## LBT Cell

# ARBIN INSTRUMENTS

# Laboratory Battery Testing Systems for Cell Applications

## An Introduction to LBT

The Laboratory Battery Testing series is Arbin's latest generation of testing equipment, derived from technology commercialized in a successful ARPA-E project (for which Arbin Instruments and its partners received a 2016 R&D 100 Award). Each LBT system offers industry-leading hardware and software flexibility, ultra-high precision measurements, and high-frequency data-sampling — all at a reasonable price-point — resulting in the best available testing equipment value in the market.

## Why Does Precision Matter?
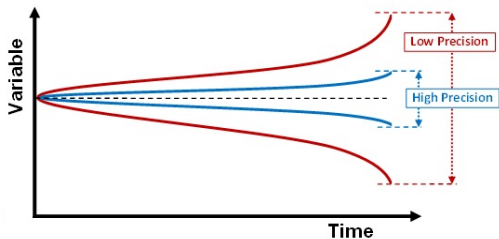
Measurement precision is more critical for long-term testing and long-term projections than control accuracy alone. Most other battery testing systems do not correctly specify their precision and/or have relatively poor precision, which hinder the conclusions drawn from results data. Important trends and electrochemical indicators may remain unnoticed; lost in the measurement noise.
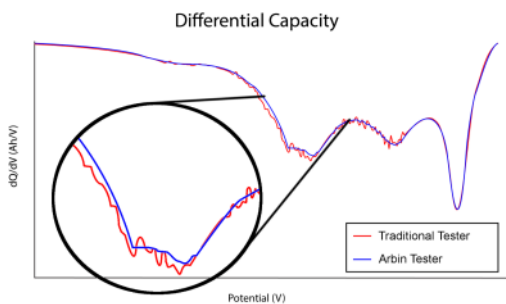
Derived from Arbin's ARPA-E project with Ford Motor Company and Sandia National Lab, our new Precision series of equipment incorporates technology developed during this time. High precision current and voltage measurements, and allows for more accurate columbic efficiency, energy efficiency, and dQ/dV calculations than was previously achievable with a commercially available testing system. The figure to the left plots differential capacity as measured from an Arbin LBT system (in blue) compared to a traditional testing system (red).

**What Affects Tester Precision**
- Resolution of DAC
- Resolution of ADC
- Non-linearity of calibration
- Short-term drift (temperature)
- Long-term drift (material properties)

**Improvements Made to Arbin Testing Systems**
- Higher Resolution (for voltage and current measurement)
- Improved software algorithms
- Improved internal temperature management
- New patented shunt design
- New materials

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## Primary Applications

- Battery Life Cycle Testing
- Electrochemical Research and Development
- Half-Cell Testing and Materials Research
- Simulation of Real World Test Profiles
- dQ/dt & Coulombic Efficiency Measurements

## Product Highlights

- Each channel provides four current ranges with industry-leading *24-bit resolution*

- Powerful embedded controllers provide ultra-fast data logging (up to *2000 points per second, per system*)

- Available integration with select Electrochemical Impedance Spectroscopy (EIS) workstations

- Can interface with Arbin's Life Cycle Chambers or 3rd party temperature chambers.

- 2-year standard warranty for each system

## Standard Features

- Fully independent high precision test channels with full potentiostatic, galvanostatic control

- Any number of channels can be operated in *parallel* for increased current-handling capacity

- Uses *True Bipolar Linear* circuitry providing cross-zero linearity and zero switching time between charge and discharge

- Each channel has digital voltage control to ensure smooth CC to CV transition

- 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.

- Each channel can output maximum current at minimum voltage

- A wide array of auxiliary inputs/outputs are available for additional data collection or control such as temperature monitoring, additional reference electrodes, and more

- For select applications, allows 3rd party software to control the LBT system

- Allows for channel expansion via networking identical systems together

## Safety Features

- Multiple levels of internal fusing and over-temperature control measures

- Each system has a fully redundant microcontroller dedicated to monitoring internal communication, voltage and current safety limits

- 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 inputs such temperature, current, or voltage measurements

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## Standard Product Configurations

| Model Name | Channel Voltage Range | Channel Current Ranges (±) | Max Continuous Channel Power |
|---|---|---|---|
| LBT20084 ±5V 200mA | -5V to 5V | 200mA / 10mA / 1mA / 100µA | 1W |
| LBT21084 ±5V 1A | -5V to 5V | 1A / 50mA / 2mA / 100µA | 5W |
| LBT21084 ±5V 5A | -5V to 5V | 5A / 500mA / 20mA / 1mA | 25W |
| LBT21084 ±5V 10A | -5V to 5V | 10A / 500mA / 20mA / 1mA | 50W |
| LBT21084 5V 5A | 0V to 5V | 5A / 500mA / 20mA / 1mA | 25W |
| LBT21084 5V 10A | 0V to 5V | 10A / 500mA / 20mA / 1mA | 50W |
| LBT21084 10V 10A | 0V to 10V | 10A / 500mA / 20mA / 1mA | 100W |

Don't see your configuration?  Arbin can build custom configurations for your application.

## Product Specifications

| | Technical Specification | Detail |
|---|---|---|
| **Voltage** | Measurement Resolution | <1µV  (24-bit) |
| | Measurement Precision | < 100ppm |
| | Control Accuracy | <  0.02% |
| | Input Impedance | 10G Ohm |
| **Current** | Noise Free Resolution | 0.0003% (18-bit) |
| | Control Accuracy | <  ± 0.02% |
| | Rise Time | <100µs to <300µs |
| **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 Computer** | | TCP/IP (Ethernet) |
| **Ventilation Method** | | Air cooled, *variable speed fans* |

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# 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† (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.

**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.

**Rest†**

The battery is disconnected from the charge/discharge circuit but remains connected to the voltage measurement circuit to enable open-circuit voltage measurement.

**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.

**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 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.

**Set Variables†**

Change test related variables including channel capacity, energy and all test counter variables.

**Channel Paralleling**

Channels may be operated in parallel for increased current-handling capabilities.
NOTE: Control types marked with (†) are available in parallel mode.

**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.

**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.

**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.

**Formula†**

Equips the user to control and limit schedule steps according to dynamic mathematical equations in addition to constants or instantaneous channel data.

**End Conditions**

Time, Voltage, Current, Capacity, Energy, ΔV, DV/dt, formula, meta-variables, and other combinations.

**Current Staircase†/Voltage Staircase**

Generates a current/voltage staircase with increasing current/voltage, and negative decreasing current/voltage staircase with adjustable step amplitude.

**Safety Check**

Includes control value check (Current, Voltage, Power), abnormal behavior check (Step Time, Capacity/Energy), and irregular impedance check.

**Network Capabilities**

Provide TCP/IP access for networking.

**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

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## Chassis Sizes

| | Dimensions (W x D x H) |
|---|---|
| 2U | 15.4" x 26.5" x 4.5" |
| 4U | 15.4" x 26.5" x 8" |
| 6U | 15.4" x 20" x 12" |
| 12U | 15.4" x 20" x 23" |
| 24U | 20" x 34" x 51" |
| 36U | 20" x 34" x 72" |
| 48U | 34" x 33" x 51" |
| 72U | 34" x 33" x 72" |

2U   4U   6U   12U   24U   36U   48U   72U
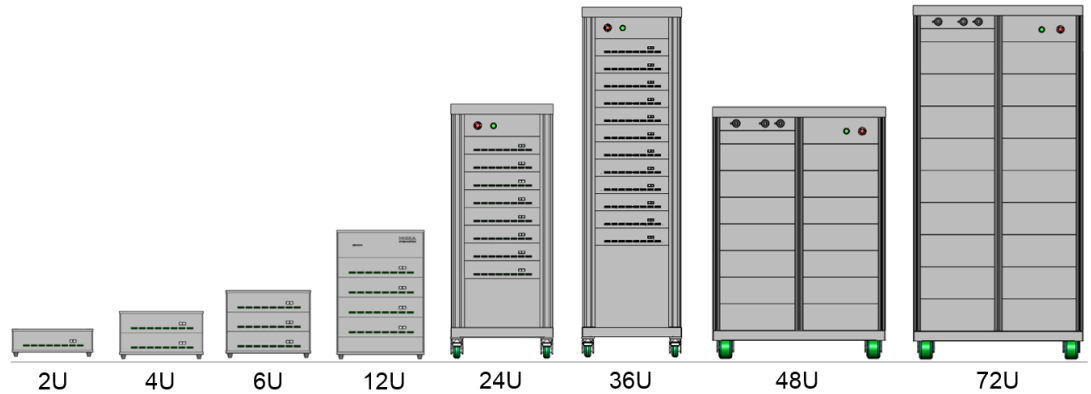
## Training & Support

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.

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We stand by our products — offering the best warranty in the industry, a **2-year warranty** for every system.

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## 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.

| | |
|---|---|
| **Auto-Calibration** | Channels may be calibrated automatically when connected to a digital multimeter (sold separately). |
| **EIS** | Interface with approved 3rd party EIS modules. Measurements from 10uHz to 20 kHz. |
| **Life Cycle Chamber** | Temperature chamber equipped with RTD to provide constant temperature from 10 to 60 degree Celsius. |
| **MTCI (Chamber Interface)** | Interface with a 3rd party temperature chamber so Arbin software can turn chamber on/off and adjust temperature. |
| **Temperature** | Thermocouple/Thermistor used to record temperature as well as control the test schedule. |
| **Auxiliary Voltage** | Used as additional reference electrodes to measure voltage. |
| **UPS** | Uninterrupted power supply for PC so tests can resume automatically after brief power outages. |
| **Digital I/O** | Send and receive a simple on/off signal to interact with external devices. |
| **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

**I/V Channel Cables**
Utilizes a low-resistance Phoenix connector and may terminate in alligator clips, lugs, banana plugs, or bare leads.

**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.

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Our product is always improving and specifications are subject to change.
Please contact your Arbin representative for the most up-to-date information.
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