EURAMET.TF-S1 Supplementary Comparison

"Comparison of time interval measurements"

(performed within EURAMET Project #1485)

Technical protocol

Content

1 Introduction

The KC in TF domain (CCTF-K001.UTC) gives participating laboratories traceability to SI second by determination UTC-UTC(k) corrections, which allows to determine frequency offsets of the local timescales and clocks as well as is generally sufficient to perform time and frequency measurements correctly. However, CCTF-K001.UTC does not directly confirm the measurement proficiency in TF domain, in principle. Whereas time interval measurements are crucial for the correct calibration of time transfer systems, determination delays of signals and timing control.

This Supplementary Comparison (SC) is aimed to support CMC claims in time interval measurements. It was proceeded by the experience with a cable delay measurement within #828 EURAMET Project, that showed that a cable delay is not well-defined measured quantity and its value is significantly dependent on the shape of signals used for cable delay measurements. For the needs of this SC, two types of TI standards were prepared within #1288 EURAMET Project: (a) TI Generator (TIGen) based on PLL loops and programmable logic and counters, which can generate 127 different time intervals within the range from c. 20 ns to c. 12 μs (4 of them are chosen for this SC) and (b) 3 Delay standards (InLambda standards) based on stabilised fiber delays of c. 20 ns, c. 100 ns and c. 300 ns respectively. TI are generated by TIGen with instability and reproducibility not exceeded 3 ps of assigned expanded uncertainty and by InLambda standards with instability and reproducibility not exceeded 10 ps of assigned expanded uncertainty - verified within #1288 EURAMET Project.

This SC gives a chance for every participating NMI/DI of EURAMET laboratories and, potentially, for some guest laboratories from neighbouring other RMOs to verify or to improve their CMC claims for time interval measurements.

In this comparison, GUM (Central Office of Measures, Poland) was selected as a pilot laboratory, which is responsible for preparing the technical protocol, coordinating the schedule, collecting and analysing the comparison data, and preparing the report. The support group, consisting of SIQ (Borut Pinter, Slovenia), LNE/OP (Joseph Achkar, France), VSL (Erik Dierikx, Netherlands), NPL (Peter Whibberley, United Kingdom), FTMC (Rimantas Miskinis, Lithuania), support the pilot laboratory in organization of the comparison, preparation the technical protocol, data analysis and preparation the report.

Each participating laboratory covers as a participation fee, except of SIQ, the part of the costs of purchasing the InLambda standards by SIQ – Slovenia Institute of Quality and Metrology (**250,- Euro netto/ participants – payed to SIQ directly after agreeing to participate in the comparison**), and covers the full costs of the measurement, transportation and eventual custom formalities as well as of any damage that may have occurred within its laboratory or during the transportation to the next participant.

The participating laboratory must accept that their results are published in the final report of the comparison, even if they are not satisfactory for the laboratory.

The SC follows the rules described in EURAMET Guide on Comparisons – EURAMET Guide No. 4, Version 1.0 (05/2016).

This technical protocol is modelled on the technical protocol of the EURAMET (then EUROMET) supplementary comparison TF.TI-K1 ”Comparison of time interval (cable delay) measurement” prepared by BEV in 2005 (EURAMET Project #828).

2 The travelling standards

2.1 General information

For this comparison, there are selected two types of traveling standards: TIGen – 1 item, and InLambda standards – 3 items.

A. **TIGen** is an electronic based time interval generator developed by AGH University of Science and Technology and GUM (Poland). TIGen is property of GUM. TIGen requires external 10 MHz input frequency and generates 127 different time intervals between 1 pps outputs. The set of generated time intervals is determined by the applied PLL lines and programmable logic and counters. All signal inputs/outputs are ended with SMA-female connectors. **TIGen is equipped with DC power supplier which has to be connected to the input terminal in the rear panel. Three auxiliary SMA-male-BNC-female adapters are attached in order to facilitate the measurements if the usage of BNC-connectors is possible only**.

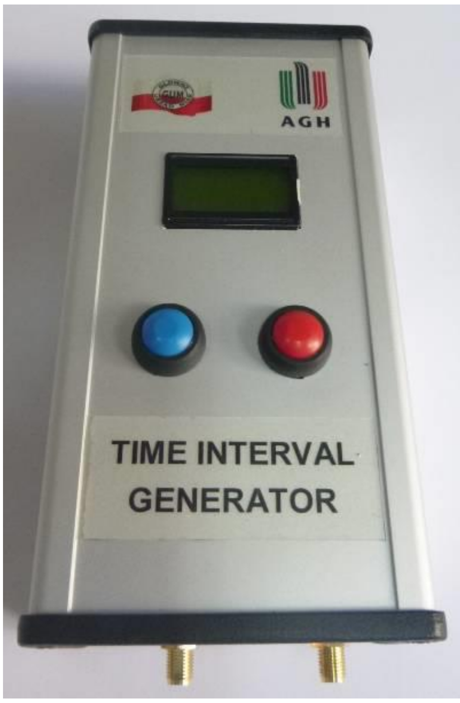
B. **InLambda** delay standards were developed by InLambda company (Instrumentation Technologies) in cooperation with SIQ (Slovenia) and are based on temperature stabilised fiber delays of approximately 20 ns, 100 ns and 300 ns respectively. InLambda standards are purchased and owned by SIQ. InLambda standards require external input pulses and should be used in pairs (in double configuration) – details are described in further sections precisely. Small influence of external temperature on the measured time intervals between output signals is recognized. All signal inputs/outputs are ended with BNC-female connectors. Power supplying – 230VAC, IEC C14 socket. **Power cords are not attached.**

No measurement cables are attached to the standards.

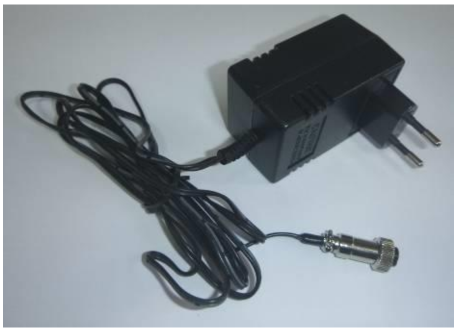
2.2 Description of the travelling standard

2.2.1 Photos

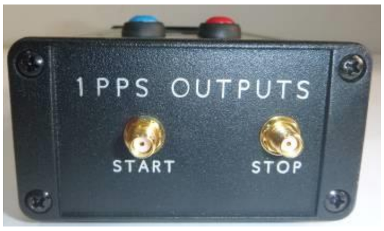
A. **TIGen**:

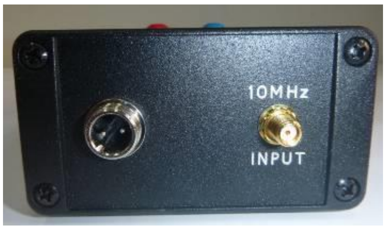


a)



b)

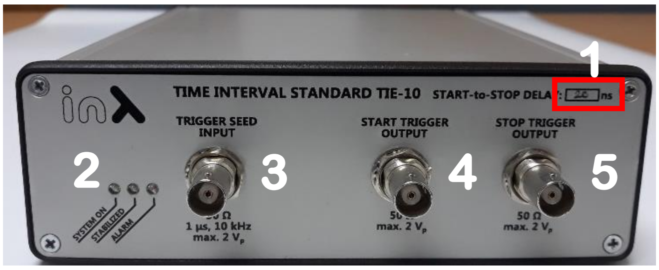
c) 

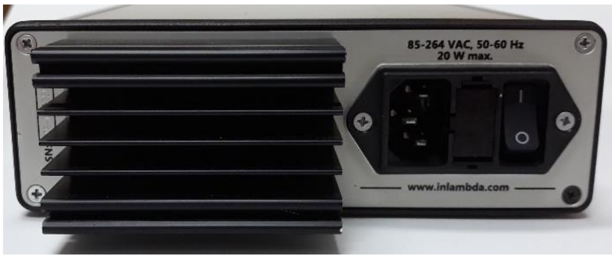
d) 

e) 

Fig 1. TIGen: a) the base unit (blue and red buttons – used for the selection of numbers of output time intervals), b) DC power supplier, c) front panel of the base unit, d) rear panel of the base unit, e) three auxiliary SMA-male-BNC-female adapters

B. **InLambda** standards – 3 items.

a) 

b) 

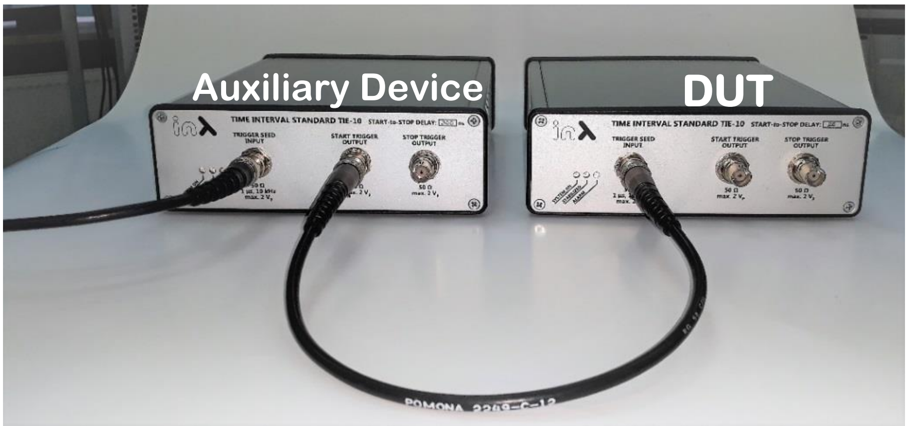
c) 

Fig 2. InLambda standards: a) front panel (1 – nominal value of delay: 20 ns, 100 ns or 300 ns, 2 – status diodes: System On, Stabilized, Alarm, 3 – input for external pulses, 4 – output of START pulses, 5 – output of STOP pulses), b) rear panel, c) required double configuration for measurements (external input pulses are passed onto the input of the auxiliary device and start output signals from the auxiliary device are passed onto the input of the device under tests (DUT))

2.2.2 <u>Data</u>

a) Mechanical dimensions:

	TIGen (base unit)	**InLambda standards**
depth x width x high	c. 18 cm x 8,5 cm x 5,5 cm	c. 26 cm x 17 cm x 6 cm (each item)
weight	< 1000 g	<1500 g (each item)

b) Specifications:

	TIGen (base unit)	**InLambda standards**
Connectors:	SMA female connectors, 50 Ω	BNC female connectors, 50 Ω
External input signals	Standard frequency: 10 MHz ± 1 Hz (<1E-7 fractional frequency), (0,5 ÷ 2) V_{p-p}	Pulse signals: Low level – 0 V, High level – 2 V
Outputs	2 x 1 pps, 2,25 V / 50 Ω	2 x pulse signals, 2 V / 50 Ω
Rise time of output pulses (20%-80%)	<0,5 ns	<0,5 ns
Number of time intervals	127 (dn0, ..., dn126)	single nominal value for every item
Range of time intervals	from about 20 ns to 12 μs	c. 20 ns for "Inλ 20" c. 100 ns for "Inλ 100" c. 300 ns for "Inλ 300"
AC Power	85-264 VAC/ (50 ÷ 60) Hz	85-264 VAC/ (50 ÷ 60) Hz
Warm-up time	15 min	< 15 min – until "Stabilized" diode stops blinking
Influence of temperature	not observed at least within: (22 ± 5) °C	when Alarm diode is off c. (0,6 ± 0,2) ps/ K for "Inλ 20" c. (1,4 ± 0,2) ps/ K for "Inλ 100" c. (2,5 ± 0,3) ps/ K for "Inλ 300"
Influence of the rise time of input pulses	not applicable	in a single configuration: c. 9 ps/ ns in a double configuration: not observed if rise time <10 ns c. 0,5 ps/ ns if rise time ≥10 ns
Stability, repeatability and reproducibility of the phase difference between output signals	not exceed ±3 ps (in reference conditions)	not exceed ±10 ps (in reference conditions)

	TIGen (base unit)	**InLambda standards**
Other information	Blue and red buttons: up and down buttons for selection time intervals	status diodes: System On, Stabilized (blinking until stabilization is reached), **Alarm (blinking during warm-up and overheat problems)**

2.2.3 Designation

A. **TIGen**:

Identification name: Time Interval Generator, Ser. No. n/a

B. **InLambda** standards:

Identification name: Time Interval Standard TIE-10

- Inλ 20 (nominal value of delay: 20 ns) Ser. No. n/a
- Inλ 100 (nominal value of delay: 100 ns) Ser. No. n/a
- Inλ 300 (nominal value of delay: 300 ns) Ser. No. n/a

2.3 Description of the measurands of the comparison (Quantities to be measured)

The time intervals between the pulse signals at the START and STOP outputs of each instruments will be measured. **The reference time intervals are defined between appearing rising slopes of the pulses at the outer ends of the dielectric of the SMA connectors (for TIGen) / BNC connectors (for InLambda standards) at the START and STOP outputs at the same trigger level**. The START and STOP pulse outputs are precisely matched, so the amplitude and the shape of output signals are closely the same. However, in order to avoid ambiguity:

The recommended and reference trigger level is fixed to 0,5 V (at 50 Ω).

In this comparison, the following time intervals will be measured:

- **dn0, dn3, dn7, dn126** (c. 20 ns, 250 ns, 1,5 μs and 12 μs) **generated by TIGen** and
- three single time intervals generated by **Inλ 20** (c. 20 ns), **Inλ 100** (c. 100 ns) and **Inλ 300** (c. 300 ns) respectively **in a double configuration** as shown in Fig. 2c.

Totally**, 7 different time intervals are to be measured**.

The reference conditions are the following:

	TIGen (base unit)	**InLambda standards**
Warm-up time	to perform measurements **after adaptation** to local environmental conditions and **after the warm-up time** – at least 15 min	to perform measurements **after adaptation** to local environmental conditions and **after the warm-up time** – until “Stabilized” diode stops blinking
External input signals	**Standard freq.. 10 MHz** ± 1 Hz (<1E-7 fractional frequency), (0,5 ÷ 2) V_{p-p} / 50 Ω (the increased noise of external frequency can cause the	**Pulse signals:** low level – **0 V**, high level – (**1,75 ÷ 2,25) V** / 50 Ω frequency: **≤ 200 Hz**,

	increased noise of the generated time intervals)	rise time: < **10 ns** (it can be applied 1 pps signals) duty cycle: **≤ 50%** pulse width: **to avoid the pulse widths close (<± 10 ns) to the measured time intervals** (observed resonance)
Ambient conditions	Temperature: **(22 ± 4) °C**,	Humidity: (50 ± 30) %
Other information		**Alarm diode is off** **Required a double configuration**
START and STOP Trigger level (fixed reference value)	**0,5 V / 50 Ω**	**0,5 V / 50 Ω**

3 Organisation

3.1 Description of the scheme/topology of the comparison

The comparison is realized in a form of three consecutive circulation loops, each of them starting from and ending in the pilot laboratory. In each circulation loop, all travelling standards travel together being circulated around the participants. First two circulation loops are organized between the European Union participants (without required ATA carnet) and the third circulation loop is arranged with ATA carnet between the last participants.

3.2 Stability check of the travelling standards

Stability check of the travelling standards will be performed by measuring the standards in the beginning and the end of comparisons and between loops by the pilot laboratory (4 times).

3.3 Time schedule

For the measurements in each laboratory and transportation a period of 2 weeks is allowed together, and extra 2 weeks for transportation with ATA carnet. The proposed starting date is December, 2019.The first comparison loop is expected to finish until the end of April, 2020, the second loop is expected to finish until the end of August, 2020, and the third loop is expected to finish not later than until the end of May, 2021. The envisaged date of conclusion (first draft) is October, 2021.

The detailed time schedule is provided in Annex 2.

3.4 Transportation

The travelling standards are transported from one participants to another participants directly. Transportation is on each laboratory's own responsibility and cost.

The travelling standards are packed in a special travelling case/box on wheels (dimensions: c. 50 x 30 x 25 cm, total weight: <15 kg).

For transportation with ATA carnet (the third circulation loop only) a courier operator and a courier service specified in the ATA carnet must be applied.

The estimated value of standards is: 9000,- EURO.

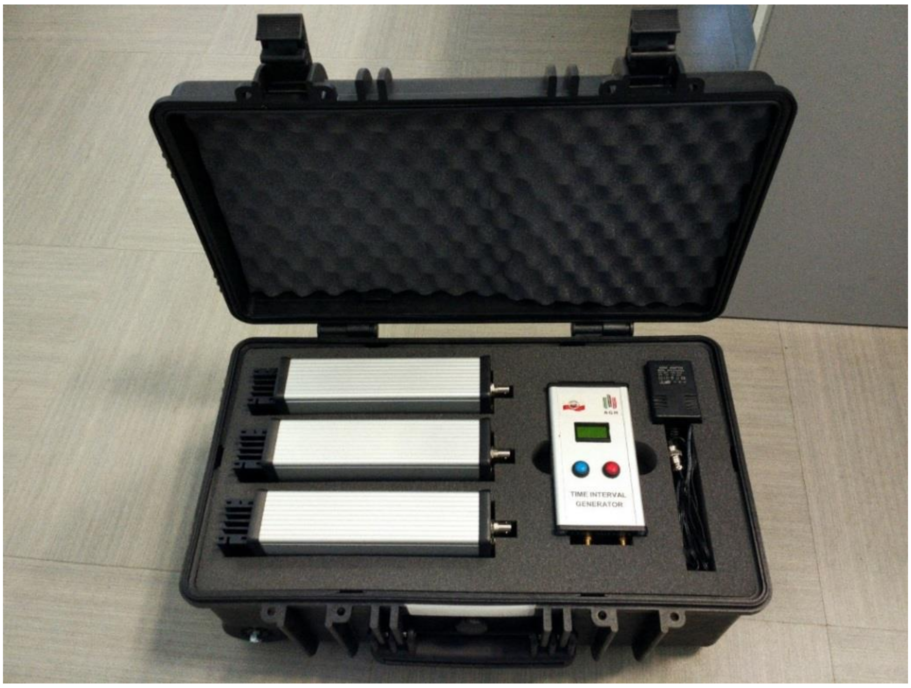


Fig 3. Case for the travelling standards containing 3 InLambda standards, TIGen standard – base unit and power supply adapter for TIGen standard

If the travelling standards travel with ATA-carnet, upon each movement of the package the person organizing the transit (specified courier agent) must ensure that the ATA carnet is presented to customs on leaving the country, and upon its arrival in the country of destination. When the package is sent unaccompanied the ATA carnet must be included with the other forwarding documents so that the handling agent can obtain customs clearance. In no case should the ATA carnet be packed with the device in the package. In some cases it is possible to attach the ATA carnet to the package.

The carnet must be saved in the laboratory very carefully because a loss of the ATA carnet may cause a serious delay in the comparison schedule.

3.5 Unpacking, handling, packing

The package contains the printed version of technical protocol and the following items.

- TIGen: the base unit, DC power supplier, three SMA-BNC adapters,
- InLambda standards: three base units.

After the receipt of the package the standards inside have to be inspected for any damage or dirt.

Fill out the "Confirmation note of receipt" form as given in Annex 5, and send it to the coordinator.

When the measurements have been finished ensure that the package is complete and protected from moisture and dirt before sending it in the original transportation travelling case to the next participant.

Fill out the "Confirmation note of dispatch" form as given in Annex 6, and send it to the coordinator.

3.6 Financial aspects, insurance

Each participating laboratory, except of SIQ, covers as a participation fee the part of the costs of purchasing the InLambda standards by SIQ – Slovenia Institute of Quality and Metrology (**250,-**

Euro netto/ participants – payed to SIQ directly after agreeing to participate in the comparison and based on the relevant invoice issued by SIQ) and the full costs of the measurement, transportation and eventual custom formalities as well as of any damage that may have occurred within their laboratory or during the transportation from their laboratory to the next participant in the loop or to the pilot laboratory (according to the schedule).

The overall costs for the organisation of the comparison are covered by the organizing pilot laboratory. The pilot laboratory is responsible for transportation and insurance of the standards during transportation from its own laboratory to the first next laboratory in each loop.

3.7 Pilot laboratory

In this comparison, GUM (Central Office of Measures, Poland) was selected as a pilot laboratory, which is responsible for preparing the technical protocol, coordinating the schedule, collecting and analysing the comparison data, and preparing the report. The work of the pilot laboratory is supported by support group.

The address of the pilot laboratory is:

Albin Czubla (coordinator) e-mail: albin.czubla@gum.gov.pl
Maciej Gruszczyński (support coordinator) e-mail: maciej.gruszczynski@gum.gov.pl

Central Office of Measures (GUM))
Elektoralna 2 Str.
00-139 Warsaw, Poland

Tel.: +48 22 581 91 56

3.8 Support group

The support group of the comparison consists of:

- SIQ (Borut Pinter, Slovenia) e-mail: borut.pinter@siq.si,
- LNE/OP (Joseph Achkar, France) e-mail: joseph.achkar@observatoiredeparis.psl.eu
- VSL (Erik Dierikx, Netherlands) e-mail: edierikx@vsl.nl
- NPL (Peter Whibberley, United Kingdom) e-mail: peter.whibberley@npl.co.uk
- FTMC (Rimantas Miskinis, Lithuania). e-mail: rimantas.miskinis@ftmc.lt

The support group helps the pilot laboratory in organization of the comparison, making decisions, preparation the technical protocol, data analysis and preparation the report as well as increases the transparency of the comparison.

Especially, SIQ additionally organizes the purchase of InLambda standards for the comparison and is authorized to issue invoices for participation fee and collecting participation fee to cover relevant costs of the purchase of InLambda standards.

3.9 Participants

Participating in the comparison is voluntary and open for TC-TF EURAMET community (priority of participation) and for others neighbouring RMOs. The total number of participants can not exceed 32 participants – in order to close the circulation loops within 18 months.

The participating laboratory must accept that their results are published in the final report of the comparison, even if they are not satisfactory for the laboratory.

The list of participants is provided in the Annex 1 and is open however the last comparison loop is expected to be finished not later than until the end of May, 2021.

The necessary condition to be included to the list of participants of the comparison is paying the participation fee directly after receiving the relevant documents/ invoice from SIQ.

4 Measurement instructions

4.1 Tests before measurement

Before measurement the SMA and BNC connectors have to be inspected if they are clean and are not damaged. Next, it should be done the following operation:

A. (in the case of) **TIGen**:

- connect DC power supplier to DC terminal in the rear panel,
- insert the plug into 230 VAC power supply (TIGen will switch automatically and display the current number of generated time interval),
- connect external standard 10 MHz frequency signal into the 10 MHz input in the rear panel,
- using blue and red button select required number of time interval (**dn0, dn3, dn7 or dn126)**,
- check the presence of 1 pps output signals (c. 2,25 V / 50 Ω),
- wait at least 15 minutes (warm-up time).

B. (in the case of) **InLambda standards:**

- prepare 3 power cords with IEC C14 connector and connect to IEC C14 sockets in the rear panels,
- insert the plugs into 230 VAC power supply and manually switch on the InLambda standards (the manual switches are at rear panels),
- with a short cable connect the START output of one InLambda standard (auxiliary device) with the pulse input of the another InLambda standard (device under tests) creating a double configuration (as in Fig. 2c),
- prepare the source of the pulse signals, check the presence of the required parameters given in the reference conditions for InLambda standards and connect external pulse signal into the pulse input of the auxiliary InLambda standard,
- check the presence of pulse output signals (c. 2 V / 50 Ω),
- wait a few minutes until the diodes Stabilized/ Alarm stop blinking (warm-up time).

4.2 Measurement performance

Measurement should be performed after adaptation of the standards to the local environmental conditions and fulfilling the required reference condition given in the table in Section 2.3.

The ambient temperature and relative humidity occurring during measurements must be monitored and given (with expanded uncertainty) together with the results in the report of measurement.

4.3 Measuring methods

The participants are free to choose their own method of measurement. However, it is recommended to perform measurements in such way to reduce differential channel delays of the used measurement system (Time Interval Counter, Oscilloscope, etc.) and differential delays of the used connecting cables between DUT and the used measurement system.

Together with the measuring results, a short description of the individual measuring methods and the type of used equipment must be included in the final report.

5 Uncertainty of measurement

All participants must provide their results with the associated uncertainty of measurement and a complete uncertainty budget. For this supplementary comparison it should be provided for 7 measured time intervals (dn0, dn3, dn7, dn126, Inλ 20, Inλ 100, Inλ 300).

The uncertainty must be evaluated at a level of one standard uncertainty and expanded uncertainty for a coverage probability of approximately 95 %. The measurement uncertainty of measurement results must be estimated according to the JCGM 100:2008 (GUM 1995 with minor corrections).

In the uncertainty budget should be taken into account all uncertainty components which are of importance in measurements. A list of the evaluated uncertainty components used by each participant should be presented in the form of a table according to the EA-4/02 M:2013 (with added the last column: "Degrees of freedom").

An example of an uncertainty budget table is given in Annex 3.

6 Reporting results

After completion of the the measurement, each participant shall prepare and send to the coordinator (albin.czubla@gum.gov.pl):

- the 'Summary of results' form as provided in Annex 4

- the Measurement report with a minimum content as listed in Annex 7

The report should be sent to the pilot laboratory no later than four weeks after the measurements have been completed. No information about differences of the reported results with respect to others will be communicated before the completion of the comparison, unless larger deviations of particular laboratories results and the preliminary reference results obtained by the pilot laboratory have been observed. In this case the laboratory in question will be contacted.

7 Principle of evaluation results

The reference values x_{Ref} for each measured time interval will be calculated as weighted averages of the measurement results obtained by the participants, according to the formula:

$$x_{Ref} = \frac{\sum_{i=1}^{N} \delta_i \frac{1}{u_i^2} x_i}{\sum_{i=1}^{N} \delta_i \frac{1}{u_i^2}}$$

where the *i*-index refers to the result obtained by the *i*-th participant (x_i - estimate of the results, u_i - standard uncertainty) from total number of *N*-participants for a given time interval, and δ_i is an additional equal to 1 for the "most reliable" results or equal to 0 for other results, i.e. $\delta_i = \begin{cases} 1 \\ 0 \end{cases}$. The most reliable results are the results for which it is unambiguously stated that the residual non-linearities of the measurement system and other non-compensated effects are included into uncertainties (eg. for SR620 – if expanded uncertainty is ≥0,15 ns) and which are consistent with other results (omitting outliers). The decision on the "reliability" will be made collectively, involving the support group.

The standard uncertainty of the reference values u_{Ref} will be calculated according to the propagation law of uncertainties, including the standard uncertainties of weighted average u_{wei}

and the standard uncertainty u_{rep} assigned to the stability, reproducibility and repeatability of travelling standards:

$$u_{Ref}^2 = u_{wei}^2 + u_{rep}^2$$

where: $$u_{wei} = \frac{1}{\sqrt{\sum_{i=1}^{N} \delta_i \frac{1}{u_i^2}}}.$$

Finally, the equivalence coefficient E_i will be calculated according to the formula:

$$E_i = \frac{x_i - x_{Ref}}{U(x_i - x_{Ref})}$$

where:

$$u^2(x_i - x_{Ref}) = u_i^2 + (1 - 2\delta_i)u_{wei}^2 + u_{rep}^2$$

and $U(x_i - x_{Ref}) = 2u(x_i - x_{Ref})$.

For $|E_i| \leq 1$ – the comparison results are positive, and for $|E_i| > 1$ – the comparison results are negative.

Due to not-negligible influence of the temperature in the case of InLambda standards, the common reference ambient temperature will be determined for recalculating the results of InLambda standards measurements with the usage of the temperature coefficients given in Specification (p. 2.2.2), correcting estimates and increasing uncertainties respectively. Then, the reference values of InLambda standards will be calculated for the reference ambient temperature and based on the temperature corrected results.

8 Report of the comparison

Within 2 months after all participant have sent the results, the pilot laboratory supported by support group will prepare a first draft A report and send it to the participants for comments. Next the draft report will be presented and discussed by TC-TF EURAMET annual meeting. Subsequently, the procedure outlined in the BIPM Guidelines will be followed.

References

[1] EURAMET Guide on Comparisons – EURAMET Guide No. 4, Version 1.0 (05/2016)

[2] CIPM MRA-D-05: Measurement comparisons in the CIPM MRA

[3] JCGM 100 :2008 (GUM with minor corrections) ”Evaluation of measurement data – Guide to the expression of uncertainty in measurement”, Sept. 2008

[4] EA-4/02 M:2013 ”Expression of the uncertainty of measurement in calibration”, Sept. 2013

[5] Technical protocol of the EUROMET supplementary comparison TF.TI-K1 ”Comparison of time interval (cable delay) measurement”, BEV, 2005 (EURAMET Project #828)

[6] Cox M G 2002 The evaluation of key comparison data, Metrologia 39 589–95

Annexes:

1. List of participants
2. Schedule of the measurements
3. Typical scheme for an uncertainty budget
4. Summary of results
5. Confirmation note of receipt
6. Confirmation note of dispatch
7. Minimum contents for the measurement report

Annex 1. Detailed list of participants

No	Contact Name	Institute	Acronym	Delivery address	Country	Telephone	e-mail
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
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17							
18							
19							
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21							
22							
23							
24							
25							
26							
27							
28							

Annex 2. Schedule of the measurements

First loop

No.	Institute	Country	Time period for measurements and transport to the next participant		Time for stabilization, measurement and transport		
			Start date	End date	Stabilization	Measurement	Transport
0							
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Second loop

No.	Institute	Country	Time period for measurements and transport to the next participant		Time for stabilization, measurement and transport		
			Start date	End date	Stabilization	Measurement	Transport
0							
1							
2							
3							
4							
5							
6							

No.	Institute	Country	Time period for measurements and transport to the next participant		Time for stabilization, measurement and transport		
			Start date	End date	Stabilization	Measurement	Transport
7							
8							
9							
10							
11							
12							

Third loop – transportation with ATA carnet

No.	Institute	Country	Time period for measurements and transport to the next participant		Time for stabilization, measurement and transport		
			Start date	End date	Stabilization	Measurement	Transport
0							
1							
2							
3							
4							
5							
6							
7							
8							

Annex 3. Typical scheme for an uncertainty budget

Supplementary comparison EURAMET.TF-S1
Time interval measurements

In addition to your measurement report, please send this information by e-mail to GUM e-mail: (albin.czubla@gum.gov.pl).

Acronym of institute: ..... Country: .....

Average date of measurements:

Remarks:

Model equation that follows from the measurement setup:

$TI = ...$

Description of the quantities in the model equation:

Quantity X_i	Description

Uncertainty budget table

Quantity X_i	Estimate x_i	Standard uncertainty $u(x_i)$	Probability distribution	Method of evaluation (A, B)	Sensitivity coefficient c_i	Uncertainty contribution $c_i \cdot u(x_i)$	Degrees of freedom ν_i
...							
...							
...							

Combined standard uncertainty	u_c	
Effective degrees of freedom	ν_{eff}	
Expanded uncertainty ($p \approx 95\%$)	U	

....

(Name) (Date)

Annex 4. Summary of results

Supplementary comparison EURAMET.TF-S1

Time interval measurements

In addition to your measurement report, please send this information by e-mail to GUM e-mail: (albin.czubla@gum.gov.pl).

Acronym of institute: ..... Country: .....

Average date of measurements: …

Remarks:

….

Measurement results with uncertainty and conditions met during measurements:

A1. TIGen standard – conditions met during measurements

<table>
<tr><th colspan="4">External standard 10 MHz reference frequency applied for TIGen standard</th><th>Required reference conditions</th><th>Meet requirements? yes / no</th></tr>
<tr><td colspan="2">Source
(Cs clock, HM, …)</td><td colspan="2"></td><td>10 MHz ± 1 Hz</td><td></td></tr>
<tr><td colspan="2">Amplitude (at 50 Ω)</td><td colspan="2"></td><td>within (0,5 ÷ 2) $V_{p\text{-}p}$</td><td></td></tr>
<tr><td colspan="3">Ambient temperature during measurements</td><td>Unit of measure</td><td>Required reference conditions</td><td>Meet requirements? yes / no</td></tr>
<tr><td></td><td>±</td><td></td><td>°C</td><td>within (22 ± 4) °C</td><td></td></tr>
<tr><td colspan="3">Ambient humidity during measurements</td><td>Unit of measure</td><td>Required reference conditions</td><td>Meet requirements? yes / no</td></tr>
<tr><td></td><td>±</td><td></td><td>%</td><td>within (50 ± 30) %</td><td></td></tr>
<tr><td colspan="6">The base equipment used for time interval measurements</td></tr>
<tr><td colspan="4">The type / brand of time interval counter/ digital oscilloscope
(eg. SR620, 53230A, …)</td><td colspan="2"></td></tr>
<tr><td colspan="4">Applied trigger level (50 Ω)
(Required: 0,5 V)</td><td colspan="2"></td></tr>
<tr><td colspan="4">Standard uncertainty component related to a residual nonlinearities or other not reduced systematic effects and included in the uncertainty budget of measurement results
(eg. 0,150 ns/2 for SR620, unknown, ≤ …, …)</td><td colspan="2"></td></tr>
</table>

A2. TIGen standard - measurement results with uncertainty:

Number of the measured Time Interval	Determined value of the measured Time Interval with expanded uncertainty (p ≈ 95 %) (in ns)			Unit of measure
"dn0"		±		ns
"dn3"		±		ns
"dn7"		±		ns
"dn126"		±		ns

B1. InLambda standards – conditions met during measurements

External input pulses applied to an auxiliary InLambda standard		Required reference conditions	Meet requirements? yes / no
Source (Cs clock, HM, frequency generator, ..)			
1 pps (yes / no)			
Frequency		≤ 200 Hz	
Low level		0 V	
High level (at 50 Ω)		(1,75 ÷ 2,25) V	
Rise time (20% to 80 %)		< 10 ns	
Duty cycle		≤ 50 %	
Pulse width		to avoid the pulse widths close **(<± 10 ns)** to the measured time intervals	
Application of a double configuration			
DUT – Device Under Test	Auxiliary used device	Required reference conditions	Meet requirements? yes / no
Inλ 20		Inλ 100 or Inλ 300	
Inλ 100		Inλ 20 or Inλ 300	
Inλ 300		Inλ 20 or Inλ 100	

Ambient temperature during measurements			**Unit of measure**	Required reference conditions	Meet requirements? yes / no
	±		°C	within (22 ± 4) °C	
Ambient humidity during measurements			**Unit of measure**	Required reference conditions	Meet requirements? yes / no
	±		%	within (50 ± 30) %	

The base equipment used for time interval measurements	
The type / brand of time interval counter/ digital oscilloscope (eg. SR620, 53230A, …)	
Applied trigger level (50 Ω) (Required: 0,5 V)	
Standard uncertainty component related to a residual nonlinearities or other not reduced systematic effects and included in the uncertainty budget of measurement results (eg. 0,150 ns/2 for SR620, unknown, ≤ …, …)	

B2. InLambda standards - measurement results with uncertainty:

The source of the measured Time Interval	Determined value of the measured Time Interval with expanded uncertainty (p ≈ 95 %) (in ns)			Unit of measure	Ambient temperature during measurements (for every standard separately – including expanded uncertainty, 95%)			Unit of measure
Inλ 20		±		ns		±		°C
Inλ 100		±		ns		±		°C
Inλ 300		±		ns		±		°C

....

(Name) (Date)

Annex 5. Confirmation note of receipt

Supplementary comparison EURAMET.TF-S1

Time interval measurement.

When you receive the travelling standards, please check the package and its contents and read out the data logger. Send this information by e-mail to GUM (albin.czubla@gum.gov.pl).

Acronym of institute: ..... Country: .....

The package was received on: ... (*date)*...

The package of travelling standards contains the following items	yes / no
Transport case – 1 item	
TIGen standard – base unit – 1 item	
InLambda standards 1 (20 ns) – 1 item	
InLambda standards 2 (100 ns) – 1 item	
InLambda standards 3 (300 ns) – 1 item	
Power supply adapter (for TIGen standard) – 1 item	
SMA (male) – BNC (female) adapters – 3 items	
Technical protocol – printed version – 1 item	
...	

If the package or its contents shows any visible damage, please describe it here.
(If possible, include a picture):

...

...

....

(Name) (Date)

Annex 6. Confirmation note of dispatch

Supplementary comparison EURAMET.TF-S1

Time interval measurements.

Before shipment of the travelling standards to the next participant or to the pilot laboratory, please check the package and its contents and send this information by e-mail to GUM (albin.czubla@gum.gov.pl).

Acronym of institute: ..... Country: .....

The package will be sent to: ...(*acronym of the next participant*)... on: ... (*date*)...

I have checked the package and it contains the following items:

The package of travelling standards contains the following items	yes / no
Transport case – 1 item	
TIGen standard – base unit – 1 item	
InLambda standards 1 (20 ns) – 1 item	
InLambda standards 2 (100 ns) – 1 item	
InLambda standards 3 (300 ns) – 1 item	
Power supply adapter (for TIGen standard) – 1 item	
SMA (male) – BNC (female) adapters – 3 items	
Technical protocol – printed version – 1 item	
...	

Remarks:

...

...

...

....

(Name) (Date)

Annex 7. Minimum contents for the measurement report

- Identification of the participating laboratory
- Description of the calibration method
- Description of the calibration set-up and equipment
- Traceability chart
- Used relationship/ equation for obtaining estimates of results and uncertainty budget,
- Obtained results of measurements with the associated standard and expanded uncertainty of measurement and a complete uncertainty budget, including information on the uncertainty components connected with residual non-linearities of the measurement system or other non-compensated effects
- Identification and description of the source 10 MHz reference frequency for TIGen standard,
- Description of the used input pulse signals for InLambda standards (low level, high level (amplitude), frequency, pulse width, rise time (20% to 80 %), duty cycle),
- Ambient conditions of measurements (the temperature and the relative humidity) – the temperature for every InLambda standard separately,
- Average date of performing measurements,
- Date and signature.