

# Arbin | Product Catalog

Powering Innovation for Over 20 Years



[www.arbin.com](http://www.arbin.com)



MSTAT



BT2000



SCTS



EVTS



FBTS



FCTS



DPH



## Arbin Contact Information

### Arbin Headquarters

762 Peach Creek Cut Off Road  
College Station, TX 77845

**Phone:** +1 979 690 2751

**Email:** sales@arbin.com

## Worldwide Locations

Canada, China, Germany, Korea, Taiwan

## Representatives

France, India, Israel, Italy, Japan, Singapore, Spain,  
Turkey and United Kingdom

For more contact information, visit [www.arbin.com](http://www.arbin.com).

## About Arbin Instruments

Arbin Instruments provides testing solutions for the battery, capacitor, and fuel cell industries. Nestled in the heart of Texas in the lush Brazos Valley, **Arbin's** headquarters and production facility is located in College Station spanning approximately 65,000 square feet, housing all administrative, manufacturing, R&D, marketing, support, sales, and operations personnel.

**Arbin** was founded by Dr. John Zhang in 1991, after discovering the need for a more accurate, reliable and robust testing system for electrochemical storage devices. He focused on **Arbin's** founding principles and customer satisfaction which led to rapid growth in both domestic and international markets.

The company's philosophy is to continue to develop the most responsive, highest quality, and most technically advanced products with superior customer service and technical support. **Arbin Instruments** believes that honesty and integrity are important principles in conducting a successful business. Based on these principles, **Arbin** has continued to see tremendous growth in annual sales from 10-20% over the last several years, seeing growth in every region around the world.

New **Arbin** technology is outstripping current competition in functionality, accuracy, and reliability. Research and development is intensely focused on the Total System Solution, constantly striving to provide turn-key custom designed, stand-alone, and in-line systems. **Arbin** reinvests about 25% of their annual revenue into research and development to ensure that customers receive the highest quality testing systems with cutting edge technology.

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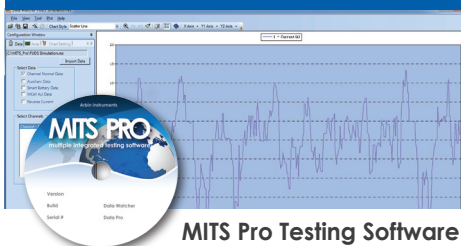
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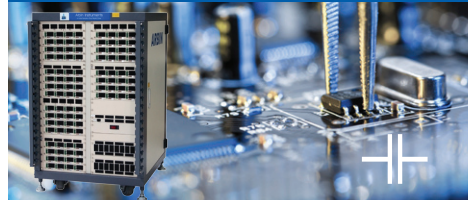
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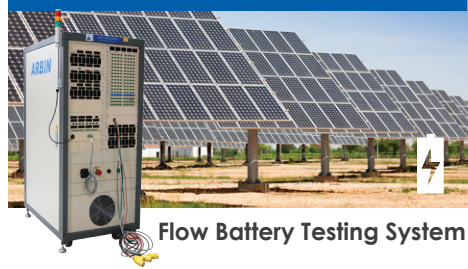
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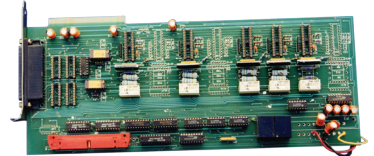
# ARBIN INSTRUMENTS

## Why Buy Arbin

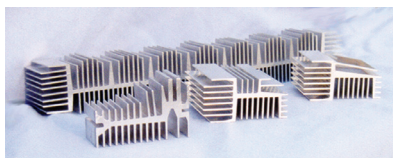
### History of Innovation

Arbin Instruments has provided testing equipment for energy storage applications for over 20 years; from our humble beginnings out of a garage, into the multi-million dollar global corporation that we are known as today with a 65,000 square-foot manufacturing facility in the heart of Texas. Dr. John Zhang, Arbin's founder, has been granted nine patents that are utilized in our products and he remains our chief research and development scientist.

Arbin was the first company to create a multi-channeled potentiostat/galvanostat device. Our innovations lead the industry by also having the most compact multi-channeled design. We accomplished this by a patented heat sink technology that was 40% more efficient than similar designs. The footprint of our boards was as much as 1/6th that of our competitors. We also introduced plug-and-play modularity that allows for easy upgrade and expansion, flexible designs, and a lower cost of production. Arbin has continued this trend by becoming the first company to offer high speed telecom pulse testing ability, increasing the efficiency of



World's 1st 8 channel, multi-electrode PST/GST circuit developed by Arbin.



Highest heat dissipation efficiency of its kind with a space saving and light weight patented design.

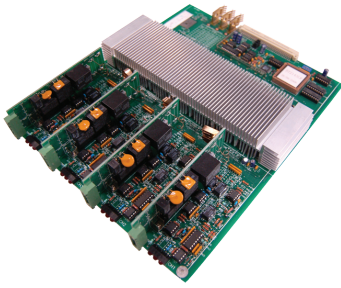
heat dissipation, standardizing our circuit designs and creating standardized modules that allow for lower overhead costs. The founder's vision has been to provide quality testing systems at the most competitive cost per channel, thus helping power innovation together with our many users around the world. Arbin balances our history of innovation and experience with the flexibility to always take on new challenges and custom projects, thus setting Arbin apart from competitors and spurring our continued growth and improvement.

### Hardware & Flexibility

Flexibility of hardware configuration is an advantage that allows Arbin to supply the most appropriate design and technology to fit each customer's testing requirements. Three different circuit design technologies are available as well as a variety of microcontroller configurations that can be selected for each customer's project. Bipolar linear, Pulse Width Modulation (PWM), and Unipolar circuit technologies each have advantages for certain applications and we will provide the best technology for a customer's testing requirements. This flexibility gives Arbin the advantage to supply customized solutions while providing a technically advanced product.

The **Bipolar linear** circuit design is suitable up to 60V and allows for no switching time between charge and discharge and ensures cross-zero linearity. Our industry leading accuracy specification, 0.02% of the full

## Hardware & Flexibility



scale, is calculated based on the full positive (charge) to negative (discharge) range. Bipolar circuitry can discharge below 0V, and has rise times as fast as 10 micro-seconds. Arbin customers can trust that our equipment will have the specifications demanded for advanced research techniques.

High powered applications that reach up to 800V may utilize our **Pulse Width Modulation (PWM)** circuitry which is regenerative. Discharge power is sent back to the grid, which is more energy efficient for our customers, produces significantly less heat, and is environmentally friendly.

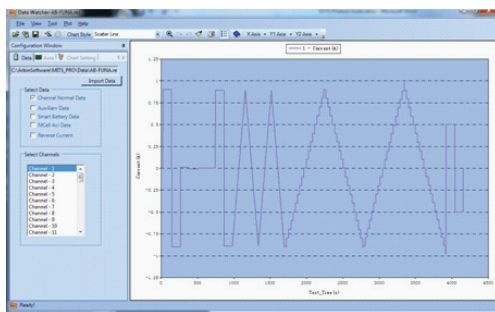
Arbin also offers **Unipolar** designs for appropriate applications for voltage up to 120V. Unipolar is a linear circuit, however, it offers a higher voltage than a Bipolar design and offers an alternative to PWM when power regeneration is not required. Unipolar circuitry has a 100ms fixed switching time.

All Arbin systems contain on-board microcontrollers inside the chassis, and the flexibility of our hardware designs extend to these control modules and not just the circuit types. We offer systems with a dedicated microcontroller for each channel, as well as systems where groups of channels share a microcontroller depending on the requirements. One of the key advantages of Arbin's design is that we maintain a constant control loop with the PC which allows us to make changes to a test on-the-fly while it is running. The benefits include being able to increase the number of cycles, adjust a control value, add steps, adjust data logging, etc., without needing to pause or stop a test.

## Software & Features

Arbin's MITS Pro software is regarded as the most powerful and flexible in the industry. Creating and starting a new test is a simple and intuitive two-step process. Arbin offers dozens of control type options including current, voltage, power, and load. A vast library of 90+ unique meta variable conditions are available in addition to our formula feature which allows near limitless potential. The sophistication to use meta variables and formulas instead of fixed numeric values alone is what makes Arbin's software superior. Other beneficial features that have helped build our customer loyalty are listed below:

APID	Test Name	Schedule Name	Status	Exit Condition	[ Cycle   Step Index	Step Time (s)	Test Time (s)	Voltage	Current
001	AS-FUNA	AS-FUNA.edu	Discharge	NA	[ 1   10 Step_L	00:00:11.478	01:04:22.888	-797.8416 (mV)	-799.9105 (mA)
002	AS-FUNA	AS-FUNA.edu	Discharge	NA	[ 1   10 Step_L	00:00:51.446	01:04:22.949	-999.6804 (mV)	-998.8127 (mA)
003	AS-FUNA	AS-FUNA.edu	Rest	NA	[ 1   17 Step_X	00:00:07.596	01:04:22.828	-717.2551 (mV)	0.0000 (mA)
004	AS-FUNA	AS-FUNA.edu	Discharge	NA	[ 1   10 Step_L	00:00:20.152	01:04:22.901	-888.2464 (mV)	-884.5240 (mA)
005	AS-FUNA	AS-FUNA.edu	Discharge	NA	[ 1   10 Step_L	00:00:16.262	01:04:22.824	-798.8515 (mV)	-888.7770 (mA)
006	AS-FUNA	AS-FUNA.edu	Discharge	NA	[ 1   10 Step_L	00:00:20.729	01:04:22.714	-888.8382 (mV)	-889.7879 (mA)
007	AS-FUNA	AS-FUNA.edu	Charge	NA	[ 1   10 Step_M	00:00:15.967	01:04:22.668	2.8887 (V)	2.8891 (A)
008	AS-FUNA	AS-FUNA.edu	Rest	NA	[ 1   17 Step_X	00:00:05.016	01:04:22.858	-328.5400 (mV)	0.0000 (mA)



- Results can be viewed graphically in real time, and data analysis is performed on a Windows-based environment.
- Arbin's DataPro Excel macro is provided with all systems for data viewing and analysis.
- Networking capability is included with Arbin systems, and we will continue to keep up with industry trends; adapting to the latest IT standards and Windows software.
- Running a simulation directly from a data text file, such as the FUDS test or other drive profile, can easily be performed without writing a complicated program.
- CAN Bus communication may be used to receive and transmit messages from a device. No third party equipment, special DLL packages, or additional licenses are required for operation.
- Arbin was the first company to offer high speed pulse testing capability for complex sub-millisecond multi-stage pulses. Pulse stage widths may be as small as 100 micro-seconds.

# ARBIN INSTRUMENTS

## Why Buy Arbin

### Software & Features

- MITS Pro software can interface with an external charger/load or 3rd party temperature chamber.
- Arbin's smart battery testing systems allow users to log data from their smart battery and compare it to the external data provided by the Arbin testing system. Testing procedures can be referenced and controlled by the data that the Arbin Testing System acquires, or by the SMBus register values. The MITS Pro software is also capable of manipulating SMBus registers during testing.

### Safety & Reliability

Arbin has built thousands of systems which are now located in over 50 different countries around the world! The first testing systems Arbin built are still operating in the US running on a DOS operating system.

We understand the need for research and industrial testing equipment to be reliable and durable. Arbin places a strong emphasis on this area and strives for continuous design improvement. Some recent improvements include integration of a small uninterrupted power supply in our PWM systems. The UPS guarantees the startup and shut down process is sequenced safely and reliably despite a power failure. Cooling efficiency was increased by altering the board alignment to maximize the convection heat transfer. An independent emergency stop button now comes standard on all PWM systems. These are just a few specific examples that demonstrate Arbin's commitment to applying innovative engineering solutions to continually improve the reliability of our hardware.



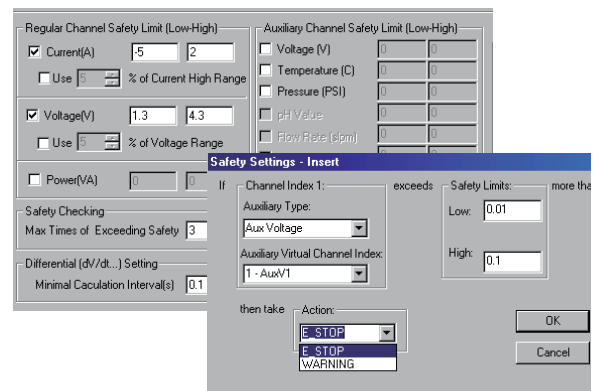
Watchdog protection circuitry

Multiple layers of safety provisions come standard with Arbin systems at the hardware and software (user interface) level. The system itself is secure internally to protect from unintentional misuse. Redundant levels of fusing are provided inside the system for protection at the channel or board, and power supply level. Thermoswitches help prevent over-heating, and a watchdog circuit

monitors the machine's internal communication and communication between the PC. The watchdog turns off the system in case of a major hardware failure. Arbin systems contain a hardware-based voltage clamp, which helps prevent voltage overshoot, and is especially critical for Li-batteries. Since it is hardware-based, the clamp reacts faster than any form of software control (<1ms) and will respond even in the case of a PC failure.

## Safety & Reliability

The software also has several safety functions which the user may implement to avoid over charging the cells, over discharging, over-heating etc. Global safety limits may be applied for each test schedule monitoring current, voltage, and temperature. Additional, more specific safety conditions may be set for individual test steps to trigger an unsafe condition, divert a test into a cool-down period, or allow for conditional procedures using most every variable or meta-variable available in our extensive library.



## Sales & Support

Buying an Arbin system is a direct and easy process. Our knowledgeable sales and application engineers will identify your requirements and specify the best solution for your testing needs. Your Arbin system will be manufactured and tested to the highest specifications in the industry, and arrive pre-calibrated and ready to use by simply connecting the supplied Ethernet cable from the Arbin system to the PC. This is only the beginning of your Arbin experience. We take pride in continuously supporting our customers throughout their time using Arbin.



Our customer service department offers regular training classes at our headquarters in Texas as well as on-site training visits. Another great resource Arbin customers have is access to the vast library of training and tutorial videos on our website. This makes it easy for novice users to learn or experienced users to refresh their knowledge at any time.

Our 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.

Arbin's customer service team is well-known throughout the industry for their responsiveness to any questions that arise. The same time and dedication is shown to all customers, whether a large OEM or small startup. Serving our customers is what drives us, and we cherish the opportunity to earn your business.

Find out more information about Arbin's testing systems and solutions by visiting our website [www.arbin.com](http://www.arbin.com), or call **+1 979-690-2751 x2** to speak with an application engineer today!



# MSTAT

Arbin's MSTAT is a multi-channel analytical, electrochemical instrument designed for fundamental research of energy storage materials



- Up to 120 Independent Potentiostat/Galvanostat Channels
- Multi-Electrode Configurations
- General Electrochemistry R&D Techniques
- Industry Leading Accuracy
- Half Cell Testing & Materials Research
- Linear Bipolar Circuitry



## General Description

Arbin Instruments' **MSTAT** contains multiple potentiostatic and galvanostatic (PST/GST) test channels, which enable multiple, independent or combined experiments to run simultaneously. This series of multi-electrode channels is necessary in order to perform comparative or combinatorial tests. This allows users to examine the properties of different materials under the same electrolytic environment.

**MSTAT** can perform electrochemical analysis such as; current scans, chronoamperometry, chronocoulometry, chronopotentiometry, cyclic voltammetry, and linear sweep voltammetry.

Arbin's **MSTAT** truly accelerates the research and development process.

### Arbin's MSTAT Capability

Number of Channels	Up to 120 Channels Per Chassis
Circuitry	Linear Bipolar
Voltage Range	0 - 24V
Current Ranges	Down to the nanoAmp Range
Current & Voltage Accuracy	0.02% or 0.05% of Full Scale Range
Resolution	16 Bit
Current Rise Time	As fast as 50µS

## Completely Independent Channels

Allows users to run multiple independent tests simultaneously

## Potentiostatic/Galvanostatic Functionality

Enables each channel to run advanced electrochemical experiments with both voltage and current control

## Linear Bipolar Circuitry

Achieves low noise, fast response rates and high accuracy control and measurement. Zero switching time when moving from charge to discharge

## Multi-Electrode Configuration

Enables each channel to run advanced electrochemical experiments

## Multiple Current Ranges

For improved accuracy over a wide range of testing conditions

## Dynamic Data Acquisition

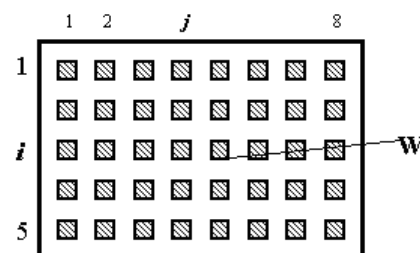
Allows users to capture data based on change in time, voltage, and current

## Plug & Play Modules

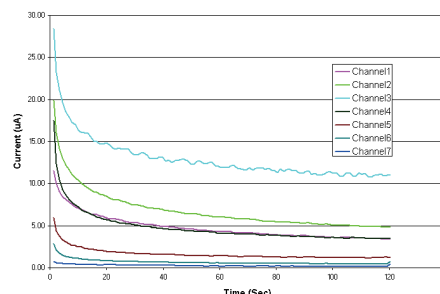
For easy expansion and maintenance

## Multi-Electrode Experiments

Also uses a working electrode array and a common counter electrode



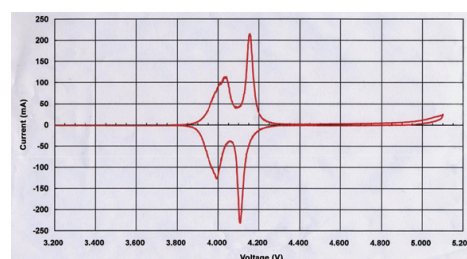
Combinatorial Array with individual reference electrodes (RE) and working electrodes (WE) sharing one common counter electrode (CCE)



Multi-electrode chronoamperogram from a combinatorial test

## General Electrochemistry R&D Techniques

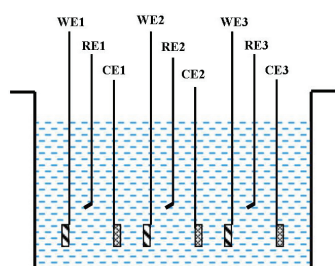
Includes cyclic voltammetry, chronopotentiometry, linear sweep voltammetry, chronocoulometry, potentiodynamic polarization, potentiostatic polarization, cyclic polarization, galvanodynamic polarization, and galvanostatic polarization.



CV of a lithium battery electrode at 50µV/second.

## Multi-Electrode Experiments

Using individual counter/reference electrodes for comparative testing



Multi-electrode cell with individual reference electrodes (RE), counter electrodes (CE), and working electrodes (WE)

## DC Internal Resistance Measurement

Standard option with all MSTAT hardware, employs a pulse method to measure the DC resistance of the cells

## Auxiliary Channels for Additional Measurements

- Multi-Electrode Voltage Measurements
- Temperature Measurement
- Temperature Chamber Controller
- Digital Input/Output
- Please see the Auxiliaries Page for more info!



# BT2000

Arbin's BT2000 is a flexible and scalable testing station designed for cell and battery modules



- Independent Test Channels
- Industry Leading Accuracy
- Potentiostat/Galvanostat Functionality
- Linear Bipolar Circuitry
- Multiple Current Ranges
- Modular Chassis Design



## General Description

Arbin Instrument's **BT2000** is a multi-channel potentiostat/galvanostat testing system designed for R&D and production of batteries and other energy storage devices. Arbin provides state of the art hardware with the highest level of specifications available in the market to meet our customers' requirements.

Arbin provides both standardized and custom-designed testing solutions to fit a wide range of applications. The modular hardware design allows for a wide array of voltage and current specifications that can provide solutions ranging from nanoAmps to thousands of Amps.

### Arbin's BT2000 Capability

Number of Channels	Up to 120 Channels Per Chassis
Circuitry	Linear Bipolar
Voltage Range	0 - 60V
Current Ranges	Up to 4000A
Current & Voltage Accuracy	0.02% or 0.05% of Full Scale Range
Resolution	14 or 16 Bit
Current Rise Time	As fast as 10µS

### Completely Independent Channels

Allows users to run multiple independent tests simultaneously

### Potentiostatic/Galvanostatic Functionality

Enables each channel to run advanced electrochemical experiments with both voltage and current control

### Linear Bipolar Circuitry

Achieves low noise, fast response rates and high accuracy control and measurement. Zero switching time when moving from charge to discharge

### Multiple Current Ranges

For improved accuracy over a wide range of testing conditions

### Flexible Control Types

Includes constant current, voltage, load and power; as well as, linear ramp, staircase, formula and other control profiles

### Dynamic Data Acquisition

Allows users to capture data based on change in time, voltage, and current

### Channel Paralleling

Allows users to parallel several I/V channels to increase current output

### Plug & Play Modules

For easy expansion and maintenance

### Cell Characterization & Qualification

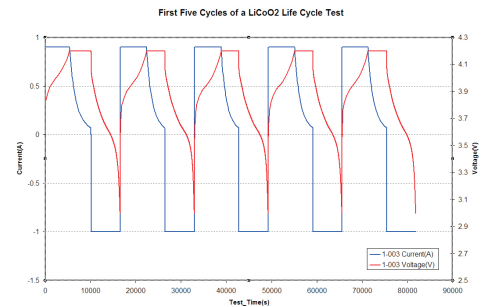
The BT2000 can test the important properties of your cells, and allow end-users to determine how the cells will react under different conditions and applications.

### Smart Battery Testing

Used to communicate with smart batteries using SMBus 1.1 or 2.0 protocol to allow users to read/write registers on the smart battery to compare data collected with the data measured by the Arbin system.

### Life Cycle Testing

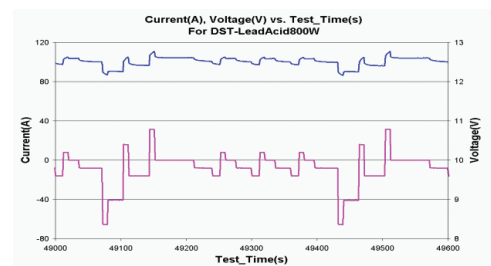
BT2000 can perform charge/discharge cycling of multiple cells or batteries simultaneously to obtain charge and discharge capacity, energy, DC internal resistance, and other valuable information.



An example of First Five Cycles of a LiCoO2 Life Cycle Test.

### Device Simulation

BT2000 allows the user to input collected dynamic device-performance information (current, voltage, power vs. time) and the system will charge/discharge according to the data profile.



The graph below displays results from a Dynamic Stress Test using Simulation Control.

### High Speed Pulse Testing

Arbin's pulse capability covers a broad range of sub-millisecond communication profiles, which can handle multi-stage pulses as fast as 100 microseconds per stage and up to 10 stages per pulse. This optional pulse hardware covers GSM/CDMA and other user-defined custom pulse profile.

### Auxiliary Channels for Additional Measurements

- Secondary Voltage Measurement
- Temperature Measurement
- Temperature Chamber Controller
- External Charger
- Digital Input/Output
- Please see the Auxiliaries Page for more info!

# SCTS

Arbin's SCTS is an innovative testing solution featuring fast rise times, with extremely accurate measurements for capacitors



- Charge/Discharge Cycling with No Cycle Limit
- Fast Response/Rise Time with Low Noise
- Industry Leading Accuracy
- Linear Bipolar Circuitry
- DC-Equivalent Series & Parallel Resistance Measurements
- Leakage Current Measurement
- Capacitance Testing
- High Speed Data Collection

## General Description

Arbin Instruments' **SCTS**, Super Capacitor Test Station, is designed for the research and development of capacitors, supercapacitors, and ultracapacitors in a variety of applications. Arbin's **SCTS** features multiple completely independent potentiostat/galvanostat channels that allows users to test multiple capacitors or modules simultaneously.

Arbin's **SCTS** provides both custom and standard designs to fit our customer's specific applications. Arbin's modular hardware design allows for a wide array of voltage and current specifications that can provide solutions ranging from materials research up to high power capacitor banks. Arbin's **SCTS** is the most advanced capacitor testing system in the market today.

### Arbin's SCTS Capability

Number of Channels	Up to 120 Channels Per Chassis
Circuitry	Linear Bipolar & Regenerative Power
Voltage Range	0 - 700V
Current Ranges	Up to 4000A
Current & Voltage Accuracy	0.02% or 0.05% of Full Scale Range
Resolution	14 or 16 Bit
Current Rise Time	As fast as 50µS

## Features

### Completely Independent Channels

Allows users to run multiple independent tests simultaneously

### Potentiostatic/Galvanostatic Functionality

Enables each channel to run advanced electrochemical experiments with both voltage and current control

### Linear Bipolar Circuitry

Achieves low noise, fast response rates and high accuracy control and measurement.

Zero switching time when moving from charge to discharge

### Multiple Current Ranges

For improved accuracy over a wide range of testing conditions

### Flexible Control Types

Includes constant current, voltage, load and power; as well as, linear ramp, staircase, formula and other control profiles

### Dynamic Data Acquisition

Allows users to capture data based on change in time, voltage, and current

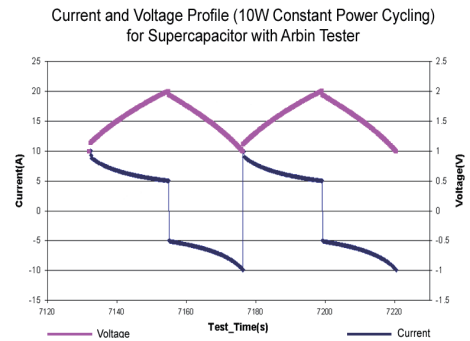
### Channel Paralleling

Allows users to parallel several I/V channels to increase current output

### Plug & Play Modules

For easy expansion and maintenance

any moment during the test. For supercapacitors, the duration of each cycle is much shorter than for batteries, usually requiring only a few seconds to a few minutes per cycle. For this reason, SCTS provides fast data acquisition and control, as well as, voltage clamp with < 1ms response time to prevent overcharging.



Constant Power cycling of a low power supercapacitor

### Online DC-ESR Measurement

SCTS's Equivalent Series Resistance (ESR) calculation is based upon time-domain impedance analysis using pulse methodology. The obtained DC-ESR value is averaged over 10 pulses. The ESR measurement function can be integrated into test procedures, so that the test regimes can contain charge/discharge cycling, capacitance and leakage current measurement, and self-discharge voltage monitoring in a single test. In ESR monitoring, a key parameter, data sampling time, is adjustable to obtain accurate ESR readings for different capacitance ranges and capacitor types. Each ESR measurement takes less than 0.4s.

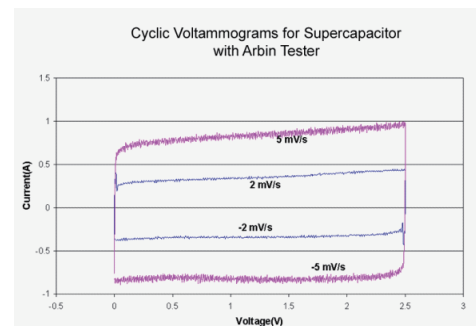
### Injection EPR Leakage Current Measurement

Following the application of a constant voltage to a capacitor, the current drawn will attain an equilibrium value ( $\Delta I/\Delta t \sim 0$ ), known as injection leakage current. To guarantee the stability and accuracy of this leakage current measurement, Arbin's SCTS employs low noise DAC and ADC.

## Applications

### Charge/Discharge Cycling

Power charge/discharge cycling is a common way to compare the capacitor's cycling efficiency. Using current/power control mode, an operator can perform a constant current or constant power discharge down to the lower voltage limit followed by a constant current or power charge up to the upper voltage limit. An indicator of the capacitor's quality, such as capacitance, can be monitored at



Cyclic Voltammogram of a supercapacitor

### Applications

#### Self-Discharge Voltage Monitoring and Dynamic Leakage Current

The magnitude of self-discharge, or internal leakage current is an important indicator of the quality of a super-capacitor. This measurement is done in parallel with injection leakage current. The open-circuit voltage of a charged capacitor is monitored with respect to time. A dynamic leakage current can be deducted from the obtained voltage-time curve. Since the leakage current varies with the voltage, a tabular data file of voltage versus time allows users to calculate it at any voltage value. The macro-command subroutine can easily convert the data to self-discharge current ISD (or dynamic leakage current).



#### Capacitance, Power, and Energy Calculations

Arbin's MITS Pro software provides an embedded Microsoft Excel® Macro that can automatically convert obtained discharge capacity and energy values to capacitance, power, and energy release data.

#### Auxiliary Channels for Additional Measurements

- Auxiliary Voltage Measurements
- Temperature Measurement
- Temperature Chamber Controller
- Digital Input/Output
- Please see the Auxiliaries Page for more info!



# EVTS

Arbin's EVTS is an advanced high power linear or regenerative based testing station for electric vehicle battery packs

- EV/HEV Battery, Module, & Pack Testing
- Linear & Regenerative Circuitry Available
- Up to 450kW Power Capability
- USABC Standard Tests: FUDS, DST, SHC, etc.
- CAN Bus Communication
- Comprehensive Safety Features
- Industry Leading Accuracy
- High Speed Data Collection



## General Description

The **EVTS** series is a specially designed linear or regenerative power potentiostat/galvanostat test station for testing high power electric vehicle (EV) and hybrid electric vehicle (HEV) batteries, packs and modules. This product is intended to provide a complete test solution for use in R&D testing that require advanced test schedules and protocols.

**EVTS** is capable of advanced charge and discharge regimes using a library of unique control types. One of the most popular features of **EVTS** is the simulation control type which allows the system to charge or discharge the pack by mimicking the actual vehicle in the lab. Simulation control allows users to easily program advanced test profiles such as Federal Urban Drive Schedule (FUDS) or Dynamic Stress Tests (DST) without writing complex test protocols/schedules. **EVTS** is easily the most advanced and comprehensive EV and HEV testing system available in the market today!

### Arbin's EVTS Capability

Circuitry	Regenerative or Linear Bipolar
Voltage Range	0 - 800V
Current Ranges	Up to 4,000A
Current & Voltage Accuracy	Linear: 0.05% of Full Scale Range Regenerative: 0.1% of Full Scale Range
Resolution	16 Bit
Current Rise Time	As fast as 1mS



## Features

### Completely Independent Channels

Allows users to run multiple independent tests simultaneously

### Regenerative Power Circuitry

Recycles discharge power back to the grid.

### Linear Bipolar Circuitry

Achieves low noise, fast response rates and high accuracy control and measurement. Zero switching time when moving from charge to discharge

### Multiple Current Ranges

For improved accuracy over a wide range of testing conditions

### Flexible Control Types

Includes constant current, voltage, load and power; as well as, linear ramp, staircase, formula, simulation, and other control profiles

### Dynamic Data Acquisition

Allows users to capture data based on change in time, voltage, and current

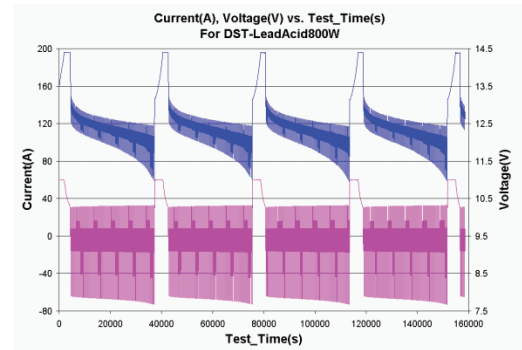
### Channel Paralleling

Allows users to parallel several I/V channels to increase current output

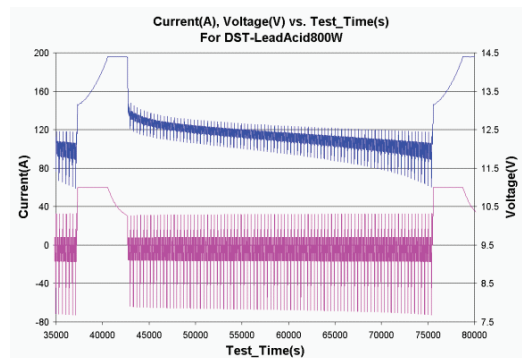
### Dual Voltage Ranges

Available upon request for higher accuracy on small and large battery packs with a single channel.

DST procedure fulfills the need to simulate variable power driving cycles of an EV battery and is performed by regular charge/discharge control.



Dynamic Stress Test for 800W lead acid battery (cycle)



Zoomed in Dynamic Stress Test for 800W lead acid battery

### Federal Urban Drive Schedule (FUDS)

EVTS can perform the Federal Urban Drive Schedule test established by USABC through use of simulation control. This feature is available for Regenerative and Bipolar circuit types.

### Partial Discharge

EVTS can run a series of partial discharges to see what effect these partial discharges have on the batteries capacity.

### Sustained Hill-Climb

EVTS can run constant power tests, as well as simulated power tests, to simulate a sustained hill-climb.

### Thermal Performance Test

EVTS, coupled with a temperature chamber, can effectively run thermal performance tests. A temperature chamber interface can be added to allow Arbin's MITS Pro software to control a third party chamber.



## Applications

### Life Cycle Testing

EVTS can perform charge/discharge cycling of batteries or modules to obtain charge and discharge capacity, energy, DC internal resistance, and other valuable information.

### Dynamic Stress Testing

EVTS effectively performs dynamic power charge/discharge using the standard Dynamic Stress Test (DST) procedures set by the US Advanced Battery Consortium (USABC). The



## More Applications

### Cold Cranking

Arbin's EVTS, coupled with a temperature chamber, can effectively simulate cold cranking conditions through the use of current, power, or simulation.

### CAN-Bus Communication

Arbin provides CAN-Bus communications for our EVTS systems that can be used to test battery packs with integrated BMS systems. Arbin's MITS Pro software allows the test equipment to be programmed to both receive CAN messages from and transmit CAN messages to customers' CAN devices. With Arbin's CAN-Bus, there is no third party equipment, 3rd party DLL package or 3rd party

licenses' needed to operate. The illustration to the right graphically represents the CAN-Bus communication for Arbin's EVTS Systems.

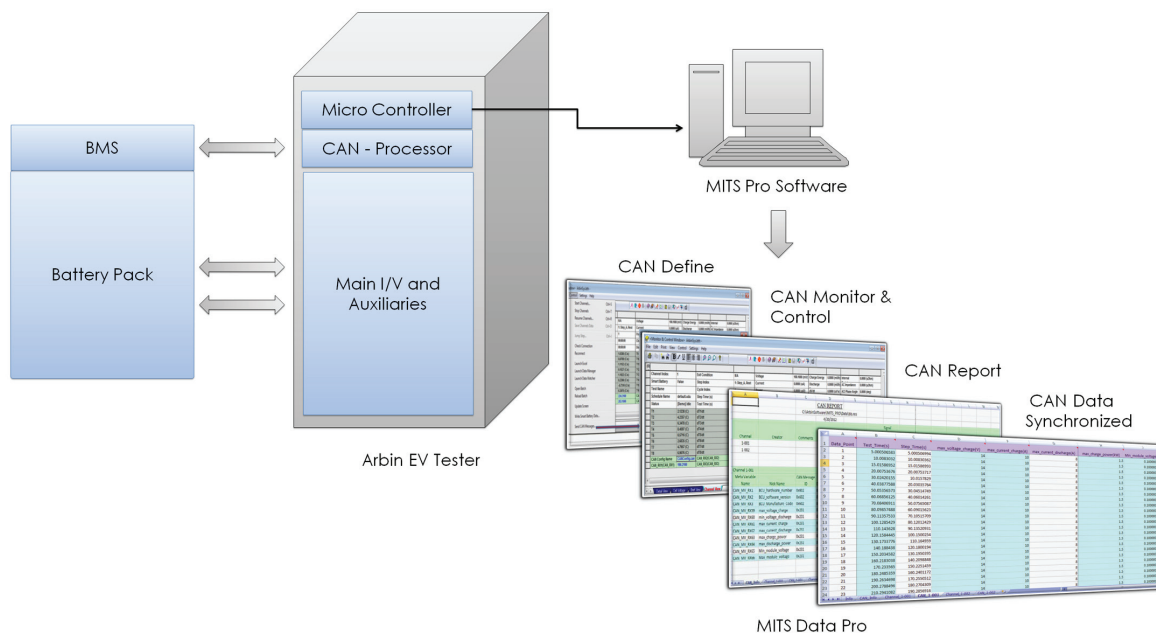
### Reserve Capacity

EVTS can perform a constant current discharge to see how long a useful voltage can be maintained on the battery.

### Auxiliary Channels for Additional Measurements

- Temperature Measurement
- Auxiliary Voltage Measurement
- Temperature Chamber Controller
- Digital Input/Output
- Please see the Auxiliaries Page for more info!

### CAN-BUS Communication Flow Chart



# FBTS

Arbin's FBTS is a fully integrated BT2000 testing station, with the capability to manage pumps, flow controllers, heaters, chillers, pressures, and more for flow battery systems

- Integrated Control of Complete Flow Battery System
- Compatible with Third Party Hardware
- Potentiostatic/Galvanostatic Functionality
- Modular Plug & Play Design
- Automatic Device Simulation



## General Description

Arbin was founded over 20 years ago as a manufacturer of battery testing equipment and added our fuel cell product line in 1997. Our experience and expertise from these two industries have allowed us to create a new product designed for **Flow Battery** applications that is able to integrate with a customer's existing **Flow Battery System** or with a new start-up.

We are able to provide programmable electronic modules for charge/discharge testing and fully integrate it with a **Flow Battery** test stand consisting of pump control, mass flow control, temperature measurement and/or control, pressure monitoring, and more; all with a myriad of safety features. The design engineers at Arbin are able to customize an **FBTS** to work with a variety of external hardware that we can control or simply interact with by using a digital relay signal.

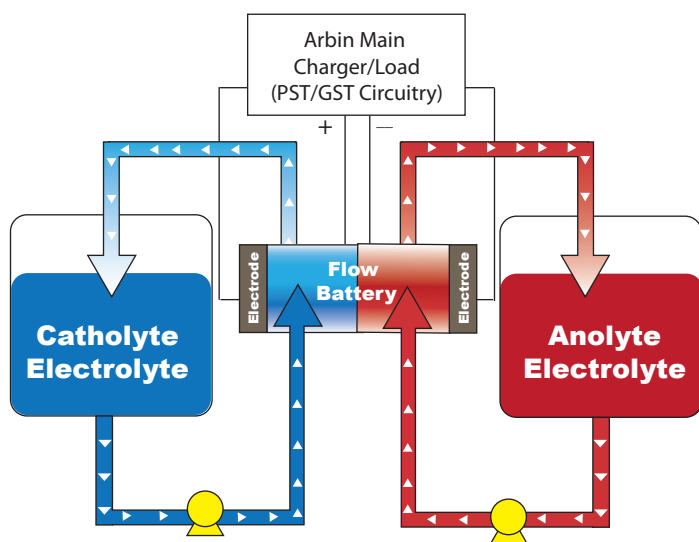
Our products range from small-scale research testing up to high powered commercial applications. Our design engineers will work with customers' engineers to meet any unique requirement, but after supplying many flow battery testing systems in the past few years, we have developed a great product and have been successful in meeting all challenges. Arbin has already provided multiple **Flow Battery Systems** to many of the world's top research and commercial organizations in this field.

### Arbin's FBTS Capability

Voltage Range	0 - 800V
Current Ranges	Up to 4,000A
Current & Voltage Accuracy	Linear: 0.05% of Full Scale Range Regenerative: 0.1% of Full Scale Range

Arbin Instruments' electronic circuitry is a completely programmable and automatic power supply that works directly with Arbin's MITS Pro software. Through the software, the user can control the current and voltage applied and drawn from the flow battery in any number of profile types.

- Current capability ranges from micro-amp level up to 1000's of amps
- Voltage capability ranges from below 0V up to 700V
- Automatic and programmable control for the entire system
- Potentiostatic/Galvanostatic charge/discharge circuitry or discharge-only option
- True bipolar circuitry allows for no switching time between charge and discharge
- Hardware-based voltage clamp
- Modular plug and play, compact design  
Multiple current ranges: customer defined current and voltage ranges: 3 current ranges are defined at the time of purchase.



Flow Battery Diagram

### Analog I/O

The Analog Input/Output module option is designed to measure and control Flow Rate or Pressure or any devices that can output 0(2)-10V as feedback signal and input 0-10V as control signal. The Analog I/O board offers control with closed loop (PID) or open loop communication depending on the application. 8ch Input for measurement, 8ch Output for control per module.

### Digital I/O

The Digital Input/Output module sends and receives a simple digital on/off signal that is available in TTL and Relay. 8ch input and 8ch output per module. These can be used to communicate with third party hardware directly or in conjunction with a 24VDC source as stated below.

### DC Power Supply Module

The DC power supply module offers ability to turn on/off solenoid valves, pumps or other devices with a 24VDC power supply. The channels of this module are associated one-to-one with Digital Output channels and provide an on/off 24 VDC power source.

### Auxiliary Voltage Input

This option is typically used to measure each cell voltage in a multi-cell battery or to measure the reference electrode voltage in a three electrode setup. The value of voltage can be recorded in the results file or used to further control the experiment. 8 channels per module.

### Temperature Measurement

This option is used to measure the temperature of any point in the setup using either our thermocouple module (E, J, K or T) or our thermistor module. The value of temperature can be recorded in the results file and/or used to further control the experiment. Minimum order quantity: 8 channels of thermocouples or 16 channels of thermistors per module.

### Customizable Features

#### Pressure Input

This option works the same way as the temperature option above but measures the pressure inside the cell using a pressure transducer. The transducer used with this option uses an operating supply voltage of 5VDC and output voltage of 0-100mV. The cell must have an opening to insert the transducer. 8 channels per module.

#### Heater/Fan Controller

This controller offers integrated temperature measurement and power output control applying PID technology. This unit uses Type K thermocouple input to provide temperature feedback measurements and provides PWM style heating/cooling power source to control the heater or fan. 4 Heating/Cooling channels or 8 Heating channels per module.

#### Mass Flow Rate Interface

The MFRI module allows users to set mass flow rates from Arbin's MITS Pro software. User needs to specify gas type and maximum flow rate when ordering. Up to 4 Mass Flow Controllers per module.

#### Temperature Chamber Interface

The Temperature Chamber Interface option (MTCI) allows the system to communicate with a temperature chamber controller during testing. The MTCI module tells the chamber controller what temperature set-point to use during each test step, allowing the user to program complex automatic temperature profiles in their tests.

Consult your Sales Engineer for a full list of supported chambers and MTCI specifications.

#### UPS

This option is designed to support the PC and detect a power outage to the Arbin tester. It will allow a test to resume automatically if power returns within a user-defined time period, or shut down the PC if power is not returned. It also helps prevent file corruption from a sudden loss of power. Included is a 1500 VA Smart UPS and proprietary cable to allow control by the Arbin software.



# FCTS

Arbin's FCTS is a turnkey and fully automated fuel cell testing solution developed for fuel cell researchers

- Systems for PEM, DM, SOFC, and more
- Integrated, Modular, "Turn-Key" Design
- 100% Automated Control
- Wide Range of Powers
- Industry Leading Performance
- Maximum Flexibility with Innovative Features
- Patented Dew Point Humidifier System



## General Description

Arbin Instruments' **FCTS** system is a completely automated testing system for various fuel cell applications. **FCTS** is designed in a modular fashion, but is integrated into one compact and powerful package. It is designed to be complete and "turn-key" – meaning that when it arrives to your door, it's ready to begin testing.

The **FCTS** line of systems includes many standard systems for testing PEM, Liquid (such as direct methanol), or a combo system that can test both. In addition to these standard systems, we specialize in custom designing systems to exactly meet your various fuel cell testing needs.

### Arbin's FCTS Capability

Circuitry	Electronic Load or Bipolar Upgrade
Power Capability	Up to 250kW
Current & Voltage Accuracy	0.05% of Full Scale Range
Resolution	14 or 16 Bit
Hardware Modules Include	Input Gas Handling Liquid Reactant Handling Gas Humidification & Heating Exhaust Treatment & Pressure Regulation Stack/Cell Temperature Control Electronic Load or Bipolar Circuit



## Features

### Custom Designed Stations

Flexibility to add individual components as required for specific user applications

### Automated Control

Provides "set-and-forget" operation

### High Quality Components & Patented Dew Point Humidifier

Provides long life and reliable operation, with technology that offers the best performance in the market

### Wide Dynamic Range

Allows testing of different sized fuel cells with the same system

### Components Manufactured In-House

Allowing for faster turn-around and product expertise

### Stoichiometric Flow Control

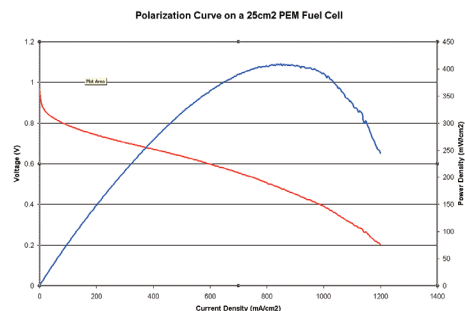
Allows users to control flowrates based on proper stoichiometric ratios

## Internal Resistance Measurement

Using current interrupt method, all Arbin FCTS systems can measure the DC Internal Resistance and use the collected value to control the test.

## Polarization Curves

Polarization curves provide useful information about the optimal operating point and performance characteristics for a fuel cell. Generating the polarization curve is an easy process with the FCTS system and this can be done with a variety of fuel cell operating conditions.



## MITS Pro 5.0 FCT Software

## Real Time Variable Monitoring and Control

Allows user quick access to useful information

(0)/1	Channel Params	Present Values	Environment Params	Present Values	Background Settings
	Channel Index	1	O <sub>2</sub> DPT	0.0000 (C)	(C): 0
	Test Name	-	O <sub>2</sub> GST	0.0000 (C)	(C): 0
	Schedule Name	-	O <sub>2</sub> GBR(100psig)	0.0000 (PSI)	(PSI): 0
	Status	-	Air_FR (10slpm)	0.0000 (sccm)	(slpm): 0
	Step Index	-	Ox1_Purge valve	0 - OFF	-
	Cycle Index	-	O <sub>2</sub> Humid ON/OFF	0 - OFF	0 - OFF
	Step Time (s)	-	F <sub>2</sub> DPT	0.0000 (C)	(C): 0
	Test Time (s)	-	F <sub>2</sub> SST	0.0000 (C)	(C): 0
	Exit Condition	-	F <sub>2</sub> GBR(100psig)	0.0000 (PSI)	(PSI): 0
	Voltage	-	H <sub>2</sub> FR (4slpm)	0.0000 (sccm)	(slpm): 0
	Current	-	Fuel Purge valve	0 - OFF	-
	Current Density	-	F <sub>2</sub> Humid ON/OFF	0 - OFF	0 - OFF
	Power	-	MeOH_ST	0.0000 (C)	(C): 0
	Power Density	-	MeOH_GBR(50psig)	0.0000 (PSI)	(PSI): 0
	Internal Resistance	-	Me_FR(80ccpm)	0.0000 (sccm)	(sccm): 0
	AC_Impedance	-	DM_ONEPASS_ON/OFF	0 - OFF	0 - OFF
	ACL_Phase_Angle	-	FC_T	0.0000 (C)	(C): 0

## Menu Driven User Interface

Provides intuitive control of the testing system

## Multiple Zone PID

Provides precise control over a wide range of testing parameters

## Stoichiometric Control

Allows user to set proper gas ratios and the system will scale flowrates accordingly



## Applications

### Cyclic Voltammetry

Cyclic Voltammetry provides insight into the fuel cell reaction kinetics. It is used to characterize the fuel cell catalyst activity in greater detail. Capacitive charging current flows in response to the linearly changing voltage. The second current response is nonlinear and corresponds to a hydrogen adsorption increase. Following, the reaction current reaches a peak and then falls off as the entire catalyst surface becomes fully saturated with hydrogen. Performing CV experiments is easy with the Arbin FCTS equipped with a potentiostat load and charging power supply option.

### Lifetime Testing

Apply a constant current discharge on the fuel cell until the voltage drops by 10% or out of the acceptable range.



## MITS Pro 5.0 FCT Software

### “On the Fly”

Modifications of test protocol allows users to make changes to a running test without stopping, pausing, or restarting

### Logical Commands

Make the FCTS highly flexible and powerful

### Data Watcher

For real time data monitoring

### Complete Data Management Utility

Allows quick and simple data importing into MS Excel

### Comprehensive Programmable Operating Conditions

Can be assigned and referenced in the test schedule

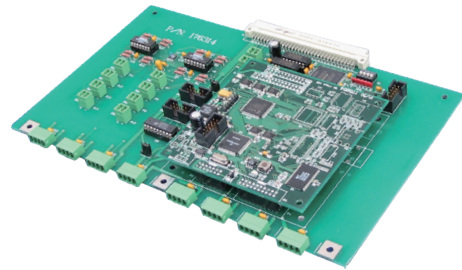
Test Setting Index	Test Setting Label	Number Of Elements	Resumable			
1	warm up1-75C	11	<input checked="" type="checkbox"/>			
	<b>Element Index</b>	<b>Type</b>	<b>Aux Index-Nickname</b>	<b>Turn On</b>	<b>Ctrl Value 1</b>	<b>Ctrl Value 2</b>
	Element 1	Temperature	1 - O_DPT	<input checked="" type="checkbox"/>	(C): 70	
	Element 2	Temperature	2 - O_GST	<input checked="" type="checkbox"/>	(C): 75	
	Element 3	Temperature	3 - F_DPT	<input checked="" type="checkbox"/>	(C): 70	
	Element 4	Temperature	4 - F_GST	<input checked="" type="checkbox"/>	(C): 75	
	Element 5	Temperature	6 - FC_T	<input checked="" type="checkbox"/>	(C): 75	
	Element 6	Flowrate	3 - Me_FR(80ccpm)	<input checked="" type="checkbox"/>	(sccm): 150	Stoch: 0
	Element 7	Flowrate	2 - H2_FR (4slpm)	<input checked="" type="checkbox"/>	(slpm): 0.165	Stoch: 0
	Element 8	Digital Output	24 - F_Humid ON/OFF	<input type="checkbox"/>		
	Element 9	Digital Output	25 - DM_ONEPASS_ON/OFF	<input type="checkbox"/>		
	Element 10	Pressure	1 - O_OBP(100psig)	<input checked="" type="checkbox"/>	(PSI): 0	
	Element 11	Pressure	2 - F_OBP(100psig)	<input checked="" type="checkbox"/>	(PSI): 0	
2	warm up2-75C	11	<input checked="" type="checkbox"/>			
	<b>Element Index</b>	<b>Type</b>	<b>Aux Index-Nickname</b>	<b>Turn On</b>	<b>Ctrl Value 1</b>	<b>Ctrl Value 2</b>
	Element 1	Temperature	1 - O_DPT	<input checked="" type="checkbox"/>	(C): 70	
	Element 2	Temperature	2 - O_GST	<input checked="" type="checkbox"/>	(C): 75	
	Element 3	Temperature	3 - F_DPT	<input checked="" type="checkbox"/>	(C): 70	
	Element 4	Temperature	4 - F_GST	<input checked="" type="checkbox"/>	(C): 75	
	Element 5	Temperature	6 - FC_T	<input checked="" type="checkbox"/>	(C): 75	
	Element 6	Flowrate	3 - Me_FR(80ccpm)	<input checked="" type="checkbox"/>	(sccm): 150	Stoch: 0
	Element 7	Flowrate	2 - H2_FR (4slpm)	<input checked="" type="checkbox"/>	(slpm): 0.165	Stoch: 0
	Element 8	Digital Output	24 - F_Humid ON/OFF	<input type="checkbox"/>		
	Element 9	Digital Output	25 - DM_ONEPASS_ON/OFF	<input type="checkbox"/>		
	Element 10	Pressure	1 - O_OBP(100psig)	<input checked="" type="checkbox"/>	(PSI): 0	
	Element 11	Pressure	2 - F_OBP(100psig)	<input checked="" type="checkbox"/>	(PSI): 0	
3	temp check-75C	11	<input checked="" type="checkbox"/>			



## Options and Auxiliaries

### Auxiliary Voltage, Temperature, & Pressure Inputs

Arbin offers many types of input measurements to custom tailor each testing system to a customers individual needs. A use of auxiliary voltage is to measure individual cell voltages within a stack.



### Digital Input/Output

Arbin offers an 8 channel I/O module that allows the system to respond to external signals or generate control signals for external equipment.

### Water Management System

Arbin's Water Management System allows users to measure the water supplied to the fuel cell, via humidification, and the water removed from the fuel cell in the exhaust stream. This allows the calculation of water generated or consumed by the fuel cell. It is also possible to dope the water with tracing elements for specific research.

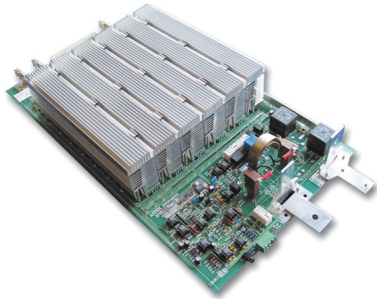
### Potentiostatic Electronic Load

This option provides the system with a charging and potentiostatic load capability which allows more complex electrochemical experiments to



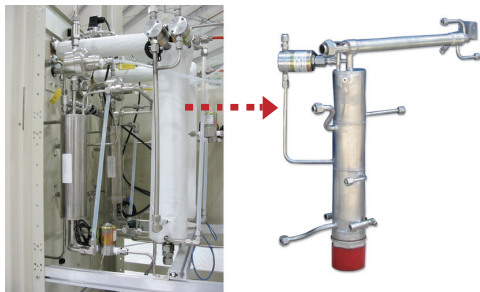
## Options and Auxiliaries

be performed. One example would be performing Cyclic Voltammetry experiments on the fuel cell or stack.



### Input Gas Handling Module

Additional Gas Inputs can be added to any FCTS system to allow for reformate simulation, MEA poisoning, trace element experiments, or additional gas flow ranges. This module includes an additional mass flow controller, mixing, plumbing, and necessary valves.



### Input Gas Pressure Regulators and Gas Filters

Arbin can offer input pressure regulators to provide appropriate supply gas conditions. This is required if there is no pressure regulation on the users gas supply. Gas filters can also be provided for customers who do not already have filters on their gas supply.

### Hydrogen Generation System

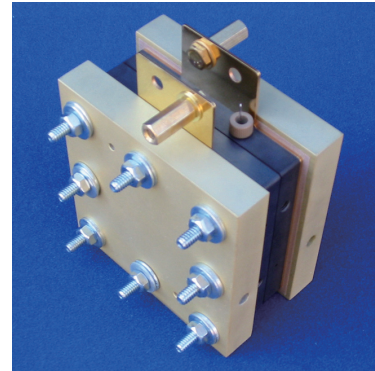
For lower power FCTS systems, Arbin offers hydrogen generation systems. These systems use DI water and electrolysis to generate high purity hydrogen for testing.

### Hydrogen Recycling System

For higher power FCTS system, Arbin offers hydrogen recycle systems which recycle unused hydrogen from the exhaust stream, compressing it, and then returning it to the FCTS input. This process is only useful for systems testing large stacks with excess hydrogen.

### Fuel Cell Fixtures

Arbin offers multiple sized PEM and DM fuel cell fixtures. We offer 5cm<sup>2</sup>, 25cm<sup>2</sup>, 50cm<sup>2</sup>, and 100cm<sup>2</sup> fuel cell fixtures, with and without reference electrodes and MEAs.



# ELOAD

Arbin's ELOAD is a stand alone chassis or can be incorporated into the FCTS testing station

- Powers Available from mW to 200kW
- Multiple Independent Channels Available
- Multiple Voltage and Current Ranges
- Automatic Programmable Linear Load
- High Power Density in a Compact Structure
- Computer Controlled
- High Accuracy and Resolution
- Industry Leading Customer Support

## General Description

Arbin Instruments' Electronic Load (**Eload**) is a multi-channel, automatic, and fully programmable linear load. **Eload** offers many advanced control types that other programmable loads do not. It utilizes Arbin's MITS Pro testing software designed specifically for testing fuel cells and other energy storage devices.

**Eload** offers higher accuracy and resolution than other available competing products. It can achieve accuracy up to 0.05% FSR. All **Eloads** come with multiple current and voltage ranges to expand their range of testing applications.

Our **Eload** is available in our FCTS product and as a stand alone product in a separate chassis. Multiple channels are also available.

### Arbin's ELoad Capability

Circuitry	Electronic Load or Bipolar Upgrade
Power Capability	Up to 250kW
Current & Voltage Accuracy	0.05% of Full Scale Range
Resolution	14 or 16 Bit

# DPH

Arbin's DPH is the most precise and reliable humidification solution, featuring fast response rates over wide operating ranges

- Precise DPT Control
- High Accuracy
- Fast Response Time
- High Turn-down Ratio
- Low Overshoot
- High Stability
- Highly Programmable
- Automatic
- Simple Integration

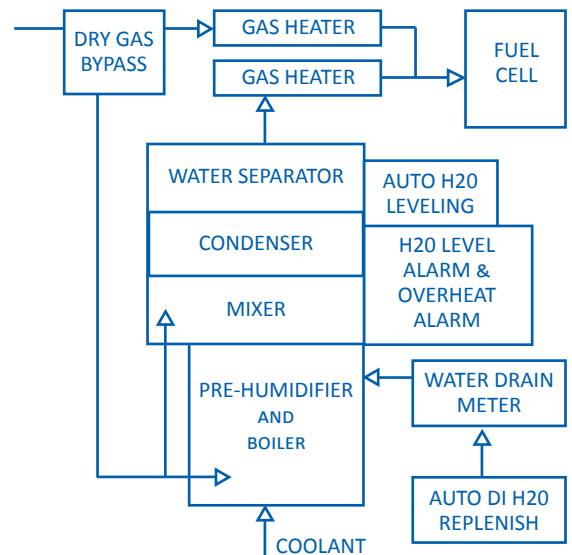
## General Description

Arbin Instruments' Dew Point Humidifier (**DPH**) uses our patented humidification technology which has several distinct advantages over other humidification technology available in the market. The **DPH** can supply the working gas at precise dew point temperatures and gas exit temperatures so the user can accurately set the appropriate relative humidity values.

Arbin Instruments' **DPH** is a key component to our FCTS test systems but it is also available as a stand alone unit which can be easily incorporated into your in-house test stand.

### Arbin's DPH Capability

Flow Rate Range	Up to 6000 slpm
Dew Point Control	± 0.5 °C



# Features

**Precise DPT Control** of  $\pm 0.5^{\circ}\text{C}$

**Accuracy on DPT** of  $\pm 2^{\circ}\text{C}$

**Response Time**

5-10°C per minute on temperature setpoint change

**Turn-down Ratio**

More than 1000:1 allows for wide range of testing flowrates

**Low Overshoot**

Less than 20% of temperature change

**Integrated Design**

Allows for small footprint

**High Stability**

Allows good performance for longer tests

**Simple Operation**

Two temperature setpoint controls

**Dew Point Temperature Range**

From ambient to 120°C

**Exit Gas Temperature Range**

From ambient to 180°C

**Stand Alone**

Or integrated within the Arbin Instruments FCTS

**Flowrates Available**

Up to 6000 SLPM

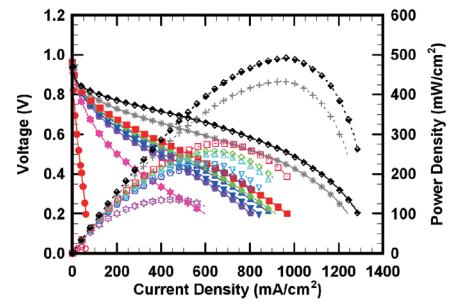
**Documented Performance**

For ease of mind

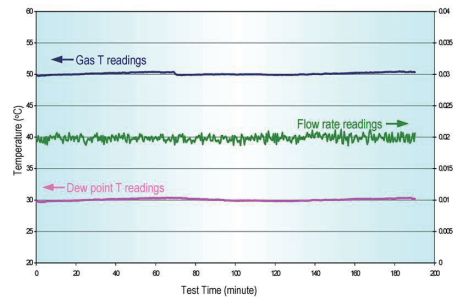
# Applications

**The Importance of Accurate Humidification**

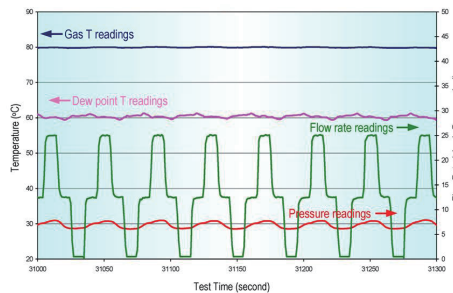
The graph below shows how proper humidification helps fuel cell performance. In this test, the red dots show a PEM fuel cell performance with dry gas. The humidity was progressively increased until the optimal humidity level was realized (black diamonds).



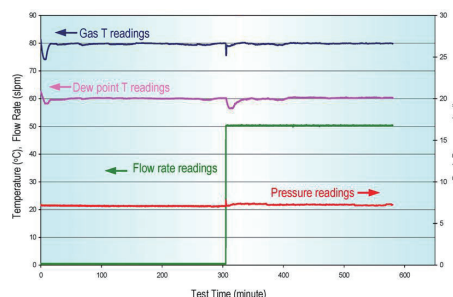
**Extremely High Turn-down Ratio** – The data below is run on a 10slpm DPH but at a flowrate of 20 sccm (turn-down ratio of 500:1). The dew point temperature was set at 30°C and the gas temperature set at 50°C. Performance is not affected by lower flowrates. Stability, response time, and accuracy are all within specification.



**Superior Stability** – For this test, the flowrate was oscillated from 25slpm to 12slpm to 0.25slpm every 10 seconds. Dew point temperature remains stable at the set-point temperature of 60°C. Gas temperature remains stable at 80°C.



**Fast Response Time** – For this test, the flowrate was changed from 0.5slpm to 50slpm (turn-down ratio of 100:1). The Dew point temperature remains relatively unaffected by this large flowrate change and quickly returns to its set-point.





# MITS Pro

Arbin's user-friendly, flexible and intuitive software for writing test schedules and reviewing data

- Independent testing on multiple channels
- Logical menu-driven programming
- "On-the-fly" modification
- Flexible user interface
- Ability to control and monitor external devices from within the software
- Software paralleling of channels
- Complete data management utility

## • General Description

Arbin's **Mits Pro** Software is the most comprehensive battery testing software solution available in the marketplace today. Over the past decade, **MITS Pro** has been developed by Software Engineers at Arbin to provide easy and intuitive control over all our test stations for any application. This flexibility has allowed Arbin to refine and simplify the software and user interface for improved stability and ease of use. Operating on a range of platforms from Windows 98 to Windows 7, the **MITS Pro** software has become the industry standard in quality and testing.

The power of **MITS Pro** comes from its capacity to create and implement tests ranging from a single step up to hundreds, all using a single interface. Using the **MITS Pro** Software, you can write new test schedules, implement test regimes, as well as monitor, view, and graph real-time data.

# Features

**Independent Testing** on multiple channels

**Logical Menu-Driven Programming**

**"On-the-fly" modification**

Of test parameters in real time without interrupting ongoing tests

**Flexibility to assign and reference** many different input and control types

**Flexible** user interface

**Ability to control and monitor** external devices from within the software

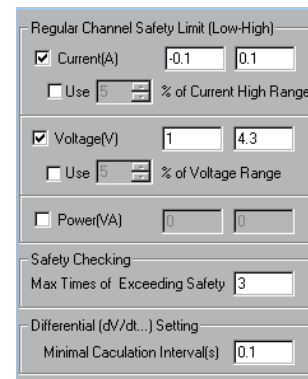
**Software paralleling of channels** allows increased current handling and automatically compiles data file

**Complete Data Management Utility**

## Examples of Control Types Available in MITS Pro:

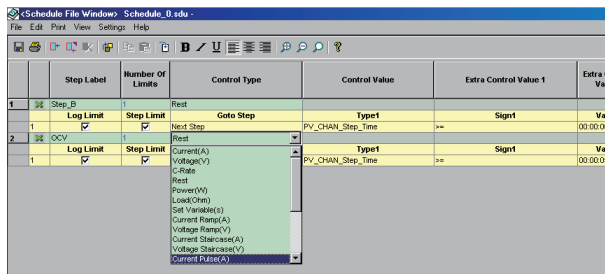
- Current
- Simulation(Drive Cycle)
- Voltage
- C-Rate
- Power
- Formula Control
- Current/Voltage Staircase
- Load
- Current Ramps
- Cyclic Voltammetry
- Custom Pulses
- Internal Resistance
- Set Variables
- CC-CV

Custom written test profiles can consist of an unlimited number of test steps, with end conditions based on changes in time, voltage, current, temperature. The test station can also react and send digital control signals to external devices to integrate the system in to existing laboratory equipment.



# Scheduling

MITS Pro allows for completely customizable test schedules to be written by the user with a simple menu-driven interface with selectable control types, and flexible end conditions. A simple pull-down menu allows for easy selection of the available control types.



Each step in the MITS Pro software consists of 4 Major Functions:

- 1 Select from the list of available Control Types
- 2 Enter the Control Value that you want applied to your devices
- 3 Enter in the End Conditions for when you want the step to end
- 4 Choose Your Data Logging Criteria

MITS Pro allows for user defined safety settings at the step, schedule, and hardware level to provide an extremely safe testing atmosphere designed to ensure total control over the test station.

# Monitor and Control

The Monitor & Control Window in MITS Pro provides the user with all the pertinent information at a glance, while tests are running. Once a Test Schedule is written and assigned in the Batch File, the Monitor & Control screen is where the user has the ability to control all channels and view real-time data values for each channel.

The Monitor & Control Window provides you with a color indicator for each channels status. This allows users to easily monitor all channels in the test bench to ensure the devices under test are behaving as anticipated.

## Monitor and Control

### On-The-Fly Test Modifications

Arbin's hardware and software design allows for real time on-the-fly test modifications to be performed on the running test schedule. With the ability for the user to modify running test schedules, the requirement to stop and restart tests is not necessary, providing for longer uninterrupted testing.

### Typical Information Provided in the Monitor & Control Screen

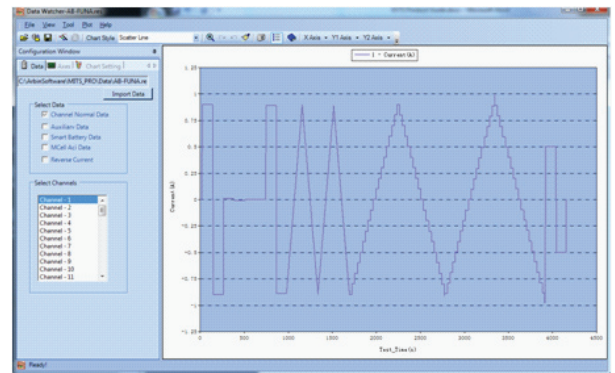
Test Name, Schedule Name, Status, Exit Condition, Step Index, Cycle Index, Step Time, Test Time, Voltage, Current, Charge/Discharge Capacity, and others!

A "Brief View" tab is also available to provide a less detailed summary of the status for each channel, which allows for easy monitoring, especially when controlling up to a hundred channels in one chassis.

(R)/G#	Test Name	Schedule Name	Status	Exit Condition	[ Cycle ] Step Index	Step Time (s)	Test Time (s)	Voltage	Current
001	AB-FUNA	AB-FUNA.sdu	Discharge	N/A	[ 1 ] 16: Step_L	00:06:11.478	01:04:32.988	-797.5616 (mV)	-799.9105 (mA)
002	AB-FUNA	AB-FUNA.sdu	Discharge	N/A	[ 1 ] 16: Step_L	00:06:51.445	01:04:32.949	-999.8604 (mV)	-998.0127 (mA)
003	AB-FUNA	AB-FUNA.sdu	Rest	N/A	[ 1 ] 17: Step_X	00:00:07.896	01:04:32.838	-717.2151 (uV)	0.0000 (uA)
004	AB-FUNA	AB-FUNA.sdu	Discharge	N/A	[ 1 ] 16: Step_L	00:06:20.152	01:04:32.901	-898.2464 (mV)	-804.3249 (mA)
005	AB-FUNA	AB-FUNA.sdu	Discharge	N/A	[ 1 ] 16: Step_L	00:06:16.252	01:04:32.824	-799.8515 (mV)	-808.7770 (mA)
006	AB-FUNA	AB-FUNA.sdu	Discharge	N/A	[ 1 ] 16: Step_L	00:06:20.729	01:04:32.744	-898.8582 (mV)	-899.7879 (mA)
007	AB-FUNA	AB-FUNA.sdu	Charge	N/A	[ 1 ] 18: Step_M	00:00:19.967	01:04:32.666	2.5097 (V)	2.5001 (A)
008	AB-FUNA	AB-FUNA.sdu	Rest	N/A	[ 1 ] 17: Step_X	00:00:09.016	01:04:32.558	-329.5490 (uV)	0.0000 (uA)

## Data Watcher

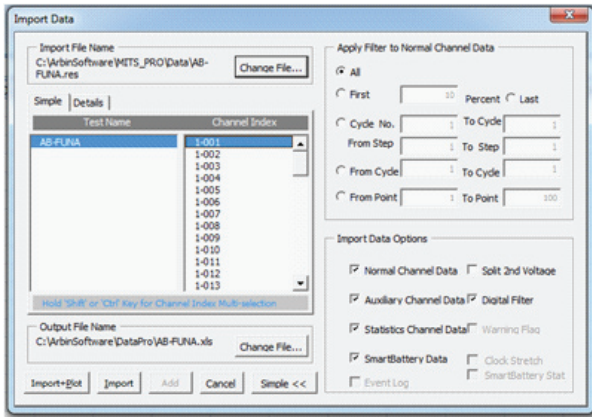
**Data Watcher** is a data plotting tool provided by Arbin which allows for quick and simple plotting of your real-time test results file. Using data watcher, the user can do simple or complex plotting to determine whether or not the battery is reacting as expected.



If a data point falls outside of expectations, the user can double click on the graph and the list of data points will appear as well as the cycle count and step number the test is in. If modifications are required to the test schedule, the user can open the specified test schedule in MITS Pro, make the modification and continue testing with no interruption.

Data Watcher is a tool provided by Arbin which allows for the plotting of both the devices test profile, as well as the statistics file which includes, for example, the charge and discharge capacity during the tests performed.

## Data Watcher



Data Watcher can be loaded on any PC to view results files from previously ran test schedules, allowing users to analyze data outside of the laboratory.

## Data Analysis

Once a test is started in the Monitor & Control Window, a Microsoft Access Database file is created which stores all of the result information. The imported file will list all of the relevant information for data analysis including:

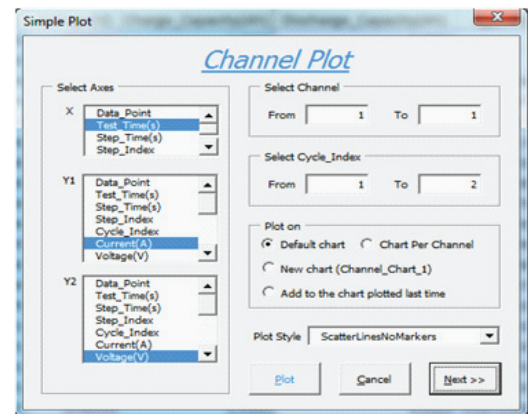
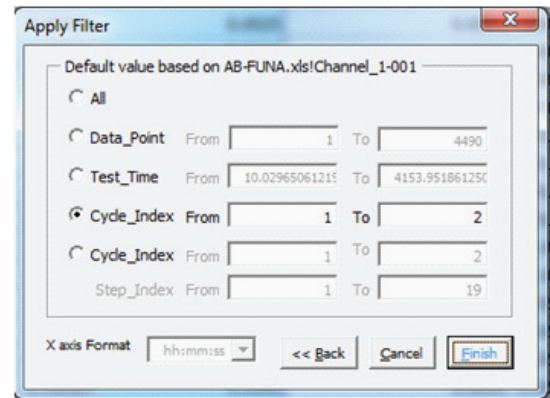
- Test Time & Date
- Current
- Charge/Discharge Capacity (Ah)
- Step & Cycle Index
- Voltage
- Charge/Discharge Energy (Wh)
- All Auxiliary Data

Arbin's Software Engineers have developed a Data Pro Macro which allows users to import the Results (.res) file in to Microsoft Excel.

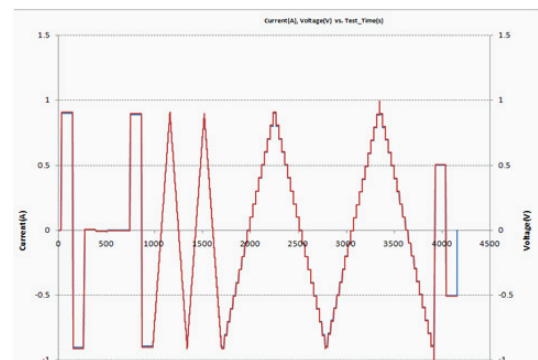
	A	B	C	D	E	F	G	H	I
1	Data_Point	Test_Time(s)	Step_Time(s)	Step_Index	Cycle_Index	Current(A)	Voltage(V)	Charge_Capacity(Ah)	Discharge_Capacity(Ah)
2	1	20.030	10.010	1	1	0.00000	-0.00010	0.0000	0.0000
3	2	20.014	20.014	1	1	0.00000	0.00001	0.0000	0.0000
4	3	30.023	10.009	2	1	0.89996	0.90966	0.0025	0.0000
5	4	40.023	20.009	2	1	0.89996	0.90935	0.0050	0.0000
6	5	50.028	30.014	2	1	0.89996	0.90935	0.0075	0.0000
7	6	60.038	40.024	2	1	0.89996	0.90966	0.0100	0.0000
8	7	70.051	50.037	2	1	0.89996	0.90997	0.0125	0.0000
9	8	80.061	60.047	2	1	0.89996	0.90966	0.0150	0.0000
10	9	90.091	70.077	2	1	0.89996	0.90997	0.0175	0.0000
11	10	100.098	80.084	2	1	0.89996	0.90997	0.0200	0.0000
12	11	110.108	90.094	2	1	0.89999	0.90997	0.0225	0.0000
13	12	120.121	100.107	2	1	0.89996	0.90997	0.0250	0.0000
14	13	130.136	110.122	2	1	0.89996	0.90966	0.0275	0.0000
15	14	140.025	120.011	2	1	0.89999	0.90997	0.0300	0.0000
16	15	150.011	10.006	3	1	-0.90001	-0.91025	0.0300	0.0025
17	16	160.035	20.009	3	1	-0.90001	-0.91025	0.0300	0.0050
18	17	170.045	30.019	3	1	-0.90001	-0.91025	0.0300	0.0075
19	18	180.056	40.031	3	1	-0.90001	-0.91025	0.0300	0.0100
20	19	190.060	50.034	3	1	-0.89997	-0.90994	0.0300	0.0125
21	20	200.075	60.050	3	1	-0.89997	-0.91025	0.0300	0.0150
22	21	210.096	70.071	3	1	-0.90001	-0.91025	0.0300	0.0175
23	22	220.137	80.111	3	1	-0.89997	-0.91025	0.0300	0.0200
24	23	230.152	90.127	3	1	-0.90001	-0.91025	0.0300	0.0225
25	24	240.184	100.158	3	1	-0.90001	-0.91025	0.0300	0.0250
26	25	250.214	110.189	3	1	-0.90001	-0.91025	0.0300	0.0275

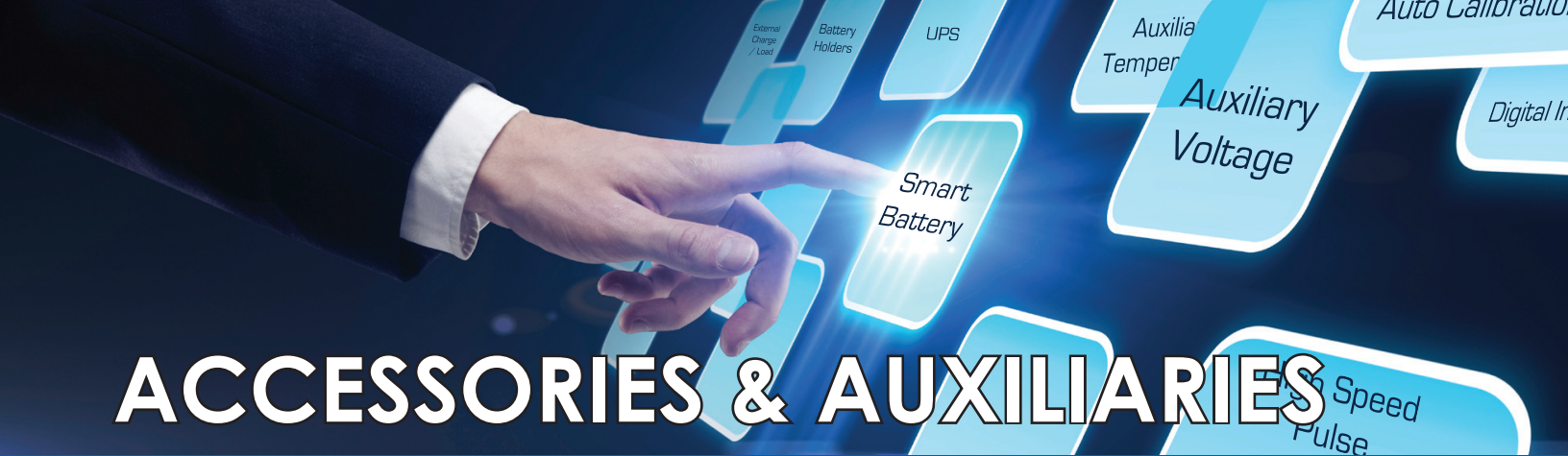
## Data Analysis

With the Arbin Data Pro Macro, any computer becomes a powerful data station, able to generate presentation-grade plots of fundamental and derived data. Data files generated in Microsoft Access tables are viewable using any spreadsheet software. There are no time consuming exporting or other steps involved to view the data.



The macro created by Arbin allows the user to plot all of the data, specific cycles or test-time, based on any criteria that you may require. The Macro and Data Watcher can be installed on any PC which allows for flexible data analysis outside of the laboratory.





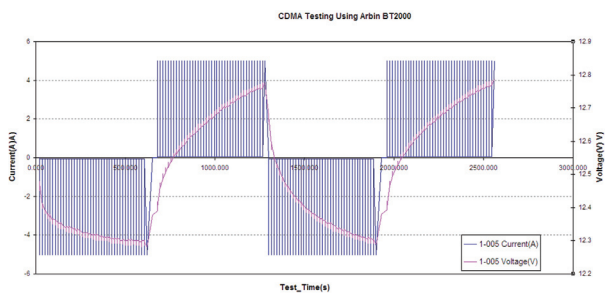
# ACCESSORIES & AUXILIARIES

Arbin Instruments offers numerous optional accessories and auxiliaries to complete your testing needs.

**Auxiliary Voltage** is typically used to measure the voltage on each cell in a multi-cell battery pack or to measure the reference electrode voltage in a multi-electrode experiment.

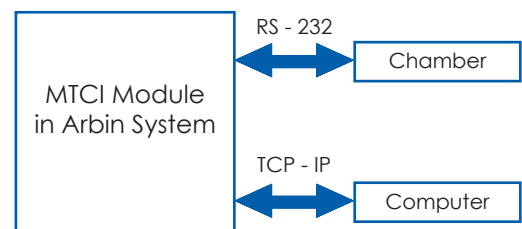
**Auxiliary Temperature** is used to measure the temperature of any point in the test setup using either a thermocouple (E, J, K or T) or a 10kΩ thermistor. The value of temperature can be recorded in the results file and/or used to further control the experiment.

**High Speed Pulse Option** provides the capability to run GSM, CDMA, TDMA or other custom designed pulses. We define a High Speed Pulse as a sub-second single or repeated pulse profile. Arbin's pulse capability covers a broad range of sub-millisecond communication profiles, which can handle multi-stage pulses as fast as 100 micro-seconds per stage and up to 10 stages per pulse profile. A single pulse profile can have a maximum length of 2700 seconds. System designs are flexible and may have a dedicated microcontroller for each channel, or a microcontroller that is shared by a small group of channels, depending on the requirement.



**Digital Input/Output** module sends and receives a simple digital on/off signal that can be used to interact with third party hardware. Available in TTL and Relay.

**Temperature Chamber Interface** or MTCI allows the system to communicate with a third party temperature chamber controller during testing. The MTCI module tells the chamber controller what temperature set-point to use during each test step, allowing the user to program complex automatic temperature profiles in their tests.



**Auto-Calibration** allows all the channels to be calibrated automatically for each current range (current < 20A), each voltage range (voltage < 70V), and each auxiliary voltage channel. The user sets the desired accuracy and the module will generate a results report upon completion.

**External Charge/Load** is useful when qualifying chargers to be used with your batteries or studying load profiles. Using this option, the user connects the battery to the main I/V channel and the charger or load to the External Charge input provided. The user can program the battery to be charged/discharged by the external charger/load at a predetermined step

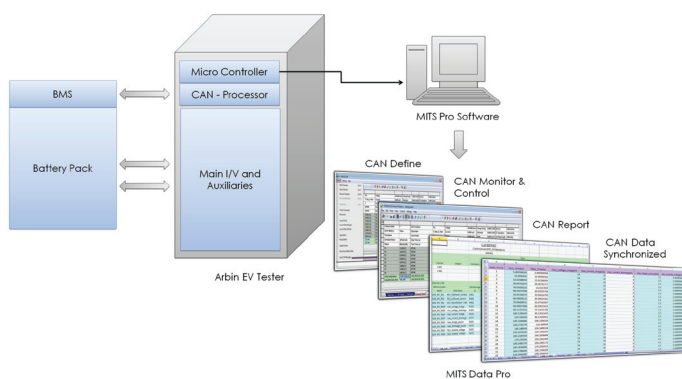
## More Options

in the schedule. The system internally and automatically connects the battery to the charger/load. During the External Charge/Load step, the Arbin system collects data about the charger/load performance. The system then disconnects the charger/load once the preset limit conditions are met.

This can also be used to have a battery connected through the external charger and the power tool connected to the main I/V channel while performing an action with the power tool such as drilling a hole. The Arbin system will record the current and voltage profile, which can then be used to simulate this same profile on other batteries.

### CAN-Bus Communication

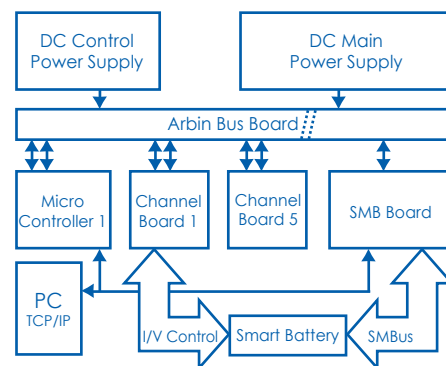
Arbin provides CAN-Bus communications for our EVTS systems that can be used to test battery packs with integrated BMS systems. Arbin's MITS Pro software allows the test equipment to be programmed to both receive CAN messages from and transmit CAN messages to customers' CAN devices. With Arbin's CAN-Bus, there is no third party equipment, 3rd party DLL package or 3rd party licenses' needed to operate. The illustration to the right graphically represents the CAN-Bus communication for Arbin's EVTS Systems.



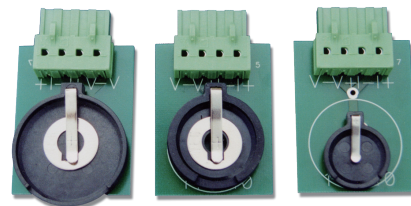
**UPS** is designed to support the PC and detect a power outage to the Arbin tester. It will allow a test to resume automatically if power returns within a user-defined time period, or shut down the PC if power is not returned. This helps prevent file corruption and protects the PC. Included is a 1500 VA Smart UPS system from

APC and proprietary cable to allow control by the Arbin software.

**Smart Battery** is used to communicate with smart batteries using SMBus 1.1 or 2.0. This feature will allow users to read/write registers on the smart battery as well as compare data collected from the smart battery with data that the Arbin system measures directly. Our MITS-Pro software for smart battery integrates the capability to view/read, write, control or program information from the Smart Battery register. The software provides advanced test scheduling options by allowing SMBus registers to be used as limit control and offers many programmable features.



**Battery Holders** are offered for Coin Cells, Flat Cells, and Cylindrical cells including high current cells up to 200A. Arbin also provides two different battery racks for coin cells or cylindrical cells, and can customize a rack or holder for unique applications upon request.



# Guide to Buying an Arbin System

## Customizable Range of Products

Voltage	Below 0V up to 800V
Current	+/- 10nA up to +/-1000's of Amps
Power	Up to 300kW

Specs	<10V, 10A	10V-60V	60V+
Circuit Type	Bipolar Linear	Bipolar Linear	Regenerative Bipolar
Accuracy	0.02% FSR	0.05% FSR	0.1% FSR
Resolution	14 or 16 bit	16 bit	16 bit
Current Rise Time	As fast as 10µs	As fast as 100µs	As fast as 100ms



## Examples of Standard Products

### Step 1: Know your application

### Step 2: Voltage range of device

### Step 3: Current range of device

### Step 4: Select a standard product

Materials Research & Development Life Cycle Testing	(-10) to 10V	100 to 500mA	BT - 2X43
Supercapacitor Testing Material Development for Capacitors	(-5) to 5V	500mA to 5A	SCTS - 5
Single Cell Development Life Cycle Testing	0 to 5V -2 to 10V	5A 5A to 10A	BT - G
Single Cell & Small Pack Testing	Up to 20V	10A	BT - I
High Capacity Single Cells Supercapacitor Testing	0 to 5V	2500A	BT - 5HC
Smart Battery Testing	Up to 25V	10A	BT-SMART
Power Tool Battery Testing External Charge Channels	Up to 60V	10 to 100A	PTBTS

**Step 5: Call Arbin Sales at +1 979 690 2751 to get a quote today!**





[www.arbin.com](http://www.arbin.com)

762 Peach Creek Cut Off Rd.  
College Station, TX 77845  
+1 979 690 2751  
[sales@arbin.com](mailto:sales@arbin.com)



MSTAT



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FCTS



DPH