CCPR-WG-SP-TG6 Fiber Optics

Workshop on industry metrology needs in Fiber optics

November 15, 2022

Meeting Report

The meeting was organized in the framework of the CCPR discussion group WG-SP-TG6 Fiber Optics activities. It was held on-line November 15, 2022. Invitation to attend the workshop was sent to members of the standardization body IEC TC86 WG2 and to CCPR members. It was also advertised during the 86th IEC General meeting held in San Francisco U.S.A. November 2-4, 2022, thanks to Mr Bouquain for this initiative.

The workshop started at 11h30 and ended at 15h00 (Paris time)

Attendees (20 persons, 12 countries):

Jing Zhang	Astar
M. Smid	CMI
Zeus Efrain Ruiz Gutierrez	CNAM
Pedro Corredera	CSIC
M. Bouquain	IEC TC86
J. Quintero	EXFO
M. Breton	EXFO
Seymour Goldstein	FLUKE
G. Brida	INRIM
J. Jimenez	LAMETRO
G. Bolanos	LAMETRO
O. Fallas	LAMETRO
J. Dubard	LNE
J. Morel	METAS
Yandong Lin	NIM China
He Gang	NIM China
Xu Nan	NIM China
M Spidell	NIST
Kuniaki Amemiya	NMIJ
Robert Ferguson	NPL

1 Presentations

The meeting started with an introduction of all participants followed by three talks:

- J. Dubard presented the structure of the BIPM and the CCPR, the terms of reference of the TG6 discussion group and the previous activities.
- J. Quintero (EXFO) did a presentation entitled “Polarization-dependent responsivity: A study of germanium and indium gallium arsenide photodetectors”. The results of the study was published in Metrologia vol 42 , N°2, 2005.

- J. Morel (METAS) did a presentation entitled “Trends in Fibre Optics Metrology” with identification of potential metrology needs in: advanced/speciality fibres, quantum technologies, fibre optics sensors, integrated optics, standardization and comparisons to support CMCs. He presented also recent development at METAS

Discussion following the presentations

M. Smid ask if there is an increase of CMC claims since the new structure defined in CCPR WG-CMC. J. Morel answers that it’s too early to notice an increase.

M. Bouquain commented on the standardization

- **PIC (photonic integrated circuit)**. Automotive industry uses integrated optics. The issues are: Coupling of rectangular waveguide with circular one, launch conditions, use of fiber due to temperature issues (-40 to 130 °C). Fiber is lighter than copper but a new danger for fiber if 5G communication. Issue also in fiber repair. Quantum technology no work at the present time
- **Sensors** work since 10 years with how to calibrate the sensors: strength, temperature (point and distributed), current and voltage,
- **Fiber**. Activities slow in the domain, Japan is active in milticore fiber. ITU Programme and consent on core and cladding diameter (more fiber in the same volume), multicore, and few modes. More studies on multicore (4 cores 25µm) need also new connectors. J. Dubard asks if there is a need for length measurement improvement. M. Bouquain replies that length for connectors is a challenge but also insertion loss and return loss. Also how to couple multicore to single core for the measurement. How to be sure to put the same amount of light in each core and measure each core separately. Other issue is crosstalk but still need to be study. Multicore fiber were of interest 20 years ago but waiting nowadays for practical realizations and applications. The key point is the fan-out.

Prior to the workshop M. Breton sent some measurement issues and added comments:

- **Probability distribution of reference connector attenuation**. Discussion at IEC for uncertainty evaluation related to Rayleigh distribution. The issue is the reproducibility with another reference connector with consequently a mixing of two Rayleigh distribution associated to each reference connector. Issue today for the revision of the standard for measurement of attenuation in the field. METAS has interest for evaluating the uncertainty using Monte Carlo technique for connector mating.
- **Uncertainty of Multimode attenuation measurement with OTDR**. Documents available at IEC but not for Multimode fibre, therefore still an issue. The comparison in preparation at CCPR level is on SM fiber. Length measurement of MM Fiber is not an issue but attenuation needs more care.
- **Reference reflectance with low uncertainty SMF**. J. Morel asks for number for the uncertainty needed. <0.5 dB, ideally 0.1dB for ORL<-15 dB.

2 Discussion on selected topics

2.1 Power meter uncertainty calibration

M. Bouquain remind that need for better uncertainty for power meter was mentioned during the previous workshop in 2016. Nowadays this is less important because there is a better understanding of the uncertainty components. No specific needs are raised today.

M. Breton indicates that NIST uncertainty capability of 0.4 to 0.5 % limited by spatial uniformity. That level is good for Exfo. M. Spidell indicates that to get lower uncertainty is very challenging. Cryogenic radiometer capability (0.01%) cannot be achieved because of the fiber coupling.

METAS has capabilities of 0.5% of uncertainty for power responsivity, and 0.6% for linearity. It offers reference artefacts for instruments calibration. CMI provides also calibration service and the limitation in uncertainty capabilities is due to the nature of the output light beam.

J. Quintero mentions that power meter calibration is no more an issue (the level of uncertainty Ok). The main issue is to measure the performance of a link with uncertainty contribution from connectors and fiber.

M. Bouquain asks if the capabilities are the same in Asia or South America? China is working at setting-up capabilities for FO power meter. The issue is the lower uncertainty claimed by manufacturer in China.

R. Ferguson indicates that there is an on-going round-robin in FO power meter led by DFM.

2.2 Connector

S. Goldstein raises the issue in visual inspection of connector. IEC standard defines test limit instead of calibration scratches and defects. Works still on going and a round robin is going on even using atomic force microscope for scratches width involving metrologist.

2.3 Needs for other instruments

J. Dubard asks about the needs for other instruments.

Wavemeter calibration needs are covered properly. P. Corredera indicates that CSIC is leading a Euramet comparison on wavemeter.

M. Bouquain indicates that for **polarisation and chromatic dispersion** measurements issues the world has changed with digital processes. The instruments on a link correct for all dispersion. Polarisation or chromatic dispersion are no more an issue. The market for chromatic and polarization dispersion measuring instruments is going down to “0”.

J. Morel asks what about **non-linear effects** associated with light power in FO? M. Bouquain replies that it is still an issue. Marine domain has put a lot of constraint on fiber specifications close to limit that are measured at the fiber manufacturer with their own equipment and not measured again on site.

Regarding **Coherent OTDR**, this type of measuring equipment is limited to 10 units worldwide.

2.4 Needs in Quantum communication

Inrim (G. Brida) is working: on improving of capabilities in near IR for FO, duplicating the METAS set-up on wavelengths not limited to the 1550 nm window, running a CCPR comparison for Single Photon Avalanche Diode (SPAD) at 850 nm and setting-up a long haul link in Italy for time and frequency signals and quantum key distribution signal.

AStar (J. Zhang) is working on single photon detectors responsivity using the fiber optics facilities

METAS (J. Morel) has identified the need to focus on metrology for sources like entangled photons and metrology for quantum based random number generators. However the use worldwide still has to evaluated. There is already companies in Switzerland that propose quantum components, but the metrology needs are not well defined yet. Concerning

standardization this is included in a topic in the framework of the EMPIR MICQ 1 and 2 projects. INRIM is leading the work. Europe is leading the work in standardization in this field.

NPL (R. Ferguson) is working on quantum grade Xconnect articles: Ampli fiber, hollow core fiber. Classical characterization are available today: insertion loss, mode field diameter

NIM (X. Nan) is working on few photons sources. There is national comparison on Quantum Efficiency of detector at 1550nm.

2.5 Metrology needs for sensors

J. Dubard ask if there are metrology needs for optical measurements or on the quantity to be measured by a sensor.

M. Bouquain replies that today the demand is more about the quantity to be measured. But there is a need for the optical characterization of the optical components part of the sensor. Standard are developed on application that includes distributed sensing that requires: spatial resolution, parameter resolution. Manufacturer needs radiometric characterization of the sensor but not the user. Regarding distributed sensing for medical application, new technologies are developed and the demand in calibration are needed in the near future. The requirements are the same as other distributed sensor.

P. Corredera pointed out that in aeronautics industries one important parameter is the distance that should be known with an uncertainty of 1 cm over 100 m.

2.6 Metrology needs for Integrated optics

METAS has started investigation but cannot offer calibration services yet

P. Corredera indicates that integrated optics is a fast growing activities but no services available yet. Classical set-ups are not adapted for these devices. Today reference devices are used to characterized such components.

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