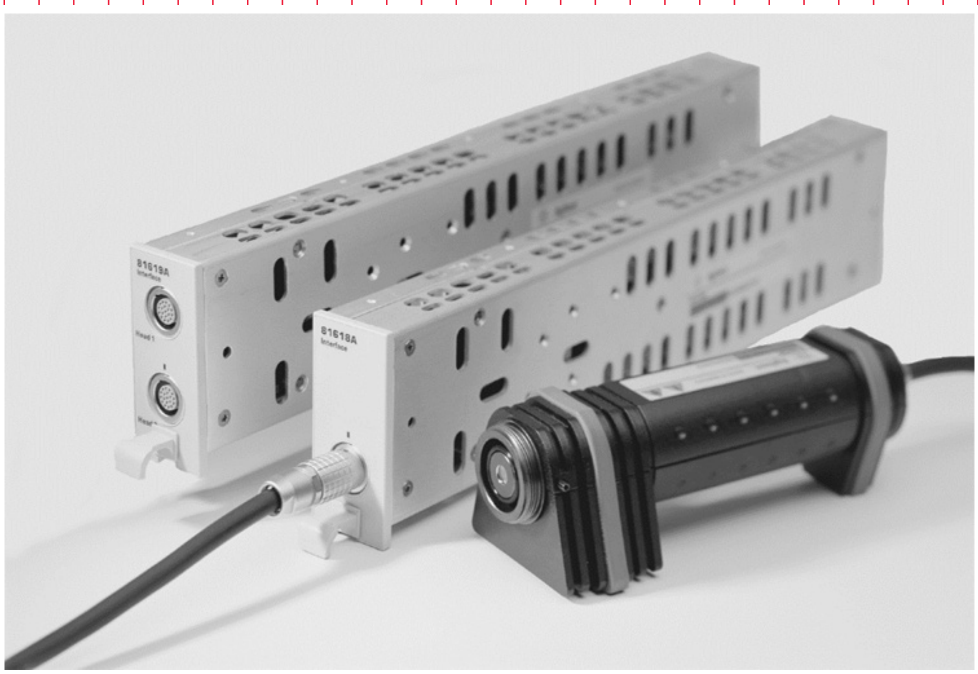
Keysight Technologies

Optical Power Meter Head

Special Calibrations

Brochure



KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights

Introduction

The test and measurement equipment you select and maintain in your production and qualification setups is one of the most important parts of ensuring the quality, reliability and performance of your end product. The specified accuracy of your instrument, which gives you confidence in the measurements they produce, can only be analyzed and certified by proper calibration. Calibration of your test and measurement equipment ensures that you can trust your measurement results and have confidence in your own precision.

Furthermore nearly all existing quality assurance standards, norms and procedures such as ISO/IEC 9001 or ISO/IEC 17025 require a periodic quality assessment for your test and measurement equipment. Following these standards requires you to regularly monitor your instruments by performing calibrations.

Optical power meters are designed to measure optical power in a specified wavelength range as accurately as possible. Due to the fact that this capability largely depends on the quality of the calibration process, it is important to carefully select your calibration provider.

Keysight Technologies, as the original equipment manufacturer for several types of optical power meters, is able to verify all specified parameters and to perform adjustments that bring out-of-specification instruments back into specification. In this way you can receive calibration services for your optical power meters that meet or even exceed your expectations on level of quality for your test and measurement systems and your end products.

With the special calibration options C01, C85 and C05 Keysight offers calibration services for its optical power meter heads for lowest measurement uncertainties as metrology grade reference standards.

Keysight's Optical Power Meter Heads

As an industry leader in optical power measurements, Keysight's offers a number of superior solutions that guarantee highest performance for your various applications. The 81623B, 81624B and 81626B optical power meter heads provide a 5 mm diameter photodetector area. The simple geometry and high quality detectors allows the heads to offer the highest accuracy measurements. Various connector interfaces for popular fiber connector types or bare fibers can be plugged to the front panel optical input.

The optical power meter heads feature firmware-correction of range discontinuities for best linearity, variable averaging time, data logging, and min-max and stability applications. The detectors of the optical power meter heads are temperature stabilized. The spectral responsivity data (Figure 1) is stored in the head, in steps of 2 nm.

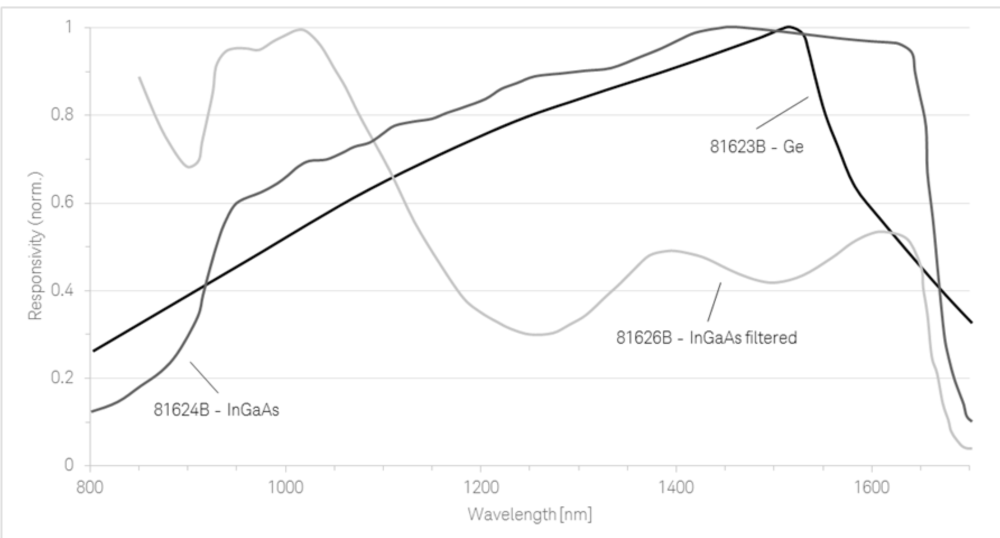


Figure 1: Sample spectral responsivity of different detector types (normalized)

Special Calibration Options

Calibration Options C01 and C85

Keysight's optical power meter heads, 81623B, 81624B and 81626B, are highly precise tools to accurately measure optical power. The accuracy of these versatile instruments can be further increased by an additional detector selection and special calibration performed in the factory's Optical Metrology Laboratory. The result is an optical power meter head that is calibrated with lowest measurement uncertainties and has tighter specifications. The specially calibrated optical power meters are most attractive for high accuracy calibration purposes.

The calibration options include the following package of measurements:
– Responsivity versus wavelength
– Linearity over the specified measurement range
– Spatial homogeneity over the detector's active area

Calibration Option C05

For 81624B optical power meter heads, the special calibration option C05 is available, which comprises a C01 selection/calibration and a calibration of the spectral responsivity directly at the Physikalisch-Technische Bundesanstalt (PTB), the German national metrology institute.

The responsivity calibration is based on tunable laser sources around 1310 nm and 1550 nm. The optical power is transferred to the optical power meter via single mode fiber. This calibration is done against a standard traced to the PTB primary standard.

The special calibration option C05 comes with a C01 calibration report and a calibration certificate from the PTB in English language, listing the relative responsivity deviation at the calibration wavelengths.

Special Calibration Option C05	
Wavelength	1300 nm, 1310 nm, 1320 nm and 1540 nm, 1550 nm, 1560 nm
Power level	10 µW (–20 dBm)
Beam geometry	Single mode fiber on head connector adaptor Keysight 81000xA
Measurement uncertainty	±0.8 %
Certificate	PTB certificate in English language, listing the relative responsivity deviation at the calibration wavelengths.

Table 1. Special Calibration Option C05

The factory's Optical Metrology Laboratory offers special calibrations, both for new power meters and power meters sent back for recalibration.

Special recalibrations according to options C01 and C85 are carried out by the factory's Optical Metrology Laboratory. Please note that standard point-type recalibrations are handled by the Keysight's service centers.

Calibration Methods and Equipment

Responsivity versus Wavelength

Keysight's Optical Metrology Laboratory uses a system based on a white-light source and monochromator filtering for the responsivity calibration of optical power meter heads according to special calibration options C01 and C85. The monochromator system consists of an electronically stabilized halogen lamp and a double monochromator for the selection of the wavelength. The spectral width is approximately 4 nm. At the output of the monochromator a lens system creates an almost parallel open beam with a numerical aperture <0.1. The collimated beam of approximately 3 mm is used to excite the center of the detector's active area.

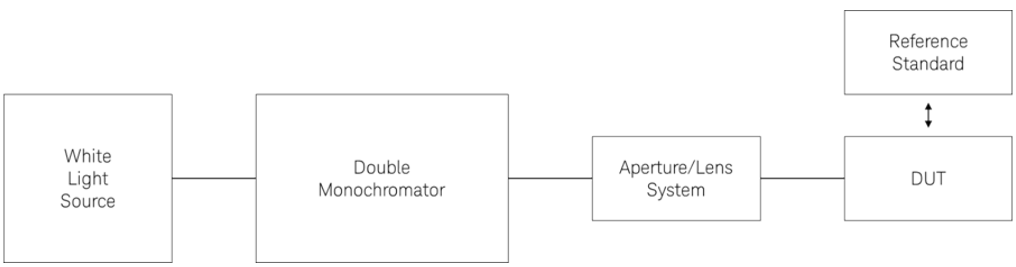


Figure 2: Spectral responsivity calibration at Keysight

During calibration, the test meter is compared to the applicable higher-level standard indicated in the traceability chain. This is done by sequential stimulation of both meters with the monochromator output. During the entire procedure, an optic-electronic feedback system ensures the stability of the lamp output.

Customers' optical power meter heads are (re-) adjusted for zero deviation by writing appropriate correction factors, determined in 2 nm steps over the full wavelength range, into the non-volatile memory of the optical heads. The system interpolates for other wavelengths.

Linearity over the Specified Measurement Range

Generally, two effects lead to nonlinearity of optical power meter heads. First, the ‘in-range’ nonlinearity is observed as the difference between the change of displayed power level and the change of input power level, without changing the power meter range. Second, the ‘ranging’ nonlinearity is observed as the change of displayed power level when switching from one power meter range to the next range without changing the input power level.

The measurement of the nonlinearity of the optical power meter heads is accomplished by a self-calibrating superposition method. The radiation is generated by appropriate laser sources. The two laser sources for each wavelength are connected to respective optical attenuators whose outputs are combined with an optical coupler and applied to the device under test, where the power is measured.

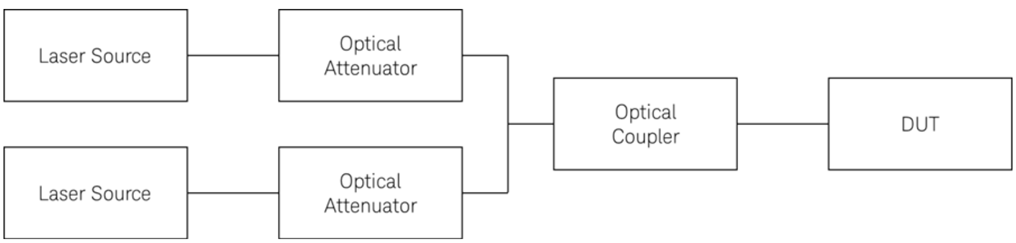


Figure 3: Linearity verification at Keysight

At the beginning, the powers of the two laser sources are adjusted to previously calculated target values with the help of the two optical attenuators. Now, the power of the first laser source (P_1) is measured separately. Then the power of the first laser is switched off and the power of the second laser source (P_2), which is approximately the same, is measured separately, too. Then the sum of the two powers is measured, $(P_1+P_2)_{measured}$. The non-linearity is calculated from the ratio of $(P_1+P_2)_{measured}$ to the expected sum, $(P_1+P_2)_{calculated}$. These steps are repeated from the lowest to the highest specified power level by doubling the power each time.

The method is self-calibrating by Keysight’s definition and doesn’t need traceability to a national laboratory.

Spatial Homogeneity over the Detector's Active Area

The optical power meter's photodetector has an active area of 5.0 mm diameter. Ideally, the responsivity of the detector would be constant over the entire active area. This would make optical power measurements independent on the diameter and position of the irradiated area. Substantial deviations from these ideal characteristics are often observed.

Testing for non-uniformity is performed by scanning the detector with a homogeneous optical beam. The grid spacing is 0.25 mm, and the total number of measurement points is 21 x 21. The center of the diode's active area acts as reference point with 100 % responsivity (per definition). All measurement points within the specification area are compared against the test limit.

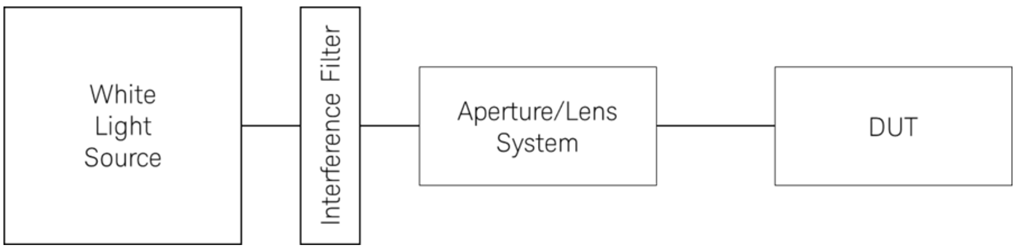


Figure 4: Homogeneity verification at Keysight

Uncertainty and Traceability

Uncertainty

The method of characterizing and accumulating uncertainties is based on the IEC 61315 standard "Calibration of fiber-optic power meters". This takes into account the random and systematic uncertainties of all optical power meters and all transfer processes in the calibration chain according to ISO/IEC Guide 98-3 standard "Guide to the expression of uncertainty in measurement" (GUM).

The special calibration options C01 and C85 for the optical power meter heads 81623B, 81624B and 81626B provide a significant improvement to this uncertainty.

The special calibration options are compliant to the ISO/IEC 17025 standard, "General require-ments for the competence of testing and calibration laboratories".

Traceability

Direct traceability to the Physikalisch-Technische Bundesanstalt (PTB), the German national metrology institute, has been established and is maintained. International traceability is given by round-robin comparisons of the PTB with other national laboratories, such as NIST (US), NPL (UK) and JMI (Japan), on a regular basis.

Keysight's traceability chain for spectral responsivity is shown in Figure 5.

Level 0: The calibration chain starts at the Physikalisch-Technische Bundesanstalt (PTB), the German national metrology institute. PTB uses thermopile radiometers, because of their flat wavelength dependence and low reflectance.

Level 1: PTB regularly calibrates Keysight's reference standards for optical power. Special calibration option C05 offers direct calibration at PTB. Keysight's reference standards for optical power are electrically calibrated pyroelectric radiometer (ECPR) or photo-detector-based optical power meter.

Level 2: Photodetector-based Metrology Laboratory working standards.

Level 3: Photodetector-based working standards used:
- for special calibrations in the Keysight's optical MetLab
- in production for the calibration of commercial power meters
- as working standards for Keysight's service organization

Level 4: Photodetector-based commercial power meters.

The working standards and Keysight's commercial power meters are based on Ge and InGaAs photodetectors.

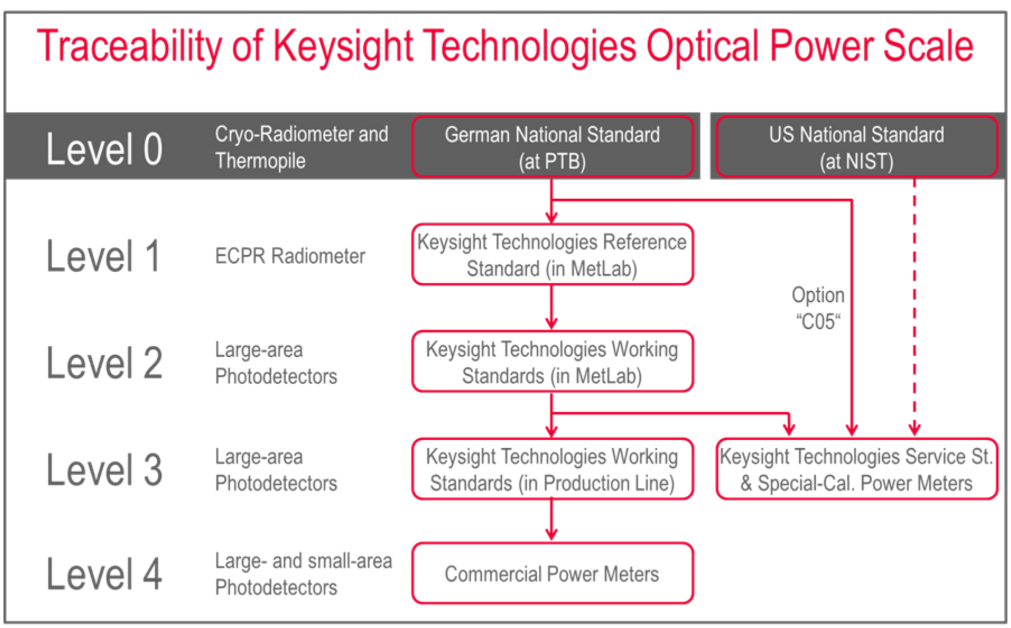


Figure 5: Keysight's traceability chain for optical power

Measurement Results

Optical Power Meter Head Special Calibrations

For product specifications Keysight's optical power meter family with the special calibration options please refer to the corresponding data sheet (http://literature.cdn.Keysight.com/litweb/pdf/5988-1569EN.pdf).

Best Measurement Capability Scope of Factory's Optical Metrology Laboratory

Keysight's Optical Metrology Laboratory is certified according to ISO/IEC 17025 standard "General requirements for the competence of testing and calibration laboratories". The laboratory is regularly internally audited with criteria specified in the Business Management System which includes requirements as stated in ISO/IEC 17025 and ISO 9001.

In Table 2, the best measurement capabilities of Keysight's Optical Metrology Laboratory are listed. The Calibration and Measurement Capabilities (CMCs) presented in this scope represent the smallest uncertainties that can be reached for the given parameter for which the Metrology Laboratory is internally certified. The assigned uncertainties during calibration will be such as to properly demonstrate the performance of the equipment and may be greater than the CMCs stated in this Schedule.

Measured Quantity, Instrument or Gauge	Range	Calibration and Measurement Capability (CMC) Expressed as an Expanded Uncertainty (k = 2)	Remarks
Spectral responsivity:			
Specific values:	600 nm to 1020 nm	2.20%	Using Si based Working-Standard. 10 nm step width; Under reference conditions as specified in the corresponding data sheet.
	800 nm to 1000 nm	2.10%	Using Ge based Working-Standard. 10 nm step width; Under reference conditions as specified in the corresponding data sheet.
	1000 nm to 1650 nm	1.70%	Using Ge based Working-Standard. 10 nm step width; Under reference conditions as specified in the corresponding data sheet.
	970 nm to 1630 nm	1.50%	Using InGaAs based Working-Standard. 10 nm step width; Under reference conditions as specified in the corresponding data sheet.
	950 nm to 1630 nm	2.50%	Using high power InGaAs based Working-Standard. 10 nm step width; Under reference conditions as specified in the corresponding data sheet.
Non-linearity:			
Specific values:	850 nm		
	-47 dBm to 3 dBm	0.02%	At a ref. power level of 10 µW (-20 dBm); Step size 3 dB; Divergent beam from SM fiber with NA = 0.1; At (23±5) °C.
	1300 nm		
	-70 dBm to 10 dBm	0.02%	At a ref. power level of 10 µW (-20 dBm); Step size 3 dB; Divergent beam from SM fiber with NA = 0.1; At (23±5) °C.
	1550 nm		
	-70 dBm to 10 dBm	0.02%	At a ref. power level of 10 µW (-20 dBm); Step size 3 dB; Divergent beam from SM fiber with NA = 0.1; At (23±5) °C; For input power >10 mW using adaptor 81000AF.
	10 dBm to 20 dBm	0.40%	
	20 dBm to 27 dBm	0.70%	
Sensor homogeneity:			
Specific values:	850 nm	0.25%	At an optical input power level of 10 µW; Using a focused beam with Ø 0.5 mm; For spot center within a concentric circle of Ø 3.5 mm; Step size 0.25 mm.
	1300 nm	0.25%	At an optical input power level of 10 µW; Using a focused beam with Ø 0.5 mm; For spot center within a concentric circle of Ø 3.5 mm; Step size 0.25 mm.
	1550 nm	0.25%	At an optical input power level of 10 µW; Using a focused beam with Ø 0.5 mm; For spot center within a concentric circle of Ø 3.5 mm; Step size 0.25 mm.

Table 2. Best Measurement Capability Scope of Factory's Optical Metrology Laboratory

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