

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.

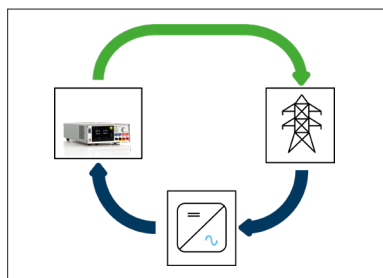
## Protection, Monitoring

- 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 local mains supply<sup>1)</sup>. 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. Regenerative systems must be registered with the energy supply authority. Mains and system protection may be necessary.

## 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:

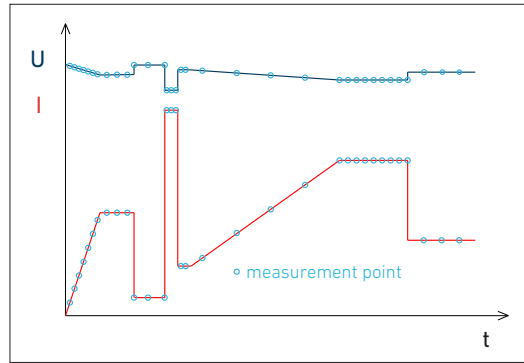
- 1 connecting element
- 2 attachment brackets with handle
- screws

### Safety Cover

Safety covers are supplied as protection against hazardous voltages. A loose cap is included for the unused load input.

## Functions

### Load Profiles (List Function)

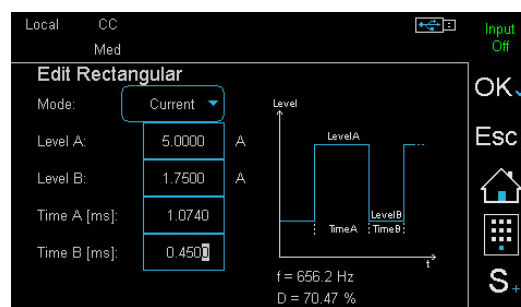


Load profile generated by List function with synchronized data acquisition of time, voltage, current

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. Individual sampling times can be defined for each curve section.

### Rectangular Function

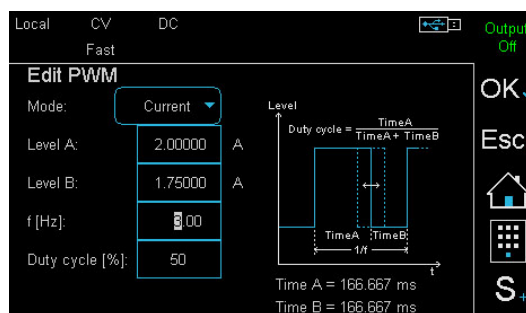


The rectangular function provides a convenient way to generate a rectangular waveform by entering absolute time and amplitude values.

High resolution is paired here with a wide range for time setting.

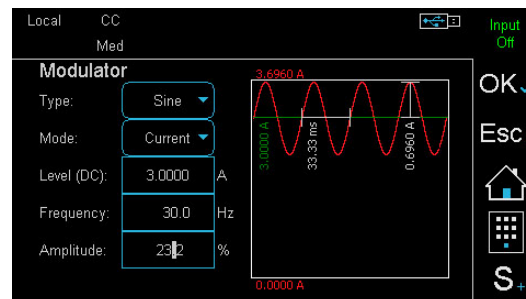
TRL  
power regeneration

### PWM Function



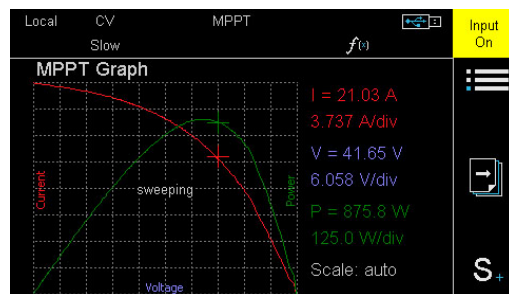
With the PWM function, the switching frequency and the duty cycle can be set for the two amplitude values in manual operation.

### 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

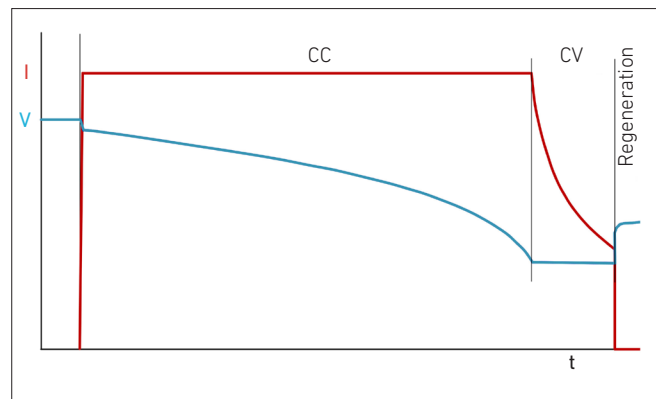


V/I and V/P characteristic at the user interface

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<sub>Ua</sub> 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.

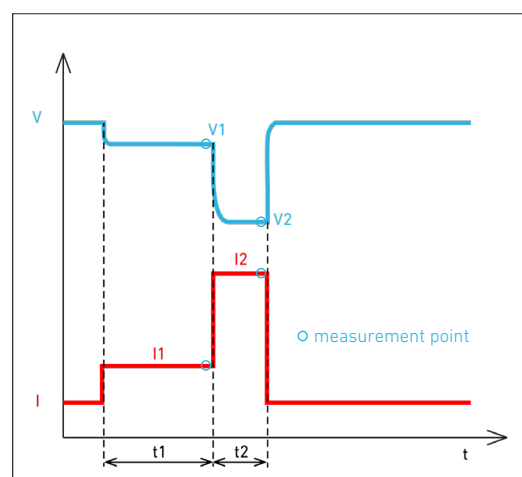
I<sub>Ua</sub> discharge (CC+CV discharge) is also possible: the test object is discharged with constant current up to a defined voltage.

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<sub>i</sub> 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:

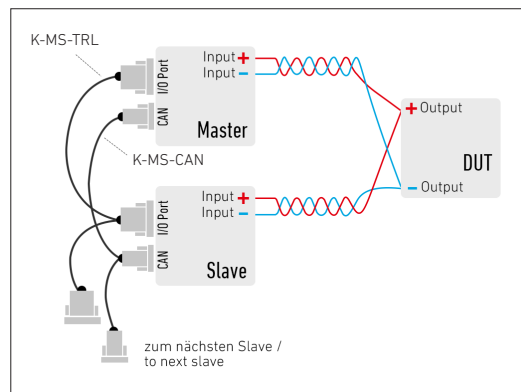
- Extern (with opt. I/O port)
- Bus
- Manual
- Voltage
- Current

## 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 loads<sup>1)</sup> can be connected in parallel in master-slave operation<sup>2)</sup>.

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



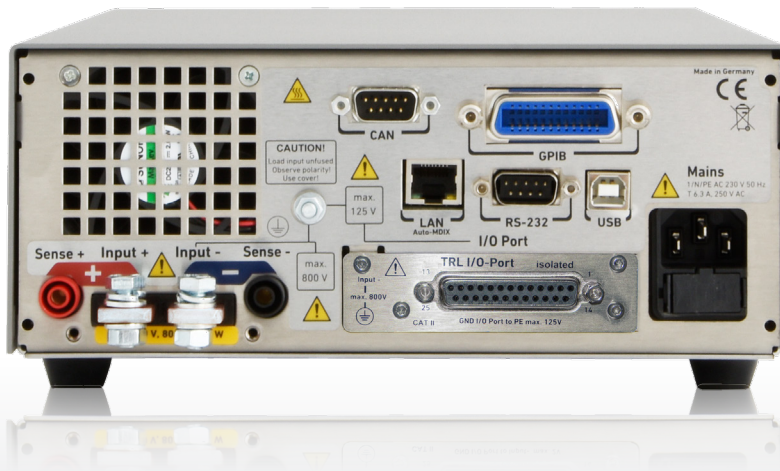
Current NI-certified LabVIEW drivers can be downloaded here:  
[www.ni.com/downloads/instrument-drivers/](http://www.ni.com/downloads/instrument-drivers/)

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 <sub>max</sub>	80 V	400 V	1,200 V
Minimum input voltage V <sub>min</sub> <sup>1)</sup>	1 V	4 V	12 V
Maximum current I <sub>max</sub>	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 <sup>2)</sup>	10 / 50 / 250 ms	10 / 50 / 250 ms	10 / 50 / 250 ms
Input capacity ca.	400 μF	120 μF	25 μF
Mains voltage <sup>3)</sup>	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) <sup>4)</sup>	85 VA	90 VA	85 VA
Maximum feed-in power	955 VA	975 VA	920 VA
Efficiency <sup>5)</sup>	90 %	90 %	90 %
Noise max. ca. <sup>6)</sup>	49 dB(A)	49 dB(A)	49 dB(A)
Load terminals <sup>7)</sup>	FKL15/4-SM6	SBU4-24	SBU4-24
Weight ca.	7.7 kg	7.2 kg	7.2 kg
Housing / 3D model <sup>8)</sup>	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 incl. cap for unused input terminals
63-000-002-00	SENSADAPT/4BAN/ PH2/1200V	Sense adapter from 4 mm plug to Phoenix PH2
		Load cables see starting at page 129

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. Safety covers are included in the delivery. Description of available terminals starting at page 125.
8. 1 U = 44.45 mm. Detailed dimensions by means of 3D models at [www.hoecherl-hackl.com/downloads](http://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) (at V or I 5 ... 10% of range)	±0.35 % ±0.7 %	±0.1 % ±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 <sup>1)</sup>	200 µs ... 1,000 s
Ramp time <sup>1)</sup>	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 <sup>1)</sup> , 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 <sup>1)</sup> , 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 <sup>1)</sup> , 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 (high active) readable digital input (by SCPI command) trigger input (positive/negative/either edge) 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.

## 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)	
<b>I/O port (option TRL06): accuracy of analog control 0 ... 5 V or 0 ... 10 V</b>		
	of setting	of corresponding range
Voltage	±0.2 %	±0.05 %
Current	±0.2 %	±0.05 %
Overcurrent protection <sup>1)</sup>	±1 %	±0.3 %
Undervoltage protection <sup>1)</sup>	±1 %	±0.3 %
	input resistance of analog inputs >10 kΩ	
<b>I/O port (option TRL06): accuracy of analog monitor outputs 0 ... 10 V</b>		
	of analog signal of actual value	offset voltage
Voltage	±0.2 %	±15 mV
Current	±0.2 %	±15 mV
	permissible load > 2 kΩ	
<b>I/O port (option TRL06): permissible voltages</b>		
Vin-io (GND - neg. load input)	max. 800 V <sup>2)</sup>	
VioPE (GND - PE)	max. 50 V <sup>2)</sup>	

<b>Input</b>	
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 Vmax	see model overview
Min. input voltage Vmin	see model overview
<b>Input: permissible voltages</b>	
Vin-PE (neg. load input - PE)	max. 800 V <sup>2)</sup>
Vin+PE (pos. load input - PE)	TRL10K12: Vmax + max. 500 V <sup>2)</sup> all others: Vmax + max. 800 V <sup>2)</sup>
<b>Power</b>	
Continuous power	see model overview (at Ta = 21 °C)
Derating	-1.2 %/°C for Ta > 21 °C
Effectivity	see model overview
<b>Protection and monitoring</b>	
Protective devices	overcurrent overpower overtemperature
Monitoring	overvoltage indication reverse polarity indication undervoltage indication (if the input voltage is too low for the set current)

<b>Terminals</b>	
Load input	see model overview
Sense	SBU4-24, see starting at page 125
<b>Operating conditions</b>	
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 fuse	see specification on the rear panel near mains fuse
Mains cable	length max. 3 m cross-section of mains leads min. 1 mm <sup>2</sup>
Own consumption	see model overview
Maximum feed-in power	see model overview

<b>Housing</b>	
Dimensions	see model overview
Color	front: RAL7035 (light grey) rear: stainless steel top: RAL7037 (dusty grey)
<b>Safety and EMC</b>	
Protection class	1
Measuring category	0 (CAT I according to EN 61010:2004)
Electrical safety	EN 61010-1:2010+A1:2019+A1:2019/AC:2019 EN IEC 61010-2-030:2021+A1:2021
EMC	EN 61326-1:2013 EN 55011:2016+A1:2017 EN 61000-3-2:2014 EN 61000-3-3:2013

<b>Standard interfaces</b>	
Data interfaces	RS-232, USB, LAN, CAN
I/O port	none
<b>Available options</b>	
Data interfaces	TRL02
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
Hardware extensions	TRL06: galvanically isolated I/O port
<b>Calibration, warranty</b>	
FCC-TRLxx	Factory Calibration Certificate, twice for free <sup>3)</sup>
Recommended calibration interval	2 years
Warranty	2 years

Technical data of production series A, rev. 3. Subject to technical changes without notice.

1. Only 0 ... 10 V
2. Positive/negative DC voltage or RMS value of a sinusoidal AC voltage
3. The second calibration is free of charge if the particular device has been registered with H&H: [www.hoechert-hackl.com/service/device-registration](http://www.hoechert-hackl.com/service/device-registration)