DATA SHEET

BT2200 Series Charge-Discharge Platform

- Cost-effective, easily configurable Li-Ion cell charge-discharge
- Modular configurations with maximum current from ± 6 A to ± 800 A, up to 256 user channels per chassis
- Supports cell formation and lifetime cell cycling on small and large capacity cells

New Challenges in Li-Ion Cell Formation and Cycling

The future of electric mobility has arrived, and the demand for Li-Ion batteries has dramatically increased. Li-Ion cell manufacturing and test environments are dynamic as massive new investments drive an increase in manufacturing and cycling capacity. The rapid growth of EVs is creating demand for a growing mix of Li-Ion cell types and capacities, while demand from traditional portable applications continues to grow as well.

The entire range of Li-Ion cell manufacturing faces intense pressures related to unit costs, material availability, return on investment, and safety. Cell manufacturers must expand capacity quickly, beginning with a prototype, laboratory-scale, or pilot cell assembly and formation processes for new cell designs. These relatively small "production lines" need versatile formation equipment scaled to the size of the line. Large formation processes dedicated to one cell type and optimized for very high unit volumes cannot meet the needs of quick reconfiguration for a pilot line to handle different cell designs.

Larger cells and new technology are working together to meet consumer demand for longer-range EVs. Also, new technology allows the creation of cells that can charge faster. An affordable cycler can test a sample of cells and determine the cell's cycle life and how the charge rate affects the cell's life. As cell capacity quickly increases, researchers, and manufacturers, need a flexible solution to source and sink larger currents. Also, the solution needs to be cost-effective to deploy in large numbers and test cells with long cycling times.

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Figure 1. BT2203B chassis with 8 BT2204B modules

BT2200 Charge-Discharge Platform

The BT2200 charge-discharge platform is cost-effective and easily configurable for Li-Ion cell formation and lifetime cell cycling. Modular configurations support cells requiring maximum currents ranging from ± 6 A to ± 800 A, with up to 256 cells or channels per chassis. You can quickly deploy different channel configurations as your cell requirements and capacities change by simply changing the external wiring connections to create new parallel combinations of physical channels for cells requiring higher- or lower-current.

The BT2200 series offers two chassis.

- BT2202A charge-discharge chassis 400/480 VAC 3-phase
- BT2203B charge-discharge chassis 200/208 VAC 3-phase

Select from two charge-discharge modules.

- BT2204B charge-discharge module offers thirty-two physical channels capable of up to ± 6.25 A charge-discharge, and 6 V. Create a user-defined channel with twice the current by connecting two channels in parallel. Triple the current using three channels. Paralleling all 32 channels provides a charge-discharge current of up to ± 200 A.
- BT2205A charge-discharge module has two physical channels, each capable of up to ± 100 A charge-discharge and 6 V. Parallel the two physical channels create a single user channel up to ± 200 A. Physical channels on more than one BT2205A module can be in parallel for even higher current up to ± 800 A.
- Up to eight modules fit in a single chassis. All modules in a chassis need to be the same type, either all BT2204B or BT2205A.

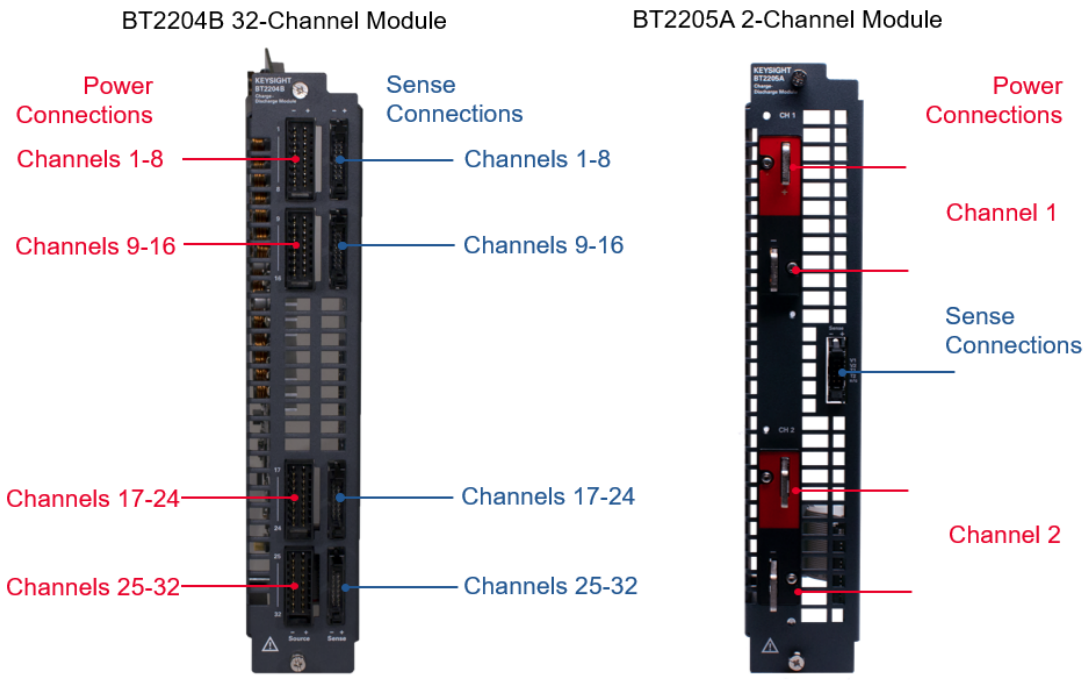


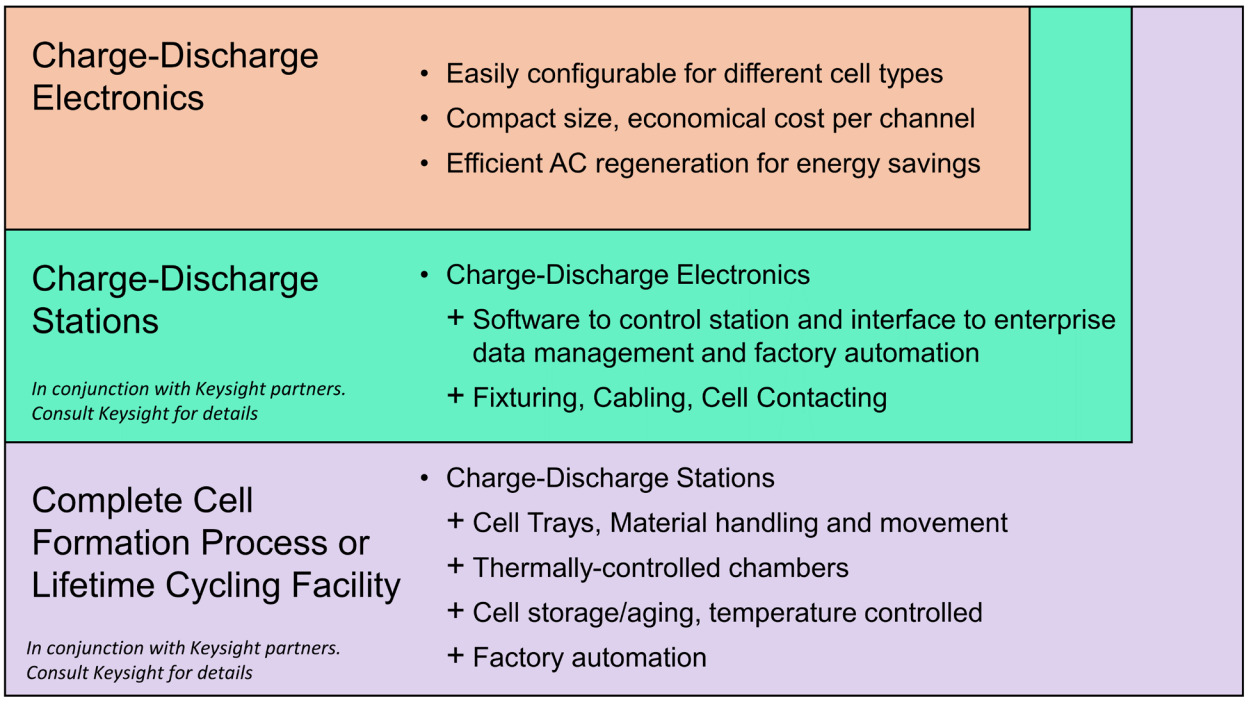
Figure 2. Charge-discharge module channel connections

Figure 3. Standard connectors simplify wiring

Multiple Cell-Formation and Lifetime Cycling Solutions to Fit Your Process

Keysight can work with you on your formation process or lifetime-cycler project to provide the right level of capability for your application. Keysight can provide:

- The BT2200 hardware that you integrate into your systems.
- Stations combining the charge-discharge hardware, cabling and fixturing, and the software to manage station operation and all your test data.
- A complete process for cell formation or lifetime cell cycling, that builds upon stations and adds cell trays, material handling, temperature chambers and aging facilities.



The BT2200 platform uses highly efficient AC power regeneration during cell discharge to reduce net energy consumption to lower your operating costs. This generates less heat in the electronics, and less waste heat that needs removing in your facility. The compact size of the BT2200 platform reduces the floor space you need to devote to your formation or cell cycling process and decreases capital expenses.

Accurate 4-wire measurements of current, voltage, and capacity are made once per second. 4-wire sensing assures proper voltage sourcing, measurements, and charge-discharge limits at the cells.

Figure 4. 4-wire connections (power and sense) to cells enable accurate measurements even with long cables to your fixture

Program the charge-discharge system through either USB or LAN.

Create up to 256 unique sequences, and each sequence may contain up to 50 steps. A step starts a charge, discharge, pre-charge, rest state, or a DC internal resistance (DCIR) measurement. During a DCIR measurement a user-defined DC pulse determines the cells internal resistance. Additionally, create up to 24 test conditions per step, which the system evaluates every second.

The user-defined test conditions monitor the following parameters during individual steps: Voltage, Current, Power, Amp*Hours, Watt*Hours, ΔV/Δt, ΔI/Δt, ΔV, ΔI. Once conditions exceed the limits, the system considers the cell as failed, and further charging/discharging of that cell stops while other cells continue with the sequence.

The BT2200 platform includes a “probe check” capability to assure good connections to your cells. Probe check tests the integrity of the power and sense leads on each channel at the beginning of charge-discharge operations before connecting to a cell and monitored continuously thereafter.

An internal calibration source is calibrated by external equipment at a one-year interval. Calibration of all individual channels use an internal transfer calibration process from the internal source.

Separate charge, discharge, and pre-charge modes provide limits to protect cells and ensure safety. Figures 5 and 6 illustrate the limits of each of the three modes.

BT2204B Operating Characteristics

Define a user channels right for your cell by paralleling physical channels. The BT2204B charge-discharge module has 32 physical channels. Each physical channel rated at ± 6.25 A.

Example user-defined channel configurations for BT2204B charge-discharge module

Default configuration: 32 physical channels each with up to 6 V or ± 6.25 A			
Max current per user channel	**Max power per user channel at module terminals**	**Number of physical channels per user channel**	**Maximum number of cells per mainframe using 8 modules**
± 6.25 A	27.34 W	1	256

Create higher current user-defined channels by parallel physical channels			
Max current per user channel	**Max power per user channel at module terminals**	**Number of parallel physical channels per user channel**	**Maximum number of cells per mainframe using 8 modules**
± 25 A	109.38 W	4	64
± 50 A	218.75 W	8	32
± 100 A	437.5 W	16	16
± 200 A	875.0 W	32	8

Physical channel charge-discharge power limits – BT2204B module

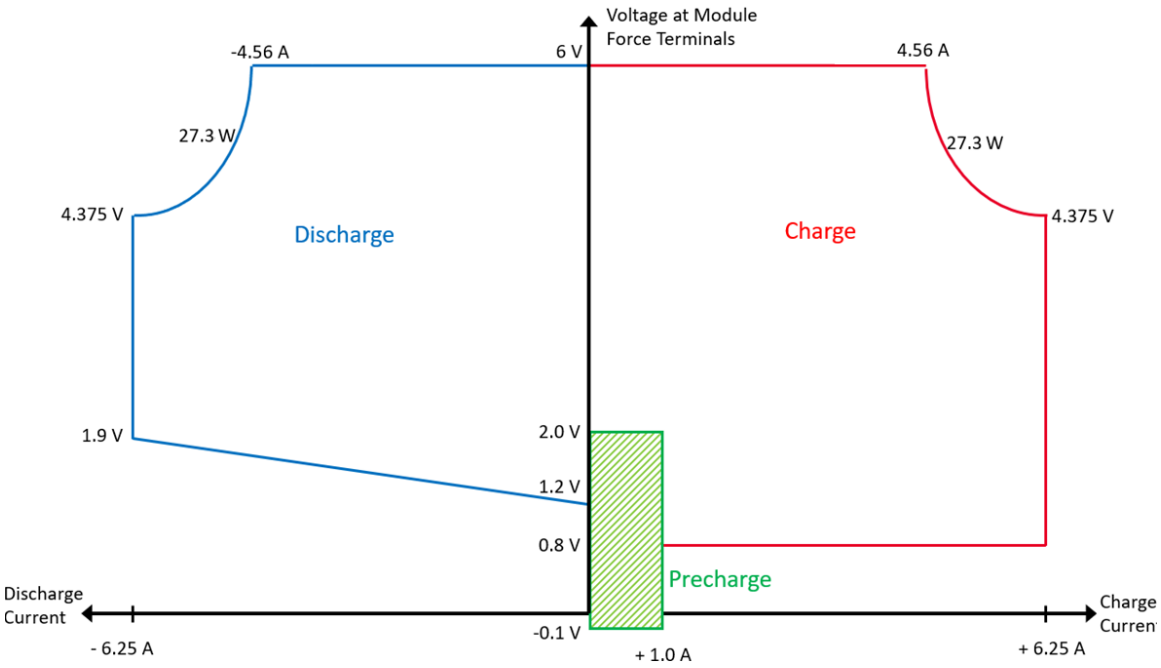


Figure 5. BT2204B charge-discharge power operating limits for one physical channel.

BT2205A Operating Characteristics

The BT2205A is for testing larger cells with higher current, it has two ± 100 A physical channels. Create user-defined channels with higher test currents by combining multiple physical channels.

Example user channel configurations for BT2205A charge-discharge module

Default configuration: 2 physical channels each with up to 6 V or ± 100 A				
Max current per user channel	**Max power per user channel at module terminals**	**Number of physical channels per user channel**	**Number of modules**	**Cells per mainframe using 8 modules**
± 100 A	437.5 W	1	1	16

Create higher current user defined channels by paralleling physical channels and modules				
Max current per user channel	**Max power per user channel at module terminals**	**Number of parallel physical channels per user channel**	**Number of modules**	**Cells per mainframe using 8 modules**
± 200 A	875.0 W	2	1	8
± 400 A	1750 W	4	2	4
± 600 A	2625 W	6	3	2
± 800 A	3500 W	8	4	2

Physical channel charge-discharge power limits – BT2205A module

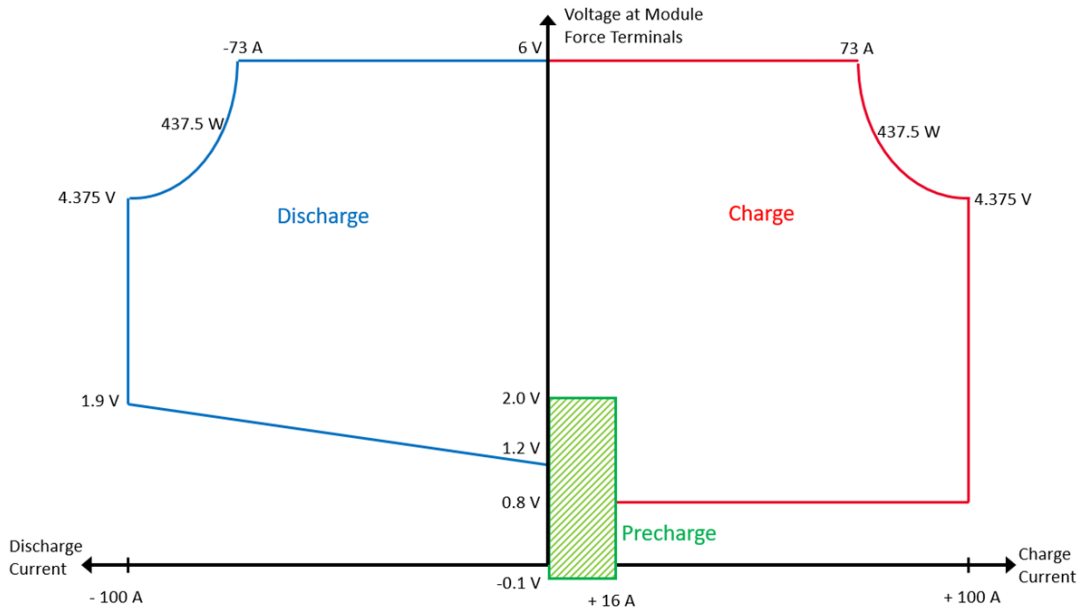


Figure 6. BT2205A charge-discharge power operating limits for one physical channel.

The tables above provide common example configurations for user-defined channels, but both modules offer much greater flexibility. For a complete set of possibilities, refer to the BT2200 Charge-Discharge Platform Configuration Guide or the BT2200 Operating & Service Guide. After configuring the hardware, the user-defined channels simplify programming by acting as a single output with a higher current.

General Characteristics

Parameter	BT2202A Charge-Discharge Chassis 400/480 VAC 3-phase	BT2203B Charge-Discharge Chassis 200/208 VAC 3-phase
Charge power limit	7 kW (sum of charging power on all channels simultaneously)	7 kW (sum of charging power on all channels simultaneously)
Discharge power limit	7 kW (sum of discharging power on all channels simultaneously)	7 kW (sum of discharging power on all channels simultaneously)
ACV input phase and range	3-phase; 400 VAC nominal +10% to -15% 3-phase; 480 VAC nominal ± 10%	3-phase; 200 VAC nominal ± 10% 3-phase; 208 VAC nominal ± 10%
Maximum input VA	11 kVA	11 kVA
Maximum input current per phase	19 A	39 A
Power factor	0.99 at nominal input and rated power	0.99 at nominal input and rated power

	Description
Programming interfaces	USB and LAN
GPIO	Configurable digital IO for fault monitoring and shutdown
BT2202A/BT2203B Chassis dimensions (WxHxD)	610 mm (24 in) x 310 mm (12.2 in) x 700 mm (27.5 in)
BT2202A/BT2203B Chassis weight	28.0 kg (61.7 lbs)
BT2204B Module weight	1.8 kg (4 lbs)
BT2205A Module weight	1.8 kg (4 lbs)

BT2200 Configuration and Ordering Information

1. Select which chassis to use depending on your AC mains supply:
    - BT2202A charge-discharge chassis 400/480 VAC 3-phase
    - BT2203B charge-discharge chassis 200/208 VAC 3-phase

2. Select which charge-discharge modules to use, depending on the amount of charge-discharge current you need for your user channels. Add up to 8 charge-discharge modules in any one chassis. Select a single type of module for each chassis, either the BT2204B or BT2205A modules.

    - BT2204B charge-discharge module. Thirty-two physical channels are capable of up to ± 6.25 A charge-discharge and 6 V per physical channel. Create user-defined channels with two parallel channels for ± 12.5 A, three parallel channels for 18.75A, etc. Combine up to 32 physical channels on each module in parallel groups for ± 200 A user-defined channels. It is not possible to parallel physical channels across more than one BT2204B module.
    - BT2205A charge-discharge module 2-Channel 100A. This module has two physical channels, each capable of up to ± 100 A charge-discharge and 6 V. Parallel the two physical channels on one BT2205A to create a higher-current user channel rated up to ± 200 A of charge-discharge current. The four physical channels on two modules can be in parallel to create a ± 400 A user channel. Up to eight physical channels on four modules can be in parallel to create a ± 800 A user channel. Please refer to the BT2200 charge-discharge platform BT2200 Charge-Discharge Platform Configuration Guide.

3. Select BT2206A filler panels. Cover any empty slots in a chassis not containing a charge-discharge module with one BT2206A filler panel per empty slot.

In addition, to the number of physical channels it is also important to consider power per physical channel, minimum voltage, and the voltage drop in the wiring.

- A physical channel cannot output the max current at the max voltage as the combination exceeds the channel power limit. Refer to the upper corners of the operating ranges shown in Figures 5 and 6.
- Figures 5 and 6 also show the minimum module terminal voltage supported at any specific value of charge-discharge current.
- There is a limit to the difference in the voltage at the cell vs. the voltage at the output terminals of the charge-discharge module. The difference is due to the voltage drop across the resistance of your wiring, connectors, and cell contacting. The resistance of the wire, determined by wire length and wire gauge (diameter), can be critical to a successful operation. Likewise, the resistance of the connectors and contacts in the current path can also be essential to functioning correctly. These factors become increasingly important at higher current levels.

For more information on the BT2200 charge-discharge platform, please visit www.keysight.com/find/BT2200 or contact your Keysight representative.

A New Way of Looking at Li-Ion Cell Self-Discharge

Li-Ion manufacturing combines cell formation and test processes to achieve the optimum mix of cost, quality, yield, process efficiency, inventory, and return on capital invested. Keysight Technologies has developed a new method of cell self-discharge measurement to improve formation and test processes. This new method of self-discharge measurement provides:

- Revolutionary improvements in the time required to discern good vs. bad cell self-discharge performance in manufacturing.
- Dramatic reductions in work-in-process, working capital, and facility costs.
- Elimination of days or weeks of cell storage time.

Traditionally, self-discharge isn't a complicated measurement – it's relatively straightforward to measure how the open-circuit voltage (OCV) of cells changes over time. The issue is how long it takes for that OCV to change enough to reliably tell whether the self-discharge of your cells is within acceptable limits.

Cell manufacturers keep far greater numbers of cells in work-in-process inventory than they would like because of the time required to measure the change in cell OCV. That negatively impacts work-in-process inventory metrics, and it consumes expensive floor space to hold that inventory in temperature-controlled environments.

BT2152B Self-Discharge Analyzer

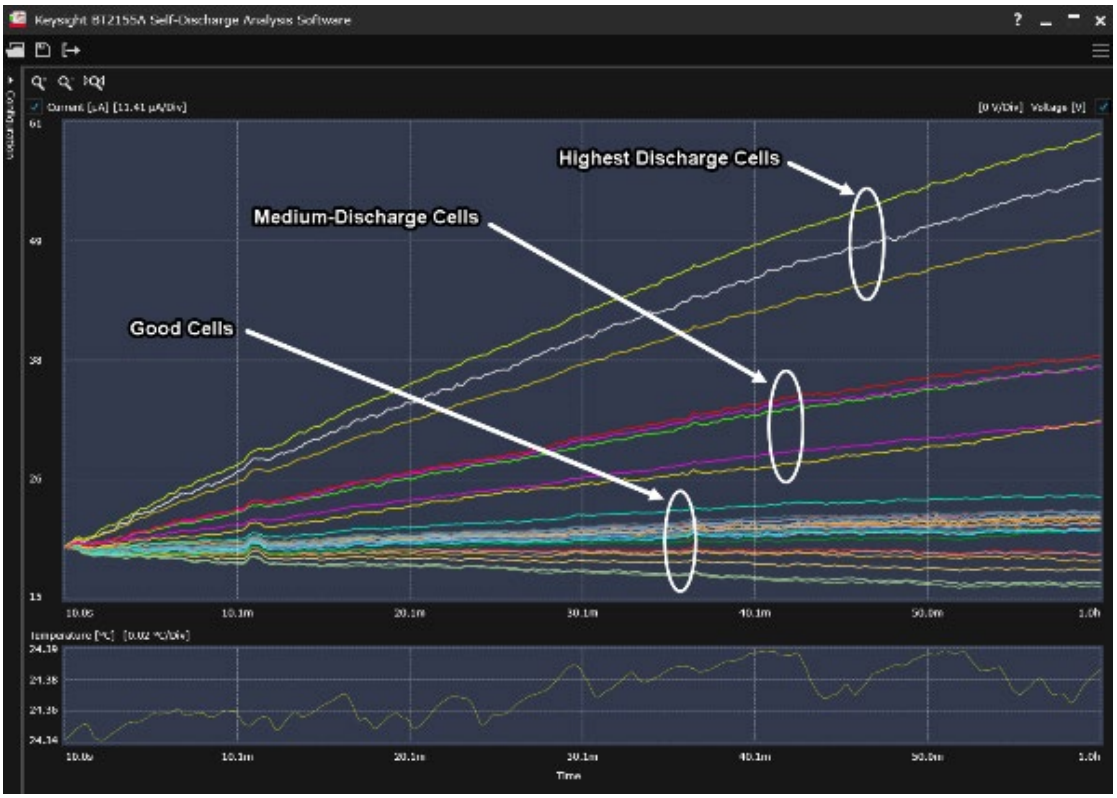
The BT2152B self-discharge analyzer quickly and accurately measures cell self-discharge current on up to 32 cells. Keysight's patented implementation of the measurement technique delivers a revolutionary reduction in the time required to discern good vs. bad self-discharge performance.

Testing indicates that for smaller cells like cylindrical 18650 or 2170 cells, the BT2152B can measure the self-discharge current in as little as 1 hour. And for larger capacity pouch cells (e.g., 10-60 Ah), the BT2152B can do this is in 1-2 hours. That measurement time is much less than the days or weeks required to detect enough change in the cell's open-circuit voltage reliably.

And of more significant impact in cell manufacturing, the analyzer's measurements allow you to see a clear difference in the self-discharge current of good vs. bad cells in typically less than 30 minutes.

The display below shows a 1-hour test of 32 2.5 Ah 18650 cells.

You can see which current measurement traces belong to the high- and medium-discharge cells. The current measurement traces of the good cells are bunched together at about 20 µA. The difference between the good cells and the bad cells is apparent within 20 minutes. A self-discharge measurement that fast will have a clear impact on cell aging times.



For more information on how you can integrate this new method of cell self-discharge measurement into your manufacturing processes, please visit www.keysight.com/find/Self-Discharge and/or contact your Keysight representative.

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

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