

# High Precision Testing Systems for Coulombic Efficiency 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.

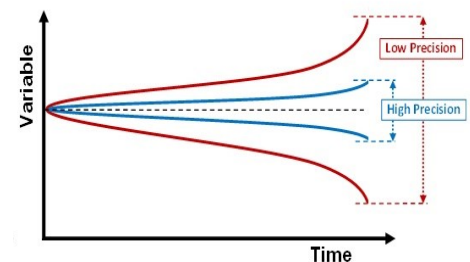
Arbin offers ultra-high precision charge/discharge testing systems for meaningful coulombic efficiency testing on cells up to 5A. The new HPS system allows users to more clearly see degradation mechanisms on a full-scale (high capacity) cell under real-world conditions. The project goal was to develop a testing system capable of 10 ppm coulombic efficiency precision at up to 5A. What sets the Arbin HPS apart from other high-precision testers is the power level. Arbin offers HPS systems at 5A, 100mA, 10mA, and 100uA.

### 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 **HPS** is a low current battery tester with high precision measurement capabilities to detect minute signatures of battery degradation trends early in the testing life cycle. This greatly reduces the battery development cycle. The HPS will assist battery development for those involved in material research.

The HPS allows researchers to conduct high precision coulombic efficiency tests on batteries or capacitors with precision reaching below **10 ppm**. Arbin's Multi Zone Temperature Chamber provides constant temperature condition.



Model	Voltage Range	Current Ranges
HPS21024	-6V ~ 6V	5A/100mA/10mA/1mA

## Product Highlights

- Each channel provides four current ranges and one voltage range with industry-leading *24-bit resolution (1 part in 16,777,216)*.
- Voltage measurement precision of 10 ppm & current measurement precision of 10 ppm.
- Increased measurement precision allows control accuracy to self-regulate while running.
- Available with Multi-Zone Temperature Chamber (MZTC) to provide constant temperature measurements for the device under testing
- Internal regulation and control with pre-set temperature for current-sensing components.
- Embedded timing device with verified long-term stability. Timing precision is 5 ppm of testing period, but no less than 900uS.
- High precision test channels with full potentiostat or galvanostat control with its own reference electrode.
- Powerful embedded controllers provide fast data logging (*2000 points per second, per system*) and control flexibility for the most advanced test requirements.
- Uses true *Bipolar Linear* circuitry providing cross-zero linearity and zero switching time between charge and discharge.

## Product Features

- Simulation for current, power, load downloaded in the microcontroller to perform nonstandard time-domain functions that may be inputted from external sources such as an ASCII data and used as control parameter with ability to hold up to 1.2 million data point with as low 10mS time interval.
- A wide array of auxiliary inputs/outputs are available for additional data collection or control such as temperature monitoring, additional reference electrodes, and more.
- 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.
- Advanced software package, Arbin MITS Pro 7.0 provides flexible scheduling, user-friendly interface, distributed system control and integrated data acquisition.
- Data Watcher and Data Pro provides easy data monitoring, analysis, and plotting capabilities.
- In house training on how to conduct tests and procedure guide to perform calibration verification.
- Optional calibration kits of equipment and high precision shunt available for purchase.

## 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.
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## Hardware Specifications

Model		HPS21024
Voltage	Control Range (min/max)	-6V ~ 6V
	Measurement Range	-6V ~ 6V
	Measurement Precision	±0.001% FS; 10PPM
	Control Accuracy	± 480µV
	Measurement Resolution	24 bit
	Control Resolution	24 bit Hardware PID
	Input Impedance	> 10 GΩ
Current	Standard Ranges	5A/100mA/10mA/1mA
	Measurement Precision	±0.001% (FS)
	Control Accuracy (±0.004% FS)	5A ± 400µA 100mA ± 8µA 10mA ± 800µA 1mA ± 80nA
	Measurement Resolution	24 Bit
	Control Resolution	24 Bit
	Minimum V at Maximum Current	-6V @ 5A
	Current Rise Time	<100µs
	Max Continuous Power Output per Channel	30W
Time	Minimum Step Time	5ms
	Data Logging Rate	2000 points per second, per system
	Data Sampling Rate	5ms per point

## Auxiliary Options & Accessories

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.

<b>Multi-Zone Temperature Chamber</b>	Temperature chamber equipped with RTD to provide constant temperature from 10 to 60 degree Celsius. Allow the usage of battery tray for coin cells, 18650 cylindrical cells or universal battery tray for any type of battery. Eight isolated temperature zones per chamber.
<b>Auxiliary Voltage</b>	Used as additional reference electrodes to measure voltage.
<b>Auxiliary Temperature</b>	Thermocouple/Thermistor used to record temperature as well as control the test schedule.
<b>MTCI (Chamber Interface)</b>	Interface with a 3rd party temperature chamber so Arbin software can turn chamber on/off and adjust temperature.
<b>Calibration Kit</b>	Calibration equipment and shunts needed to perform calibration.
For more information please visit: <a href="http://www.arbin.com/products/accessories/auxiliaries.htm">www.arbin.com/products/accessories/auxiliaries.htm</a>	

## Featuring: Multi-Zone Temperature Chamber (MZTC)



1. Digital Temperature Display with Push Button Control
2. Communication: TCP/IP

<b># Independent Chambers</b>	8 Isolated Chambers
<b>Total # of Cells Allowed</b>	8~32* (For more information on battery trays, refer to the MZTC sheet.)
<b>Connection</b>	I/V measurements to battery tray with build in RTD temperature sensors
<b>Temperature Range</b>	10 to 60 degree Celsius
<b>Accuracy</b>	±0.5 degree Celsius
<b>Point of Stability</b>	±0.5 degree Celsius
<b>Controller and Display</b>	Display chamber temperature, control through software or manual setting
<b>Modular External Size (WxDxH)</b>	12.5" x 16" x 22"
<b>Chamber Internal Size (WxDxH)</b>	4.5" x 7" x 3"
<b>Maximum Current Allowed</b>	Up to 60A*

\*Determined by tray type used to interface with cells.

## Software Control Specifications

<p><b>Current<sup>†</sup> (A)</b> Outputs constant current to the cell or battery at the value specified. Positive current refers to charge and negative current refers to discharge.</p>	<p><b>Voltage Cycle V</b> 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.</p>
<p><b>Voltage<sup>†</sup> (V)</b> Outputs constant voltage to the cell or battery at the value specified. Outputs constant voltage to the cell or battery at the value specified.</p>	<p><b>Current and Power Simulation<sup>†</sup></b> Non-standard time-domain functions may be inputted from external sources such as ASCII data streams and used as control parameters for repetitive tests.</p>
<p><b>C-Rate<sup>†</sup></b> C-Rate is a method for indicating the discharge as well as the charge current of a battery. It can be expressed as <math>I=M*C</math> where <math>I</math>=current (A); <math>C</math>=battery capacity; <math>M</math> is the C-rate value.</p>	<p><b>DC Internal Resistance</b> This function applies a 10-pulse train with 1ms pulse width of the specified magnitude following a constant-current charge or discharge step.</p>
<p><b>Rest<sup>†</sup></b> The battery is disconnected from the charge/discharge circuit but remains connected to the voltage measurement circuit to enable open-circuit voltage measurement.</p>	<p><b>Formula<sup>†</sup></b> Equips the user to control and limit schedule steps according to dynamic mathematical equations in addition to constants or instantaneous channel data.</p>
<p><b>Power<sup>†</sup> (W)</b> Outputs constant power to the cell of battery at the value specified. Outputs constant power to the cell of battery at the value specified.</p>	<p><b>End Conditions</b> Time, Voltage, Current, Capacity, Energy, <math>\Delta V</math>, <math>DV/dt</math>, formula, meta-variables, and other combinations.</p>
<p><b>Load<sup>†</sup> (Ohm)</b> Applies a constant resistance load to the battery at the value specified. The load control type will always produce a negative current.</p>	<p><b>Current Staircase<sup>†</sup>/Voltage Staircase</b> Generates a current/voltage staircase with increasing current/voltage, and negative decreasing current/voltage staircase with adjustable step amplitude.</p>
<p><b>Current Ramp<sup>†</sup>/Voltage Ramp</b> Generates a current/voltage ramp with a positive scan rate for increasing current/voltage, and negative scan rate generates decreasing current/voltage ramp.</p>	<p><b>Safety Check</b> Includes control value check (Current, Voltage, Power), abnormal behavior check (Step Time, Capacity/Energy), and irregular impedance check.</p>
<p><b>Set Variables<sup>†</sup></b> Change test related variables including channel capacity, energy and all test counter variables.</p>	<p><b>Data File Content</b> 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.</p>

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

## 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 maintenance 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.

