



PVE300 Photovoltaic Device Spectral Response EQE (IPCE), IQE

PVE300

The PVE300 is a turnkey solution for the determination of solar cell spectral response/ EQE (IPCE) and IQE.

The ability to characterise both photovoltaic devices and materials renders the PVE300 a key component in research and production-line quality processes.



Key features include:

Speed and Accuracy

Using a monochromatic probe and NMI traceable calibrated reference diodes, the PVE300 allows the quick and accurate determination of solar cell characteristics.

Measurement of all Device Types

Compatible with all types of photovoltaic devices and architectures: c:Si, mc:Si, a:Si, µ:Si, CdTe, CIGS, CIS, CZTS, Ge, dye-sensitised, organic/polymer, multi-junction (2-, 3-, 4– junctions and more), quantum well, quantum dot, chalcogenides and perovskites.

Tailored Electrical Interface

A full range of detection electronics are available to accommodate the requirements of all device types, including AC or DC , in short-circuit or voltage biased.

Wide Spectral Range

The standard spectral range of 300-1100nm, may be extended to 1800nm and beyond.

• Simplicity of Operation

Fully automated through the USB interface and controlled by the Benwin+ windows software, the PVE300 directly reports measurement results including spectral response, EQE, IQE and AM1.5 J_{sc} .

• Flexibility

A range of options include mounts for substrate, superstrate or packaged devices, integrating sphere accessory for measurements of total reflectance and transmittance, a choice of single or multiple channel bias sources, including an AM1.5 matched bias source and a motorised XY stage for device mapping.



Measurement of spectral response/external quantum efficiency (IPCE)





Measurement of total reflectance and transmittance

Convert EQE to internal quantum efficiency







PVE300 System Components

Monochromatic Probe



A dual Xenon/ quartz halogen source and TMc300, 300mm focal length monochromator ensures optimum illumination from the UV to the NIR. Operation in AC or DC mode.

DTR6 Integrating Sphere



The DTR6 integrating sphere is mounted on an optical rail to the upper of the PVE300 chamber to allow the measurement of total reflectance and total transmittance

Constant Current Power Supply



A 610 constant current supply is required for each light source (xenon, quartz halogen and solar simulator). The excellent stability of the 610 ensures constant lamp output.

Detection Electronics



The 417 unit houses the detection electronics of the PVE300 system. Modules include:

• 474 Transformer/low noise amplifier

• 477 AC transimpedance pre-amplifier

- 498 DC/AC trans-impedance pre-amplifier/ ADC
- 496 DSP lock-in amplifier
- 218 Optical chopper controller



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Fully automating the PVE300 over the USB interface, Benwin+ allows quick and easy system calibration and device measurements.



Data may be analysed directly or exported to another platform as required.

Relay Optic

A reflective optic relays an image of the monochromator exit port onto the sample plane, providing a probe of any shape up to 6x6mm.

Solar Simulator

A variable intensity quartz halogen-based solar simulator with computer controlled shutter is mounted to the wall of the PVE300.

Light is transported via sixbranch fibre to ensure uniform illumination in the sample plane.



Temperature Controlled Vacuum Mount

For front/front and front/ rear contact devices, this 200x200mm mount provides the user with a convenient manner of electrical probing and allows controlling sample temperature, by a quartet of Peltier devices (15-65°C). Powered by the VC-TE-30.



PV-SS6

For rear/ rear contact devices, this 165x165mm mount provides the user with a convenient means of electrically probing the sample using magnetic based probes.



Reference Detectors

The system is calibrated with reference to NMI traceable calibrated photodiodes (silicon 300-1100nm; germanium 800-1800nm).





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Configuration

The following options are required for the configuration of the PVE300.

Single point measurement or device mapping

- PVE300: Single point sample measurement
- PVE300_XY: Includes motorised X-Y stage allowing the determination of device uniformity and IPCE .

Spectral range

- Monochromatic probe 300-1100nm, Si reference diode
- Monochromatic probe 300-1800nm, Si and Ge reference diodes
- Maximum range 250-3000nm: Please enquire

Sample Mount

- Temperature controlled vacuum mount: Measurement of front/ front and front/ rear contact devices with sample temperature control
- PV_SS6: Measurement of rear/ rear and front/ rear contact devices
- Custom requirements: Please enquire.

Monochromatic Probe Mode-AC/DC

- AC mode: Optical chopper (10Hz-2kHz) located in dual source
- AC/DC mode: Arrestable optical chopper located in dual source
- DC chopped mode: Shutter-based chopper (0-2 Hz) located in dual source.

Detection Electronics

- Semiconductor, polymer/ organic cells: 474 Transformer/low noise amplifier & 496 DSP lock-in amplifier
- Dye-sensitised devices: 498 DC/AC trans-impedance amplifier/ADC

Measurement of reflectance/ transmittance

• Inclusion of DTR6 integrating sphere to measure total reflectance or transmittance of device.

Light Bias Source

• Inclusion of a variable intensity quartz halogen-based solar simulator with computer controlled shutter. Light transported via six-branch fibre to ensure uniform illumination in the sample plane.















Optional Extras

The PVE300 has been designed to be compatible with all types of photovoltaic device and architectures. The following extras are included to meet with specific device requirements.



Multiple Light Bias Sources

In the measurement of multi-junction devices, multiple solar simulators are required, one to bias the subcell under test at one sun, the other filtered simulator to ensure that the non-tested subcells are sufficiently illuminated that they do not current limit the tested subcell response.

Voltage Biasing

In the case of multiple junction cells and some thin film devices, testing under voltage bias is important. To this end, a Keithley 2400 Source Meter can be connected directly to the transformer primary coil, thereby biasing the device under test.

Custom Sample Mount

Whilst the electrical and thermal connection of substrate devices is relatively trivial, the same cannot be said of superstrate or packaged devices. With an in-house design service, Bentham can design a mount suitable for your application.

Custom Electrical Probe

Our design service includes the manufacture of custom electrical probing schemes. The addition of a motorised stage to both the probe and sample mount allows for the measurement of multiple devices on a single PCB.

High Irradiance Monochromatic Bias Source

For ultimate flexibility in the measurement of multiple junction cells, a high irradiance monochromatic source, assembled from a 450W xenon lamp and 300mm focal length monochromator provides a tuneable source 300-1100nm.

Temperature Sensor

Where accurate knowledge of the temperature of a device under test is required, a non-contact infrared temperature sensor is available. Mounted to the top of the PVE300 chamber, the sensor is directed to the vicinity of the sample illuminated by the monochromatic probe.

Programmable Bias Source

The fully programmable solar simulator includes a solenoid-based shutter for illumination/ extinction of the solar simulator and a motorised bi-lateral slit between source and fibre to vary the solar simulator irradiance at the sample plane.

Specifications

Monochromatic Probe

Probe light source:	75W Xenon and 100W Quartz halogen
Monochromator configuration:	Triple grating, symmetric, single Czerny -Turner, 300mm focal length
Bandwidth:	Adjustable fixed slit, 1-10nm typical
Resolution:	0.3nm (1200g/mm); 0.6nm (600g/mm)
Dispersion:	2.7nm/mm (1200g/mm);
	5.4nm/mm (600g/mm)
Wavelength Range:	300-1100nm (1200g/mm);
	1100-2500nm (600g/mm)
Wavelength accuracy:	± 0.2nm (1200g/mm);
	± 0.4nm (600g/mm)
Relay Optic:	Mirror-based, 1.2x magnification
Probe size:	Up to 6x6mm

Temperature-Controlled Vacuum Mount

Temperature control:	4x70W Peltier-based heat pump, water- cooled hot side
Temperature range:	15-65°C
Temperature Feedback:	Centrally-positioned sensor situated 3mm below sample plane
Temperature stability:	± 1°C
Solar Simulator	
Transport to sample:	Branched glass fibre bundle
Bias source irradiance:	0-1.5 suns
Bias source uniformity:	±1% over 1 cm ²
Filter Option:	Two 50mm square filter holders
Source Options:	Quartz halogen/ Xenon/ Class B AM1.5

Automation	
Software control:	BenWin+ Windows application
Interface:	USB
Reference Diodes	
Diode & Range:	Silicon 300-1100nm; Germanium 800-1800nm
Traceability	PTB, Germany
Voltage Bias (Keithley 2400)	
Voltage Range: Current Limit:	-20 to 20V 1A
XY Stage	
Travel: Resolution:	300mm in X & Y 0.1mm
DTR6 Integrating Sphere	
Port Size:	15mm Ø (5 &10mm Ø port reducers supplied)
Coating:	Ba ₂ SO ₄
Detector:	Silicon/ Germanium/ Silicon- InGaAs sandwich

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