Photovoltaic (PV) IV Test Stations

Elements of a PV IV 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.

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

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.

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.
PV IV system chucks and accessories

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
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.

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**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
- **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
- **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
- **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

**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

**Kepco 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

**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
- **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

**Monitor cell**
- **15171** Bowden Rs determination method attenuator, 156x156
- **15172** Bowden Rs determination method attenuator, 200x200
- **15173** Bowden Rs determination method attenuator, 300x300

**Vacuum pumps**
- **15275** Vacuum pump, 115VAC. 40 LPM; 650 mm Hg max vacuum
- **15276** Vacuum pump, 230VAC. 40 LPM; 650 mm Hg max vacuum

**Multiplexers**
- **15275** Multiplexer, 64 1A capable relays

**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.