

Photovoltaic (PV) IV Test Stations

Elements of a PV IV system



Abet Technologies at EU PVSEC 2012, Frankfurt; the best way to explore the elements of a PV IV system is to visit us at one of the shows- our website lists the forthcoming exhibitions.

Adaptable System Configurations

A large variety of the elements of a PV IV system are available from Abet Technologies to match the specific test requirements of different cell types and sizes. Some of those elements, like our solar simulators, software and reference cells are more fully described in their own catalog sections. Here we focus on the remaining parts of the system.

Electronic load options

PV IV curves span a range of currents from pA levels to tens of Amps. Since not everybody needs to cover that whole range of values we describe the useful ranges for load options available from Abet.

Different models of Keithley SourceMeters™ cover a wide range of current levels. The more economical 2400 series SourceMeters™ work well with low to mid-range capacitance cells. Stabilizing circuits can be used to extend their load capacitance capabilities but at some cost to speed. The 2600 series units offer native High Capacitance mode, for up to 50 µF capacitance cells, and higher speed of operation.

Abet NIDAQ/Kepeco loads offer economical choice up to 40 A but are not very useful below 100 mA range. Combine them with one of the Keithley SourceMeters™ to create a dark curve to high current illuminated curve capable system.

- Solar Simulator
- Electronic load
- Vacuum chuck
- Contact probes
- Data acquisition and analysis software
- Reference cell
- Temperature monitoring or control
- Dark enclosure
- Alignment microscope

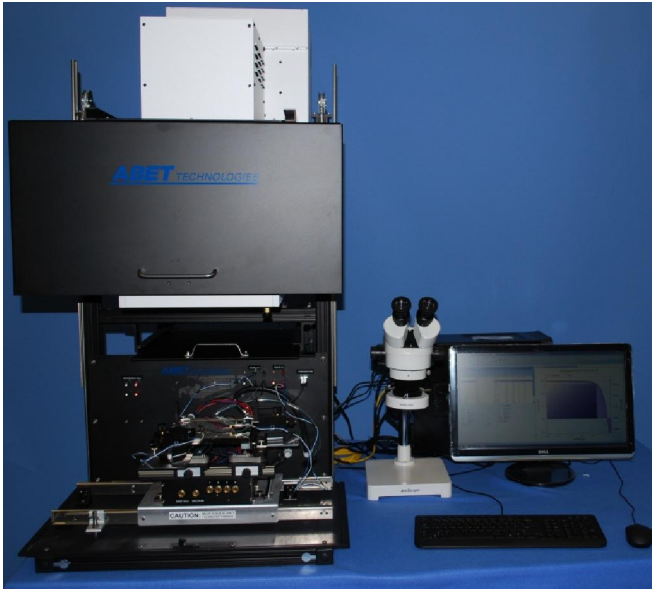
Our new 15295 universal load combines two high speed Agilent 34410A DMMs with a custom bipolar amplifier and a multifunctional USB interface to produce a seamless electronic load system capable of dark curve through 15 A current metrology for up to 1 mF capacitance cells. Adding a third DMM allows simultaneous reading of a monitor cell.

In the table below we list the current measurement specifications for a range of loads available from Abet. Please consult manufacturer's individual instrument data sheets for the full range of their specifications. Please ask us if you need a different load type.

Abet Standard Loads	Max current	Resolution	Accuracy
15295 Abet Universal Load, max. cell capacitance 1 mF	15 A	100 pA	40 nA
NIDAQ/Kepeco load	10 A	3µA	88µA
NIDAQ/Kepeco load	40 A	12µA	350 µA
Keithley 2401 (and 2400)	1 A	50 pA	300 pA
Keithley 2420	3 A	500 pA	700 pA
Keithley 2440	5 A	500 pA	700 pA
Keithley 2601B	3 A	100 fA	100 pA
Keithley 2601B, 50 µF max. high cap. mode	3A	1 pA	500 pA
Keithley 2635B	1.5 A	1 fA	120 fA
Keithley 2635B, 50 µF max. high cap. mode	1.5 A	1 pA	400 pA

All specifications subject to change without notice.

PV IV system chucks and accessories

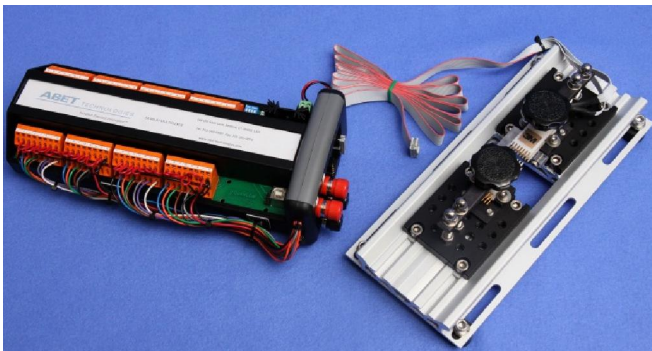


Abet Technologies 11018A Sun 3000 Solar Simulator with a 15514 Dark Enclosure with 15448 Slide assembly, 15510 Vacuum Chuck, 15511 Micromanipulator base, two 15250 Micromanipulators, 15552 Stereo Zoom Microscope, and a PC with Tracer™ PV IV software

Multiple device cell test stations

Sandbox designs, placing a variety of test devices on a single substrate, are often used to cut the cost and speed development efforts. Abet Technologies developed a number of test arrangements to work with such devices. Here we show two of those.

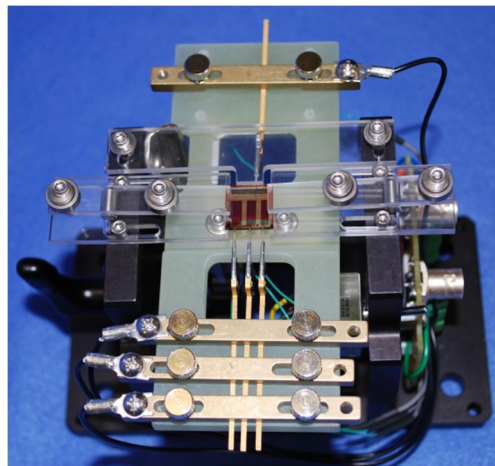
The 15510 station uses modified chip testing clips to contact device electrodes located on 2.54 mm centers. In this system 14-contact clips (7 positions, top and bottom) are used. The signals can be selected manually or a 15277 Multiplexer, with 64 relays, 1A capacity, can be used to speed up test procedures under Tracer™ software control.



15510 station with 15277 Multiplexer

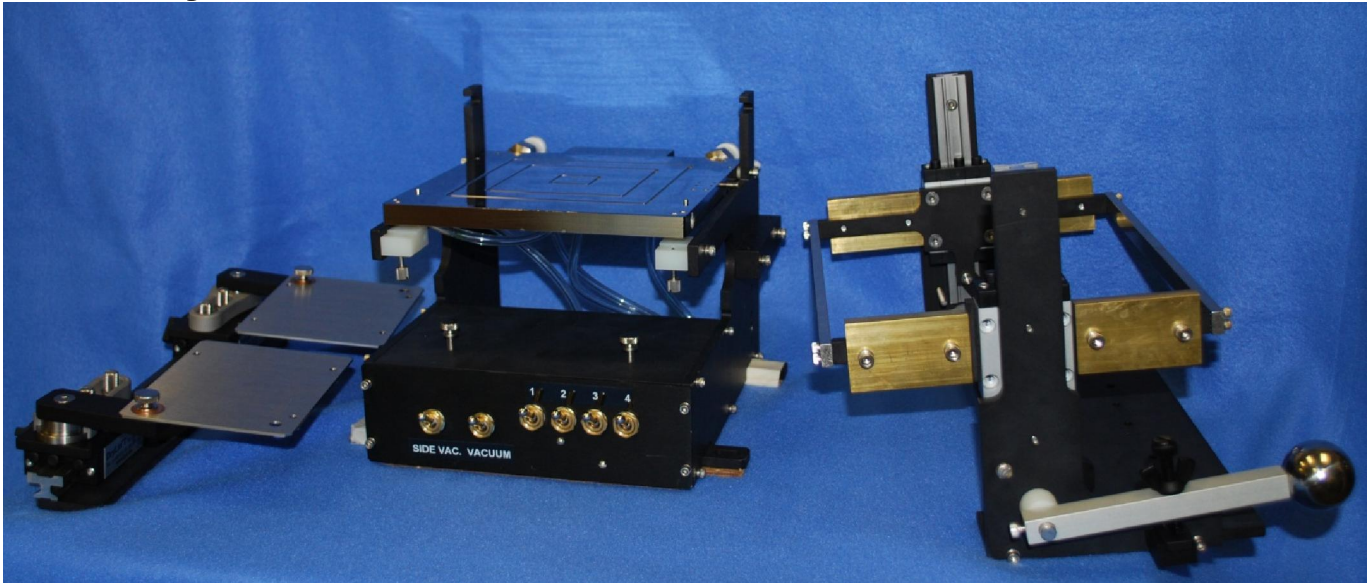
- Vacuum chucks with zones for standard and custom cell sizes, 3 mm to 300 mm
- Four wire test methodology standard
- Top-bottom, top-top, and bottom-bottom contact geometries accommodated
- Electrical contacts: spring loaded bus bars, micromanipulators and custom base pads
- Bus bar and micromanipulator options easily field switchable
- Dark enclosures
- Glove box compatible models
- Multi-cell devices accommodating models
- Top, side or bottom illuminated models
- Wide temperature range cooling/heating
- Basic models can be field modified for temperature control
- Calibrated temperature monitoring
- Attenuator for Bowden method of R_s determination included in most models
- All tools and components for normal use and maintenance included

The 15545 back contact station has adjustable contacts for up to three devices and one common contact. A three position toggle switch allows selection of the DUT. Up to 25x25 mm cells accommodated.



15545 Back contact, three device cells test station

PV IV system chucks and accessories



From left to right, 15511 micromanipulator base option, 15510 vacuum, chuck, 15512 probe bar actuator option (no probe bars shown)

Wide selection of cell types and sizes

Abet Technologies expanding line of PV IV test stations is trying to keep up with the ever growing variety of cell types and sizes being developed around the world. The front page of this catalog shows a photograph of the 3x3 to 300x300 mm cell test station. Below we describe a sampling of some of the other Abet cell test stations offerings.

The Abet versatile 3x3 to 156x156 mm cell size 15510 vacuum chuck above is temperature control ready – just add a recirculating cooler and temperature control is accomplished. A calibrated temperature sensor is included.

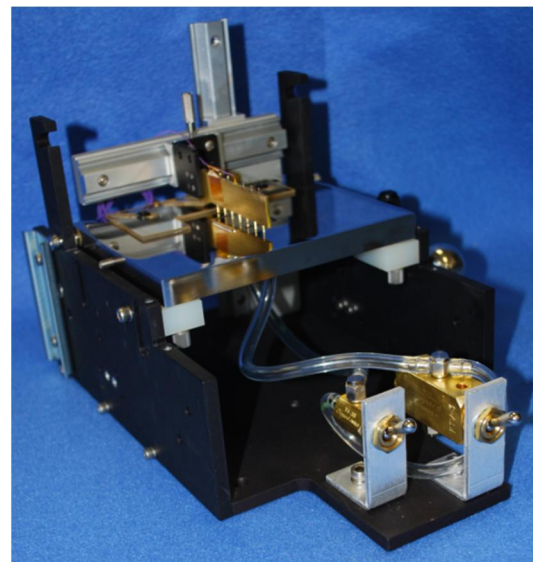
Four main section vacuum zones are matched to the most common cell sizes. An edge vacuum zone allows easy testing of DSSC cells once the 15515 base and a 15250 micromanipulator are added. Add a 15512 probe bar actuator for bus bar metallized cells or the 15511 micromanipulator base and 15250 or 15251 micromanipulators for cells with custom located contact pads.

The 15290 reconfigurable back contact option allows testing of various back contact geometry cells.

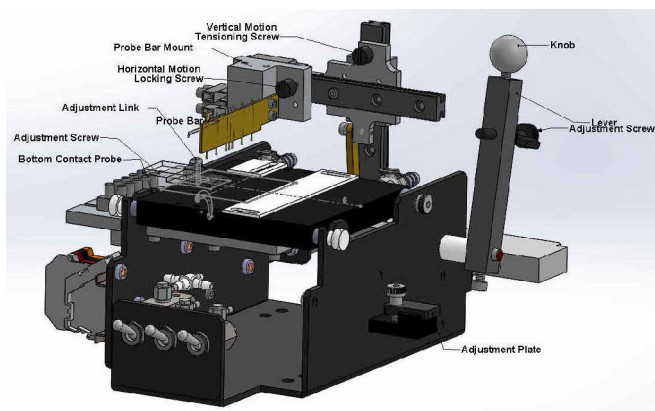
A set of cell locators is included to allow reproducible positioning of the devices. A locating bracket correctly positions the chuck with respect to Abet Solar Simulator.

Most of the characteristics of the 15510 156x156 mm chuck based stations are shared by other Abet stations for 50x50, 210x210, and 300x300 mm cells:

- Multi-zone vacuum design allows testing of cells down to 3x3 mm size
- Cell locators and solar simulator locator bracket guarantee reproducible metrology
- Calibrated temperature sensor facilitates STC correction
- Simple connection to a recirculating cooler provides temperature control from dew point to 70°C for standard chucks, higher on special order
- Micromanipulator and bus bar probes options are easily swappable by the user



15500 50x50 vacuum chuck with 15502 probe bar option



Abet Technologies 15540 DSSC Test Station, 50x50 mm

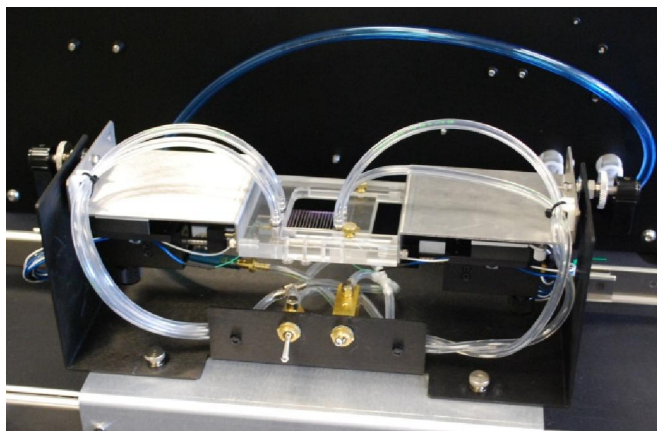
Multifunctional Solutions

Abet Technologies model 15540 DSSC glass sandwich cell test station can accommodate 5x5 to 50x50 mm sized cells. The station is temperature control ready. Add a recirculating cooler for temperature control. There are three vacuum zones to accommodate various cell sizes.

The station comes with three bottom contact Kelvin probes, one top contact Kelvin probe for smaller cells and one spring contact probe bar for larger cells. Cell locators and solar simulator locating bracket guarantee reproducible metrology.

Abet Technologies model 15511 Flip Chuck is used for back contact cells with small contact pads. The chuck allows contact alignment under a microscope and then is flipped 180° for top illumination. It is usually mounted on a slide to allow translation between the alignment and exposure locations. Up to 50x50 mm active area can be probed on a maximum of a 100x100 mm substrate.

Two 15250 micromanipulators are required to contact the cell.



15511 Flip chuck with two 15250 micromanipulators on a 15448 slide assembly

Micromanipulators



Abet Technologies 15250 and 15251 (insert) Micromanipulators

Abet offers high and low resolution micromanipulators. Use the low resolution 15251 micromanipulator for contacting pads down to .5 mm. For higher resolution work use the precision 15250 micromanipulators. The right and left-handed 15250 micromanipulators are mounted on switchable magnetic bases and come with a set of extender rods to allow contacts on up to 300x300 mm stages. The extender kits also allow right angle probe mounting to further extend their positioning flexibility. Each micromanipulator is shipped with a Kelvin probe.

Heating/Cooling Recirculators

The 15281 Temperature Stabilization Recirculators hold your test station at 25°C for standardized cell testing conditions.

The 15285 Heating/Cooling Recirculator, on the right, has a -20°C to 135°C range (please check the working fluid and chuck temperature limits which will typically be narrower). Other specifications are as follows: 0.1°C temperature resolution, 0.07°C temperature stability, 0.1 bar pressure, 10 l/min flow rate, 200W cooling capacity at 20°C, 1100 W heater, 7 l reservoir, and 54.1 x 22.1 x 64.5 cm dimensions.



Dark Enclosures

Abet Technologies offers a series of dark enclosures to allow dark curve metrology. All the enclosures include bulkhead connections for all the electrical, cooling fluid and vacuum services the chucks require.

Accessories

Numerous accessories such as **vacuum pumps**, **stereo zoom microscopes** and **positioning slides** allow construction of versatile test systems.

Ordering Information, PV IV Stations

Software

15000 Tracer™ PV IV Control and Measurement Software

Stations

- 15500** 50x50 mm cells multi-zone vacuum chuck with calibrated temperature interface, temp. control ready
- 15501** Micromanipulator base option for 15500. Order micromanipulators and probes separately
- 15502** Probe bar and actuator option for 15500. Includes one probe bar
- 15503** Additional probe bar and mount for 15502
- 15504** Dark enclosure for the 1550x family of stations
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- 15510** 156x156 mm cells multi-zone vacuum chuck with calibrated temperature interface, temp. control ready; special DSSC cell vacuum zone included
- 15511** Micromanipulator base option for 15510. Order micromanipulators and probes separately
- 15512** Probe bar and actuator option for 15510. Includes two probe bars
- 15513** Additional probe bar and mount for 15512
- 15514** Dark enclosure for the 1551x family of stations
- 15515** DSSC bottom contact micromanipulator base option for 15510
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- 15520** 210x210 mm cells multi-zone vacuum chuck with calibrated temperature interface, temp. control ready
- 15521** Micromanipulator base option for 15520. Order micromanipulators and probes separately
- 15522** Probe bar and actuator option for 15520. Includes two probe bars
- 15523** Additional probe bar and mount for 15522
- 15524** Dark enclosure for the 1552x family of stations
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- 15530** 300x300 mm cells multi-zone vacuum chuck with calibrated temperature interface, temp. control ready; auxiliary front section for small cells metrology
- 15531** Micromanipulator base option for 15530. Order micromanipulators and probes separately
- 15532** Probe bar and actuator option for 15530. Includes two probe bars
- 15533** Additional probe bar and mount for 15532
- 15534** Dark enclosure for the 1553x family of stations

Special cells stations

- 15110** Station, Multiplexer Enabled, 12 devices, 2.54 pad spacing
- 15111** Station, flippable for microscope alignment, 100x100 mm, order micromanipulators separately
- 15540** 50x50 mm DSSC cells test station, three vacuum zones
- 15545** Back contact, three device cells test station, 25x25 mm

Micromanipulators and probes

- 15250-R** Micromanipulator, precision, right handed
- 15250-L** Micromanipulator, precision, left handed
- 15251** Micromanipulator, low resolution. For 50x50 or smaller devices
- IK1B10D1F** Kelvin probe with flat tip BeCu .38 mm dia contacts separated by 0.64 mm.
- IK2B10D1F** Long mount Kelvin probe with flat tip BeCu .38 mm dia contacts separated by 0.64 mm

Other Kelvin and single contact probes available. Please inquire.

Ordering Information (cont'd)

Electronic loads

- 15295** Universal electronic load with two Agilent 34410A High Speed DMMs, Dark Curve to 15 A range
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- Keithley SourceMeter™** - see page 24 for suggested models
- 778927-01** USB to GPIB adapter for 2400 series
- 15274** Stabilizing circuit for Keithley 2400 series
- 15282** Shutter controller box for Keithley 2401
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- Kepeco Bipolar Amplifiers** – 5A to 40A maximum range; please ask Abet to help you choose the best model; stabilizing, calibrated shunt resistors included
- USB-6211** NIDAQ, noise reducing circuitry included
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- 15286** Keithley/NIDAQ software controlled switching option

Temperature control/measurement

- 15281** Temperature stabilizing recirculator, 25°C
- 15285** Heating/cooling recirculator
- 15170** Calibrated temperature interface, USB

Accessories and spares

- 15290** Reconfigurable back contact option for the 15510 vacuum chuck
- 15291** Reconfigurable back contact option for the 15530 vacuum chuck
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- 15552** Stereo zoom probe alignment microscope, 3.5-45X, LED ring illuminator
- 15553** Stereo zoom probe alignment microscope, 3.5-45X, LED ring illuminator, USB camera, 2 Megapixels
- 15447** Stand-alone microscope alignment slide assembly
- 15448** Microscope alignment slide assembly for the 15514 dark enclosure
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- 15185** Monitor cell
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- 15171** Bowden R_s determination method attenuator, 156x156
- 15172** Bowden R_s determination method attenuator, 200x200
- 15173** Bowden R_s determination method attenuator, 300x300
-
- 15275** Vacuum pump, 115 VAC. 40 LPM; 650 mm Hg max vacuum
- 15276** Vacuum pump, 230 VAC. 40 LPM; 650 mm Hg max vacuum
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- 15277** Multiplexer, 64 1A capable relays
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- 15201-S** Replacement spring loaded pins (8), serrated end

Solar Simulators

See Solar Simulator pages

Reference cells

See Reference cell pages

Abet Technologies regularly continues to upgrade our products, therefore all specifications are subject to change without notice.