number of data bits transmitted with each character via USB VCP interface.

The optional parameter MIN queries the lowest bit number, the parameter MAX queries the highest bit number.

Query Syntax	SYSTem:COMMunicate:VCP:BITS? [MIN|MAX]
Return Value	<NR1>

SYSTem:COMMunicate:VCP:PARity

This command sets the parity of each character transmitted via USB VCP interface.

The parameter may have one of the following values:
EVEN: the parity of each character is even.
NONE: the parity is neither checked nor generated
ODD: the parity of each character is odd

Syntax	SYSTem:COMMunicate:VCP:PARity <parity>
Parameter	EVEN|NONE|ODD
Example	SYST:COMM:VCP:PAR EVEN
Query Syntax	SYSTem:COMMunicate:VCP:PARity?
Return Value	EVEN|NONE|ODD

SYSTem:COMMunicate:VCP:SBITs

This command sets the number of stop bits for each character transferred via USB VCP interface.

The numeric parameter specifies the number of stop bits per data byte.

Syntax	SYSTem:COMMunicate:VCP:SBITs <NRf>
Parameter	1 ... 2|MIN|MAX
Example	SYST:COMM:VCP:SBIT 2
Query Syntax	SYSTem:COMMunicate:VCP:SBITs? [MIN|MAX]
Return Value	1|2

SYSTem:COOLing

This command sets the cooling mode for the power stage.

If the parameter AUTO is set the power stage is cooled temperature-controlled. If the parameter FULL is set the power stage is cooled with full fan speed.

Syntax	SYSTem:COOLing[:MODE] <mode>
Parameter	AUTO|FULL
**RST Value*	AUTO
Example	SYST:COOL FULL
Query Syntax	SYSTem:COOLing[:MODE]?
Return Value	AUTO|FULL

SYSTem:DATE

This command sets the date.

All parameter values have to be in numeric format. The first parameter specifies the year, the second parameter the month and the third parameter the day.

Similarly, the query reads the year with the first returned value, the month with the second and the day with the third value.

Syntax	SYSTem:DATE <NRf>,<NRf>,<NRf>
Parameter1	2000 ... 2099
Parameter2	1 ... 12
Parameter3	1 ... 31
Example	SYST:DATE 2016,10,28
Query Syntax	SYSTem:DATE?
Return Value	<NR1>,<NR1>,<NR1>

SYSTem:ERRor?

This query reads the next error from the error queue (error queue) and deletes this error from the queue.

The error queue is a FIFO (first in, first out) buffer, i.e. older error messages are read first. If more errors have occurred than the queue can accommodate the last error entry will be -350,"Queue Overflow;DI".

The returned entry consists of the error/event number, a text for the error description and information about the error source <source>.
If the error occurred in the Data Interface (CAN, GPIB, LAN, RS-232, USB) the third parameter will be the string "DI". If the error occurred in the internal Analog Interface of one of the load channels the third parameter will be the string "AI*n*" (*n* = load channel's sub address).

If the error queue is empty the response is:
0,"No error"

Query Syntax	SYSTem:ERRor[:NEXT]?
Return Value	<NR1>,<string>;<source>

A table of possible error codes is listed in appendix 9.1 Error Codes.

SYSTem:ERRor:ALL?

This query reads all error entries from the error/event queue and deletes them from the queue.

The single error entries (see SYSTem:ERRor[:NEXT]?) sent in the order of occurrence are comma-separated and consist of the error/event number, an information about the error description and the error source <source>.

If the error queue is empty the response is:
0,"No error"

Query Syntax	SYSTem:ERRor:ALL?
Return Value	<NR1>,<string>;<source>{,<NR1>,<string>;<source>}

A table of possible error codes is listed in appendix 9.1 Error Codes.

SYSTem:ERRor:COUNt?

This query specifies the number of unread entries in the queue for errors and events (error queue).

The returned numeric value specifies the number of error queue entries.

Query Syntax	SYSTem:ERRor:COUNt?
Return Value	<NR1>

A table of possible error codes at the electronic loads is listed in appendix 9.1 Error Codes.

SYSTem:HELP:HEADers?

This query reads all SCPI headers from the electronic load.
The headers are separated from each other by a line feed (10 dec.) character.

Therefore, at the end of the SCPI header list the electronic load sends two line feed characters (10 dec.), one for the termination of the last row and one for the termination of the response.

In the first line the electronic load sends a number sign (#) followed by a number. The first digit of this number defines the number of the following digits which itself define the number of characters in the following lines including all line terminators.

If there is no query available for a header the character string /nquery/ is appended to the header.

If there is only a query available for the header (and no command) the character string /qonly/ is appended to the header.

Query Syntax	SYSTem:HELP:HEADers?
Return Value	#<NR1> <header 1><LF> {<header n><LF>}

SYSTem:KLOCk

This command sets the activation state of the keylock function.

The parameter OFF or 0 deactivates the keylock function, the parameter ON or 1 activates it.

If the keylock function has been activated by remote control it cannot be deactivated locally. This state is indicated by the 'R' character in the lock symbol on the user interface.

Syntax	SYSTem:KLOCk <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	SYST:KLOC ON
Query Syntax	SYSTem:KLOCk?
Return Value	0|1

SYSTem:LOCal

This command activates the local control of the electronic load via the user interface.

Syntax	SYSTem:LOCal
Example	SYST:LOC

SYSTem:PRESet

This command resets all Data Interface settings saved in the electronic load's non-volatile memory to factory default settings.

The concerning parameters are described in chapter 4.24 Factory Reset.

Syntax	SYSTem:PRESet
Example	SYST:PRES

SYSTem:REMote

This command activates the control of the electronic load via a data interface (e.g. RS-232, GPIB, LAN, USB).

Syntax	SYSTem:REMote
Example	SYST:REM

SYSTem:SLINk

This command sets the activation state for the SyncroLink.

The parameter ON or 1 activates the SyncroLink, the parameter OFF or 0 deactivates the SyncroLink.

Syntax	SYSTem:SLINk[:STATe] <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	SYST:SLIN ON
Query Syntax	SYSTem:SLINk[:STATe]?
Return Value	0|1

SYSTem:SLINk

This command sets the delay time for SyncroLink.

The numeric parameter specifies the delay time in the base unit seconds. The parameter MIN sets the lowest permissible value for the delay time, the parameter MAX sets the highest permissible value for the delay time.

Syntax	SYSTem:SLINk:DELay <NRf>|MIN|MAX
Parameter	<0 ... 0.01>|MIN|MAX
**RST Value*	0
Example	SYST:SLIN:DEL 0.4
Query Syntax	SYSTem:SLINk:DELay?
Return Value	<NR3>

SYSTem:TIME

This command sets the time.

All parameters have to be numeric. The first parameter specifies the hour, the second parameter specifies the minute and the third parameter specifies the second.

Similarly, the query reads the hour with the first returned value, the minute with the second and the seconds with the third value.

Syntax	SYSTem:TIME <NRf>,<NRf>,<NRf>
Parameter1	0 ... 23
Parameter2	0 ... 59
Parameter3	0 ... 59
Example	SYST:TIME 10,22,30
Query Syntax	SYSTem:TIME?
Return Value	<NR1>,<NR1>,<NR1>

SYSTem:VERSion?

This query reads the version number of the SCPI standard the SCPI command syntax and semantics of this electronic load are based on.

The returned value has got the following format:
YYYY.V

YYYY: Release year of SCPI standard
V: Revision number of SCPI standard in the year of release

Query Syntax	SYSTem:VERSion?

Return Value	<NR1>.<NR1>
Example	1999.0

5.11.17 TRIGger Subsystem, ABORt Subsystem, INITiate Subsystem

<system specific>

ABORT

This command stops the trigger system, i. e. resets the trigger system to IDLE state. The triggered values follow the immediate values. The INIT:CONT state is set to OFF.

Syntax	ABORt
Example	ABOR

INITiate

This command initializes the trigger system, i.e. changes the trigger system from idle state to initiated state. In this state the trigger system is ready to receive and process trigger events.

This command has no query form.

Syntax	INITiate[:IMMediate]
Parameter	None
Example	INIT

INITiate:CONTinuous

This command activates/deactivates continuously initializing the trigger system after receiving and processing a trigger event.

The parameter OFF or 0 deactivates continuously starting the trigger system, the parameter ON or 1 activates continuously starting.

Syntax	INITiate:CONTinuous <boolean>
Parameter	0|OFF|1|ON
**RST Value*	OFF
Example	INIT:CONT ON
Query Syntax	INITiate:CONTinuous?
Return Value	0|1

TRIGger:DELay

This command sets the delay time between receiving a trigger and triggering an action.

The numeric parameter specifies the delay time in the base unit seconds. If the optional parameter MIN is specified, the lowest permissible value for the delay time is set; if the optional parameter MAX is specified, the highest permissible value for the delay time is set.

Syntax	TRIGger:DELay <NRf>|MIN|MAX
Parameter	<0 ... 10>|MIN|MAX
**RST Value*	0
Example	TRIG:DEL 0.4
Query Syntax	TRIGger:DELay?
Return Value	<NR3>

5.11.18 VOLTage Subsystem

<channel specific>

VOLTage

This command sets the setting value for the regulated input voltage in voltage operating mode.

The numeric parameter specifies the voltage in the base unit volts. The parameter MIN sets the lowest admissible value 0 for the voltage, the parameter MAX sets the highest admissible value for the voltage.

The <max>/MAX value is specified in technical data.

Syntax	VOLTage[:LEVel][:IMMediate] <NRf>|MIN|MAX
Parameter	0 ... <max>|MIN|MAX
Unit	V|MV
**RST Value*	MAX
Example	VOLT 45.6
Query Syntax	VOLTage[:LEVel][:IMMediate]? [MIN|MAX]
Return Value	<NR3>

VOLTage:TRIGgered

This command sets the value for the triggered input voltage in voltage operating mode.

The numeric parameter specifies the voltage in the base unit volts. The parameter MIN sets the lowest admissible value 0 for the voltage, the parameter MAX sets the highest admissible value for the voltage.

The <max>/MAX value is specified in technical data.

Syntax	VOLTage[:LEVel]:TRIGgered <NRf>
Parameter	0 ... <max>|MIN|MAX
Unit	V|MV
**RST Value*	MAX
Example	VOLT:TRIG 1.08E1
Query Syntax	VOLTage[:LEVel]:TRIGgered? [MIN|MAX]
Return Value	<NR3>

VOLTage:PROTection

This command sets the value for the input voltage protection in all operating modes.

The numeric parameter specifies the voltage in the base unit volts. The parameter MIN sets the lowest admissible value 0 for the undervoltage protection, the parameter MAX sets the highest admissible value for the undervoltage protection.

The <max>/MAX value is specified in technical data.

Syntax	VOLTage:PROTection[:LEVel] <NRf>
Parameter	0 ... <max>|MIN|MAX
Unit	V|MV
**RST Value*	0.0
Example	VOLT:PROT 1.65
Query Syntax	VOLTage:PROTection[:LEVel]? [MIN|MAX]
Return Value	<NR3>

5.12 Common Commands Overview

Command	Parameter	Description
*CLS		Clear status
*ESE	<NRf>	Set value of Standard Event Status Enable Register
*ESE?		Read value of Standard Event Status Enable Register
*ESR?		Read value of Standard Event Status Register
*IDN?		Read device identification
*OPC		Set Operation Complete Bit
*OPC?		Get Operation Complete Bit
*OPT?		Read options
*RCL	<NRf>	Recall device settings
*RST		Reset device settings
*SAV	<NRf>	Save device settings
*SRE	<NRf>	Set value of Service Request Enable Register
*SRE?		Read value of Service Request Enable Register
*STB?		Read Status Byte
*TRG		Generate trigger event
*TST?		Execute selftest
*WAI		Wait until all commands are executed

5.13 Device-Dependent Commands Overview

Command	Parameter	Unit	Description
ABORt			Reset trigger system to IDLE state
ACQuisition			
[:STATe]	<Boolean>		Set activation state of the data acquisition function
[:STATe]?			Query activation state of the data acquisition function
:TRIGgered	<Boolean>		Set trigger state of the data acquisition function
:TRIGgered?			Query trigger state of the data acquisition function
:CONTinuous	<Boolean>		Set activation state of continuous data acquisition
:CONTinuous?			Query activation state of continuous data acquisition
:STIMe	<NRf>|MIN|MAX	[S|MS]	Set acquisition interval
:STIMe?	[MIN|MAX]		Query acquisition interval
CHANnel			
[:SELect]	<NRf>|<name>		Select channel
[:SELect]?	[MIN|MAX]		Query selected channel
:ADDRess	<NRf>		Set new address of selected channel
:ADDRess?	[MIN|MAX]		Query address of selected channel
:CATalog?			Query list of available channels

:COUNt?			Query number of available channels
:FOCus	<NRf>|<name>		Focus channel
:FOCus?	[MIN|MAX]		Query focused channel
:GROup			
[:SELect]	<NRf>|<name>		Select channel group
[:SELect]?	[MIN|MAX]		Query selected channel group
:MEMBers	<NRf>{,<NRf>}		Assign channels to selected group
:MEMBers?			Query channels from selected group
:NAME	<NRf>,<string>		Set name of specified group
:NAME?	<NRf>		Query name of specified group
:ID?			Query ID string of selected channel
:NAME	<NRf>,<string>		Set name of specified channel
:NAME	<NRf>		Query name of specified channel
CURRent			
[:LEVel]			
[:IMMediate]	<NRf>|MIN|MAX	[A|MA]|KA	Set setting value for load current
[:IMMediate]?	[MIN|MAX]		Query setting value for load current
:TRIGgered	<NRf>|MIN|MAX	[A|MA]|KA	Set setting value for triggered load current
:TRIGgered?	[MIN|MAX]		Query setting value for triggered load current
:PROTection			
[:LEVel]	<NRf>|MIN|MAX		Set value of current protection
[:LEVel]?	[MIN|MAX]		Query value of current protection
DATA			
:POINts?	[VMEM]		Query number of saved data points
:REMove?	<NRf>		Read data points
DISPlay			
:TEXT	<String>		Display string in notification window at user interface
:TEXT?			Read string in notification window at user interface
FORMat			
[:DATA]	ASCii|REAL,<NRf>		Set data format of queried <NRf> values
[:DATA]?			Query data format of queried <NRf> values
:BORDer	NORMal|SWAPped		Set byte order for read measurement data in real format
:BORDer?			Query byte order for read measurement data in real format
:SREGister	ASCii|HEXadecimal		Set data format of queried status register values
:SREGister?			Query data format of queried status register values
FUNCtion			
:DISCharge			
[:STATe]	<Boolean>		Set activation state of discharge function
:CHARge?			Query consumed charge
:ENERgy?			Query consumed energy
:STOP			
:CHARge	<NRf>|MIN|MAX		Set value of stop condition charge
:CHARge?	MIN|MAX		Query value of stop condition charge

:CURRent			
[:LEVel]	<NRf>|MIN|MAX	[A|MA|KA]	Set value of stop condition minimum current
[:LEVel]?	MIN|MAX		Query value of stop condition minimum current
:ENABle	CHARge|CURRent|ENERgy|TIME|VOLTage, <Boolean>		Set activation state for the specified event to stop discharge function
:ENABle?	CHARge|CURRent|ENERgy|TIME|VOLTage		Query activation state for the specified event to stop discharge function
:ENERgy	<NRf>|MIN|MAX		Set value of stop condition energy
:ENERgy?	MIN|MAX		Query value of stop condition energy
:EVENt?			Query stop event
:TIME	<NRf>|MIN|MAX	[S|MS]	Set value of stop condition discharge time
:TIME?	MIN|MAX		Query value of stop condition discharge time
:VOLTage			
[:LEVel]	<NRf>|MIN|MAX	[V|MV]	Set value of stop condition minimum voltage
[:LEVel]?	MIN|MAX		Query value of stop condition minimum voltage
:TIME?			Query discharge time
:MODE	CURRent|POWer|RESistance|VOLTage		Set operating mode
:MODE?			Query operating mode
:MPPT			
[:STATe]	<Boolean>		Set activation state of MPP tracking function
[:STATe]?			Query activation state of MPP tracking function
:ENERgy?			Query energy accumulated in MPPT mode
:MPP?			Query latest MPP found
:SWEep			
[:IMMediate]			Sweep immediately
:DATA			
:POINTS?	MIN|MAX		Query number of measurement couples of latest sweep
:DATA?			Query latest swept characteristic
:DIRection			Set sweep direction
:DIRection?			Query sweep direction
:PERiod	<NRf>|MIN|MAX	[S|MS]	Set sweep period
:PERiod?			Query sweep period
:TIME	<NRf>|MIN|MAX	[S|MS]	Set sweep time
:TIME?			Query sweep time
:TIME?			Query execution time since MPPT function activation
:PROTection			
[:STATe]	<Boolean>		Set activation state of current or voltage protection
[:STATe]?			Query activation state of current or voltage protection

:MODE	CURRent|VOLTage		Set current or voltage protection mode
:MODE?			Query mode of protection
:SPEed	SLOW|FAST		Set regulation speed
:SPEed?			Query regulation speed
INITiate			
[:IMMediate]			Set trigger system to INIT state
:CONTinuous	<Boolean>		Set activation state of continuously initializing the trigger system
:CONTinuous?			Query activation state of continuously initializing the trigger system
INPut			
[:STATe]	<Boolean>		Set load input state
[:STATe]?			Query load input state
:TRIGgered	<Boolean>		Set trigger state of input
:TRIGgered?			Query trigger state of input
:WDOG			
[:STATe]	<Boolean>		Set activation state of watchdog
[:STATe]?			Query activation state of watchdog
:DELay	<NRf>|MIN|MAX		Set watchdog delay
:DELay?	[MIN|MAX]		Query watchdog delay
:RESet			Reset watchdog
LIST			
[:STATe]	<Boolean>		Set activation state of list processing
[:STATe]?			Query activation state of list processing
:TRIGgered	<Boolean>		Set trigger state of list processing
:TRIGgered?			Query trigger state of list processing
:ACQuisition			
[:ENABle]	<Boolean>		Set activation state for data acquisition at list execution
[:ENABle]?			Query activation state for data acquisition at list execution
:COUNt	<NRf>|MIN|MAX		Set number of list iterations
:COUNt?			Query number of list iterations
:CURRent			
[:LEVel]	<NRf>{,<NRf>}	[A|MA|KA]	Define list of current settings
[:LEVel]?			Query list of current settings
:POINts?	[MIN|MAX]		Query number of specified settings in current list
:DWELl	<NRf>{,<NRf>}	[S|MS]	Define list of dwell times
:DWELl?			Query list of dwell times
:POINts?	[MIN|MAX]		Query number of specified dwell times in dwell time list
:MODE	CURRent|RESistance|VOLTage		Set list mode
:MODE?			Query list mode
:POINts?			Query number of executed list points since list activation
:POWer			
[:LEVel]	<NRf>{,<NRf>}	[W|MW|KW]	Define list of power settings
[:LEVel]?			Query list of power settings

:POINts?	[MIN|MAX]		Query number of specified settings in power list
:RESistance			
[:LEVel]	<NRf>{,<NRf>}	[OHM|KOHM]	Define list of resistance settings
[:LEVel]?			Query list of resistance settings
:POINts?	[MIN|MAX]		Query number of specified settings in resistance list
:RTIMe	<NRf>{,<NRf>}	[S|MS]	Define list of ramp times
:RTIMe?			Query list of ramp times
:POINts?	[MIN|MAX]		Query number of specified ramp times in ramp time list
:STIMe			
:DWELl	<NRf>{,<NRf>}		Set sample time intervals for dwell time list
:DWELl?			Query sample time intervals for dwell time list
:POINts?	[MIN|MAX]		Query number of specified values for sample times for dwell time list
:RTIMe	<NRf>{,<NRf>}		Set sample time intervals for ramp time list
:RTIMe?			Query sample time intervals for ramp time list
:POINts?	[MIN|MAX]		Query number of specified values for sample times for ramp time list
:TIME?			Query duration since list activation
:VOLTage			
[:LEVel]	<NRf>{,<NRf>}	[V|MV]	Define list of voltage settings
[:LEVel]?			Query list of voltage settings
:POINts?	[MIN|MAX]		Query number of specified settings in voltage list
MEASure			
:CURRent?			Query current measurement value
:POWer?			Query power measurement value
:RESistance?			Query resistance measurement value
:TEMPerature?			Query temperature measurement value
:VOLTage?			Query voltage measurement value
:EXTernal?			Query external voltage measurement value
POWer			
[:LEVel]			
[:IMMediate]	<NRf>|MIN|MAX	[W|MW|KW]	Set setting value for power
[:IMMediate]?	[MIN|MAX]		Query setting value for power
:TRIGgered	<NRf>|MIN|MAX	[W|MW|KW]	Set triggered value for power
:TRIGgered?	[MIN|MAX]		Query triggered setting value for power
:PEAK?			Query currently possible peak power
RESistance			
[:LEVel]			
[:IMMediate]	<NRf>|MIN|MAX	[OHM|KOHM]	Set setting value for resistance
[:IMMediate]?	[MIN|MAX]		Query setting value for resistancee
:TRIGgered	<NRf>|MIN|MAX	[OHM|KOHM]	Set triggered value for resistance
:TRIGgered?	[MIN|MAX]		Query triggered setting value for resiatance

SERVice			
:CALibration			
[:STATe]	<Boolean>[,<Code>]		Set activation state for calibration state
[:STATe]?			Query activation state for calibration state
:EXTernal			
:HIGH	<NRf>		Set reference value of upper external measurement adjustment point
:LOW	<NRf>		Set reference value of lower external measurement adjustment point
:LEVel			
:HIGH			Set reference value of upper adjustment point
:LOW			Set reference value of lower adjustment point
:MEASure			
:HIGH			Set reference value of upper measurement adjustment point
:LOW			Set reference value of lower measurement adjustment point
:PROTection			
:HIGH			Set reference value of upper protection adjustment point
:LOW			Set reference value of lower protection adjustment point
[:PARameter]			
:STRing	<NRf>,<string>		Write string to parameter
:STRing?	<NRf>		Read string from parameter
:VALue	<NRf>,<NRf>		Write value to parameter
:VALue?	<NRf>		Read value from parameter
:PRODuction			
[:STATe]	<Boolean>[,<Code>]		Set activation state for production state
[:STATe]?			Query activation state for production state
SETTing			
:EXTernal			
[:STATe]	<Boolean>		Set activation state of external control
[:STATe]?			Query activation state of external control
:ENABle	INPut|ILEVel, <Boolean>		Set activation state of an external signal for regulation control
:ENABle?	INPut|ILEVel|		Query activation state of an external signal for regulation control
STATus			
:CHANnel			
:OPERation			
[:EVENt]?			Query Channel Operation Status Event register
:CONDition?			Query Channel Operation Status Condition register

:ENABle	<NRf>		Set Channel Operation Status Enable register
:ENABle?			Query Channel Operation Status Enable register
:PRESet			Preset channel specific Status Enable registers of currently selected load channel
:QUEStionable			
[:EVENt]?			Query Channel Questionable Status Event register
:CONDition?			Query Channel Questionable Status Condition register
:ENABle	<NRf>		Set Channel Questionable Status Enable register
:ENABle?			Query Channel Questionable Status Enable register
:OPERation			
[:EVENt]?			Query Operation Status Event register
:CONDition?			Query Operation Status Condition register
:PRESet			Preset Status Enable registers
:QUEStionable			
[:EVENt]?			Query Questionable Status Event register
:CONDition?			Query Questionable Status Condition register
SYSTem			
:BEEP	<NRf>|MIN|MAX	[S|MS]	Activate system beeper for specified duration
:COMMunication			
:CAN			
:ADDRess	<NRf>|MIN|MAX		Set address of the CAN interface
:ADDRess?	[MIN|MAX]		Query address of the CAN interface
:BAUD	<NRf>|MIN|MAX		Set baud rate for the CAN interface
:BAUD?	[MIN|MAX]		Query baud rate for the CAN interface
:TERMination			
[:STATe]	<boolean>		Set activation state of CAN termination
[:STATe]?			Query activation state of CAN termination
:GPIB			
:ADDRess	<NRf>|MIN|MAX		Set address of the GPIB interface
:ADDRess?	[MIN|MAX]		Query address of the GPIB interface
:LAN			
:DHCP			
[:STATe]	<Boolean>		Set activation state of using DHCP protocol
[:STATe]?			Query activation state of using DHCP protocol
:DNS			
[:ADDRess]	<string>		Set static IP address of DNS server
[:ADDRess]?	[ACTual|STATic]		Query IP address of DNS server
:GATEway			
[:ADDRess]	<string>		Set static IP address of Gateway

[:ADDRess]?	[ACTual|STATic]		Query IP address of Gateway
:HOSTname?			Query host name of electronic load
:IP			
[:ADDRess]	<string>		Set static IP Address of LAN interface
[:ADDRess]?	[ACTual|STATic]		Query IP Address of LAN interface
:MAC			
[:ADDRess]?			Query MAC Address of LAN interface
:PORT	<NRf>		Set TCP Port number of LAN interface
:PORT?			Query TCP Port number of LAN interface
:SUBNet			
[:MASK]	<string>		Set Subnet Mask of LAN interface
[:MASK]?	[ACTual|STATic]		Query Subnet Mask of LAN interface
:SERial			
:BAUD	<NRf>|MIN|MAX		Set baud rate for the RS-232 interface
:BAUD?	[MIN|MAX]		Query baud rate for the RS-232 interface
:BITS?	[MIN|MAX]		Query number of data bits of RS-232 interface
:MODE	[SCPI|SLINk]		Set communication mode of RS-232 interface
:MODE?			Query communication mode of RS-232 interface
:PARity	EVEN|NONE|ODD		Set Parity of RS-232 interface
:PARity?			Query Parity of RS-232 interface
:SBITs	<NRf>|MIN|MAX		Set number of stop bits of RS-232 interface
:SBITs?	[MIN|MAX]		Query number of stop bits of RS-232 interface
:VCP			
:BAUD	<NRf>|MIN|MAX		Set baud rate of USB VCP interface
:BAUD?	[MIN|MAX]		Query baud rate of USB VCP interface
:BITS?	[MIN|MAX]		Query number of data bits of USB VCP interface
:PARity	EVEN|NONE|ODD		Set Parity of USB VCP interface
:PARity?			Query Parity of USB VCP interface
:SBITs	<NRf>|MIN|MAX		Set number of stop bits of USB VCP interface
:SBITs?	[MIN|MAX]		Query number of stop bits of USB VCP interface
:COOLing			
[:MODE]	AUTO|FULL		Set cooling mode of fans
[:MODE]?			Query cooling mode of fans
:DATE	<year>,<month>, <day>		Set date
:DATE?			Query date
:ERRor			
[:NEXT]?			Read next entry from the error queue

:ALL?			Read all entries from the error queue
:COUNt?			Query number of entries in the error queue
:HELP			
:HEADers?			Query all SCPI command headers
:KLOCk	<Boolean>		Set activation state of the keylock function
:LOCal			Activate local control
:PRESet			Set factory settings
:REMote			Activate remote control by a data interface
:SLINk			
[:STATe]	<Boolean>		
[:STATe]?			
:DELay	<NRf>|MIN|MAX	[S|MS]	Set delay for SyncroLink
:DELay?	[MIN|MAX]		Query delay for SyncroLink
:TIME	<hour>,<minute>, <second>		Set time
:TIME?			Query time
:VERSion?			Query version of compatible SCPI standard
TRIGger			
:DELay	<NRf>|MIN|MAX	[S|MS]	Set setting value for trigger delay
:DELay?			Query setting value for trigger delay
VOLTage			
[:LEVel]			
[:IMMediate]	<NRf>|MIN|MAX	[V|MV]	Set setting value for voltage
[:IMMediate]?	[MIN|MAX]		Query setting value for voltage
:TRIGgered	<NRf>|MIN|MAX	[V|MV]	Set triggered value for voltage
:TRIGgered?	[MIN|MAX]		Query triggered setting value for voltage
:PROTection			
[:LEVel]	<NRf>|MIN|MAX	[V|MV]	Set value for undervoltage protection
[:LEVel]?	[MIN|MAX]		Query value for undervoltage protection

6 External Control by I/O Port

6.1 PMLA Standard and HP

PMLA standard and HP models are equipped with a standard I/O Port which allows to control settings and make measurements.

The standard version has up to 3 x 37-pin D-sub female connectors **B1**. Each connector provides signals for up to 4 channels. The HP version has one 9-pin D-sub female connector **B1**.

6.1.1 I/O Port

The I/O Port is not isolated!
All inputs and outputs of a channel are electrically connected to the negative load terminal. Additional connections of one of the pins of the I/O Port to one of the load input terminals or sense terminals can produce short circuits or ground loops which cause malfunction, incorrect measurement data or can even damage the device!

If a standard model is not equipped with all load modules the pins of the unavailable modules are not connected. This is also the case when load modules with higher power than 150 W are installed. Then the channel's pins of each further module per 150 W are not connected. The HP version only has one load channel anyway.

See also:
2.4.4 Input Connector
2.4.6 Permissible Potentials at the Device Terminals

6.1.2 Controllable Functions

To use the I/O Port it must be either locally activated in the menu "Basic configuration" or remotely by the SCPI commands in the SETTing:EXTernal group.

The following settings can be externally controlled:

- Input state
- Level (setting value)

If the load input is controlled via I/O port and the user presses the "Input" key on the front panel the user input is ignored. This is signalized by temporarily fading over a "Notification" window at the user interface. If the setting value is controlled via the I/O Port and the rotary encoder is turned the user input is discarded and also the "Notification" window is displayed.

Local operation:
Main Menu -> Settings -> Basic settings -> Ext. control
Checkbox "External control activation": activate higher-level activation of the signals to be controlled externally.
Checkbox "Input state": activate external control of the load input.
Checkbox "Setting control": activate external control of the analog control of the setting.

Digital remote control:
5.11.14 SETTing Subsystem

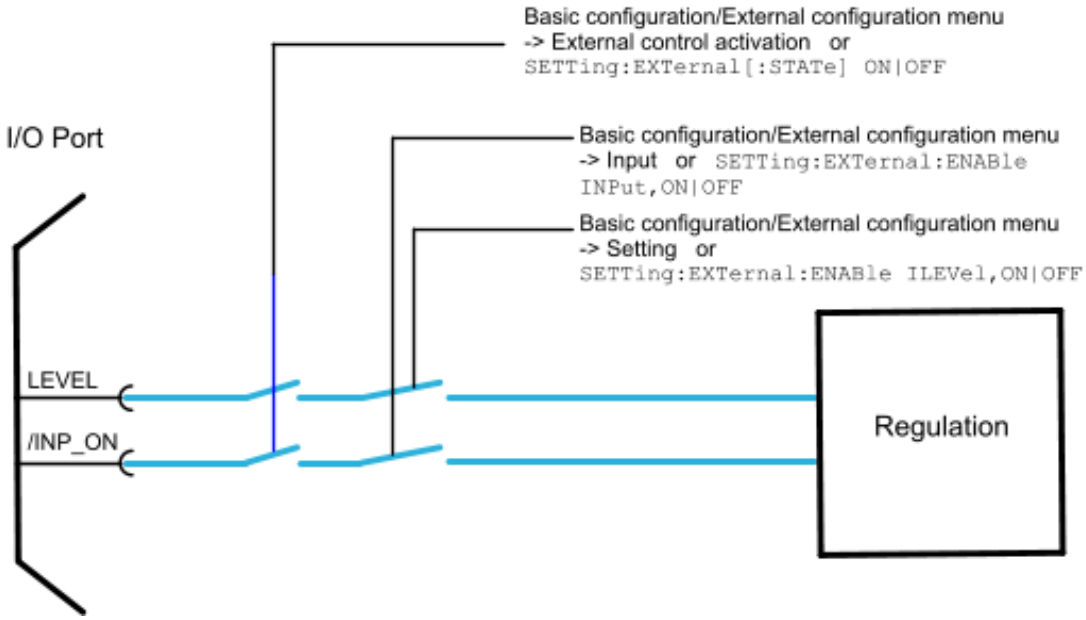
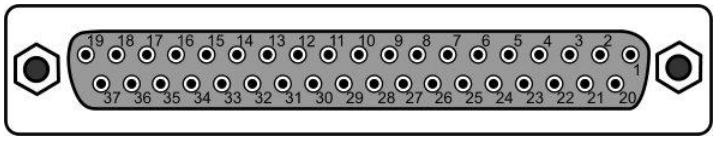


Figure 6.1: Schematic structure of the external controllable functions

6.1.3 Pin Assignment Standard Variant

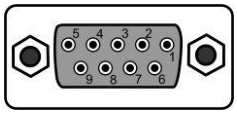


Pin	Input 1-4 Name	Input 5-8 Name	Input 9-12 Name	Description	Direction[1)]	Level[2)]
1	Input4 Sense +	Input8 Sense +	Input12 Sense +	positive sense terminal	I	Umax
2	Input4 Level -	Input8 Level -	Input12 Level -	negative setting control input	I	10 V
3	Input4 VMON	Input8 VMON	Input12 VMON	voltage monitor output	O	10 V
4	Input4 /INP_ON	Input8 /INP_ON	Input12 /INP_ON	control input for load input	I	Logic
5	NC	NC	NC		NC	
6	Input3 Sense -	Input7 Sense -	Input11 Sense -	negative sense terminal	I	Umax
7	Input3 Level +	Input7 Level +	Input11 Level +	positive setting control input	I	10 V
8	Input3 IMON	Input7 IMON	Input11 IMON	current monitor output	O	10 V
9	Input3 GND	Input7 GND	Input11 GND	Ground		
10	Input2 Sense +	Input6 Sense +	Input10 Sense +	positive sense terminal	I	Umax
11	Input2 Level -	Input6 Level -	Input10 Level -	negative setting control input	I	10 V
12	Input2 VMON	Input6 VMON	Input10 VMON	voltage monitor output	O	10 V
13	Input2 /INP_ON	Input6 /INP_ON	Input10 /INP_ON	control input for load input	I	Logic
14	NC	NC	NC		NC	
15	Input1 Sense -	Input5 Sense -	Input9 Sense -	negative sense terminal	I	Umax
16	Input1 Level +	Input5 Level +	Input9 Level +	positive setting control input	I	10 V

17	Input1 IMON	Input5 IMON	Input9 IMON	current monitor output	O	10 V
18	Input1 GND	Input5 GND	Input9 GND	Ground		
19	NC	NC	NC		NC	
20	Input4 Sense -	Input8 Sense -	Input12 Sense -	negative sense terminal	I	Umax
21	Input4 Level +	Input8 Level +	Input12 Level +	positive setting control input	I	10 V
22	Input4 IMON	Input8 IMON	Input12 IMON	current monitor output	O	10 V
23	Input4 GND	Input8 GND	Input12 GND	Ground		
24	Input3 Sense +	Input7 Sense +	Input11 Sense +	positive sense terminal	I	Umax
25	Input3 Level -	Input7 Level -	Input11 Level -	negative setting control input	I	10 V
26	Input3 VMON	Input7 VMON	Input11 VMON	voltage monitor output	O	10 V
27	Input3 /INP_ON	Input7 /INP_ON	Input11 /INP_ON	control input for load input	I	Logic
28	NC	NC	NC		NC	
29	Input2 Sense -	Input6 Sense-	Input10 Sense -	negative sense terminal	I	Umax
30	Input2 Level +	Input6 Level +	Input10 Level +	positive setting control input	I	10 V
31	Input2 IMON	Input6 IMON	Input10 IMON	current monitor output	O	10 V
32	Input2 GND	Input6 GND	Input10 GND	Ground		
33	Input1 Sense +	Input5 Sense +	Input9 Sense +	positive sense terminal	I	Umax
34	Input1 Level -	Input5 Level -	Input9 Level -	negative control input	I	10 V
35	Input1 VMON	Input5 VMON	Input9 VMON	voltage monitor output	O	10 V
36	Input1 /INP_ON	Input5 /INP_ON	Input9 /INP_ON	control input for load input	I	Logic
37	NC	NC	NC		NC	

[1] Signal direction: O: output, I: input, NC: do not connect!
[2] Signal level: Logic: see technical data, 10 V: 0 ... 10 V DC, Umax: maximum input voltage of channel

6.1.4 Pin Assignment HP Variant



Pin	Name	Description	Direction[1]	Level[2]
1	GND	Ground		
2	LEVEL-	negative setting control input	I	10 V
3	VMON	voltage monitor output	O	10 V
4	/INP_ON	control input for load input	I	Logic
5	n.c.	not used. Do not connect!		
6	GND	Ground		
7	LEVEL+	positive setting control input	I	10 V
8	IMON	current monitor output	O	10 V
9	/STAT_INP_ON	status output for load input	O	Logic

[1] Signal direction: O: output, I: input
[2] Signal level: Logic: see technical data, 10 V: 0 ... 10 V DC

6.1.5 Logic Inputs for Load Inputs

The input /INP_ON enables switching on and off the load input of the corresponding channel. The control input has a built-in pull-up resistor (10 kΩ) to 3 V. If left unconnected an open pin is therefore logic "high".

The input is low active and can be controlled either by a logic level or by the contact of an external relay or switch.

The control inputs refer to the GND. The activation of the control input can therefore be done by shorting the corresponding pin to GND.

6.1.6 Analog Control Input

In all operating modes the setting value for each load channel can be controlled by an external analog signal with 0 ... 10 V for 0 ... 100 % of the corresponding range.

In CC and CV operating modes, control is real-time (analog), while in CP and CR modes it is software-controlled.

Connect the control input LEVEL + to the positive output of the control source, connect the control input LEVEL - to the negative output of the control source.

The inputs are of differential type and can compensate common mode voltages of up to 2 V between the negative load input and the analog control input.
At higher common mode voltages you should connect the control source also to the GND pin of the device.

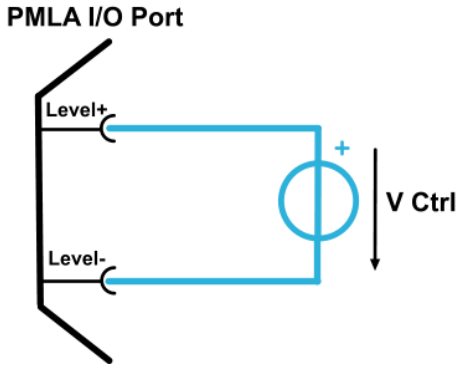


Figure 6.2: Analog setting control

Mind the maximum permissible operating voltages at the inputs of the device!

See also:
2.4.4 Input Connector
2.4.6 Permissible Potentials at the Device Terminals

Negative control voltage doesn´t damage the device but can cause increased dead times for the following setting.
This effect can already appear at a few mV of negative control voltage.

6.1.7 Analog Monitor Outputs

Each channnel has got 2 analog monitor outputs.

VMON: Voltage Monitor Output
IMON: Current Monitor Output

The Monitoring outputs are referred to GND.
The output voltage is 0 ... 10 V for 0 ... 100 % of the corresponding range.

The outputs can be loaded with max. 5 mA (2 kΩ).
The voltage between GND and negative load terminal must not exceed ±2 V.
Higher voltages can damage the device!

See also:
2.4.4 Input Connector
2.4.6 Permissible Potentials at the Device Terminals

6.1.8 Connecting to a DAQ System

Figure 6.3 shows an example of how to control multiple load channels via DAQ system.

For each channel, the InputX GND pin is galvanically connected to the associated negative load input on the input connector. To avoid ground loops, the DAQ channels must be galvanically isolated from each other. If this is not possible, a separate DAQ system shall be used for each load channel.

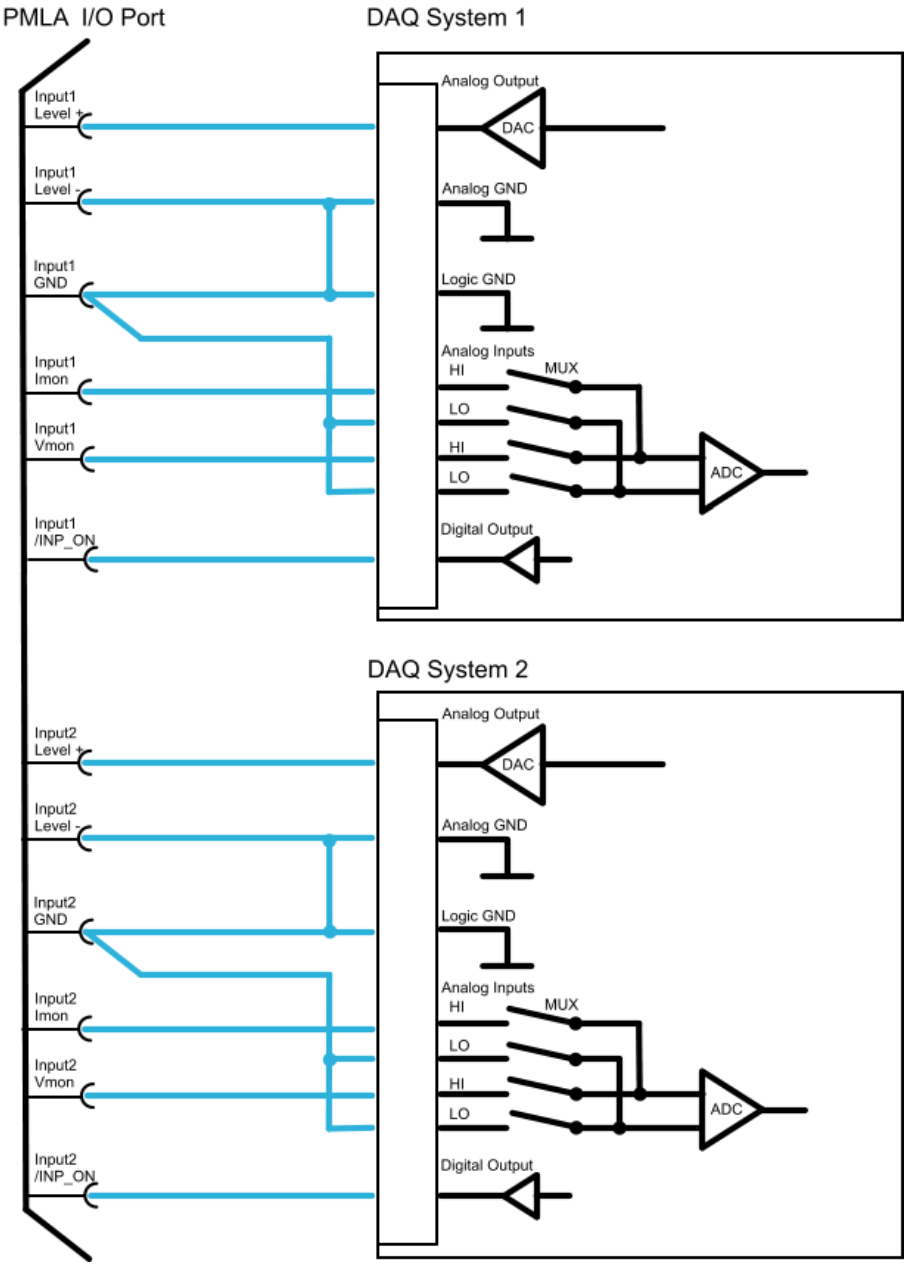


Figure 6.3: Connecting to different DAQ systems to avoid ground loops

6.1.9 Sense Inputs

The pin assignment of the sense connectors at the analog I/O port is given in 6.1.3 Pin Assignment and 6.1.4 Pin Assignment HP Variant.

See also 2.4.2 Load and Sense Lines!

6.2 PMLA LP

The PMLA LP version does not have an I/O port.
The LP version cannot be controlled externally and does not provide any analog monitor signals.

7 Analog Master-Slave Mode (Standard and HP Variants)

7.1 Function

With standard or HP variants, to increase the power or current capability a maximum of 5 load channels can be operated in parallel, connected in an analog master-slave mode.

One control channel provides the analog control signal for the other channels via its IMON output. The analog-controlled channels operate in CC mode without overcurrent or undervoltage protection.

This method of control is not possible with PMLA LP variants, as the corresponding external control lines are not available.

7.2 Wiring of the Load Channels

The load inputs of all paralleled channels and the sense terminals of the controlling channel have to be connected to the DUT.

Connect the cables at the DUT's output as shown in the following drawing, and not at the channels' inputs.

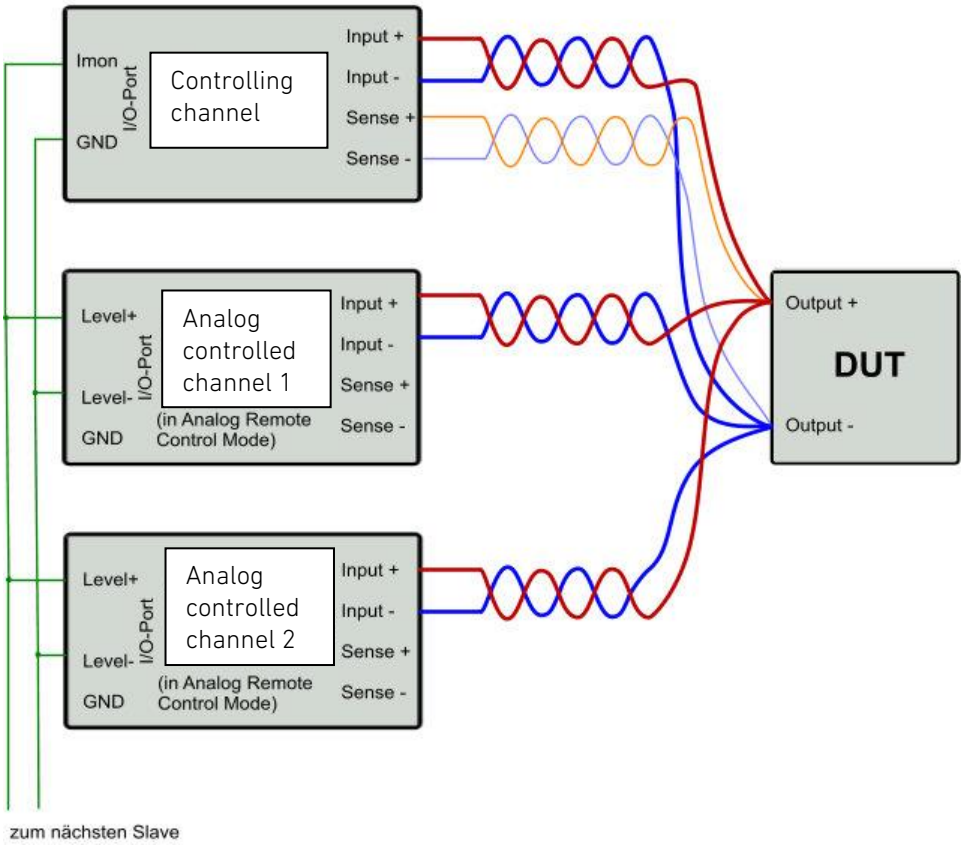


Figure 7.1: Wiring in analog Master-Slave mode

A serial wiring to increase the input voltage is inadmissible!

The wiring is made by the I/O Port connector(s) of the corresponding channels.
Connect the pins as follows:

Signal Master channel	Connect to	Signal Slave channel*
IMON	←→	LEVEL+
GND	←→	LEVEL-

* and further slave channels

Nominal settings are to be made at the controlling channel. It controls the current consumption of the analog-controlled channels.

- Set the analog-controlled channels to CC mode.
- Deactivate the overcurrent and undervoltage protection at the analog-controlled channels. However, at input voltage switching applications you should activate undervoltage protection.
- Activate "Extern" as control source at the analog-controlled channels and enable the signal path for external control of the setting.
- Activate the load inputs of all analog-controlled channels and of the controlling channel.

See:
4.1 Selecting the Control Source
5.11.14 SETTing Subsystem

If channels with different current or power ranges are used, observe the corresponding different current distributions! Each channel must work in its own allowed operating range.

8 Troubleshooting

8.1 Oscillations

Very often improper wiring is the reason for oscillations.
Long cables (in worst case not twisted) have high inductances which affect the regulation capability of the electronic load.

Check the wiring as first measure.

See also: 2.4.1Safety Instructions When Connecting the Device Under Test, 2.4.2 Load and Sense Lines.

Use only very short and twisted load cables at regulation speed "FAST"! Otherwise the risk of oscillations is high!

When power supplies or other circuit arrangements stabilizing an output parameter by a control loop are tested then two controllers are connected together when applying the electronic load to the DUT. When a phase shift of more than 180° and an amplification higher than 1 are reached by the system, the oscillation condition is fulfilled and the system starts to oscillate.

This state is no fault of the electronic load but a normal physical state which is unwanted in tests.

See also: 4.4 Regulation Speed.

In practical applications, an MKT capacitor of approx. 1 µF with a series resistance of approx. 1.5 Ω (5 W) connected in parallel to the load input often helps for stabilization.

8.2 Electromagnetic Coupling

Especially in resistance mode there is the risk that an input coupling from the input lines to the voltage measurement may occur if sense lines are used.

Since in resistance mode the exact acquisition of the input voltage is important to make the correct current setting a magnetic coupling into the sense-lines causing a positive feedback makes the system instable.

At first, you have to reduce the coupling.

That means:
Separate the sense lines as far as possible from the input lines. (Also separate the sense lines from all other lines drawing current, e.g. mains supply). The sense lines should be twisted to eliminate the induced voltage.

See also: 2.4.1Safety Instructions When Connecting the Device Under Test, 2.4.2 Load and Sense Lines.

Never twist the sense lines with any of the current-drawing lines!
The load input lines should be twisted or at least run in parallel to compensate the magnetic fields.

Keep all lines as short as possible!

If all these steps don't bring the desired success, a capacitor may be connected between the sense lines.

8.3 Distorted Slew Rate in Dynamic Operation

8.3.1 Causes

To reach the best possible current slew rate in dynamic mode the following conditions have to be fulfilled:

- The dynamic input resistance of the voltage supply has to be very low. Voltage drops at the load terminals caused by the dynamic behavior of the voltage source or by the induction of the cables will counteract to a fast current rise time.
- The impedance of the input lines must be very low.
- The input lines must be low-inductive. Inductive lines (all cables have got an inductive component) in addition with its ohmic resistance result in a limitation of the maximum possible current slew rate. The electronic load cannot perform a fast current slew rate if the slew rate is limited by the connecting lines.
- Furthermore, the connecting lines behave like an energy storage (self-induction) and deliver current into load and DUT when being unloaded.

8.3.2 Measuring the Current Slew Rate

The current slew rate measurement must be made with a suitable current clamp probe (e.g. Tektronix Current Measurement).

Current measurements via measurement shunts mostly deliver faulty results since most shunts are inductive. Such measurements deliver slower slew rates with overshoots.

8.4 Distorted Monitor Signals

Especially when switched-mode power supplies are tested, situations may occur where the monitor outputs for current and voltage (IMON, VMON) at the I/O Port are distorted. The reason for this distortion has to be searched in the test setup.

Switched-mode power supplies have got filters in the output circuit and among others so-called Y-capacitors from the output to Protective Earth.

Also, the electronic load and other instruments include filters because of EMC reasons.

The common mode distortion voltage (voltage between each output terminal of the power supply and protective earth) causes a fault current through the EMC capacitors and the electronic load (or other instruments) back to the output.

This fault current often generates high-frequent superpositions at the measurement signals.

At dynamic tests very high interference voltages may occur.
To solve this problem, you can supply the electronic load and/or the other instruments by insulating transformers with low coupling capacity. Thereby the interference circuit is interrupted, and the measurement quality is improved.

8.5 Effects of the Input Capacity

Each electronic load has a certain input capacity{ XE "input capacity" \f } (see technical data). This is hardly noticeable with clean DC input voltages.

However, if the voltage at the load input is superimposed with an AC voltage component, the load current also contains an AC current component depending on the amplitude and frequency of the AC voltage. This is not an oscillation of the electronic load.

If the amplitude portion or the frequency of the AC voltage component is high, an overload of the input capacity can occur!

The accuracy values given in the technical data apply for clean DC voltages at the load input.

9 Appendix

9.1 Error Codes

9.1.1 Command Errors

An error in the range [-199 ... -100] indicates that a syntax error has been detected in a command sent to the electronic load. The occurrence of any error in this classification causes the Command Error Bit (bit 5) in the Event Status Register to be set.

Error Code		Description
-100	Command Error	Generic syntax error.
-101	Invalid character	A syntactic element contains a character which is invalid.
-104	Data type error	The parser recognized a data element different than one allowed.
-108	Parameter not allowed	More parameters were received than expected for the header.
-109	Missing parameter	Fewer parameters were received than required for the header.
-110	Command header error	An error was detected in the header.
-120	Numeric data error	A numeric data element produced an error.
-130	Suffix error	Generated when parsing a faulty suffix.
-138	Suffix not allowed	A suffix was encountered after a numeric element which does not allow suffixes.
-140	Character data error	Generated when parsing a faulty character data element.
-150	String data error	Generated when parsing a faulty string data element.
-160	Block data error	Generated when parsing a faulty block data element.
-170	Expression error	Generated when parsing a faulty expression data element.
-180	Macro error	Generated when defining a faulty macro or executing a macro.

9.1.2 Execution Errors

An error in the range [-299 ... -200] indicates that an error has been detected at the execution of a command. The occurrence of any error in this classification the Execution Error Bit (bit 4) in the Event Status Register to be set.

Error Code		Description
-200	Execution error	Generic execution error.
-210	Trigger error	A trigger error occurred.
-211	Trigger ignored	A trigger event was received but ignored.
-213	Init ignored	Indicates that a request for a trigger initiation was ignored.
-220	Parameter error	A parameter error occurred.
-221	Settings conflict	A legal command was parsed but could not be executed due to the current device state.
-222	Data out of range	A legal command was parsed but could not be executed because the interpreted value was outside the valid range as defined by the device.
-224	Illegal parameter value	An exact value from a list of possibles was expected.
-226	Lists not same length	The start of LIST function was aborted due to different lengths.
-230	Data corrupt or stale	Invalid data occurred.
-240	Hardware error	A legal command or query could not be executed because of a hardware problem.
-250	Mass storage error	A mass storage error occurred.
-280	Program error	A program-related execution error occurred.
-290	Memory use error	A user request has directly or indirectly caused a memory-related error.

9.1.3 Device-Specific Errors

An error in the range [-399 ... -300] indicates that the load has detected a device-specific error which is not a command error, a query error, or an execution error; some device operations did not properly complete, possibly due to an abnormal hardware or firmware condition.
The occurrence of any error in this classification causes the Device-Dependent Error Bit (bit 3) in the Event Status Register to be set.

Error Code		Description
-300	Device-specific error	Generic device-dependent error.
-310	System error	A device-specific system error occurred.
-315	Configuration memory lost	Non-volatile configuration data has been lost.
-320	Storage fault	The firmware detected an error when using the data storage.
-330	Self-test failed	An error occurred during self-test.
-340	Calibration failed	An error occurred during calibration/adjustment.
-350	Queue overflow	The error queue is full, and the causing error was not entered.
-360	Communication error	Generic communication error. Error might be parity error or framing error in data received from serial interface.

9.1.4 Query Errors

An error in the range [-499 ... -400] indicates that the output queue control of the electronic load has detected a problem produced by the message exchange protocol described in IEEE 488.2, chapter 6.
The occurrence of any error in this classification causes the Query Error Bit (bit 2) in the Event Status Register to be set.

Error Code		Description
-400	Query error	Generic query error.
-410	Query interrupted	A query was interrupted.
-420	Query unterminated	A query was not terminated.
-430	Query deadlocked	A query freezed due to full input and output buffers.

9.1.5 Non-standardized Errors

Error codes with positive numbers are errors which are not specified in SCPI standard but defined by the electronic load's manufacturer.

Errors with positive error numbers should not occour with a faultless device.

The following error codes can occur during the firmware update precedure.

Error Code	Description
602	File open error
604	File read error
605	File close error
1000	General update error
1002	USB flash drive not found
1003	Update file not found
1004	Multiple update files for the target hardware found
1005	CRC mismatch in the update file
1006	The bootloader recognized an error
1008	The update file and the target hardware are incompatible

All other errors can result from misconduct or damage to the electronic load. To get detailed information about the displayed error code please contact the H&H support.

9.2 Device Parameters

The following list shows the operator-relevant device parameters and their functions.

Reserved parameters may not be written!

Par. No.	Function	Ex works value	Access
0 ... 9	*reserved*		-
10	Control constant Kp for operating mode CP in FAST regulation speed	0	read, write
11	Control constant Ki for operating mode CP in FAST regulation speed	0.1	read, write
12	Control constant Kp for operating mode CP in SLOW regulation speed	0	read, write
13	Control constant Ki for operating mode CP in SLOW regulation speed	0.02	read, write
14	Control constant Kp for operating mode CR in FAST regulation speed	0	read, write
15	Control constant Ki for operating mode CR in FAST regulation speed	0.01	read, write
16	Control constant Kp for operating mode CR in SLOW regulation speed	0	read, write
17	Control constant Ki for operating mode CR in SLOW regulation speed	0.02	read, write
18 ... 19	*reserved*		-
20	MPPT accuracy	0.001	read, write
21	MPPT minimum voltage	10	read, write
22 ... 100	*reserved*		-
101 ...	Production and calibration parameters		read

9.3 Information for Special Models

You will find information for special versions in the file TechDat_PMLA_*dn*.pdf (*dn* = device number) on the supplied USB flash drive device.

9.4 Supplied Accessories

The supplied accessories are listed in the file TechDat_PMLA_*dn*.pdf (*dn* = device number) on the supplied USB flash drive device.

9.5 Technical Data

You will find the technical data for your electronic load in the file TechDat_PMLA_*dn*.pdf (*dn* = device number) on the supplied USB flash drive device.

9.6 Declaration of Conformity

You will find the Declaration of Conformity for your electronic load in the file TechDat_PMLA_*dn*.pdf (*dn* = device number) on the supplied USB flash drive device.

10 Index

abbreviations ... 18
accessories ... 8
address ... 34
adjustment ... see calibration
battery test ... see discharge function
beeper ... 76
calibration ... 16
cardiac arrest ... 11
CAT ... see measurement category
CC ... see current mode
channel ... 34
channel group ... 34
cleaning ... 16
coding pins ... 28
control input ... 154
CP ... see power mode
CR ... see resistance mode
current mode ... 52
current protection ... 33
data format ... 107
data interface ... 51
delay time ... see latency time
discharge function ... 67, 108
earthing ... see protective earth
electric arcs ... 11
electronic load ... 7
environment ... 13
error code ... 161
error queue ... 137
fan speed control ... 72
FIFO ... 137
firmware update ... 81
focus ... 35
format ... see data format
fuse ... 11, 26, 33
gloves ... 8, 12
ground loop ... 151, 155
group addressing ... see channel group
hairnet ... 8, 12
Hazards ... 11
Help ... 48
I/O port ... 25, 51
I/O Port ... 19, 151
IEEE 488.2 ... 90, 107
infinite ... 115
input ... 17, 58, 154
input resistance ... 58
keylock ... 76, 138
latency time ... 73
LIST ... 114
  count ... 60
  dwell times ... 59
  list set ... 60
  load profile ... 59
  measurement data point ... 60
  mode ... 59, 63, 65
  ramp times ... 59
  sample times ... 59
  settings ... 59
mains cable ... 15
maintenance ... 15
measurement data point ... 60
memory position ... 77
MPPT ... 111
muscle cramp ... 11
name ... 35
OCP ... 57
operating mode ... 13, 51, 63, 110
OPP ... 33
OTP ... 33
overtemperature ... 33
overvoltage ... 11, 26, 33
pacemaker ... 12
power mode ... 53
power protection ... 33
preset ... 80
protection
  overcurrent ... 57
  undervoltage ... 57
protection class ... 10
Protection class \f ... 12
protective earth ... 10, 19, 23, 25, 160
PWM voltage ... 75
regulation speed ... 58
remote ... 83
repair \f ... 16
resistance mode ... 54
reverse polarity ... 11, 26
reverse voltage ... 33
ring buffer ... 64
RV ... 33
safety cover ... 30
safety shoes ... 8, 12
SCPI ... 91
selection ... 35
setting ... 16, 63, 105
  immediate ... 55
  triggered ... 56, 72
stop condition ... 67
sweep ... 70
thermal energy ... 11
touch protection ... 30
transmission rate ... 85
trigger ... 72
  delay ... 72
Trigger event ... 140
trigger model ... 72
user ... 9
UV ... 33
VCP ... see Virtual COM Port

Virtual COM Port.....89
warranty 16