ELECTRONIC LOAD 100.30
MANUAL
WITH INTEGRATED IEC INTERFACE

IEEE 488

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GENERAL INTRODUCTION

What is an "electronic load"?

The "electronic load" is an electronic current consumer. It consumes the electric power offered by an external source and converts it completely into heat.

The special characteristic is that the current or power consumption of the device can be precisely controlled. If a function generator is then connected, any arbitrary load curve can be realized.

Two current or resistance values can be set for the electronic load 100.30 with the possibility of manual or automatic switching between them. The switch-over frequency can also be adjusted within a large range.
So far so good, but:

What is an electronic load really needed for?

High quality demands on power supplies are nothing new. In order to ensure that the finished product actually meets these demands, the power supply must be subjected to hard tests as early as the development phase. One of these tests is loading via a load current!

Earlier, such tests had to be performed using resistors. The result did not provide much information about the regulation characteristics of the device, however, and were therefore not sufficient.

Things are quite different with the electronic load. It permits arbitrary load jumps to be simulated as well as a static loading. The true regulation characteristics of a "test object" are revealed only by such dynamic tests.
Of course, the electronic load offers a good deal more. Some of the most important applications are described on the following pages.

Electronic load areas of application

The electronic load is connected to the "test object" like a normal "consumer". And it is not just power supply units which are possible test objects, but also all devices and subassemblies which must deliver current. These include, for example, batteries, generators, transformers or even driver circuits. However, it is important to know that the AC voltage must first be rectified and filtered before connection to the electronic load.

The most important features of the electronic load 100.30 at a glance:

- The very low input voltage of 50 mV at 1 A, 300 mV at 10 A, 1 V at 30 A.
- I-constant operation from 0 to 30 A. R-constant operation from ∞ to 50 mΩ. (Both operating modes can be remote-controlled by an external control voltage.)
- 250 W continuous power, 500 W pulsed power (electronically monitored).
- LCD display for load current/voltage with automatic range switch-over.
- Desired current display, thus permitting the device to be set without connected test object.
- Two load values can be set separately.
- Built-in alternating generator 1 Hz to 1 kHz, continuously variable.
- Floating trigger signal for clean oscilloscope images.
- Extensive electronic safety devices to protect against maloperation.
- Convection cooling, thus without fan noise; maintenance-free.
- Compact table-top housing with tip-up feet, stackable.
- Can be connected in parallel in master-slave configuration (up to min. 1 250 W).

OPERATING MODES

Constant-current operation

In this operating mode, the electronic load consumes precisely the amount of current set on the device. The applied voltage is irrelevant as long as the maximum voltage of 100 V and maximum power of 250 W (or briefly 500 W in clocked operation) are not exceeded. However, a minimum voltage is required at the input so that the electronic load can operate. The higher the required current, the higher the necessary minimum voltage at the input. It is, however, below 1 V in all cases (refer to Technical Data).

Resistance operation

In this mode, the electronic load behaves like a resistor whose value can be adjusted. The numerous large and clumsy slide resistors of the past can thus be replaced very conveniently.

The 4 resistance ranges

These make sure that you can set the device easily in all ranges. Since the applied voltage influences the current which flows, it must also be possible to change the adjustment range of the potentiometer, otherwise difficulties would occur with the setting potentiometer resolution.

The following example will demonstrate this:
Let us assume that you want to obtain a 30 A load current with a 1 V input voltage. For this purpose, the setting potentiometer is turned to the limit stop. In other words, you have the full adjustment range of the potentiometer at your disposal.
You then wish to obtain a load current of 30 A for a 2 V input voltage. You now have only half the potentiometer's adjustment range at your disposal. For 4 V, this is reduced to only a quarter and then to a sixtieth for 60 V. Although setting is already impossible here, the situation is aggravated even further, because 30 A would have to flow if the potentiometer were turned up by a sixtieth of its range for 60 V input voltage. However, since only slightly above 4 A are permitted for 60 V (250 W), the adjustment range of the potentiometer shrinks to a four hundred and fiftieth.
On our electronic load, it is sufficient to press the corresponding button for the suitable resistance range and the adjustment range of the potentiometer is then correspondingly adapted. It could not be simpler.
Incidentally, automatic range switch-over would be pointless here, because the current would jump considerably in the event of a change from one range to another.
Thanks to our special circuit technology, it is possible to also vary the resistance value by means of an external control voltage. As a result of this circuit, the resistance value changes slightly with the applied voltage, but this is not disadvantageous in most cases.

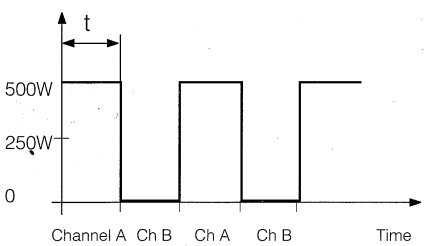
The alternating generator

Continuous switching between channels A and B is performed as soon as the alternating generator is switched on. The switching frequency can be adjusted within a wide range by the corresponding potentiometer, whereby the duty cycle is always 1 : 1.

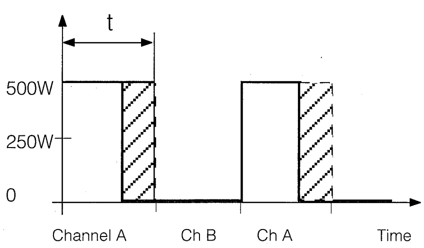
Power monitoring

This function ensures that the power transistors are not exposed to an inadmissibly high load when you as the user inadvertently demand too much power from the device. During static operation, the device permits a continuous power of 250 W. In alternation operation, the device allows up to 500 W briefly if the average power of 250 W is not exceeded. The increased power must, however, be present for only a limited time: the higher the average power, the shorter the possible time. In practice, this means that time-related limitations are necessary for low clock frequencies in order to protect the device against damage.
All these aspects are monitored fully-automatically. You as the user cannot damage anything here.

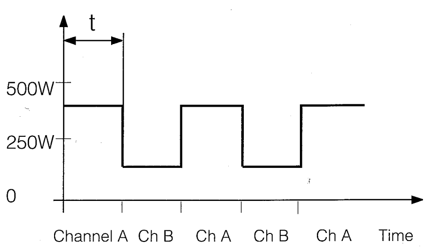
Here are a few examples to illustrate unit power consumtion:



a) Channel A consumes 500 W, while channel B does not consume any power at all. The average power is 250 W. The time is sufficiently short (or the frequency high enough) to avoid the necessity for any time-related limitations.



b) As for figure a, but with lower frequency. The time is too long for a power of 500 W. For this reason, the power consumption time is limited (hatched area).

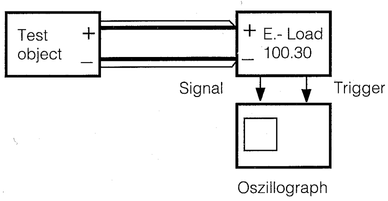


c) This power distribution produces 250 W on average and the frequency is high enough to avoid the necessity for time-related limitations.

APPLICATIONS

Dynamic test of a power supply

Important power supply dynamic regulation characteristics can be determined by means this test. An oscilloscope is required to observe the output voltage of the test object during load changes.

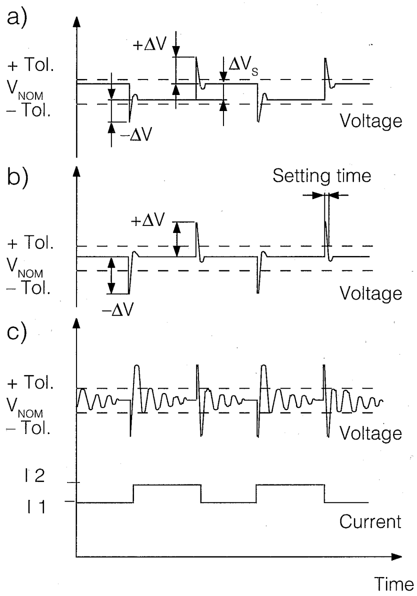


The trigger output of the electronic load is connected with the trigger input of the oscilloscope by a BNC cable. If it is wished to observe the voltage directly at the input of the electronic load, the measured signal can be tapped at the socket "V-monitor".
Remember, however, that you are monitoring the voltage drops on the load lines as well here. You then obtain an image like that shown in Figure a).
Today's power supply units often possess sensor lines which serve the purpose of compensating for such voltage drops. You should therefore use these sensor lines and connect them to the electronic load as well in parallel to the load lines.
Select two load currents on the electronic load with which your test object should be loaded alternately. Select AC coupling on the oscilloscope. Now start the alternating generator and observe the voltage dips and peaks produced by test object on the oscilloscope. The height, duration and curve form of the dips and peaks provides information about the dynamic regulation characteristics of the test object. The smaller and shorter the dips and peaks, the better the regulation characteristics; however, the device must not tend to oscillate (refer to Figure c).

a) Typical regulation response with voltage drop ΔVs caused by supply load line resistances.

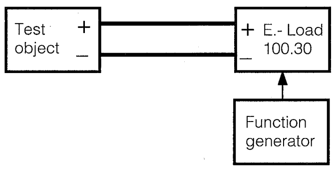
b) Good regulation response with compensation of the load line voltage drops by sensor line operation.

c) Poor regulation response, tendency to oscillation.



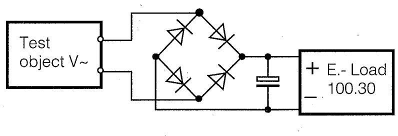
Loading the test object with a defined load current curve

In some tests, e.g. battery discharging for determination of capacity, an exactly defined load current curve is required. For this purpose, the electronic load is switched to "ext. mod." and controlled with a control voltage of 0...5 V. The control voltage can be provided by an arbitrary source, e.g. a function generator. The current which is consumed by the electronic load follows the control voltage proportionally.



Loading an AC current source

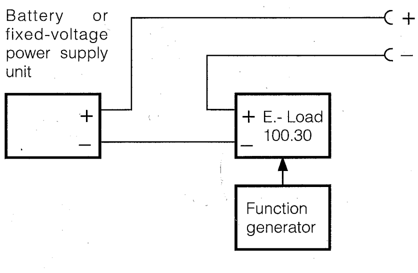
Since the electronic load can load only unipolar current sources, current sources with a bipolar output, e.g. mains transformers, generators or power amplifiers, must be rectified before they can be loaded by the electronic load.



Current source with variable current

A precise, controllable current source can be realized in conjunction with a voltage source (battery or power supply unit). Such current sources can be used for many different tests, such as:

- determination of the optimum charging current curves for batteries.
- current load tests.
- pull-up/drop-out tests on relays.



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BASIC OPERATION

- The active functions of the device are indicated by LEDs in the keys. Ext. modulation and constant-current simulation are active after initial switch-on.
- Select the required operating mode by pressing the corresponding key. In the case of "resistance" mode, the current depends on the voltage at the input. Consequently, a suitable resistance range must also be selected for this. If the available voltage is too high for a resistance range, the resistance function is no longer linear, this being indicated by the LED "Vin >". This can be remedied by selecting a higher resistance range.
- By pressing "A" or "B", select a channel and set the required load by means of the corresponding potentiometers (coarse and fine). The flowing current is then shown on the display if a test object is already connected. The display shows 0.00 A if no test object is connected. The current which is set on the device is displayed by pressing the key "IDes.".
- It is possible to set a second load current by selecting a different channel. It is then possible to switch over between two load currents by simply pressing the required channel.
- If "ALT" is selected, the device automatically alternates between the two channels, whereby the switching frequency can be selected by means of the corresponding potentiometer. The alternating generator can be switched off by selecting one of the two channels "A" or "B".
- An arbitrary number of devices can be connected in parallel to increase the current or maximum power, whereby each device must be set individually and thus makes its contribution to the overall current.
- If two or more devices are used, there is the possibility of MASTER-SLAVE operation. This has the advantage that only one device must be operated. The "SLAVES" automatically follow.
  For this purpose, all devices are connected to the test object in parallel and the "Ext. Mod." sockets of all devices connected by a BNC cable. Set the same operating mode on all devices (also the same resistance range for "resistance" mode).
  Additionally set the operating mode "Ext. Mod." on all "SLAVES". You can then operate the "MASTER" like a single device. The overall current is the total of all individual currents.

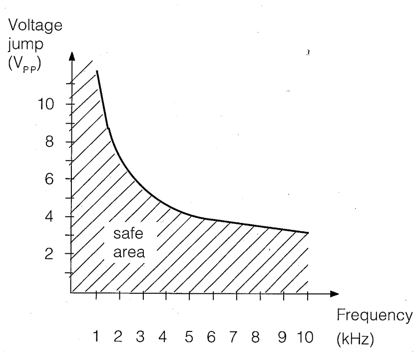
Important:
Never disconnect the negative load line from the devices during operation. This prevents the load current from flowing via the BNC cable if you have an external ground loop.
The BNC sockets "V-monitor" and "Ext. Mod." must not be coupled with each other externally.

IMPORTANT OPERATING INSTRUCTIONS

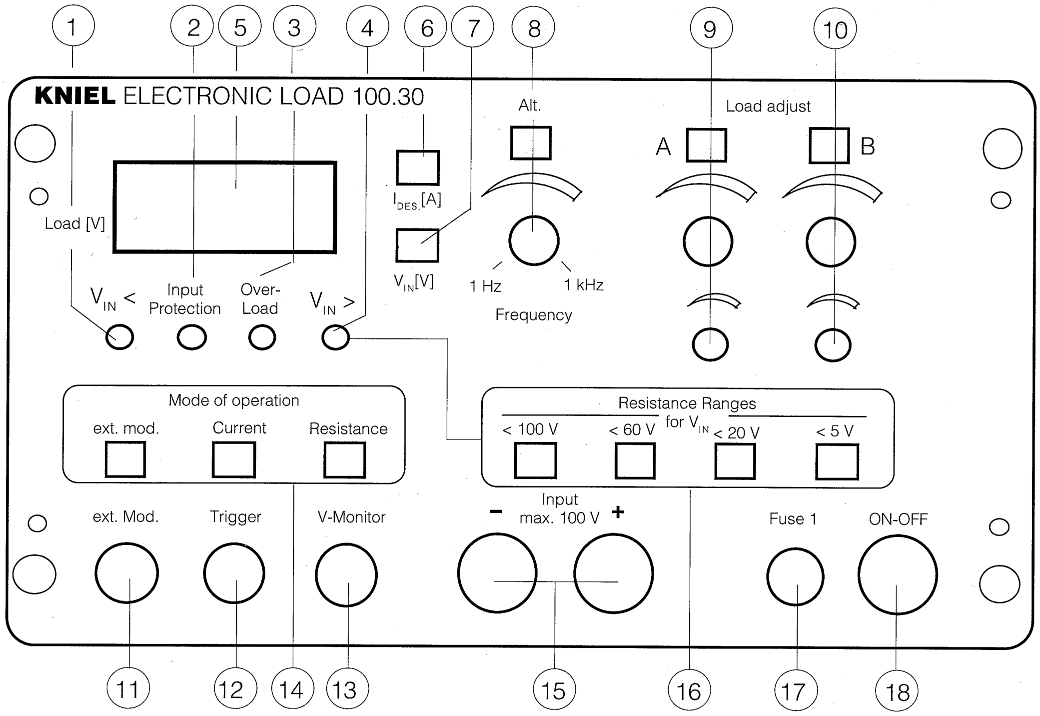
Although the electronic load 100.30 is equipped with extensive protective devices to guard against maloperation, care must be taken in alternating operation with very high current jumps in conjunction with a high frequency. This applies particularly in the case of ext. modulation, because the frequency can be increased practically arbitrarily here.
There are the following reasons for this: Very large load changes can be generated in alternating operation - in extreme cases up to 30 A. Even if the source is completely stable, e.g. a battery, there are voltage drops on the load lines so that large voltage jumps can occur at the input of the electronic load. This alone is, however, of no significance. It becomes dangerous when the alternating frequency is increased, thus making the voltage jumps follow each other in more rapid succession. These in turn act on the input capacitor which heats up as a function of the voltage jumps and frequency.
If you are working with very high current jumps, make sure that you use short, heavy-duty load lines in order to keep the voltage jumps as low as possible. If, however, your load lines are long and/or thin, then you either cannot perform any large current jumps or you must not increase the frequency too much. The voltage jumps at the electronic load can be observed at the BNC socket (V-monitor" using an oscilloscope.

Note:
A current jump from 3 A to 8 A (or vice versa) produces the same voltage jump at the electronic load as a current jump from 20 A to 25 A (or vice versa). Only the current difference is therefore decisive for a voltage jump at the electronic load.

Example:
Laod lines with a length of 1 m each and a conductor cross-section of 1.5 mm alone already cause a voltage drop of approx. 2 V for a current jump of 30 A. This does not yet take into account contact resistances and connectors, terminals, etc., which normally cause still higher voltage drops. The voltage dips and peaks which the connected test object causes as a result of the load change must also not be neglected. They often supply the largest share of all voltage drops! The diagram below illustrates the electronic load safe operating range. Transgression of the limit line involves inadmissible operation leading to damage of the device.



FUNCTIONS



Functions:

(1) Indicates that the applied voltage is too low, with the result that the set current cannot flow.

(2) Indicates that the input protection circuit has blocked an overvoltage and that the device has been switched off. Polarity reversal at the input also triggers this device reaction. In this case, disconnect the test object from the device immediately. The device is not damaged by an inverse current of 10 A for max. 1 sec.
Overvoltages caused by short voltage peaks of the test object are also reliably blocked, but a DC voltage of > 110 V will damage the device.
If the overvoltage or reverse polarity was within the limit values, the device can be put back into operation again by switching off and switching on again.

(3) Indicates that the device has switched itself off because the required power is too high (> 250 W rms). The device switches itself on again as soon as the power is in the permitted range. The device also switches off in the event of an overheated cooler owing to blocked convection cooling and then switches itself back on again after a cooling period.

(4) Indicates that the input voltage is to high for the selected resistance range. The resistance function is no longer linear. Select a larger resistance range.

(5) LCD display for flowing current (also refer to 6 and 7 for display of other quantities).

(6) When this key is pressed, the current set on the device is displayed approximately. This permits presetting of the device current even if no test object is connected.

(7) The input voltage is displayed when this key is pressed.

(8) The alternating generator is switched on by key operation, and the frequency is selected by the potentiometer. (Switch off by pressing 9 or 10.)

(9) Load channel A is switched on by key operation, load adjustment by means of the 2 potentiometers for coarse and fine.

(10) As for 9, but load channel B.

(11) Input for external device modulation. The function of the potentiometers for load adjustment can be re-placed here by a control voltage (0...5 V). The operating mode "ext. mod." must be selected for this purpose (refer to Technical Data).

(12) A trigger signal is available here for oscilloscope triggering. In order to avoid problems, this output is floating.

(13) The applied input voltage is available here for tapping. When connected to an oscilloscope, the unit input voltage can herewith be observed in order to, for instance, inspect the dynamic regulation characteristics of the test object. This socket is connected in parallel to the input sockets.

(14) Selection of the operating mode by key operation.

(15) Input sockets for connection of the test object (4 mm laboratory sockets).

(16) Selection of the resistance range by key operation. These keys are of significance only for the operating mode "resistance". The voltage values indicate up to which input voltage the individual resistance range can be used.

(17) Mains fuse 0.135 A slow-blow.

(18) ON-OFF switch of the device.

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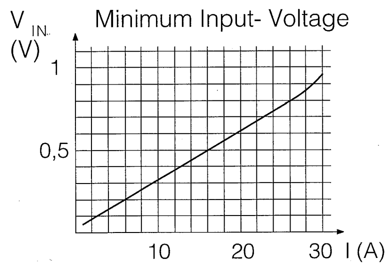
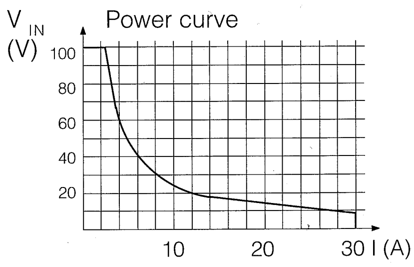
TECHNICAL DATA

(Guaranteed after an ON time of 30 minutes.)		
Max. input voltage	100 V	Drift of the current adjusted in dependence on charge and temperature, max. 1 % of $I_{max.}$
Min. input voltage	see diagram	
Current range	0... 30 A	
Max. continuous power	250 W	
Max. pulsed power	500 W	
Simulation modes	I-constant, R-constant	
	< ± 1 ‰ of Imax.	<--- Noise
Rise time (10... 90 %) for an arbitrary current jump	max. 20 µs	
Operating temperature range	0... + 40° C	
Cooling	Convection	
Protective circuitry against maloperation	Power limitation, switches off in the event of overheating, reverse polarity protection	
Response threshold of overvoltage protection	approx. 110 V	
Programming by ext. control voltage (Impedance > 10 kΩ)		
for I-const.	0...5 V / 0...10 kHz, arbitrary curve shape	
for R-const.		
1st range	(< 100 V) 0... 5 V corresponds to approx. ∞... 2.5 Ω	
2nd range	(< 60 V) 0... 5 V corresponds to approx. 200... 1 Ω	
3rd range	(< 20 V) 0... 5 V corresponds to approx. 20... 0.2 Ω	
4th range	(< 5 V) 0... 5 V corresponds to approx. 2... 0.05 Ω	
LCD display	For current/voltage (3 1/2 digits) ± 1 %	
LED displays	For undervoltage, input protection, overload, wrong resistance range, switchable functions	
Desired adjustment	2 values can be set, each with coarse / fine potentiometer	
Alternating generator	Adjustable from 1 Hz to 1 kHz, curve shape square-wave, duty cycle 1 : 1	
Parallel connection	An arbitrary number of devices; or 1 master and 4 slaves	
Mains input	220 V, ± 10 %; 45... 66 Hz (please enquire about other values)	
Load connection	4 mm laboratory sockets, front-side	
Dimensions (width x height x depth)	260 x 162 x 290 mm	
Weight	approx. 5 kg	





ORDERING INFORMATION

Article	Article No.
Electronic-Load 100.30	**450-002-04**

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INTRODUCTION

IEEE bus-controlled, electronic resistance simulation which reacts without delay to changes in input voltage and hardly deviates from the behavior of a "genuine" resistor.

Special characteristics:

- The device is very easy to program. The programming data are transferred in plain text (ASCII string). You thus program directly in amperes or ohms. Switch-over to the corresponding control mode and the suitable resistance range is selected fully automatically.
- The applied voltage, flowing current and resistance of the device can be read back to the control computer at any time, just like the instantaneous operating states and error messages which are signalled by SRQ.
- Integrated drift compensation compensates for disturbing drift interference. This is important particularly for long-term tests where defined currents or resistances must be maintained exactly over a long period. When a current/resistance value has been programmed, this can be automatically reestablished after a mains failure as well.
- The device requires only low input voltages for operation (e.g. 300 mV for 10 A load current).

Brief operating instructions
(Detailed manual on request.)

Manual operation
The device possesses the capability of compensating for the temperature drifts of **programmed** current and resistance values. In order to enable use of this possibility for purely manual operation as well, the device also possesses a "self-programming" function. The principle is simple: the device is operated quite normally, whereby the setting movements at the control knobs are continuously monitored by the device. As soon as no changes have been recorded for a certain time, the set current or resistance is measured and the device then programs itself to the measured value. Any deviation caused by drift is compensated for immediately. If the setting knobs are turned again, the device returns to actual manual operation and is ready for the next self-programming operation. The only thing which must be remembered is that it is possible to change the operating mode and resistance ranges only in actual manual mode. This state is indicated visually by illumination of the IDes. LED. A further useful feature is automatic setting of the last-programmed value when the device is switched on. This is indicated by flashing of the IDes. LED. This feature can be switched on and off, as can the self-programming function.

Operation via the IEEE bus

The electronic load can be controlled by any computer via the IEEE bus interface if the computer is equipped with such an interface.
The commands which are transmitted to the electronic load are normal ASCII character strings (plain text) and consequently easily comprehensible. Several commands can be transmitted at once in one line separated by spaces (max. 80 characters). The following are accepted as end characters: "CR" or "LF" or the combination "CR/LF". The device must be switched to the operating mode "ext. mod/IEEE" for control via the IEEE bus (set automatically upon switching on) or must be set to this mode by the command "LOCK" from the computer, whereby manual operation is then simultaneously blocked.

Overview of commands by way of examples

Command	Action
I = 2.48	The device is preset to 2.48 A constant current (range 0...30)
R = 1.25	The device is preset to 1.25 Ω (range 0.05...1000)
LIMITI = 4.5	A maximum current of 4.5 A can be programmed.
LIMITOFF	A set limit is cancelled
LOCK	The device can no longer be operated manually (IEEE enable)
UNLOCK	The "LOCK" command is cancelled.
I?	The flowing current is measured *
U?	The applied voltage is measured *
R?	The instantaneous device resistance is measured *
RESET	All protective functions are reset
SET	Preset programming data are activated
AUTOSET	The following programming data are activated immediately ("SET" not required)
AUTOSETOFF	Programming data are preset only and activated only with "SET"
VNR?	The version number of the driver software is output

* The measured result is transmitted as an ASCII string to the computer after the next talk call (INPUT command from the computer).

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TECHNICAL DATA

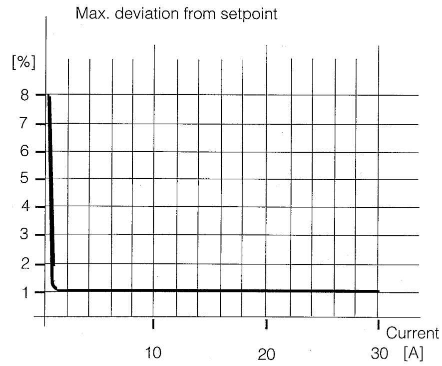
They are essentially identical with the technical data of the electronic load 100.30 which is capable of purely manual operation. The following additional data apply to IEEE bus operation:

IEEE bus functions		T6, L4, SH1, AH1, SR1, RL0**, PP0, DC1, DT1, E1
I-constant range		0... 30A Resolution: 8 mA
R-constant range		0.05... 1000 Ω Resolution dependent on resistance range (see diagram)
~~Stat. deviations of the current~~ (current noise)		< 1 ‰ of Imax. (see diagram)
Progr./measuring accuracy	for current up to 20 A	< 0.25 % or 30 mA*
	for current over 20 A	< 0.5 %
	for voltage	< 0.1 % or 100 mV*
	for resistance	< 1 %
Current drift during long-term operation	cold	< 0.5 % or 30 mA*
	after 30 min. warm-up	< 1 ‰ or 15 mA*
Service life of the battery for data retention		> 10 years (battery replacement at works)

* The higher value in each case applies.

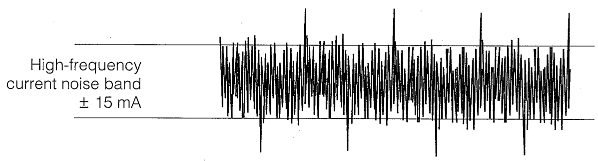
** Remote/local switch-over initiated by own commands, thus permitting mixed operation as well.

Resolution for R-operation



The adjustment accuracy for the resistance depends essentially on the resistance range. In principle, the smaller the resistance, the more precise the adjustment. The second criterion is the applied voltage (the higher the voltage, the more accurate the adjustment).
The final criterion for adjustment accuracy is the flowing current.
The relative error for small currents is greater because digital stepping makes itself most noticeable here.

Current noise
(Also applies to manually-operable electronic load 100.30.)



At high resolution, the adjacent high frequency noise band is visable and is always present.

ORDERING INFORMATION

Article		Article No.
E-Load 100.30 IEC	max. 100 V, 30 A with integrated IEEE interface	**450-005-04**

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KNIEL System-Electronic GmbH
Kurzheckweg 8 • D-76187 Karlsruhe
Postfach 210849 • D-76158 Karlsruhe
Tel. 0721/9592-0 • Fax 0721/9592-100