Technical Protocol

Version 1.2 (2024-03-18)

APMP.TF-S1
Comparison of Standards for the Calibration of Stopwatches

Coordinated by:

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Contents

1. Purpose

This serves as the technical protocol for a comparison of standards used for the calibration of stopwatches. A digital stopwatch is used as the unit under test (the travelling standard) for this comparison. The comparison is organized by the Working Group on Test and Calibration of the Technical Committee for Time and Frequency (TCTF) in the Asia Pacific Metrology Programme (APMP). This protocol complies with the guidelines prepared by the Consultative Committee for Time and Frequency (CCTF) for key, supplementary and pilot comparisons [1].

This comparison will be performed between three participants. The National Metrology Institute of Malaysia (NMIM) will coordinate (pilot) the comparison, supported by the National Measurement Institute of Australia (NMIA), and the National Measurement Standards – National Standardization Agency of Indonesia (SNSU-BSN) will participate in the comparison. This comparison is conducted in preparation for a stopwatch comparison of the APMP-APAC Joint Proficiency Testing Working Group, which will be piloted by the SNSU-BSN, Indonesia.

In preparation for this comparison all participants completed a questionnaire to ensure that measurements can be carried out as specified in this protocol.

The method of determining the comparison reference value and its uncertainty was agreed to by the participants before commencement of this comparison.

2. Travelling Standard

The travelling standards are a set of two Casio model HS-70W stopwatches, serial numbers TCTF-2 and TCTF-3. These are high precision stopwatches with a resolution of 0.001 s. A model HS-70W (serial number TCTF-1) stopwatch was used for the APMP TCTF stopwatch comparison (2018 to 2020), in which 9 economies participated [2].

The travelling standards will be shipped in a ruggedized transit case with dimensions 19.5 cm x 24.0 cm x 11.1 cm. The weight of the packed travelling standards is less than 1 kg.

Figure 1. Casio model HS-70W serial numbers TCTF-2 and TCTF-3

3. Environmental conditions

The environmental conditions for this comparison are:
Temperature: (23 ± 2) °C
Humidity: (50 ± 20) %RH

The travelling standard should be orientated facing up during measurements.

Deviations from these conditions must be noted on the result sheet and reported to the pilot laboratory.

4. Measurements

Upon arrival of the travelling standards:

- Check the condition of the package carefully for damage.
- Check the travelling standards for damage and functionality. Report any damage to the pilot laboratory without delay.
- Complete the Receipt Form (appendix A) and send it to the pilot laboratory.

Should a travelling standard found to be faulty, either on receipt, during or after the measurements, the participant must inform the pilot laboratory without delay. The pilot laboratory will then inform the participant how to proceed.

The travelling standards should be allowed at least three hours in the laboratory environment before any measurements are performed.

Both travelling standards should be measured at the following time intervals:
10 s,
3 600 s (1 hour), and
10 800 s (3 hours).

The normal laboratory procedure for the calibration of stopwatches should be used. The result must be reported as a fractional time difference using $\frac{\Delta t}{T}$ where Δt is the difference between the laboratory and travelling standards, and T is the nominal time interval.

In addition to these measurements, the frequency offset of the travelling standard can be measured. If this measurement is performed, the result must be reported as a fractional frequency difference using $\frac{\Delta f}{f}$ where Δf is the difference between the laboratory and travelling standards, and f is the nominal frequency (internal quartz oscillator of 32.768 kHz or any derived frequency).

Section 8 of NIST Special Publication 960-12: Stopwatch and Timer Calibrations [3] contains information to determine if the selected measurement method meets the required uncertainty of measurement. Participants should ensure that the method used, and the comparison time interval, allow them to meet their required uncertainty. If this is not the case, contact the pilot laboratory to discuss options.

The uncertainty of measurement must be calculated according *to JCGM 100:2008 – Evaluation of measurement data – Guide to the expression of uncertainty in measurement* [4] for a 95% level of confidence. In uncertainty evaluations, all uncertainty

components considered should be included. The coverage factor and the effective degrees of freedom should be reported.

At the conclusion of the measurements:

- Complete the result sheet (appendix B) and send it to the pilot laboratory before dispatching the travelling standards.
- Complete the Dispatch Form (appendix C) and send it to the pilot laboratory and the next participant.
- Send the travelling standards to the next participant.

5. Comparison reference value

The comparison reference value will be the average of measurements performed by the pilot laboratory. The reference uncertainty will be the weighted mean of the uncertainties calculated by the pilot laboratory for its measurements during the comparison.

The results of this supplementary comparison link to key comparison CCTF-K001.UTC [5] through the participation of the pilot laboratory in CCTF-K001.UTC.

6. Evaluation and reporting of results

On receipt of a participant's result sheet, the pilot laboratory will perform a preliminary examination of the data. If an anomalous result is identified, the participant will be informed and invited to check the results for errors. If no error is found and reported by the participant with the amended results, the results will stand and be used in evaluation of the comparison.

The results will be reported as degrees of equivalence and as En values.

At the conclusion of the comparison, after all results have been received, the pilot will prepare the Draft A report. In the Draft A report, participants will remain anonymous. Once the Draft A report has been approved by all participants, the pilot will prepare the Draft B report in which participants are identified. When the Draft B report has been approved by all participants, it becomes the final report that will be submitted for publication.

7. Organisation of the comparison

The comparison is coordinated by the National Metrology Institute of Malaysia.

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National Metrology Institute of Malaysia
Lot PT 4803
Bandar Baru Salak Tinggi
43900 Sepang
Selangor
Malaysia

Tel: +60 194518801
Email: ahmads@sirim.my

Address for dispatch of travelling standard:
Mr Ahmad Sahar Omar
National Metrology Institute of Malaysia
Lot PT 4803
Bandar Baru Salak Tinggi
43900 Sepang
Selangor
Malaysia

Tel: +60 194518801
Email: ahmads@sirim.my

The National Measurement Institute, Australia has agreed to support this comparison.

The travelling standards are small, lightweight, and relatively inexpensive items so it is inappropriate to use an ATA Carnet for this comparison. To assist customs clearance, include a pro-forma invoice from your institute to the next participant with the package (also include a copy with the dispatch form). The pro-forma invoice should contain a statement that the items are scientific equipment sent to the participant for the purpose of a measurement comparison and that it has no commercial value. Its value for customs purposes should be stated as US $100 for each stopwatch.

Each participant is responsible for costs in its own country (for example customs duties, insurance, etc.) and for shipping the travelling standards to the next participant.

8. Documents to be submitted

8.1 Receipt form – refer to appendix A
8.2 Results sheet – refer to appendix B
8.3 Dispatch form – refer to appendix C
8.4 Measurement report – refer to appendix D

9. Participants

No	Institute acronym	Shipping address	Contact person
1	NMIM	National Metrology Institute of Malaysia Lot PT 4803, Bandar Baru Salak Tinggi, 43900 Sepang, Selangor, Malaysia	Ahmad Sahar Omar ahmads@sirim.my +60 194518801
2	SNSU-BSN	SNSU-BSN, Kompleks Puspiptek Gedung 420, Tangerang Selatan 15314, Banten – Indonesia	A. Mohamad Boynawan boynawan@gmail.com
3	NMIA	National Measurement Institute Australia 36 Bradfield Rd Lindfield NSW 2070 Australia	Louis Marais time@measurement.gov.au

10. Comparison schedule

Date	Participant	Action
2024-03-11	NMIM	Shipping to next participant
2024-03-18	NMIA	Measurements
2024-04-01	NMIA	Shipping to next participant
2024-04-15	SNSU-BSN	Measurements
2024-04-29	SNSU-BSN	Shipping to pilot
2024-05-13	NMIM	Measurements
2024-06-03	NMIM / NMIA	Analysis and reporting
2024-06-17	NMIM / NMIA	Draft A report
2024-07-01	NMIM / NMIA	Draft B report
2024-07-29	NMIM / NMIA	Final report

11. Amendment record

No	Date	Version	Changes
0	2023-11-17	1.0	Initial version
1	2024-01-30	1.1	1. Added reference uncertainty to section 1. 2. Fixed typing errors found in the document. 3. Added a paragraph in section 4 on procedure in case an artefact is found to be faulty. 4. Added description of reference uncertainty calculation to section 5. 5. Added statement linking this comparison to CCTF-K001.UTC to section 5. 6. Corrected numbering error in paragraph 8 (7.x → 8.x). 7. Updated comparison schedule in section 10. 8. Added a reference for CCTF-K001.UTC in section 12.
2	2024-03-18	1.2	1. Fixed several typographical errors. 2. Amended the comparison schedule (paragraph 10).

12. References

[1] CCTF Guidelines for Planning, Organizing, Conducting and Reporting Key, Supplementary and Pilot Comparisons, Version 1 (May 2018), https://www.bipm.org/documents/20126/30132586/cc-publication-ID-518/9a746860-62a0-9952-1660-3c68f725b006, last accessed 2023-09-22.

[2] APMP TCTF Digital Stopwatch Comparison, http://apmp.minethink.com/fms/others3.php?tc_id=TF, last accessed 2023-10-31.

[3] NIST Special Publication 960-12: Stopwatch and Timer Calibrations (2009 edition), January 2009, https://tf.nist.gov/general/pdf/2281.pdf, last accessed 2023-10-26.

[4] JCGM 100:2008 – Evaluation of measurement data – Guide to the expression of uncertainty in measurement, September 2008, https://www.bipm.org/documents/20126/2071204/JCGM_100_2008_E.pdf, last accessed 2023-10-25.

[5] CCTF-K001-UTC, Calculation of the reference time scale UTC (Coordinated Universal Time), 1977 - present, https://www.bipm.org/kcdb/comparison?id=735, last accessed 2024-01-30.

Appendix A. Receipt form

When the package is received, complete this form, and send it to the pilot laboratory.

To: Name: Ahmad Sahar Omar
Institute: National Metrology Institute of Malaysia
Tel: +60 194518801
Email: ahmads@sirim.my

From: Name: _____
Institute: _____
Tel: _____
Email: _____

Arrival date: _____

Is there any damage to the package? ☐NO ☐YES

If there is damage to the package, please send photographs of the damage to the pilot laboratory.

Briefly describe the damage here: _____

_____

_____

Check the condition of the carrying case and travelling standards.

Are the carrying case and the travelling standards in a good condition? ☐YES ☐NO

If NO, describe the issue: _____

_____

_____

Check the functioning of the stopwatches by starting and stopping a time interval measurement, and then resetting the stopwatch.

Does the stopwatch operate normally? ☐YES ☐NO

If NO, describe the issue: _____

_____

_____

Signature of person completing this form: _____

Appendix B. Results sheet

Participant (Name of institute): _____

Date(s) of measurements: _____

Orientation of stopwatches during measurements (e.g., horizontal, face up): _____

Environmental conditions

Maximum temperature: _____ °C Maximum humidity: _____ %RH

Minimum temperature: _____ °C Minimum humidity: _____ %RH

Time interval measurement results for s/n TCTF-2

Time Interval, T (s)	Deviation from nominal, Δt (s)	Δt/T (s/s)	Uncertainty (s/s)
10			
3 600			
10 800			

Time interval measurement results for s/n TCTF-3

Time Interval, T (s)	Deviation from nominal, Δt (s)	Δt/T (s/s)	Uncertainty (s/s)
10			
3 600			
10 800			

Frequency measurement results

Stopwatch serial number	Frequency, f (Hz)	Deviation from nominal, Δf (Hz)	Δf/f (Hz/Hz)	Uncertainty (Hz/Hz)

Confirm that a description of the measurement method is attached ☐

Confirm that a copy of the raw data for the reported results is attached ☐

Measurements performed by		Results checked by	
Name	_____	Name	_____
Position	_____	Position	_____
Signature	_____	Signature	_____

Appendix C. Dispatch form

When the package is ready for dispatch, complete this form, and send it to the pilot laboratory and the next participant.

To: Name: _____

Institute: _____

Tel: _____

Email: _____

From: Name: _____

Institute: _____

Tel: _____

Email: _____

Comments on the performance of the travelling standards: _____

_____

_____

_____

_____

Confirm that the travelling standards are in a good condition	☐
Confirm that a pro-forma invoice in included in the shipping documentation and that a copy has been sent to the next participant	☐
Confirm that the results sheet (appendix B) has been sent to the pilot laboratory	☐

Courier (if applicable): _____ Tracking no: _____

Airline: _____ Flight no: _____Dated: _____

Dispatch date: _____

Signature of person completing this form _____

Appendix D. Measurement report

A detailed measurement must be submitted to the pilot laboratory within two weeks of completing the measurements.

The measurement report must contain the following:

1. A detailed description of the measurement method followed with a diagram indicating connections between the standards and instruments used. The diagram must include the traceability link for the measurement. If a frequency measurement was performed, a separate section detailing that measurement must be included in the report.
2. A description of the traceability to Coordinated Universal Time (UTC) for the measurement.
3. The measurement results with the associated uncertainties.
4. A detailed uncertainty analysis for each measurement result.
5. A statement that these results have been authorised for release by a person authorised to do so. This is required for publication of the results.

A template for the measurement report is attached. This may be used, suitably amended, as the basis for your report.