

Application Note #11

Energy Storage Test with PLI Series

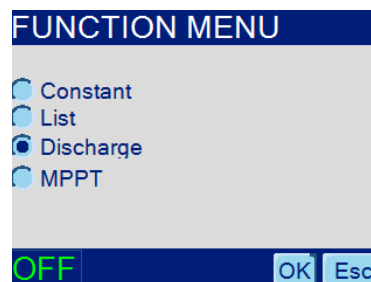
An implemented test function enables discharging energy storages such as accumulators, batteries, ultracaps etc. in an easy way and supplying determined values like charge and energy.

Caution when handling energy storage devices!

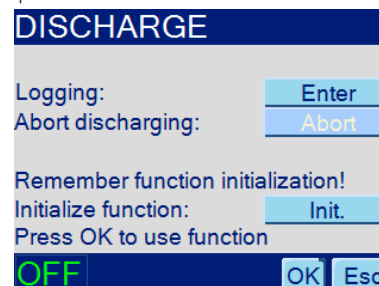


At improper handling irreversible damages up to fire outbreaks can happen to the unit under test. Read the operation and test conditions of your UUT carefully, also the user manual of the electronic load and the connection notes at the end of this document. Do not leave your energy storage unattended while a test is running!

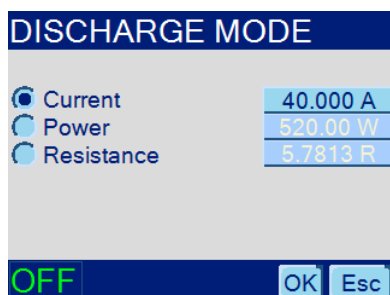
The Discharge function Discharge is selected in the FUNCTION menu.



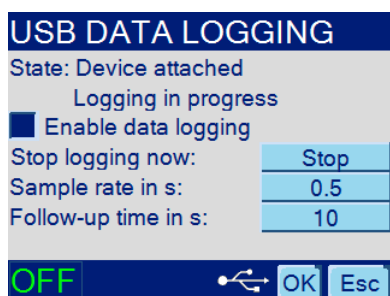
In the DISCHARGE menu you decide whether data are logged to a USB mass storage device and in which operation mode the discharge will proceed.



In the DISCHARGE MODE menu you select the operating mode current, power or resistance and the corresponding setting value for discharge. Confirming by OK, you get to the next menu. The setting value may be varied also later on at the running test.

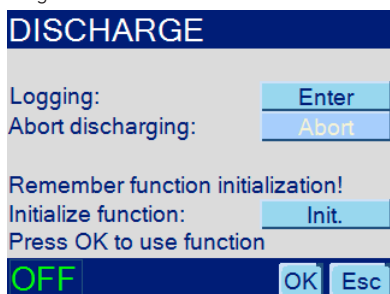


In the USB DATA LOGGING menu the data logging is activated or deactivated. Activation is only possible when an USB MSD is attached.



After activation the sample rate can be set to 0.5 ... 10 s and the follow-up time (duration after test has stopped) up to 999 s.

Confirm with OK to get back to the DISCHARGE menu. Then go to the initialize function by the Init. button to choose the operating mode and the setting value for the discharge.



After choosing the operating mode and the corresponding setting value you automatically are guided to the DISC. STOP COND. menu. Here you activate and define the stop conditions for the discharge.

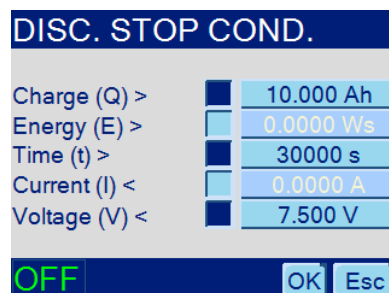
You must activate at least one stop condition, otherwise you won't get to the next menu but will go back to the DISCHARGE MODE menu.

Any number of stop conditions may be activated. The first one detected will stop the discharge. triangle-shaped voltage will be reduced and the power curve will also get smoother. Now the electronic Load is working very close to the MPP.

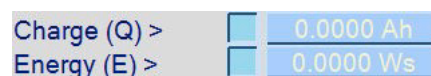


If possible, you shall always activate a second stop condition to protect the UUT.

Example: You discharge a 10000 mAh accumulator down to a minimum voltage X as stop condition. You expect a discharge time of about 30000 s. Additionally set a time stop condition which is a little more than these 30000 s. Furthermore you could activate and set the charge stop condition to the value defined by the specified UUT's capacity.



Charge and energy are checked for overrun. That means discharging is stopped if the cumulated charge or, respectively, the energy is equal or higher than the corresponding stop condition value. The charge condition is well suitable as safety condition (when testing accumulators or batteries; we recommend to set the charge condition to the value of the UUT's capacity).



The time is checked for overrun. That means discharging is stopped if the elapsed time is equal or higher than the corresponding stop condition value. The time is reset when the input is switched on and therefore when the discharging is started.



The voltage is checked for underrun. That means discharging is stopped if the measured voltage is equal or lower than the corresponding stop condition value.



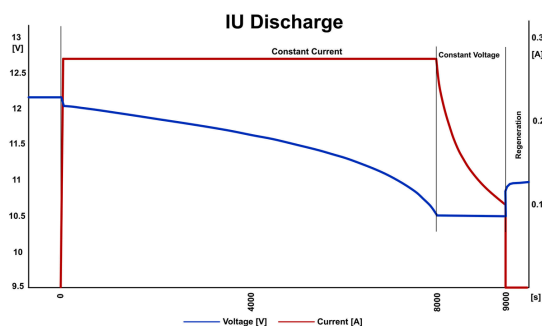
IUa Discharge, CCCV/CPCV/CRCV Discharge

A special discharge mode is to discharge the UUT via an IUa characteristic where it is first loaded in constant-current mode and discharged down to a certain voltage. When this minimum voltage is reached the electronic load implicitly changes to constant-voltage mode and keeps the voltage constant until the measured current is equal or lower than the current stop condition. Only then the load input is switched off and the test is finished.

This works in principle also with constant-power or constant-resistance mode.



Note that the voltage limit at which the electronic load changes to constant-voltage mode is represented by the Voltage Protection (see below).



The PROTECTION menu is the last stage in configuring the discharge function. It is one of the most important things helping to protect the UUT.

Current prot.: The maximum allowable current is set here. The default value is the maximum possible current of the electronic load. Match this value to the maximum tolerable current of your UUT to prevent damage caused by overcurrent, especially in power and resistance operating modes. When discharging in current mode the current protection value shall be a little higher than the discharge current.

Voltage prot.: The minimum allowable voltage to draw current from the UUT is set here. This voltage is controlled by the electronic load's hardware. As When the Current (I) < stop condition is not activated, due to safety reasons you shall set the voltage value so that the UUT won't be deeply discharged or even destroyed. In contrast, when the Current (I) < stop condition is activated the Voltage prot. value is the setting value for transitioning from the discharging operation mode to constant-voltage regulation with current reduction.

PROTECTION [3]

Current prot.: 40.00 A

Voltage prot.: 0.500 V

Volt. prot. mode:

☒ Regulation (CC-CV)

☐ Switching

OFF OK Esc

Measured voltage: Discharge state: stopped

Cumulated charge: Disc. mode: Current

Elapsed test time since Input On: V = 4.524 V I = 0.0000 A

Stop event, only displayed when stop condition fulfilled: Q = 3.340 Ah E = 44.000 Wh

Discharge function active: t = 523 s

Setting: 4.470 A

DISC Ctrl. Mode Input

Local CC Off

State of Discharge function running or stopped

Discharge mode: Current, Power, Resistance

Measured current

Cumulated energy

Stop event at completed or stopped discharge: User abort, time, current, voltage, energy, charge

Setting value: current, power or resistance

Input state: Input On or Input Off

The Log File

The Data Logging function generates a folder named DISCHAR on the USB MSD. Each test generates a file in this folder. The file name is composed of the electronic load's date and time at start of test:

Example: PLI_2016-02-04-01-02-33.CSV

The test was started on Feb 04, 2016 at 1:02.33.

The csv file can be opened with a spreadsheet program such as MS Excel. It contains the following information:

Row 1: Date, time at test start

Row 2: Measured values with units

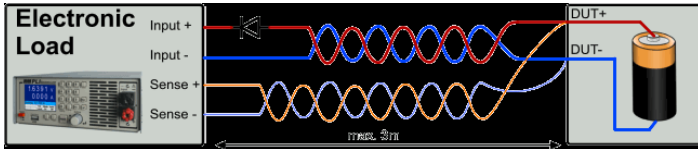
From row 3: Elapsed time, voltage, current

Penultimate row: Date, time at test end

Last row: Stop condition, cumulated charge and energy

Wechseldatenträger (E:)		
DISCHAR		
PLI_2016-02-04_01-02-33.CSV		
;Data log start: 2016-02-04 01:02:33		
;Rel. time in s	Voltage in V	Current in A
0	12.038941	0
1	10.978352	7.99712
2	10.960367	7.997163
3	10.938271	7.997205
4	10.922342	7.997205
5	10.904871	7.997163
6	10.884831	7.997163
7	10.86813	7.997163
8	10.847833	7.997205
9	10.836528	7.997205
10	10.816489	7.997205
11	11.87939	0
12	11.895577	0
13	11.906368	0
14	11.909964	0
15	11.909964	0
;Data log end: 2016-02-04 01:02:48		
;Stop condition: Time	Charge: 0.02199 Ah	Energy: 0.24014 Wh

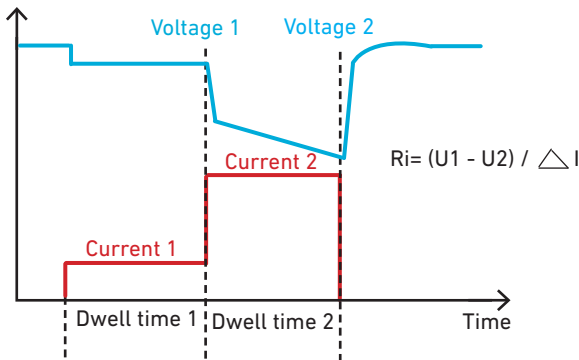
! You must take particular caution when connecting an energy storage device to an electronic load! PLI series loads are protected against reverse polarity up to its nominal current. This is realized by a reverse diode. That means connecting an energy storage device in reverse polarity is similar to a short-circuit. Therefore we recommend to connect an external diode or a fuse into the load circuit as shown:



Another feature of the PLI series loads is the measurement of the internal DC resistance of energy storage systems such as batteries, accumulators, capacitors, as well as cables, power supplies and so on. The R_i determination is based on the voltage reduction during a current change.

The current changes from a low value to a higher value. At the end of each current level the voltage is measured and the voltage difference is divided by the current difference.

These two currents and the associated dwell times are adjustable.



Setting Menus for Internal Resistance Measurement

FUNCTION MENU	RI MEASUREMENT
<input type="radio"/> Constant	Current 1: 5.200 A
<input type="radio"/> List	Dwell time 1: 10.000 s
<input type="radio"/> Discharge	Current 2: 15.000 A
<input checked="" type="radio"/> Ri measurement	Dwell time 2: 3.000 s
<input type="radio"/> MPPT	<input checked="" type="checkbox"/> Save result on USB
	DUT directory: DUT25
	Abort measurement: abort
OFF OK Esc	OFF OK Esc

Load level 1	$I_1 = 5.2000 \text{ A}$	$t_1 = 10 \text{ s}$	stopped	Aktivations state of IRes measurement
Load level 2	$I_2 = 15.000 \text{ A}$	$t_2 = 3 \text{ s}$		Value of dwell time t1 for load level I1
Measured voltage	$V = 12.100 \text{ V}$	$I = 0.000 \text{ A}$		Value of dwell time t2 for load level I2
Elapsed time since start by Input On	$t = 13 \text{ s}$			Measured load current
IRes-function status	$R_i = 0.0325 \text{ mOhm}$			Determined internal resistance at finished test
	Setting: IRes			Indicates that parameters of IRes measurement are set
	IRES	Ctrl. Local	Mode CC	Activation state of load input: Input On or Input Off
			Input Off	

The result of the measurement is displayed at the User Interface and can be saved to a USB flash drive. The data is also available to be read by one of the Data Interfaces.