

Electronic DC Loads

MOBILE REGENERATIVE LOAD TRL SERIES



- Energy recycling to the local power grid
- Low heat waste, silent
- Basic operating modes CC, CV, CR, CP
- Combined operating modes
CC+CV, CR+CC+CV, CP+CC+CV, CV+CC
- Load and sense terminals front and rear
- Adjustable protections for current and undervoltage
- Square, PWM and modulation function
- List function with synchronized DAQ
- MPP Tracking
- Test of energy storage devices
- Internal resistance measurement function
- Master-slave operation for parallel connection
- Data storage directly to USB flash drive
- Electronic protection
- I/O port as standard
- Galvanically isolated I/O port optional
- Bilingual help system (German/English)

TRL Series – Brief Profile

The DC loads of the TRL series feed the absorbed energy back into the local supply network.

They do not require a fixed installation, but can simply be plugged into the wall socket. Because these loads are also very quiet, they are perfect for the developer in the lab.

Modern operation via a brilliant 4.3" touchscreen gives the user a comfortable smartphone feeling.

The TRL series also comes with many data interfaces as standard, only GPIB is optional.

Interfaces

- RS-232
- USB
- LAN
- GPIB
- CAN
- Analog
- Analog isolated

● Standard ○ Option — not available

Operating Modes

The devices have the basic operating modes constant current, constant voltage, constant resistance and constant power (CC, CV, CR, CP mode). Additionally, a protection value for undervoltage and overcurrent can be set. This allows the combined operating modes CC+CV, CR+CC+CV, CP+CC+CV, CV+CC to be realized.

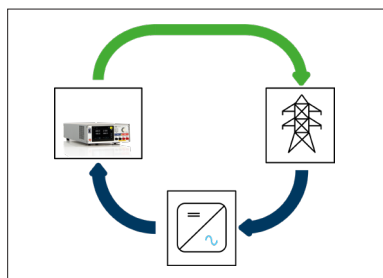
Protection, Monitoring

- Overcurrent protection
- Undervoltage protection
- Power protection
- Overtemperature protection
- Overvoltage indication
- Reverse polarity indication

Loading Capacity

There are 3 voltage classes of 80 V, 400 V and 1,200 V. All models have a maximum power of 1,000 W.

Energy Recycling, Cooling



Energy recycling principle

The absorbed power is fed back into the mains supply¹⁾. This alone reduces electricity costs, and the environment is only minimally heated. Powerful fans are not required for regenerative loads, which makes the devices pleasantly quiet compared to linear loads and thus perfect for laboratory operation.

Galvanically Isolated I/O Port (Option TRL06)

Analog signals
in realtime!

The optional I/O port provides analog and digital signals for external control. The galvanical isolation prevents ground loops and it is possible to test bipolar voltages with common analog control using two devices.

Outputs:

- Analog voltage monitor output 0 ... 10 V
- Analog current monitor output 0 ... 10 V
- Load input activation state
- Overload status
- Programmable logic output
- Trigger output

Inputs:

- Analog load setting I and V with 0 ... 5 V and with 0 ... 10 V
- Analog protection setting I and V with 0 ... 10 V
- Load input activation
- Operating mode selection CC - CV
- Control speed selection
- Remote shut-down
- Readable digital input
- Trigger input

Factory Calibration Certificate (FCC-TRLxx)

2 x for free

We supply a free Factory Calibration Certificate (FCC) with the devices. The calibration process is subject to supervision in accordance with DIN EN ISO 9001. This calibration certificate documents the traceability to national standards to illustrate the physical device in accordance with the International System of Units (SI). Within the 2-year warranty period, we will calibrate a second time free of charge if the respective device will have been registered:

<https://www.hoecherl-hackl.com/service/device-registration>

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 guide for the first period of use. Depending on the intended use, service life, relevance of the application and ambient conditions, the operator should adjust this interval accordingly.

1. The operation in the sense of a power generation into the public electricity grid is not provided with these energy recycling loads.

Mechanics, Options and Rack Installation

Mechanics

The TRL series is designed in stable 19" technology and can be used as a desktop unit or installed in 19" racks by the aid of optional installation kits.

Set-up Foot

standard



TRL1008

TRL10K12

Installation kit for 1 device with 1/2 19", 2 U (Option TRL10)



Including:

- 1 device extender
- 2 attachment brackets with handle
- screws

Installation kit for 2 devices with 1/2 19", 2 U (Option TRL11)



Including:

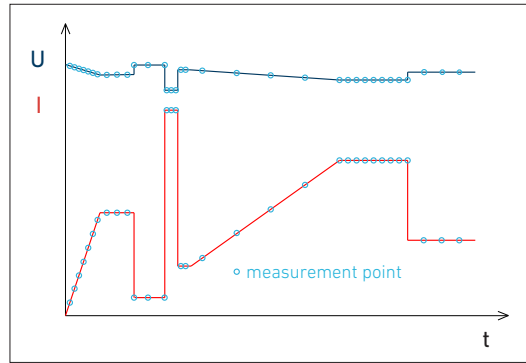
- 1 connecting element
- 2 attachment brackets with handle
- screws

Safety Cover

For models with touchable load inputs (flat copper bars), a safety cover is supplied as touch protection for the used load input (front or rear). A loose cap is included for the unused load input.

Functions

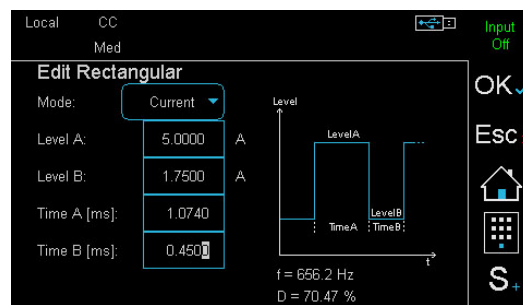
Load Profiles (List Function)



Load profile generated by List function with synchronized data acquisition of time, voltage, current

In all operating modes CC, CV, CR, CP the electronic loads can produce load profiles by List function. Up to 300 settings with variable dwell and ramp times are possible. Voltage and current are measured synchronously and stored with a time stamp. Associated sampling times can be defined for each curve section.

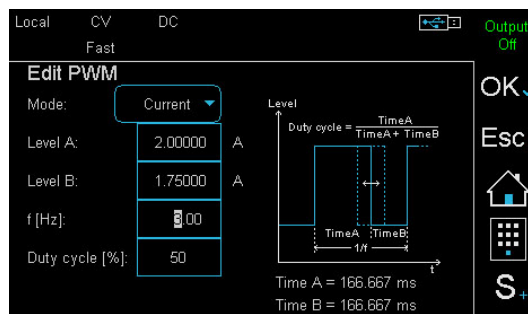
Rectangular Function



The rectangular function provides a convenient way to generate a rectangular waveform by entering absolute time and amplitude values. High resolution is paired here with a wide range for time setting.

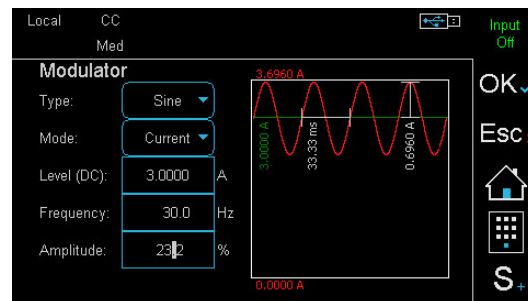
TRL
power regeneration

PWM Function



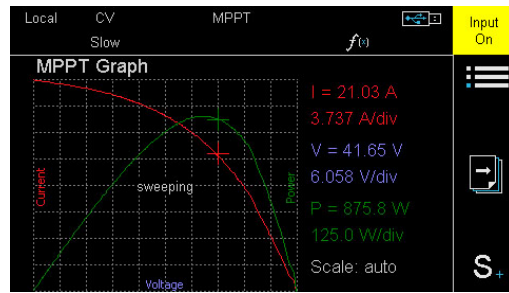
With the PWM function, the switching frequency and the duty cycle can be set for the two amplitude values in manual operation.

Modulator



The modulator adds a sinusoidal, square-wave or triangular signal to a static setting in CC or CV mode. Frequency and modulation depth are adjustable.

MPP Tracking

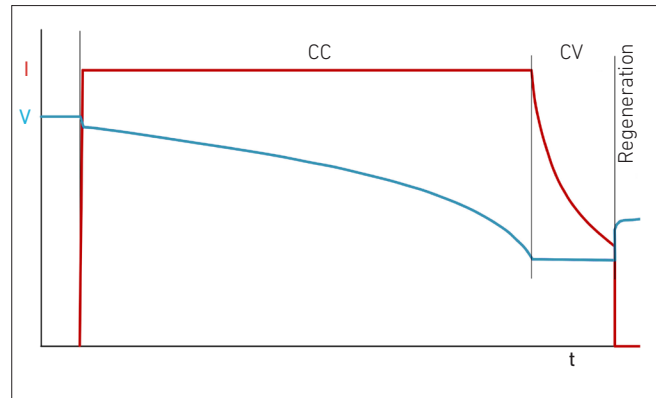


V/I and V/P characteristic at the user interface

The Maximum Power Point Tracking (MPPT) function consists of the two sub-functions Sweeping and Tracking, which alternate continuously in an adjustable interval.

If the measured open circuit voltage at startup is higher than the minimum voltage, the electronic load performs a sweep and then adjusts the global MPP found. The swept V/I curve is displayed together with the V/P curve in the function graph of the user interface. The currently determined MPP is marked by a '+' in the diagram. The V/I characteristic can be read via a data interface.

Discharge Function, Energy Storage Test



I_{Ua} discharge with follow-up time

The discharge function tests energy storage devices such as batteries, ultracaps and electrolytic capacitors etc. by discharging them in CC, CP or CR mode. The discharge function can be combined with the list function so that pulsed discharge is possible.

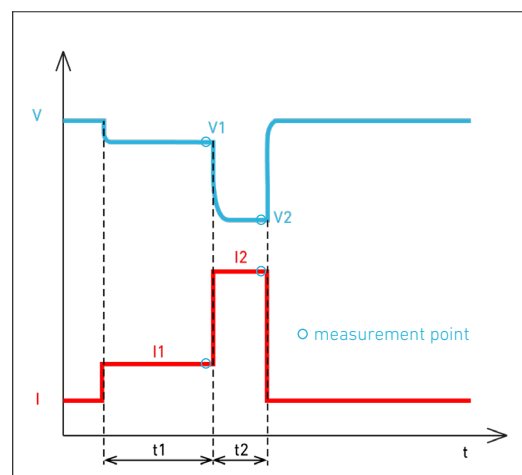
I_{Ua} discharge (CC+CV discharge) is also possible: the test object is discharged with constant current up to a defined voltage.

This voltage is then kept constant until a defined minimum current is reached.

Stop criteria are charge, energy, time, current, voltage.

During data logging, a follow-up time can be defined to observe the regeneration phase.

Internal Resistance Measurement



R_i calculation timing

The electronic load can measure the internal DC resistance of the connected DUT. The determination of the internal resistance R_i is based on the principle specified in various standards for batteries and accumulators, e.g. DIN EN 61951, DIN EN 61960.

At intervals of a few seconds, the load measures the terminal voltage of the DUT (V_1 , V_2) at two defined load levels (I_1 , I_2) and calculates R_i from this.

The load levels I_1 and I_2 as well as their durations are adjustable.

In manual mode, the load can store the parameters and the result of the measurement on a connected USB mass storage device at the touch of a button, so that a high throughput with many DUTs may be achieved.

Data Logging (DAQ)

(Internal memory or to USB flash drive)

The electronic load is able to synchronously store data records of voltage and current with time stamp internally in a defined interval. Up to 40,000 data records are stored in a ring buffer and can be read via a data interface. After recording is finished, the data can also be transferred to a USB flash drive.

For processes with storage intervals in the seconds range, the data can also be stored directly on the USB flash drive.

Trigger Model

Several functions or settings can be triggered by a configurable trigger model:

- Activate/deactivate load input
- Start/stop LIST function
- Start/stop data acquisition
- Set triggered settings of all operating modes

Available trigger sources:

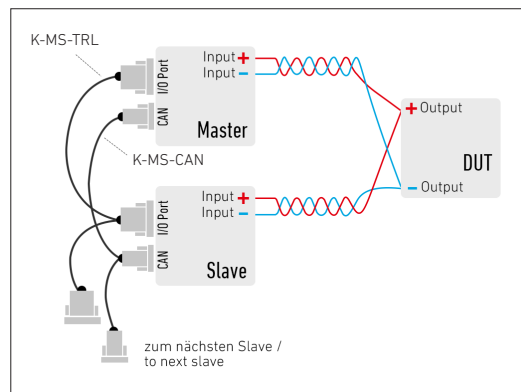
- Extern (with opt. I/O port)
- Bus
- Manual
- Voltage
- Current

Changing Regulation Speed

Sometimes special DUTs or very long load cables require modification of the electronic load's regulation time constant to avoid oscillations and establish stable operation.

Regulation speed slow - medium - fast are selectable. See model overview.

Master-Slave Operation



Master-slave operation in system connection

To increase the power or current, up to 5 loads¹⁾ can be connected in parallel in master-slave operation²⁾.

The system operates externally as if it were one single device. The master unit controls the total current of the system, displays the total measured values and supplies these when queried via one of the data interfaces.

Wiring:

One set each of K-MS-TRL and K-MS-CAN master-slave cables on all slave units (available from H&H or can be assembled by the user).

To be able to access monitor signals etc. when using the master-slave cable K-MS-TRL, we offer a SubD25 doubler as an accessory.

Watchdog Function

In digital remote operation, the electronic load has got a watchdog function switching the load input off if the previously programmed watchdog delay expires without resetting the watchdog.

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

Save Settings

In order to be able to quickly reconstruct recurring test tasks, the settings active in the electronic load can be stored in non-volatile memory (internal or external to USB flash drive) so that they can be reloaded at a later time. 9 internal memory positions are available.

The load can alternatively set reset values at power-up, the last active settings at power-down or memory position 1 to 9.

Drivers



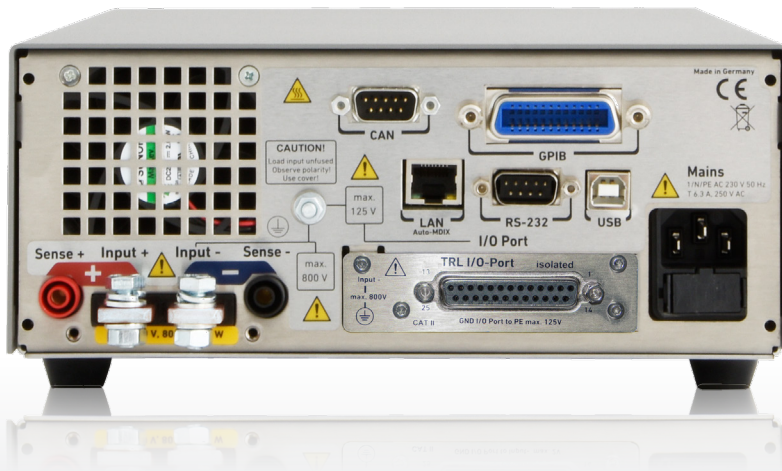
Current NI-certified LabVIEW drivers can be downloaded here:
www.ni.com/downloads/instrument-drivers/

1. Equal models and equal firmware versions
2. In master-slave mode reduced function scope, controlling via CAN interface not possible

TRL1008



TRL1008



| Model (Order number) | TRL1008 | TRL1040 | TRL10K12 |
|-------------------------------------------------------|-------------------------------|-----------------------|-----------------------|
| Maximum input voltage V _{max} | 80 V | 400 V | 1,200 V |
| Minimum input voltage V _{min} ¹⁾ | 1 V | 4 V | 12 V |
| Maximum current I _{max} | 60 A | 15 A | 5 A |
| Continuous power | 1,000 W | 1,000 W | 1,000 W |
| Voltage setting | 0 ... 80 V | 0 ... 400 V | 0 ... 1,200 V |
| Current setting | 0 ... 60 A | 0 ... 15 A | 0 ... 5 A |
| Resistance setting | 0.017 ... 13.4 Ω | 0.267 ... 268 Ω | 2.4 ... 2,400 Ω |
| Power setting | 0 ... 1,000 W | 0 ... 1,000 W | 0 ... 1,000 W |
| Rise and fall time fast / medium / slow ²⁾ | 10 / 50 / 250 ms | 10 / 50 / 250 ms | 10 / 50 / 250 ms |
| Input capacity ca. | 400 μF | 120 μF | 25 μF |
| Mains voltage ³⁾ | 1/N/PE AC 230 V 50 Hz | 1/N/PE AC 230 V 50 Hz | 1/N/PE AC 230 V 50 Hz |
| Power consumption (own consumption) ⁴⁾ | 85 VA | 90 VA | 85 VA |
| Maximum feed-in power | 955 VA | 975 VA | 920 VA |
| Efficiency ⁵⁾ | 90 % | 90 % | 90 % |
| Noise max. ca. ⁶⁾ | 49 dB(A) | 49 dB(A) | 49 dB(A) |
| Load terminals ⁷⁾ | FKL15/4-SM6 with safety cover | SBU4-24 | SBU4-24 |
| Weight ca. | 7.7 kg | 7.2 kg | 7.2 kg |
| Housing / 3D model ⁸⁾ | ½19", 2 U / TRL_M1 | ½19", 2 U / TRL_M2 | ½19", 2 U / TRL_M2 |

Options and Accessories

| Order number | Article | Description |
|---------------|------------------------------|---------------------------------------------------------------------------------|
| 52-200-001-26 | TRL02 | GPIB interface extension |
| 67-004-030-26 | K-RS-SNM 9-9 | RS-232 cable (null-modem cable) |
| 53-100-001-26 | TRL06 | Galvanically isolated I/O port |
| 64-314-000-26 | TRL10 | 19" installation kit for 1 device with ½ 19", 2 U |
| 64-315-000-26 | TRL11 | 19" installation kit for 2 devices with ½ 19", 2 U |
| 67-008-020-26 | K-MS-TRL+K-MS-CAN | Cable set master-slave, consisting of K-MS-TRL and K-MS-CAN (2 m each) |
| 67-036-020-26 | K-MS-TRL | Master-slave cable I/O port (2 m) |
| 67-037-020-26 | K-MS-CAN | Master-slave cable CAN (2 m) |
| 63-000-006-26 | SubD25 Doubler | Adapter 1x Sub-D 25 male connector to 2x Sub-D 25 female connector for I/O port |
| 65-002-000-26 | FCC-TRLxx | Factory Calibration Certificate |
| 64-401-000-26 | SAB-TRL | Additional safety cover for load terminals incl. cap for unused input terminals |
| 63-000-002-00 | SENSADAPT/4BAN/ PH2/1200V | Sense adapter from 4 mm banana plug to Phoenix PH2 |
| | | Load cables see starting at page 127 |

1. Minimum input voltage for maximum static load current.
2. Rise and fall times are defined from 10 ... 90 % and 90 ... 10 % of maximum current (constant current mode, tolerance ±20 %).
3. Mobile connection via cold device plug. Mains voltage tolerance ±10 %.
4. Power consumption in idle operation (without load current).
5. Maximum achievable efficiency.
6. Measured at the front in distance of 1 m.
7. Load and sense terminals both at front and rear panel. Description of available terminals starting at page 123.
8. 1 U = 44.45 mm. Detailed dimensions by means of 3D models at www.hoecherl-hackl.com/downloads.

| Operating modes, functions | | |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| Basic operating modes | CC, CP, CR, CV | |
| Combined operating modes | CC+CV, CR+CC+CV, CP+CC+CV, CV+CC | |
| Functions | DC load MPP Tracking for solar panel test energy storage device test internal resistance measurement List function rectangular function (in local operation also in PWM mode) modulation (sine, triangle, square) data acquisition (internally or to USB flash drive) save and recall of device settings watchdog in remote operation master-slave mode for power extension | |
| User interface | 4.3" TFT touch display | |
| Accuracy of setting | | |
| | of setting | of corresponding range |
| Voltage | ±0.2 % | ±0.05 % |
| Current | ±0.5 % | ±0.05 % |
| Resistance (at 5 % to 100 % of voltage range) | ±1.4 % | ±0.3 % of current range ±0.5 % of resistance range |
| Power (at V and I > 10 % of range) | ±0.35 % | ±0.1 % |
| (at V or I 5 ... 10% of range) | ±0.7 % | ±0.25 % |
| Resolution | 14 bits | |
| Accuracy of adjustable protections | | |
| | of setting | of corresponding range |
| Overcurrent protection | ±1 % | ±0.3 % |
| Undervoltage protection | ±1 % | ±0.3 % |
| Resolution | 12 bits | |
| Accuracy of measurement slow | | |
| | of measured value (real value) | of corresponding range |
| Voltage | ±0.01 % | ±0.025 % |
| Current | ±0.2 % | ±0.05 % |
| Resistance | is calculated from current and voltage | |
| Power | is calculated from current and voltage | |
| Resolution | 23 bits | |
| Sampling time | 250 ms, not triggerable | |
| Accuracy of display | | |
| Number of decimal places | 4 | |
| Accuracy | accuracy of measurement slow ±1 digit of the display value | |
| Accuracy of measurement fast | | |
| | of measured value (real value) | of corresponding range |
| Voltage | ±0.1 % | ±0.1 % |
| Current | ±0.7 % | ±0.1 % |
| Resistance | is calculated from current and voltage | |
| Power | is calculated from current and voltage | |
| Resolution | 16 bits | |
| Sampling time | 200 µs ... 1,000 s, resolution 200 µs | |
| Accuracy of trigger voltage and current | | |
| Trigger voltage | ±1 % of voltage range | |
| Trigger current | ±1 % of current range | |
| Sampling time | 200 µs | |

| Dynamic function LIST | |
|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Operating modes | CC, CV, CR, CP |
| No. of load levels | max. 300, with corresponding ramp and dwell times |
| Accuracy of load levels | see accuracy of setting |
| Dwell time ¹⁾ | 200 µs ... 1,000 s |
| Ramp time ¹⁾ | 0 ... 1,000 s |
| Resolution | 200 µs |
| Accuracy of setting times | ±0.02 % |
| Sampling time | see accuracy of measurement fast |
| Delay at triggered start | max. 300 µs |
| Dynamic function rectangular | |
| Operating modes | CC, CV |
| No. of load levels | 2 |
| Accuracy of load levels | see accuracy of setting |
| Pulse times ¹⁾ , resolution | 1 µs ... 9999.999 ms, resolution 1 µs |
| Accuracy of setting times | 0.02 % |
| Dynamic function PWM | |
| Operating modes | CC, CV, CR |
| No. of load levels | 2 |
| Accuracy of load levels | see accuracy of setting |
| Frequency ¹⁾ , resol. | 0.1 Hz ... 10 kHz, resolution 0.1 Hz |
| Duty cycle, resol. | 1 ... 99 %, resolution 1 % |
| Dynamic function modulation | |
| Operating modes | CC, CV |
| Waveforms | sine, square, triangle |
| Frequency ¹⁾ , resol. | 0.1 Hz ... 10 kHz, resolution 0.1 Hz |
| Modulation depth | 0 ... 100 % |
| Data acquisition | |
| to external USB flash drive | |
| Sampling time | 0.1 ... 30.0 s, resolution 0.1 s |
| Measurement data | timestamp, voltage, current |
| No. of measurement points | limited by flash drive memory capacity |
| File format | .csv |
| to internal memory | |
| Sampling time | 200 µs ... 1,000 s, resolution 200 µs, synchronized with dynamic function |
| Measurement data | timestamp, voltage, current |
| No. of measurement points | max. 40,000 in ring buffer |
| Settings memory | |
| No. of memory positions | 9, selectable (incl. programmed list) 1 for last device settings at power-off or power failure |
| I/O port (option TRLO6): inputs and outputs | |
| Inputs | analog load setting I and V 0 ... 5 V and 0 ... 10 V analog protection setting I and V 0 ... 5 V and 0 ... 10 V load input activation (low active) operating mode selection CC/CV control speed selection fast/slow remote shut-down (low active) readable digital input (by SCPI command) trigger input (high active) control input (activates I/O port, low active) |
| Dig. input levels | logical low: 0 ... 0.8 V, logical high: 3 ... 30 V |

The specified accuracies refer to an ambient temperature of 23 ±5 °C. The specified accuracies are valid when the sense lines are connected and when the unit is connected to undisturbed voltages (ripple and noise < 0.1 %). At voltages with higher disturbance values the accuracy can change for the worse.

1. The applicable time or frequency range is limited by the rise/fall time of the respective model.

2. only 0 ... 10 V

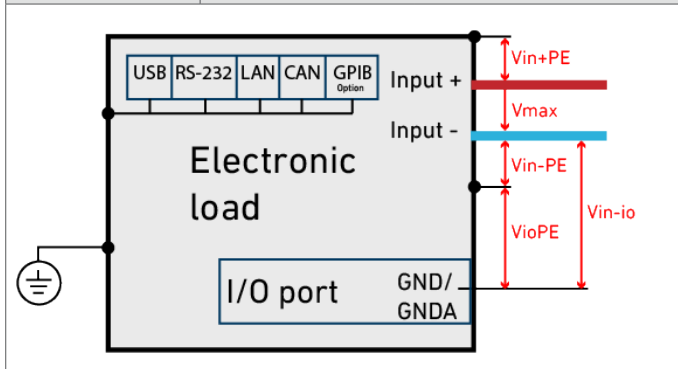
Technical Data

| | |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Outputs | analog voltage monitor output 0 ... 10 V analog current monitor output 0 ... 10 V load input activation state (low active) overload status (OV, OCP, OPP, OTP, low active) programmable logic output (by SCPI command) trigger output (low active) |
| Dig. output levels | logical low: 0 ... 0.8 V logical high: 5 V/24 V selectable, max. 10 mA (push-pull) |

| I/O port (option TRL06): accuracy of analog control 0 ... 5 V or 0 ... 10 V | | |
|-----------------------------------------------------------------------------|------------|------------------------|
| | of setting | of corresponding range |
| Voltage | ±0.2 % | ±0.05 % |
| Current | ±0.2 % | ±0.05 % |
| Overcurrent protection ²⁾ | ±1 % | ±0.3 % |
| Undervoltage protection ²⁾ | ±1 % | ±0.3 % |
| input resistance of analog inputs >10 kΩ | | |

| I/O port (option TRL06): accuracy of analog monitor outputs 0 ... 10 V | | |
|------------------------------------------------------------------------|----------------------------------|----------------|
| | of analog signal of actual value | offset voltage |
| Voltage | ±0.2 % | ±15 mV |
| Current | ±0.2 % | ±15 mV |
| permissible load > 2 kΩ | | |

| I/O port (option TRL06): permissible voltages | |
|-----------------------------------------------|--------------------------|
| Vin-io (GND - neg. load input) | max. 800 V ¹⁾ |
| VioPE (GND - PE) | max. 125 V ¹⁾ |



| Input | |
|------------------------------|-------------------------------------------------------------------------------------------|
| Input resistance | >50 kΩ when load input is off diode function at reverse polarity up to nominal current |
| Input capacity | see model overview |
| Parallel operation | up to 5 devices in master-slave operation |
| Max. input voltage V_{max} | see model overview |
| Min. input voltage V_{min} | see model overview |

| Input: permissible voltages | |
|-------------------------------|---------------------------------------------|
| Vin-PE (neg. load input - PE) | max. 800 V ¹⁾ |
| Vin+PE (pos. load input - PE) | $V_{max} + \text{max. } 800 \text{ V}^{1)}$ |

| Power | |
|------------------|------------------------------------------------|
| Continuous power | see model overview (at $T_a = 21 \text{ °C}$) |
| Derating | -1.2 %/°C for $T_a > 21 \text{ °C}$ |
| Effectivity | see model overview |

| Protection and monitoring | |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Protective devices | overcurrent overpower overtemperature |
| Monitoring | overvoltage indication reverse polarity indication undervoltage indication (if the input voltage is too low for the set current) |

| Terminals | |
|---------------------------------------------------|------------------------------------------------------------------------|
| Load input | see model overview |
| Sense | SBU4-24, see starting at page 123 |
| Operating conditions | |
| Operating temperature | 5 ... 40 °C |
| Stock temperature | -25 ... 65 °C |
| Max. operating height | 2,000 m above sea level |
| Pollution degree | 2 |
| Overvoltage category of mains | II |
| Max. humidity | 80 % at 31 °C, linear decreasing to 50 % at 40 °C |
| Min. distance rear panel to wall or other objects | 20 cm |
| Cooling | 2-stage air cooling |
| Noise, weight | see model overview |
| Mains voltage | see model overview |
| Mains cable | length max. 3 m cross-section of mains leads min. 1 mm ² |
| Own consumption | see model overview |
| Maximum feed-in power | see model overview |

| Housing | |
|------------|-----------------------------------------------------------------------------------|
| Dimensions | see model overview |
| Color | front: RAL7035 (light grey) rear: stainless steel top: RAL7037 (dusty grey) |

| Safety and EMC | |
|--------------------|------------------------------------------------------------------------|
| Protection class | 1 |
| Measuring category | 0 (CAT I according to EN 61010:2004) |
| Electrical safety | DIN EN 61010-1 DIN EN 61010-2-030 |
| EMC | DIN EN 61326-1 DIN EN 55011 DIN EN 61000-3-2 DIN EN 61000-3-3 |

| Standard interfaces | |
|---------------------|-----------------------|
| Data interfaces | RS-232, USB, LAN, CAN |
| I/O port | none |

| Available options | |
|---------------------|-----------------------------------------------------------------------------------------------------------------------|
| Data interfaces | GPIB |
| Mechanical options | TRL10: 19" installation kit for 1 device with ½ 19"; 2 U TRL11: 19" installation kit for 2 devices with ½ 19"; 2 U |
| TRL08 | additional safety cover for load input incl. cap for unused load terminals |
| Hardware extensions | TRL06: galvanically isolated I/O port |

| Calibration, warranty | |
|----------------------------------|---------------------------------------------------------------|
| FCC-TRLxx | Factory Calibration Certificate, twice for free ²⁾ |
| Recommended calibration interval | 2 years |
| Warranty | 2 years |

Technical data of production series A, rev. 2. Subject to technical changes without notice.

1. positive/negative DC voltage or RMS value of a sinusoidal AC voltage
2. The second calibration is free of charge if the particular device has been registered with H&H: www.hoechert-hackl.com/service/device-registration