ARBIN INSTRUMENTS

LBT Cell

# Linear Battery Testing for Cell 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.

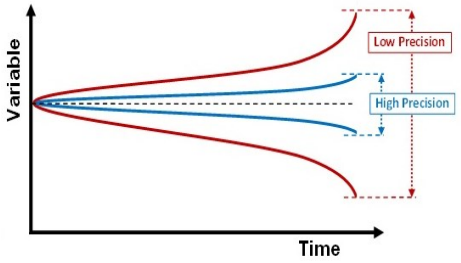
Derived from Arbin's ARPA-E project with Ford Motor Company and Sandia National Lab, our new Precision series of equipment incorporates technology developed during this time. High precision current and voltage measurements, and allows for more accurate columbic efficiency, energy efficiency, and dQ/dV 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 ±5V-200mA** | -5V to 5V | 200mA/10mA/1mA/100µA |
| **LBT ±5V-1A** | -5V to 5V | 1A/50mA/2mA/100µA |
| **LBT ±5V-5A** | -5V to 5V | 5A/500mA/20mA/1mA |
| **LBT ±5V-10A** | -5V to 5V | 10A/500mA/20mA/1mA |
| **LBT 5V-5A** | 0V to 5V | 5A/500mA/20mA/1mA |
| **LBT 5V-10A** | 0V to 5V | 10A/500mA/20mA/1mA |

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## Product Highlights

- Allows integration with an approved EIS module for performing scanning AC impedance measurements.
- Each channel provides four current ranges with industry-leading *24-bit resolution*
- Powerful embedded controllers provide fast data logging (*2000 points per second, per system*) and control flexibility for the most advanced test requirements

## Primary Applications

- Electrochemistry, Battery & Supercapacitor Testing
- HPC Measurements (Coulombic Efficiency)
- Electrochemical Research and Development
- Half-Cell Testing and Materials Research
- Life Cycle Testing
- Simulation of real world test profiles

## Product Features

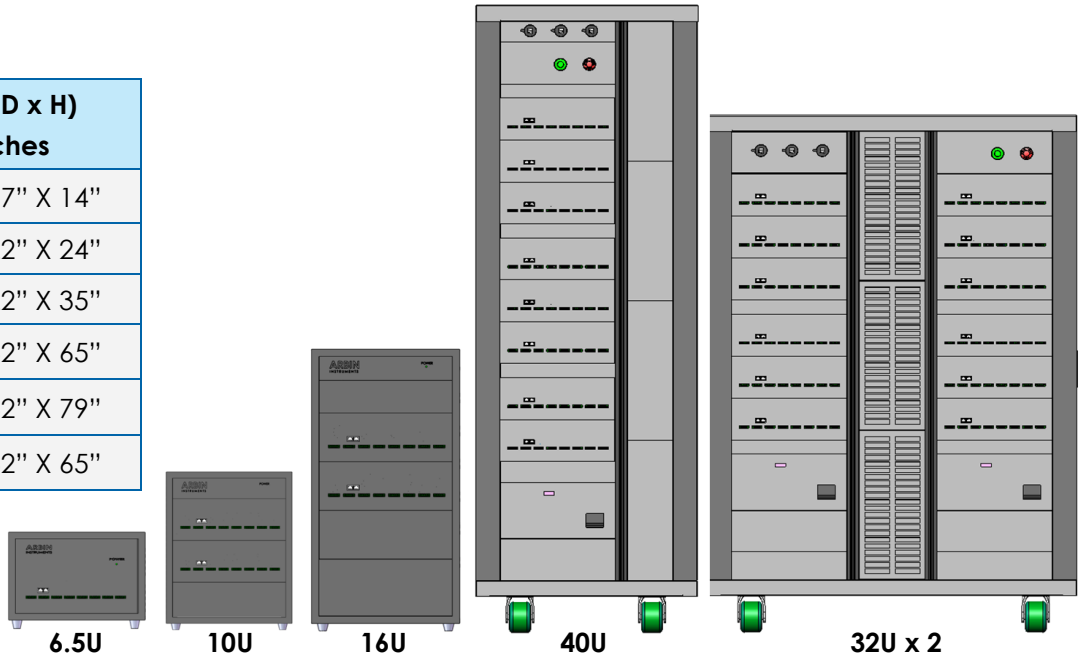
- Fully independent high precision test channels with full potentiostatic, galvanostatic control.
- Uses *true Bipolar Linear* circuitry providing cross-zero linearity and zero switching time between charge and discharge.
- Any number of channels can be operated in *parallel* for increased current-handling 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

| Channel Size | (W x D x H) Inches |
|---|---|
| 8 channels † | 16" X 17" X 14" |
| 16 channels ‡ | 16" X 22" X 24" |
| 24 channels | 16" X 22" X 35" |
| 48 channels | 27" X 32" X 65" |
| 64 channels | 27" X 32" X 79" |
| 96 channels | 45" X 32" X 65" |

† up to 4 units may be combined.

‡ up to 2 units may be combined.

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Specifications subject to change without notice.

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## Hardware Specifications

| Model | | LBT ±5V-200mA | LBT ±5V-1A | LBT ±5V-5A |
|---|---|---|---|---|
| Voltage | Control Range (min/max) | -5V to 5V | -5V to 5V | -5V to 5V |
| | Measurement Resolution | <1μV (24-bit) | <1μV (24-bit) | <1μV (24-bit) |
| | Measurement Precision | < 100ppm | < 100ppm | < 100ppm |
| | Control Accuracy | < ± 0.02% | < ± 0.02% | < ± 0.02% |
| | Input Impedance | 10G Ohm | 10G Ohm | 10G Ohm |
| Current | Standard Ranges | 200mA/10mA/1mA/100μA | 1A/50mA/2mA/100μA | 5A/500mA/20mA/1mA |
| | Noise Free Resolution | 0.0003% (18-bit) | 0.0003% (18-bit) | 0.0003% (18-bit) |
| | Measurement Precision | < 100ppm | < 100ppm | < 100ppm |
| | Control Accuracy | < ± 0.02% | < ± 0.02% | < ± 0.02% |
| | Minimum V at Maximum Current | -5V @ 200mA | -5V @ 1A | -5V @ 5A |
| | Current Rise Time* | ~100μS | ~100μS | ~100μS |
| | Max Continuous Power Output per Channel | 1W | 5W | 25W |

| Model | | LBT ±5V-10A | LBT 5V-5A | LBT 5V-10A |
|---|---|---|---|---|
| Voltage | Control Range (min/max) | -5V to 5V | 0V to 5V | 0V to 5V |
| | Measurement Resolution | <1μV (24-bit) | <1μV (24-bit) | <1μV (24-bit) |
| | Measurement Precision | < 100ppm | < 100ppm | < 100ppm |
| | Control Accuracy | < ± 0.02% | < ± 0.02% | < ± 0.02% |
| | Input Impedance | 10G Ohm | 10G Ohm | 10G Ohm |
| Current | Standard Ranges | 10A/500mA/20mA/1mA | 5A/500mA/20mA/1m | 10A/500mA/20mA/1m |
| | Noise Free Resolution | 0.0003% (18-bit) | 0.0003% (18-bit) | 0.0003% (18-bit) |
| | Measurement Precision | < 100ppm | < 100ppm | < 100ppm |
| | Control Accuracy | < ± 0.02% | < ± 0.02% | < ± 0.02% |
| | Minimum V at Maximum Current | -5V @ 10A | 0V @ 5A | 0V @ 10A |
| | Current Rise Time* | ~100μS | ~100μS | ~100μS |
| | Max Continuous Power Output per Channel | 50W | 25W | 50W |

*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<br>Option: Various battery holders for coin cells, 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

- Multiple levels of internal fusing and over-temperature control measures
- System watchdog and over-charging / over-discharging protection.
- Testing schedules can have layers of global and step-driven safety limits for voltage, current and power.
- Logic-driven scheduling interface allows for additional safety layers based on testing inputs, including Tests begin with a built-in logic check of all control values.
- Tests begin with a built-in logic check of all control values

## Training & Support

Arbin's knowledgeable customer service team is well-known throughout the industry for their responsiveness and dedication. Application engineers are always available by phone or email, and with equipment running in over 50 countries, Arbin has experienced support technicians nearby to help install equipment, answer questions, and provide any repairs that may be necessary over the life of your system. Additionally, our expansive library of video tutorials make it easy for novice users to learn or experienced users to refresh their knowledge at any time.

## 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.

| | |
|---|---|
| **EIS** | Interface with approved 3rd party EIS modules. Measurements from 10uHz to 20 kHz. |
| **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. |
| **Auto-Calibration** | Channels may be calibrated automatically when connected to a digital multimeter (sold separately). |
| **Life Cycle Chamber** | Temperature chamber equipped with RTD to provide constant temperature from 10 to 60 degree Celsius. |
| **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 coin cells, cylindrical cells, flat/pouch cells, and more.

**Battery Rack:**

Two standard racks are available for coincell & cylindrical cells.

# Software Control Specifications

| | |
|---|---|
| **Current† (A)**<br>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**<br>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)**<br>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†**<br>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†**<br>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**<br>This function applies a 10-pulse train with 1ms pulse width of the specified magnitude following a constant-current charge or discharge step. |
| **Rest†**<br>The battery is disconnected from the charge/discharge circuit but remains connected to the voltage measurement circuit to enable open-circuit voltage measurement. | **Formula†**<br>Equips the user to control and limit schedule steps according to dynamic mathematical equations in addition to constants or instantaneous channel data. |
| **Power† (W)**<br>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**<br>Time, Voltage, Current, Capacity, Energy, ΔV, DV/dt, formula, meta-variables, and other combinations. |
| **Load† (Ohm)**<br>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**<br>Generates a current/voltage staircase with increasing current/voltage, and negative decreasing current/voltage staircase with adjustable step amplitude. |
| **Current Ramp†/Voltage Ramp**<br>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**<br>Includes control value check (Current, Voltage, Power), abnormal behavior check (Step Time, Capacity/Energy), and irregular impedance check. |
| **Set Variables†**<br>Change test related variables including channel capacity, energy and all test counter variables. | **Network Capabilities**<br>Provide TCP/IP access for networking. |
| **Channel Paralleling**<br>Channels may be operated in parallel for increased current-handling capabilities.<br>NOTE: Control types marked with (†) are available in parallel mode. | **Data File Content**<br>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