ARBIN INSTRUMENTS

LBT
Module HC

Linear Battery Testing For High Power Module Applications

Why Does Precision Matter?

Measurement precision is more critical for long-term testing and long-term projections than control accuracy alone. Most other battery testing systems do not correctly specify their precision and/or have relatively poor precision, which hinder the conclusions drawn from results data. Important trends and electrochemical indicators may remain unnoticed; lost in the measurement noise.

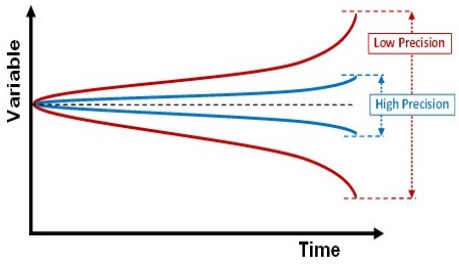
Derived from Arbin's ARPA-E project with Ford Motor Company and Sandia National Lab, our new Precision series of equipment incorporates technology developed during this time. High precision current and voltage measurements, and allows for more accurate columbic efficiency, energy efficiency, and dQ/dV calculations than was previously achievable with a commercially available testing system.

What Affects Tester Precision

- Resolution of DAC
- Resolution of ADC
- Non-linearity of calibration
- Short-term drift (temperature)
- Long-term drift (material properties)

Arbin Tester Improvements

- Higher Resolution
- Improved software algorithms
- New ways of temp. management
- New patented shunt design
- New materials
- New method of time keeping



Product Description

Arbin's Linear Battery Testing series commercializes technology established during a 3-year ARPA-E project developing ultra-high precision testing systems. This product consists of independent potentiostat, galvanostat channels for testing batteries and other electrochemical devices, and is intended to provide an economical, yet expandable solution for applications requiring high-precision measurements and fast data sampling. All Arbin testing systems come with a PC preloaded with our MITS 7 and Data Watcher software for creating test profiles, real-time data monitoring, and data plotting and analysis.

Model	Voltage Range	Current Ranges
LBT 40V-20A	0V to 40V	20A/5A/100mA
LBT 40V-75A	0V to 40V	75A/10A/500mA
LBT 40V-150A	0V to 40V	150A/10A/500mA
LBT 60V-15A	0V to 60V	15A/5A/100mA
LBT 60V-50A	0V to 60V	50A/10A/500mA
LBT 60V-100A	0V to 60V	100A/10A/500mA
LBT 100V-10A	0V to 100V	10A/1A/100mA
LBT 100V-30A	0V to 100V	30A/5A/100mA
LBT 100V-90A	0V to 100V	90A/10A/500mA

PRECISION POWERED BY ARBIN

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Product Highlights

- Each channel provides three current ranges with *16-bit resolution*
- Powerful embedded controllers provide fast data logging (*2000 points per second, per system*) and control flexibility for the most advanced test requirements
- Communicate with internal battery management system (BMS) via CANBus protocols
- Simulate complex test profiles directly from a data file of time-vs-power or time-vs-current data

Primary Applications

- R&D for Battery and Supercapacitor modules
- Simulation of real world test profiles
- Validate internal battery management system using CANBus protocols
- Life Cycle Testing
- Cranking amp tests

Product Features

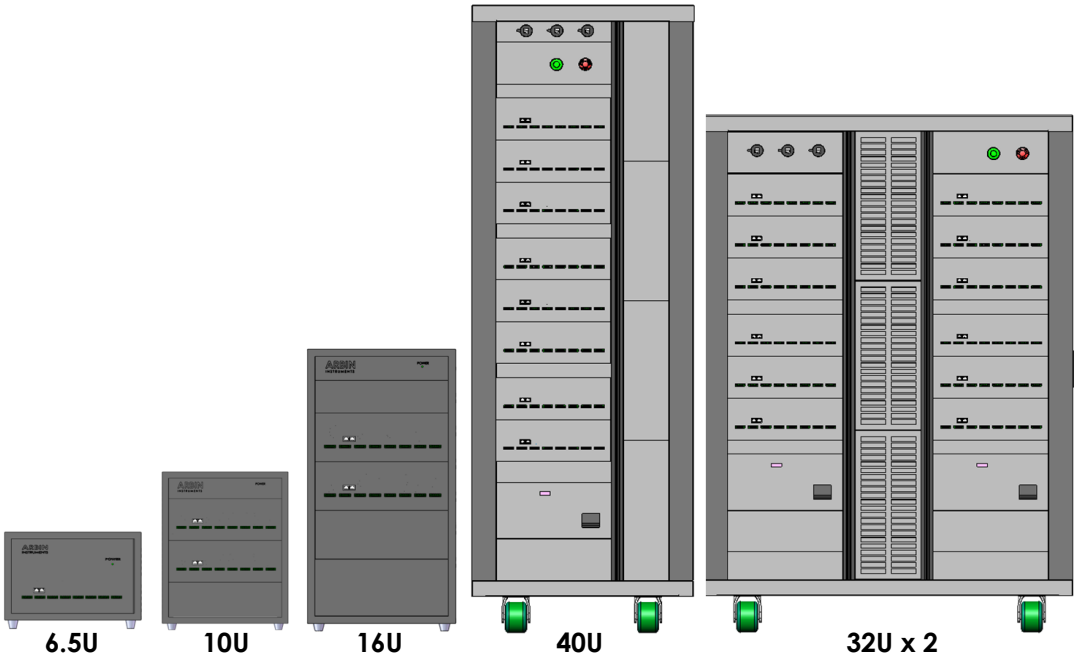
- Fully independent high precision test channels with full potentiostatic, galvanostatic control.
- Uses *true Bipolar Linear* circuitry providing cross-zero linearity and zero switching time between charge and discharge.
- Any number of channels can be operated in *parallel* for increased current-handling capacity.
- Each channel in the test station is safely controlled by a user-defined individual voltage clamp set in the software and applied at the hardware level.
- A wide array of auxiliary inputs/outputs are available for additional data collection or control such as temperature monitoring, additional reference electrodes, and more.
- Arbin's advanced software package, MITS 7.0, provides flexible scheduling, a user-friendly interface, distributed system control, and data acquisition.
- Software provides easy data analysis and plotting based in Data Watcher and Microsoft Excel.

Chassis Sizes

(W x D x H) Inches
16" X 17" X 14"
16" X 22" X 24"
16" X 22" X 35"
27" X 32" X 65"
27" X 32" X 79"
45" X 32" X 65"

† up to 4 units may be combined.

‡ up to 2 units may be combined.



Hardware Specifications

Model		LBT 40V-20A	LBT 40V-75A	LBT 40V-150A
Voltage	Control Range (min/max)	0V to 40V	0V to 40V	0V to 40V
	Measurement Resolution	~1mV (16-bit)	~1mV (16-bit)	~1mV (16-bit)
	Measurement Precision	< 100ppm	< 100ppm	< 100ppm
	Control Accuracy	< ± 0.02%	< ± 0.02%	< ± 0.02%
	Input Impedance	4M Ohm	4M Ohm	4M Ohm
Current	Standard Ranges	20A/5A/100mA	75A/10A/500mA	150A/10A/500mA
	Noise Free Resolution	0.0015% (16-bit)	0.0015% (16-bit)	0.0015% (16-bit)
	Measurement Precision	< 100ppm	< 100ppm	< 100ppm
	Control Accuracy	< ± 0.02%	< ± 0.02%	< ± 0.02%
	Minimum V at Maximum Current	40V @ 20A	40V @ 50A	40V @ 120A
	Current Rise Time*	~1mS	~1mS	~1mS
	Max Continuous Power Output per Channel	800W	2,000W	4,800W

Model		LBT 60V-15A	LBT 60V-50A	LBT 60V-100A
Voltage	Control Range (min/max)	0V to 60V	0V to 60V	0V to 60V
	Measurement Resolution	<2mV (16-bit)	<2mV (16-bit)	<2mV (16-bit)
	Measurement Precision	< 100ppm	< 100ppm	< 100ppm
	Control Accuracy	< ± 0.02%	< ± 0.02%	< ± 0.02%
	Input Impedance	4M Ohm	4M Ohm	4M Ohm
Current	Standard Ranges	15A/5A/100mA	50A/10A/500mA	100A/10A/500mA
	Noise Free Resolution	0.0015% (16-bit)	0.0015% (16-bit)	0.0015% (16-bit)
	Measurement Precision	< 100ppm	< 100ppm	< 100ppm
	Control Accuracy	< ± 0.02%	< ± 0.02%	< ± 0.02%
	Minimum V at Maximum Current	60V @ 20A	60V @ 50A	60V @ 120A
	Current Rise Time*	~1mS	~1mS	~1mS
	Max Continuous Power Output per Channel	1,200W	3,000W	7,200W

*Time required for current output to get from 10%-90% of requested value; there is no switching time between charge and discharge.

Hardware Specifications cont.

Model		LBT 100V-10A	LBT 100V-30A	LBT 100V-90A
Voltage	Control Range (min/max)	0V to 100V	0V to 100V	0V to 100V
	Measurement Resolution	~3mV (16-bit)	~3mV (16-bit)	~3mV (16-bit)
	Measurement Precision	< 100ppm	< 100ppm	< 100ppm
	Control Accuracy	< ± 0.02%	< ± 0.02%	< ± 0.02%
	Input Impedance	4M Ohm	4M Ohm	4M Ohm
Current	Standard Ranges	10A/1A/100mA	30A/5A/100mA	90A/10A/500mAS
	Noise Free Resolution	0.0015% (16-bit)	0.0015% (16-bit)	0.0015% (16-bit)
	Measurement Precision	< 100ppm	< 100ppm	< 100ppm
	Control Accuracy	< ± 0.02%	< ± 0.02%	< ± 0.02%
	Minimum V at Maximum Current	100V @ 20A	100V @ 50A	100V @ 120A
	Current Rise Time*	~1mS	~1mS	~1mS
	Max Continuous Power Output per Channel	2,000W	5,000W	12,000W

*Time required for current output to get from 10%-90% of requested value; there is no switching time between charge and discharge.

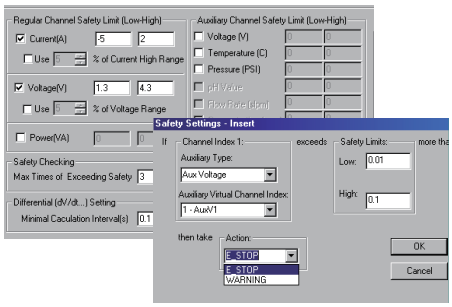
Product Specifications

Time	**Minimum Step Time**	5ms
	Data Logging Rate	2000 points per second, per system
	Measurement Resolution	100µs
Bipolar Linear Circuit Type		Allows cross-zero linearity and no switching time between charge/ discharge
Connection for Batteries		4-Pin I/V Cable with alligator clips Option: Various battery holders for cylindrical cells or flat cells.
Connection for Computer		TCP/IP (Ethernet)
Ventilation Method		Air cooled, *variable speed* fans
Computer Specifications		PC with i7 CPU, 22" flat-screen monitor is included, preloaded with our MITS Pro testing software

Safety Features

All Arbin test stations are designed and manufactured based on industry regulations and arrive CE certified. The Arbin system includes an array of safety features that protect the user, the devices under test, and the test station.

- The system itself is secure internally to protect from unintentional misuse. The system is equipped with an emergency stop button and multiple levels of fusing are provided inside the system for protections at the channel/board and power supply level. Arbin's Watchdog circuit monitors the machine's internal communication between the PC and onboard microcontrollers and will stop all tests if there is a failure that poses a risk. A light tower array is used to visually alert the user to potential problems and the PC can be programmed to sound an audible alarm.



- The user is able to implement safety limits in the software for current, voltage, total power, as well as temperature or other auxiliary readings. These values can be programmed to send the system into a rest state for a period of time, or simply stop the test and disconnect the charge/discharge circuitry. There are separate limits available for each test schedule as a whole, and individual steps within the test schedule.

- A Redundant Safety System can be provided to independently monitor the devices under test, and can disconnect the device if a safety setting has been exceeded. Safety is the highest priority when testing high power devices, and Arbin's Redundant Safety System provides an additional safety system, independent of the Arbin hardware and software, to ensure a safe testing environment. The system has the ability to monitor current, voltage, and temperature. If any user-defined safety settings are reached, the device under test will be disconnected from the Arbin test channel. A hardware interlock can also be provided with this system to completely power off the Arbin test station.

- The reliability of testing can be increased even further by adding a smart UPS to the controlling PC. This will allow tests to automatically resume after a brief power failure if they are in a safe condition and permits user intervention in the process. There is provision for the user to intervene if desired before the channels resume. This is an essential component for any user with an unreliable power source unless the entire facility is on backup power.

Available Auxiliary Options

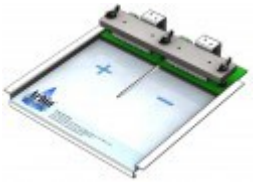
Arbin Instruments provides a wide variety of auxiliary modules for expanding the capability of the main charge/discharge control circuitry. Modules can either be placed in the main chassis, or in a small external chassis.

Auxiliary Voltage	Used as additional reference electrodes to measure voltage.
Temperature	Thermocouple/Thermistor used to record temperature as well as control the test schedule.
MTCI (Chamber Interface)	Interface with a 3rd party temperature chamber so Arbin software can turn chamber on/off and adjust temperature.
Digital I/O	Send and receive a simple on/off signal to interact with external devices.
Analog I/O	Control any device operating on a 0(2)-10V signal.
UPS	Uninterrupted power supply for PC so tests can resume automatically after brief power outages.
RSMS	An external, fully independent multi-channel programmable relay with touch interface that allows users to set additional safety limits for voltage, current, power and temperature.
For more information please visit: www.arbin.com/products/accessories/auxiliaries.htm	

Available Accessories

Battery Connections

A variety of battery holders are available for cylindrical cells and flat/ pouch cells.



Software Control Specifications

Current† (A) Outputs constant current to the cell or battery at the value specified. Positive current refers to charge and negative current refers to discharge.	**Voltage Cycle V** This mode, commonly called Cyclic Voltammetry, permits the user to create linear sweeps in one step, eliminating the need to jump steps to reverse sweep directions.
Voltage† (V) Outputs constant voltage to the cell or battery at the value specified. Outputs constant voltage to the cell or battery at the value specified.	**Current and Power Simulation†** Non-standard time-domain functions may be inputted from external sources such as ASCII data streams and used as control parameters for repetitive tests.
C-Rate† C-Rate is a method for indicating the discharge as well as the charge current of a battery. It can be expressed as I=M*C where I=current (A); C=battery capacity; M is the C-rate value.	**DC Internal Resistance** This function applies a 10-pulse train with 1ms pulse width of the specified magnitude following a constant-current charge or discharge step.
Rest† The battery is disconnected from the charge/discharge circuit but remains connected to the voltage measurement circuit to enable open-circuit voltage measurement.	**Formula†** Equips the user to control and limit schedule steps according to dynamic mathematical equations in addition to constants or instantaneous channel data.
Power† (W) Outputs constant power to the cell of battery at the value specified. Outputs constant power to the cell of battery at the value specified.	**End Conditions** Time, Voltage, Current, Capacity, Energy, ΔV, DV/dt, formula, meta-variables, and other combinations.
Load† (Ohm) Applies a constant resistance load to the battery at the value specified. The load control type will always produce a negative current.	**Current Staircase†/Voltage Staircase** Generates a current/voltage staircase with increasing current/voltage, and negative decreasing current/voltage staircase with adjustable step amplitude.
Current Ramp†/Voltage Ramp Generates a current/voltage ramp with a positive scan rate for increasing current/voltage, and negative scan rate generates decreasing current/voltage ramp.	**Safety Check** Includes control value check (Current, Voltage, Power), abnormal behavior check (Step Time, Capacity/Energy), and irregular impedance check.
Set Variables† Change test related variables including channel capacity, energy and all test counter variables.	**Network Capabilities** Provide TCP/IP access for networking.
Channel Paralleling Channels may be operated in parallel for increased current-handling capabilities. NOTE: Control types marked with (†) are available in parallel mode.	**Data File Content** Channel data; test time, step time, voltage, current, capacity, energy, first/second derivative of I or V, auxiliary input data (optional). Statistical data: cycle number, cycle capacity/energy, max voltage, etc.

Control types marked with (†) are available in parallel mode