A pilot comparison on calibration of fiber optic power meter

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A pilot comparison on the calibration of a fiber optic power meter has been carried out between TUBITAK UME, IO-CSIC and AS Metrosert, within the EURAMET project "Supporting smart specialization and stakeholder linkage in Photometry and Radiometry (20SCP01 Smart PhoRA). The agreed wavelengths and power levels for comparison were 1310 nm and 1550 nm and 0 dBm (1 mW) and -23 dBm (5 µW), respectively. TUBITAK UME piloted the comparison and its power meter was used as the comparison artefact. This contribution describes the methodology used in the comparison, the traceability and uncertainties of each of the laboratories involved and the analysis of the results.

INTRODUCTION

In 2020, European Metrology Programme for Innovation and Research (EMPIR) Project, Smart PhoRa "Supporting smart specialization and stakeholder linkage in Photometry and Radiometry" was started. Work package 3 (WP3) of this project is focused on metrology for fibre optics. In this WP3, Eesti Metroloogia Keskasutus (the NMI of Estonia AS Metrosert) is work jointly with the DI of Spain (IO-CSIC) and NMI of Turkey (TUBITAK UME) to provide metrology for smart specialization in fibre optics [1]. The aim of this WP3 is to develop the expertise of NMIs/DIs in Estonia and Turkey to enable them to fulfil the needs of their regional industry in the field of fibre optics in the sense of a smart specialisation.

One of the activities of WP3 was to organise a pilot study in spectral responsivity of fibre optics detector between the tree laboratories. A commercial fiber optic power meter device owned by TUBITAK UME was circulated between the laboratories.

COMPARISON ARTEFACT

The comparison artefact was HP 8153A Lightwave Multimeter having HP 81532A model of power sensor (Fig. 1).

Figure 1. Comparison artefact

Power sensor includes a InGaAs sensor element with 5 mm in diameter which covers the range from 800 nm to 1700 nm in a power range from +3 dBm to -110 dBm. The instrument has FC-adaptor in order to connect FC/PC fiber optic patchcord.

MEASUREMENTS

The measurand was the calibration factor of the optical power over a FC/PC connector. The calibration of the device at each the laboratory was performed at nominal laser wavelengths of 1310 nm and 1550 nm. The corrections in dB at each wavelength were determined using the following equation:

$$P_c = P_{ref}(dBm) - P_{DUT}(dBm) \qquad (1)$$

where P_c is the determined calibration factor, P_{ref} is the reference optical power measured using the reference device by each the laboratory and P_{DUT} is the optical power measured by the artefact.

At TUBITAK UME, P_{ref} was measured using a FC-adaptored InGaAs-detector, which is traceable to optical power scale of PTB [2]. The best expanded uncertainty (k = 2) with this realization is ±2.2 % (± 0.098 dB). IO-CSIC uses as reference an electrically calibrated pyroelectric radiometer (ECPR RS-5900) traceable to the optical power scale of the IO-CSIC, with a best expanded uncertainty (k = 2) is ±1.0 % (±0.043 dB) [4, 5]. On the other hand, AS Metrosert uses a transmission trap radiometer, consisting of two InGaAs photodiodes in polarisation independent configuration [6], traceable to the Aalto University optical power scale (the best expanded uncertainty (k = 2) is ±5.0 % (±0.20 dB).

The laser sources used in the comparison are the ones used by each laboratory in their regular protocols. TUBITAK UME used two DFB laser sources with central wavelengths of 1310.0 nm and 1549.9 nm, IO-CSIC used two tunable lasers at 1310.0 nm and 1550.0 nm, while AS Metrosert used two Fabry-Perot lasers with central wavelengths of 1309.2 nm and 1545.5 nm, with 6 and 8 longitudinal modes respectively.

RESULTS & DISCUSION

The results of the comparison are shown in Table 1 and Fig. 2.

Table 1. Correction factor and uncertainty obtained by each laboratory.

Lab.	λ (nm)	Power level (dBm)	Correction (dB)	Uncertainty (dB (k = 2))
TUBITAK UME	1310.0	0	0.035	0.098
	1310.0	-23	0.012	0.098
	1549.9	0	-0.048	0.097
	1549.9	-23	-0.045	0.097
IO-CSIC	1310.0	0	-0.029	0.043
	1310.0	-23	-0.041	0.043
	1550.0	0	-0.006	0.043
	1550.0	-23	0.007	0.043
AS Metrosert	1309.2	0	0.15	0.20
	1309.2	-23	-0.01	0.28
	1545.5	0	0.07	0.20
	1545.5	-23	-0.07	0.29

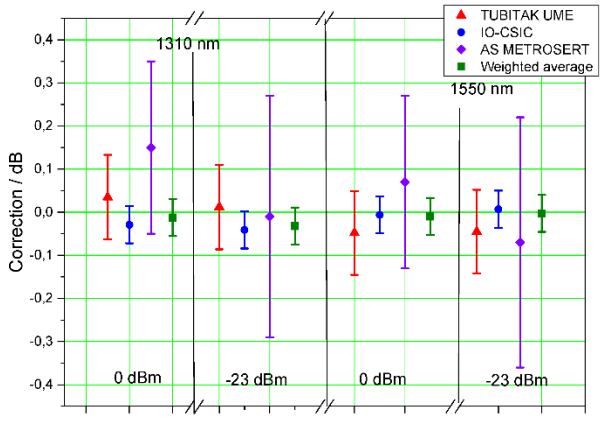

Figure 2. Result of the comparison, in green the average correction weighted by the uncertainty of the laboratories.

The results of the comparison are compatible as shown in Table 2, where the values of IO-CSIC have been taken as a reference because it is the laboratory that has an approved CMC.

Table 2. Calculated E_n values.

λ / nm	Power level / dBm	CSIC/TUBITAK UME	CSIC/AS Metrosert
1310.0	0,0	0,60	-0,88
1310.0	-23,0	0,49	-0,11
1549.9	0,0	-0,40	-0,37
1549.9	-23,0	-0,49	0,26

CONCLUSION

A pilot comparison on the calibration of fiber optic power meter between three metrology institutes (TUBITAK UME, IO-CSIC and AS Metrosert) is performed within the described European project study. In the comparison, TUBITAK UME was the pilot laboratory, IO-CSIC and AS Metrosert were participating laboratories. Comparison measurements have been completed and are under evaluation. Therefore, results obtained at agreed wavelengths and optical power levels including measurement uncertainties will be presented at the conference.

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