Keysight Technologies
EV1003A Hybrid-Electric/Electric Vehicle Power-Converter Test Solution

RP7900 Series Regenerative Power System
SD1000 Safety Disconnect Solution
PA2200 Series IntegraVision Power Analyzer

Solution Brochure

Accelerate power-converter testing – safely

Only Keysight’s power-converter test solution allows you to accelerate your test without having to worry about the safety of your people.
Introduction

The hybrid-electric and electric vehicle (HEV/EV) market has been growing rapidly. Increasing vehicle electrification in the automotive market brings with it new challenges in design and manufacturing. Probably the most noticeable change is the addition of high-voltage, high-power batteries to a platform that is traditionally 12 volts. Hybrid electric and full electric vehicle batteries are 300 volts and higher. These high voltages bring with them additional costs and risks.

Higher costs and risks for high-voltage, high-power components

Purchasing EV test equipment suitable to handle this new high-voltage, high-power environment can be in the range of 4-times more expensive than that of low-power equipment (e.g. 1 kW vs. 10 kW power sources), and many times even higher. Operating expenses will also increase, and at an even greater multiple. For example, the amount of electricity consumed by a 10 kW power source is 10X that of a 1 kW power source when sourcing full power. All this power creates an enormous amount of heat that needs to be mitigated by increasing your facility’s cooling capability. Moreover, you now need to comply with high-voltage safety regulations, such as NFPA 79 in the United States. Extra equipment, such as a safety disconnect system, needs to be considered. This leads again to higher cost since you need to design, implement, and support this safety system. Finally, support and maintenance plans become much more complex, especially if you are deploying these systems worldwide.

Keysight’s Solution

Keysight is partnering with industry leaders in the HEV/EV market to help them transition their EV tests smoothly into the world of high-voltage, high-power test. Keysight has designed a solution specifically to address the safety, regulatory, and environmental issues mentioned above. This solution is the only commercial-off-the-shelf (COTS) regenerative power system with highly integrated safety features that protect your devices under test and your people. The regenerative capabilities enable the energy consumed to be put back onto the grid cleanly, saving costs from energy consumption and cooling, while not interfering with the grid. Keysight’s solution and worldwide support give you the confidence to deploy high-voltage, high-power solutions to meet the fast paced, high-growth demands of the HEV/EV market.

After reviewing this brochure, please do not hesitate to contact Keysight to learn more.
Key features of the EV1003A Power Converter Test Solution

Deliver safe and effective testing of EV/HEV components

Safeguard your people and your devices under test
- Handle faults and ensure output is secured (i.e., disconnected) with redundant safety disconnect system
- Responds rapidly by disconnecting within 15 ms after a fault occurs
- Includes four disconnection points (relays) with two each on the positive and negative sides
- Rely on sensing that ensures the grid is live before regenerating power back to the grid (“anti-islanding”)
- Get an extra layer of safety with control of external AC contactors to disconnect all three phases
- Protect your device under test with over-voltage, over-current, and over-temperature (OVP, OCP, and OT)
  - Supports remote inhibit, which is triggered by external inputs such as contact closure or low TTL line

Utilize a compact solution that serves as a power source and an electronic load, just like a battery
- Get sourcing and sinking (electronic load) up to 950 V, up to 40 A, and up to 10 kW
- Operate in two-quadrant mode as power source and regenerative electronic load
- Replace the capabilities of multiple power supplies with auto-ranging output
- Create up to 100 kW power or loading through easy parallel connection of up to 10 units
- More accurately emulate high-voltage, high-power battery (up to 50 Ω) with programmable resistance (model dependent)
- Leverage features rarely found in 10 kW power sources: list mode, best-in-class measurement accuracy
- Reduce footprint with compact size: up to 10 kW of sourcing and loading in 3U
  - Compare to typical 6 kW load at 4U and typical 12 kW load at 6U

Reduce costs for cooling and electricity with an eco-friendly design
- Count on conversion efficiency that returns more than 85% of power to the grid during regeneration
- Minimize interference with other electronics with clean power being returned to the grid
  - Performs regeneration with less than 3% total harmonic distortion (typical) at full load
- Shrink overall energy consumption: Less heat from dissipation means less air conditioning when sinking (DC to AC)
  - Lessens electricity use with >85% efficiency when sourcing (AC to DC) and sinking/regenerating (DC to AC)
Solution Components

RP7900 Regenerative Power System

The RP7900 Series Regenerative Power System is the core of the solution. It provides the battery emulation capabilities for vehicle electrification tests, such as 2-quadrant (source/sink) operation and programmable output resistance. It also provides the added benefit of regenerating >85% of power back to the grid.

<table>
<thead>
<tr>
<th>Specification</th>
<th>RP7951A/RP7961A</th>
<th>RP7952A/RP7962A</th>
<th>RP7953A/RP7963A</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC ratings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage source</td>
<td>0 to 500 V</td>
<td>0 to 500 V</td>
<td>0 to 950 V</td>
</tr>
<tr>
<td>Current source and sink</td>
<td>0 to ±20 A</td>
<td>0 to ±40 A</td>
<td>0 to ±20 A</td>
</tr>
<tr>
<td>Power</td>
<td>5 kW</td>
<td>10 kW</td>
<td>10 kW</td>
</tr>
<tr>
<td>Output ripple &amp; noise</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV peak-to-peak</td>
<td>500 mV</td>
<td>500 mV</td>
<td>1000 mV</td>
</tr>
<tr>
<td>Load regulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td>30 mV</td>
<td>30 mV</td>
<td>60 mV</td>
</tr>
<tr>
<td>Current</td>
<td>9 mA</td>
<td>17 mA</td>
<td>9 mA</td>
</tr>
<tr>
<td>Voltage programming accuracy</td>
<td>0.03% + 60 mV</td>
<td>0.03% + 60 mV</td>
<td>0.03% + 120 mV</td>
</tr>
<tr>
<td>Voltage measurement accuracy</td>
<td>0.03% + 80 mV</td>
<td>0.03% + 80 mV</td>
<td>0.03% + 160 mV</td>
</tr>
<tr>
<td>Current programming &amp; measurement accuracy</td>
<td>0.1% + 12 mA</td>
<td>0.1% + 24 mA</td>
<td>0.1% + 12 mA</td>
</tr>
<tr>
<td>Transient response</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recovery time</td>
<td>500 μs</td>
<td>500 μs</td>
<td>500 μs</td>
</tr>
<tr>
<td>Settling band</td>
<td>1.25 V</td>
<td>1.25 V</td>
<td>2.375 V</td>
</tr>
</tbody>
</table>

1. From 20 Hz to 20 MHz with resistive load, terminals ungrounded, or either terminal grounded
2. At 25°C ±5°C after a 30 minute warm-up; measurement NPLC=1; valid for 1 year, see Calibration Interval
3. Time to recover to within the settling band following a step change from 50% to 100% of full load
### Safety Disconnect System

The safety disconnect solution was designed to work exclusively with the RP7900 Series. In less than 15 ms the safety disconnect will remove the output voltage in order safeguard your DUT and your people in response to a fault. Faults can be generated by the RP7900 or a user (emergency switch).

---

This is an abbreviated list of characteristics. For the full list of characteristics, please see “Appendix A” in the Keysight RP7900 Series Operating and Service Guide, literature number RP7900-90001. [http://literature.cdn.keysight.com/litweb/pdf/RP7900-90901.pdf](http://literature.cdn.keysight.com/litweb/pdf/RP7900-90901.pdf)

Supplemental characteristics are not warranted but are descriptions of performance determined either by design or by type testing. All supplemental characteristics are typical unless otherwise noted.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Keysight SD1000A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power relay ratings</td>
<td>500 VDC; 60 ADC</td>
</tr>
<tr>
<td>Relay life (typical)</td>
<td>1,000,000 cycles</td>
</tr>
<tr>
<td>Regulatory compliance - EMC</td>
<td>Complies with European EMC Directive for test and measurement products</td>
</tr>
<tr>
<td></td>
<td>Complies with Australian standard and carries C-Tick mark</td>
</tr>
<tr>
<td></td>
<td>This ISM device complies with Canadian ICES-001</td>
</tr>
<tr>
<td></td>
<td>Cet appareil ISM est conforme à la norme NMB-001 du Canada</td>
</tr>
<tr>
<td>Safety</td>
<td>Complies with European Low Voltage Directive and carries the CE-marking.</td>
</tr>
<tr>
<td></td>
<td>Conforms to US and Canadian safety regulations.</td>
</tr>
<tr>
<td></td>
<td>Declarations of Conformity for this product may be downloaded from the Web. Go to <a href="http://regulations.corporate.keysight.com">http://regulations.corporate.keysight.com</a> and click on Declarations of Conformity</td>
</tr>
<tr>
<td>Environmental</td>
<td>Operating environment 2.5 MHz (–3 dB)</td>
</tr>
<tr>
<td>Temperature range</td>
<td>0°C to 55°C (Maximum continuous power available is derated at 1% of rating per degree C from 40°C to 55°C)</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>95% or less (non-condensing)</td>
</tr>
<tr>
<td>Altitude</td>
<td>Up to 2000 meters</td>
</tr>
<tr>
<td>Storage temperature</td>
<td>–30°C to 70°C</td>
</tr>
<tr>
<td>Output terminal isolation</td>
<td>No output terminal may be more than ±950 VDC from any other terminal or chassis ground.</td>
</tr>
<tr>
<td>AC Input</td>
<td>Nominal rating Single phase; 100–240 VAC input, 50-60 Hz</td>
</tr>
<tr>
<td>Input Range</td>
<td>86–264 VAC; 47–63 Hz</td>
</tr>
<tr>
<td>Power consumption</td>
<td>150 W</td>
</tr>
<tr>
<td>Typical weight</td>
<td>33 lbs (15 kg)</td>
</tr>
</tbody>
</table>
PA2200 Series IntegraVision Power Analyzer

The IntegraVision Power Analyzer makes EV test for AC and DC power measurements simple. Easily measure power on any of the vehicles power converters, such as AC-to-DC power conversion efficiency of the on-board charger.

This is an abbreviated list of specifications and characteristics. For the full list of specifications and characteristics, please see the IntegraVision PA2200 Series Data Sheet, literature number 5992-0324EN


<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic accuracy (50/60 Hz)</td>
<td>0.05% of reading</td>
</tr>
<tr>
<td>Best power accuracy (50/60 Hz)</td>
<td>0.1% of reading</td>
</tr>
<tr>
<td>Power channels (voltage and current)</td>
<td>PA2201A: 2 Channels, PA2203A: 4 Channels</td>
</tr>
<tr>
<td>Voltage measurement bandwidth (-3 dB)</td>
<td>2.5 MHz (-3 dB)</td>
</tr>
<tr>
<td>Current measurement bandwidth (2 A or 50 A Input)</td>
<td>100 kHz (-3 dB)</td>
</tr>
<tr>
<td>Current measurement bandwidth (external input)</td>
<td>2.5 MHz (-3 dB)</td>
</tr>
<tr>
<td>Maximum voltage</td>
<td>1000 Vrms (2000 V peak)</td>
</tr>
<tr>
<td>Maximum current</td>
<td>Direct input: 2 A rms (6 A peak) or 50 A rms (100 A peak)</td>
</tr>
<tr>
<td>Record size</td>
<td>Maximum 1.5 M points on each waveform simultaneously</td>
</tr>
<tr>
<td>Digitizing speed</td>
<td>Maximum 5 M samples/second at 16 bits on each waveform simultaneously</td>
</tr>
<tr>
<td>Display size and type</td>
<td>12.1-inch capacitive multi-touch/gesture enabled display</td>
</tr>
</tbody>
</table>

**Power channels (voltage and current)**

**Voltage**
- Connector safety: Banana Plug
- Maximum voltage: 1000 Vrms, 2000 Vpeak
- Input impedance: 2 MΩ || 12.5 pF
- Ranges: 5 V, 10 V, 20 V, 50 V, 100 V, 200 V, 500 V, 1000 V

**Current**
- Directly connected: Pluggable Terminal Block, Phoenix Contact PN: 1967469
- Maximum current: 2 A rms, 6 A peak or 50 A rms, 100 A peak
- Input impedance:
  - 2 A input: 60 mΩ + 0.10 μH
  - 50 A input: 6 mΩ + 0.06 μH
- Ranges:
  - 2 A input: 10 mA, 20 mA, 50 mA, 100 mA, 200 mA, 500 mA, 1 A, 2 A
  - 50 A input: 200 mA, 500 mA, 1 A, 2 A, 5 A, 10 A, 20 A, 50 A

**External transducer**
- Connector: Isolated BNC
- Maximum current: 10 Vrms, 30 V peak
- Input impedance: 100 kΩ || 100 pF
- Ranges: 50 mV, 100 mV, 200 mV, 500 mV, 1 V, 2 V, 5 V, 10 V

**Crest factor**
- 3 at full-scale (Unless in conflict with maximum input ratings)
- Maximum Crest Factor of 30 at 10% of full scale

**Current input protection**
- Internal current shunt measurement paths are not fused. Current limit protection (fuse or breaker) and appropriate wire sizing should be provided by the user.
- Currents in excess of 140% of the rated rms currents may cause permanent damage to the current measurement shunts. An internal protection mechanism is provided for the 2A shunt to avoid damage due to mis-wiring, but it should not be relied upon in situations where higher than 2 A rms currents are expected.

**Isolation**
- Voltage and current terminals are isolated from earth ground to 1000 V CAT II rating. Voltage is isolated from current with 1000 V CAT II rating
Evolving Since 1939

Our unique combination of hardware, software, services, and people can help you reach your next breakthrough. We are unlocking the future of technology.
From Hewlett-Packard to Agilent to Keysight.

myKeysight
www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

http://www.keysight.com/find/emt_product_registration
Register your products to get up-to-date product information and find warranty information.

Keysight Services
www.keysight.com/find/service
Keysight Services can help from acquisition to renewal across your instrument's lifecycle. Our comprehensive service offerings—one-stop calibration, repair, asset management, technology refresh, consulting, training and more—helps you improve product quality and lower costs.

Keysight Assurance Plans
www.keysight.com/find/AssurancePlans
Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.

Keysight Channel Partners
www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight’s measurement expertise and product breadth, combined with channel partner convenience.

www.keysight.com/find/ev1003a

For more information on Keysight Technologies’ products, applications or services, please contact your local Keysight office. The complete list is available at:
www.keysight.com/find/contactus

Americas
Canada (877) 894 4414
Brazil 55 11 3351 7010
Mexico 011 800 254 2440
United States (800) 829 4444

Asia Pacific
Australia 1 800 629 485
China 800 810 0189
Hong Kong 800 938 693
India 1 800 11 2626
Japan 0120 (421) 345
Korea 080 769 0800
Malaysia 1 800 888 848
Singapore 1 800 375 8100
Taiwan 0800 047 866
Other AP Countries (65) 6375 8100

Europe & Middle East
Austria 0800 001122
Belgium 0800 58680
Finland 0800 523252
France 0805 980333
Germany 0800 6270999
Ireland 1800 832700
Israel 1 809 343051
Italy 800 599100
Luxembourg +32 800 58580
Netherlands 0800 0233200
Russia 8800 5099286
Spain 800 000154
Sweden 0200 692255
Switzerland 08000 805353
Opt. 1 (DE)
Opt. 2 (FR)
Opt. 3 (IT)
United Kingdom 0800 0260637

For other unlisted countries:
www.keysight.com/find/contactus
(BP-9-7-17)

www.keysight.com/go/quality
Keysight Technologies, Inc.
DEKRA Certified ISO 9001:2015 Quality Management System

This information is subject to change without notice.
© Keysight Technologies, 2017
Published in USA, September 8, 2017
5992-2283EN
www.keysight.com