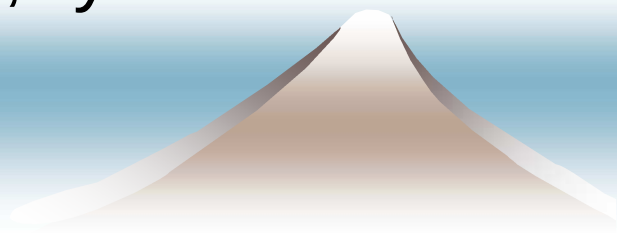
Calibration service at NICT

Organization of NICT

- Organization
  - President – 5 Vice Presidents
    - 7 Research Centers
    - 7 Departments
- Location
  - Headquarters ;Tokyo
  - Yokosuka Research Laboratory ;Kanagawa
  - Kobe Research Laboratory ;Hyougo
  - Keihanna Research Laboratory ;Kyoto



Organization of NICT (2)

- Research Centers
  - New Generation Network Research Center
  - International Security Research Center
  - Applied Electromagnetic Research Center

  Tokyo
  - New Generation Wireless Communications Research Center → Kanagawa
  - Kobe Advanced ICT Research Center → Hyougo
  - Knowledge Creating Communication Research Center
  - Universal Media Research Center

  Kyoto

Organization of NICT (3)

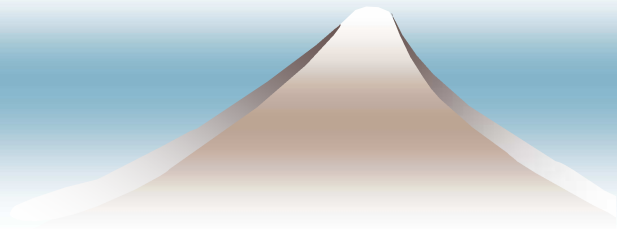
- Departments
  - Collaborative Research Department
  - Research Promotion Department
  - Key Technology Research Promotion Department
  - ICT Proactive Outreach Department
  - General Affairs Department
  - Financial Affairs Department
  - Strategic Planning Department

Tokyo

Our Group

- Our Group
  - New Generation Network Research Center
    - Network Architecture Group
    - Photonic Network Group
    - Quantum ICT Group
    - Advanced Device Research Group
    - Space - Time Standards Group
      - Japan Standard Time Project → Disseminate Time & Frequency
      - Atomic Frequency Standard Project
      - Space-Time Measurement Project
      - Satellite Time Measurement Project

Calibrate Frequency



Calibration service at NICT

- NICT Calibration scope is only frequency standard
- NICT performs two calibration services
  - Carried in calibration service
  - Remote calibration service
    - Frequency Range 1 MHz, 5 MHz, 10 MHz
    - Frequency Accuracy(BMC)

      5×10^{-14} (Carried in system)

      5×10^{-13} (Remote system)

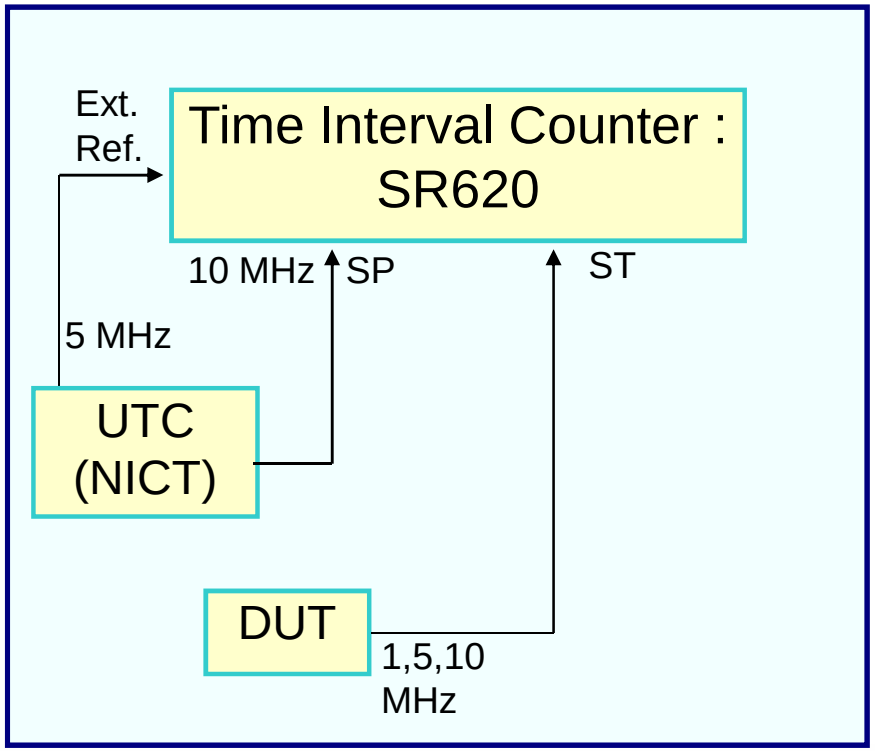
NiCT

BMC of Calibration services

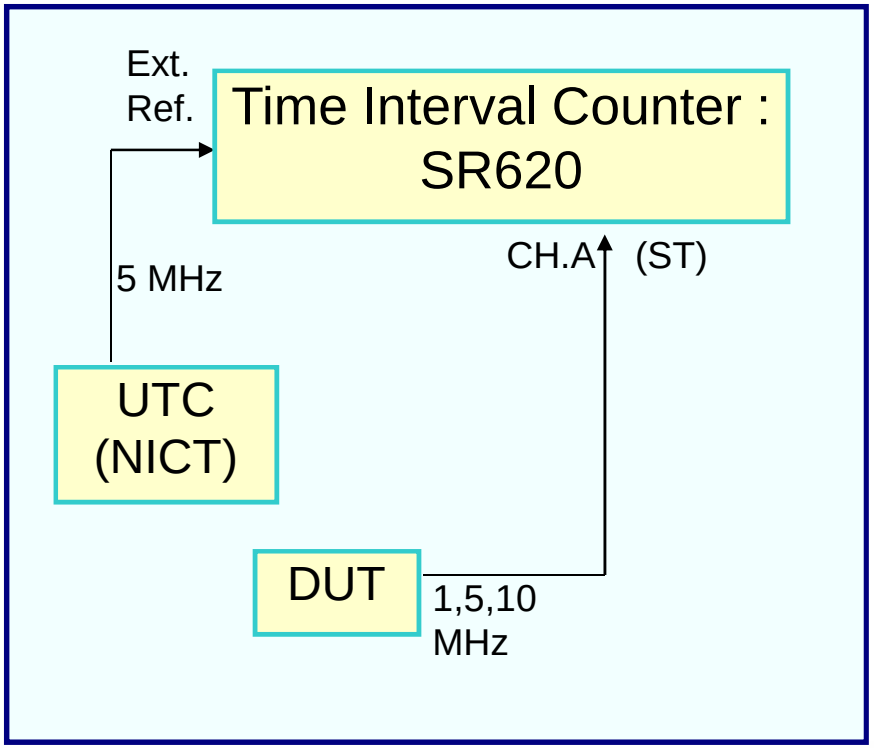
Quantity	Calibration Range		Best Measurement Capability (k=2)	Remark
	Instrument or Artifact	Measure and Level or Range		
Frequency	Frequency standards	1MHz, 5MHz, 10MHz	5.0E-14	TI method
	Frequency standards	1MHz, 5MHz, 10MHz	2.5E-12	DF method
	Frequency standards	1MHz, 5MHz, 10MHz, or 1pps	5.0E-13	Remote

NiCT

Block Diagram of Carried in Calibration System

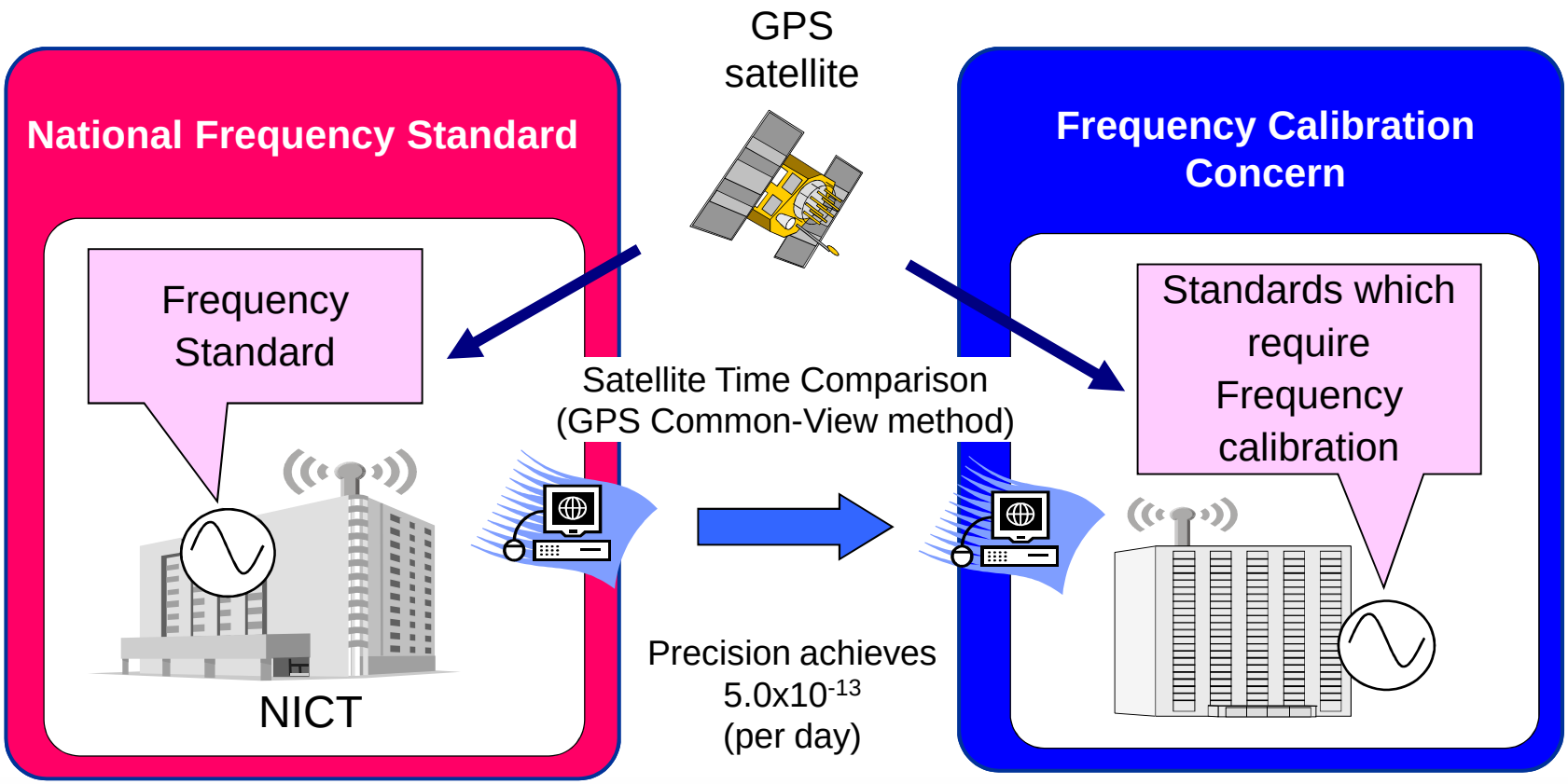


Time Interval Measurement System



Direct Frequency Measurement System

Remote Calibration System



Carried in Calibration System

Temperature and humidity are controlled in a electromagnetic shielded room

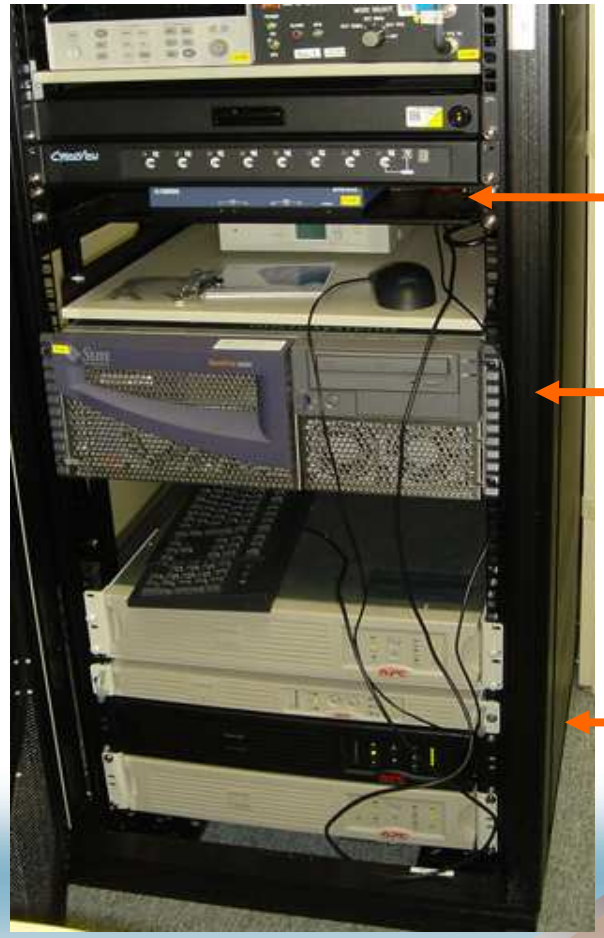
Base station for Remote Calibration

Internet server 1
Application server
Internet server 2
NAS

Control PC

Multi-channel
GPS receiver

Temp. & Hum.
Measurement unit



Internet router

Data server

UPSs

NiCT

Status of quality system

- Satisfied ISO/IEC 17025

- Accredited to ISO/IEC 17025 by NITE
  - Pathway: Third party accreditation.
  - Accreditation Body:

    NITE (National Institute of Technology and Evaluation)

Certification

(English Translation)

Certification of Accreditation

To: Makoto Nagao
President
National Institute of Information and Communications Technology

IAJapan hereby accredits the following laboratory as calibration laboratory under the ASNITE Accreditation Program. This organization meets the requirements of ISO/IEC 17025:2005 (JIS Q 17025:2005).

Accreditation No. and: ASNITE 0004 C
Additional Information
Name of Laboratory: New Generation Network Research Center,
Research Department 1,
National Institute of Information and Communications Technology
Address of Office: 4-2-1, Nukui-Kitamachi, Koganei
Tokyo, 184-8795 JAPAN
Accreditation Scope: As attached
Date of Accreditation: 31 January 2003
Date of Latest Issue: 1 April 2007

Makoto Misono
President
National Institute of Technology and Evaluation

This certificate was issued under the accreditation program complying with the rule of MRAs of ILAC (International Laboratory Accreditation Cooperation) and APLAC (Asia-Pacific Laboratory Accreditation Cooperation).

Attachment

Accreditation Category for Calibration Laboratory: Time and Frequency
Permanent laboratory or On-site calibration: Permanent laboratory

Quantity	Calibration Range		Calibration and Measurement Capability (k=2)		Date of Accreditation
	Instrument or Artifact	Measurand Level or Range			
Frequency	Frequency Standards	1 MHz 5 MHz 10 MHz	5.0×10^{-14}		1 April 2007
	Frequency Standards (Remote Frequency Calibration Method)	1 MHz 5 MHz 10 MHz	Baseline Length 1000km	5×10^{-13}	2 May 2006

(End of Attachment)

Staffs

- Supervisor 1
- Quality manager 1
- Project leader 1
  (Technical management)
- Managers 2
  (Calibration 1, Reception 1)
- Staffs 3
  (Calibration 2, Reception 1)

Number of calibrations and others

- The number of calibrations

  30 - 40 / year

- Audits , Reviews
  - Full audits : Every 2 years

    (They are performed by NITE)

Status of our system (History)

- Jan. 2001: Started the calibration service
  - BMC was 1E-13
- Mar. 2001: International peer review
  - NICT was certified to be accordance with the ISO/IEC 17025 by NITE.
- Oct. 2002: Assessed as ISO/IEC 17025 by NITE
- Jan. 2003: Accredited to Carried in service
  - NITE accredited to the frequency calibration (carried in) system for ISO/IEC 17025.
- MAY 2005: Remote calibration service was Started

NiCT

Status of our system (History2)

- Aug. 2005: CMC data were listed in the KCDB
- Feb. 2006: New carried in system was launched
- Feb. 2006: International peer review
  - For changed carried in system and Remote calibration service
- May 2006: Accredited to Carried in & Remote services
  - NITE also accredited to the frequency remote calibration system for ISO/IEC 17025.
- APR.2007: BMC was changed to 5E-14(carried in system)

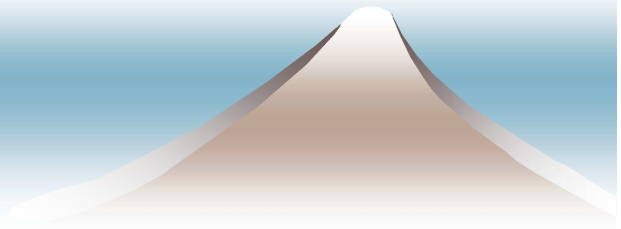
NiCT

Future work

- To change CMC data in the KCDB of BIPM
  - NICT's CMC data were listed in the KCDB in Aug. 2005.
  - NICT established a new calibration system (Carried in) and a remote calibration system.
  - Changed BMCs of above systems are accredited by NITE in April 2007 and in May 2006 respectively.
- To add new Calibration menu
  - 1Hz to 100MHz frequency calibration (for Carried in system)
  - Light frequency calibration & Frequency calibration using JJY are under active consideration now.

NiCT

Thank you for your attention



Application of uncertainties to CMC budgets

Taeg Yong Kwon

Korea Research Institute of Standards and Science

October 24 ~ 25, 2007

KRISS

21 countries (Full members)

APMP TCTF members (25)

Economy	Organisation
Australia	National Measurement Institute, Australia (NMIA)
Bangladesh	Bangladesh Standards and Testing Institution(BSTI)
China	National Institute of Metrology(NIM)
Chinese Taipei	Telecommunication Laboratories
Egypt	National Institute for Standards(NIS)
Fiji	Ministry of Commerce, Industry, Trade & Public Enterprises
Hong Kong	Standards and Calibration Laboratory(SCL)
India	National Physical Laboratory(NPL)
Indonesia	Research Centre for Calibration, Instrumentation and Metrology; Indonesian Institute of Sciences (KIM-LIPI)
Japan	National Metrology Institute of Japan(NMIJ/AIST)
	National Institute of Information and Communications Technology(NICT)
Korea	Korea Research Institute of Standards and Science(KRISS)
Malaysia	National Metrology Laboratory,SIRIM Berhad

Economy	Organisation
Nepal	Nepal Bureau of Standards and Metrology(NBSM)
New Zealand	Measurement Standards Laboratory(MSL)/(IRL)
Pakistan	National Physical & Standards Laboratory(NPSL)
Philippines	Industrial Technology Development Institute(ITDI)
Singapore	National Metrology Centre, SPRING Singapore
South Africa	National Metrology Institute of South Africa (NMISA)
Sri Lanka	Measurement Units, Standards and Services Departrment(MUSSD)
Syria	National Standards and Calibration Laboratory(NSCL)
Thailand - NIMT	National Institute of Metrology (Thailand)
Thailand - DSS	Department of Science Service(DSS)
Thailand - TISTR	Thailand Instiute of Scientific & Technological Research(TISTR)
Vietnam	Vietnam Metrology Institute(VMI)

KCDB CMC List (Current Status)

- 25 Countries (26 NMIs)

APMP (7)

Country	NMI
Australia	NMIA
China	NIM
Chinese TAIPEI	TL
Hong Kong, China	SCL
Japan	NICT
	NMIJ
Korea, Republic of	KRISS

- 21 countries in APMP
- 5 countries: CMC review in progress
- 2nd CMC review getting started

EUROMET (16)

Country	NMI
Austria	BEV
Belgium	SMD
Czech Republic	IPE
Finland	MIKES
Germany	PTB
Hungary	MKEH
Ireland	NML
Italy	INRIM
Poland	GUM
Slovenia	MIRS/SIQ
Spain	ROA
Sweden	SP
Switzerland	METAS
The Netherlands	NMi-VSL
Turkey	UME
United Kingdom	NPL

SIM (2)

Country	NMI
Panama	CENAMEP
United States	NIST

COOMET (1)

Country	NMI
Russian Federation	VNIIFTRI

Contents

- Review
  - CCTF Guidelines
  - TCTF Guidelines
  - making CMCs in accordance with the CCTF and TCTF guidelines
- Discussion
  - Review Comments
- Summary
  - Things to be considered for making CMCs
- JCRB documents
  - Procedure for modifying CMCs in Appendix C of the KCDB website

CCTF WGMRA Guidelines

- CCTF WGMRA Guideline 1 (Rev. 20021209)
  - The Service Category classification scheme for T&F entries
- CCTF WGMRA Guideline 2 (Rev. 20021205)
  - The estimation of uncertainties for T&F CMC entries
- CCTF WGMRA Guideline 3 (Rev. 20021210)
  - The uncertainty extrapolation for T&F CMC entries

CCTF WGMRA Guideline 1

The Service Category classification scheme for T&F CMC entries
The following Service Category classification for T&F CMC entries should be followed:

1. Time scale difference 2(4)
    - 1.1 Local clock
        - 1.1.1 Local clock vs. UTC(NMI)
        - 1.1.2 Local clock vs. UTC
    - 1.2 Remote clocks
        - 1.2.1 Remote clock vs. UTC(NMI)
        - 1.2.2 Remote clock vs. UTC
2. Frequency 3(5)
    - 2.1 Standard frequency source
        - 2.1.1 Local frequency standard
        - 2.1.2 Remote frequency standard
    - 2.2. General frequency source
        - 2.2.1 General frequency source
    - 2.3 Frequency meter
        - 2.3.1 Frequency counter
        - 2.3.2 Frequency meter
3. Time Interval 3(10)
    - 3.1 Period source
        - 3.1.1 Period source
    - 3.2 Time Interval source
        - 3.2.1 Rise/fall time source
        - 3.2.2 Pulse width source
        - 3.2.3 Time difference source
        - 3.2.4 Delay source
        - 3.3Period meter
        - 3.3.1 Period meter
    - 3.4 Time Interval meter
        - 3.4.1 Rise/fall time meter
        - 3.4.2 Pulse width meter
        - 3.4.3 Time difference meter
        - 3.4.4 Delay meter

Only the second sub-level items (underlined) should be selected for the column "Service category" and "Instrument or Artifact" of the CMC table.

CCTF WGMRA Guideline 2

The estimation of uncertainties for T&F CMC entries

In the field of time and frequency metrology, ……. clocks and so on. The CCTF WGMRA ha s decided to accept **the definition of Best Measurement Capability (BMC)** on the CMC ta ble entries as **the uncertainty level of NMI's measurement system**. Therefore each NMI can claim the uncertainty of its calibration system **in the hypothetical case of an ideal Dev ice Under Test (DUT).** The calibration certificates issued by NMIs, however, have to indicat e the uncertainty of the calibration results including the influence of the DUT.

APMP TCTF Guideline

Column 17

*Write "**Excluded DUT's Effect**" if the uncertainty is estimated **for the hypothetical case**, "Included DUT's Effect" if it is estimated for actual DUT effect. And state comments here if necessary on entries in Column 1 to 16.*

CCTF WGMRA Guideline 2

The estimation of uncertainties for T&F CMC entries

In the field of time and frequency metrology, ……. clocks and so on. The CCTF WGMRA has decided to accept **the definition of Best Measurement Capability (BMC)** on the CMC table entries as **the uncertainty level of NMI's measurement system**. Therefore each NMI can claim the uncertainty of its calibration system **in the hypothetical case of an ideal Device Under Test (DUT).** The calibration certificates issued by NMIs, however, have to indicate the uncertainty of the calibration results including the influence of the DUT.

CCTF
WGMRA Guideline 2
(Rev. 20040402)
The estimation of uncertainties for T&F CMC entries

In the field of time and frequency metrology, ….. clocks and so on. The CCTF WGMRA recommends that the CMCs claimed by each NMI or designated laboratory refers to the hypothetical case of an ideal Device Under Test (DUT). The calibration certificates issued by NMIs, however, have to indicate the uncertainty of the actual calibration results including the influence of the DUT. The WGMRA therefore recommends that the CMC entries into the KCDB contain the following statement "The uncertainty depends on the performance of the DUT"

CCTF WGMRA Guideline 3

The uncertainty extrapolation for T&F CMC entries

The results of a Key Comparison (KC) …… Capability (BMC). The CCTF has declared **UTC-UTC(k)** as published in BIPM Circular T as **the sole KC in the T&F field**. BIPM Circular T is giving the deviation for each contributing laboratory in the form of UTC -UTC(k) with **a given combined uncertainty for intervals of 5 days**.

From this, the corresponding deviation and its uncertainty for frequency and time interval at 5 days can be derived. **Real calibrations at NMIs may be done and specified at intervals and averaging times tau shorter than 5 days**. In that case there is **a need to extrapolate the 5-day results of the KC to express the uncertainty in each CMC entry for shorter averaging times**. Extrapolation should take into account the properties (TDEV, ADEV, MDEV, drift, ageing) of the Reference Standard used for calibration, obtained from generally accepted and published studies or from specifications of the manufacturer, and according to a fully documented procedure. Only in the case of an uncertainty claim better than this extrapolation result, a special review in the RMO is necessary.

CCTF WGMRA Guideline 3

CCTF

WGMRA Guideline 3

(Rev. 20040402)

The uncertainty extrapolation for T&F CMC entries

The results of a Key Comparison (KC) will provide the deviation and its uncertainty for each participating laboratory. This uncertainty will be reflected in the corresponding CMC entry and should be considered as its lowest uncertainty limit.

The CCTF has declared UTC-UTC(k) as published in BIPM Circular T as a KC in the T&F field. BIPM Circular T gives the deviation for each contributing laboratory in the form of UTC -UTC(k) with a given combined uncertainty for intervals of 5 days.

From this, the corresponding deviation for frequency and its corresponding uncertainty is therefore available for time intervals of 5 days.

Real calibrations at NMIs may be done and specified at intervals and averaging times tau shorter than 5 days. In that case there is a need to extrapolate the 5-day results of the KC to express the uncertainty in each CMC entry for shorter averaging times.

Extrapolation should take into account the properties (TDEV, ADEV, MDEV, drift, ageing) of the Reference Standard used for calibration, obtained from generally accepted and published studies or from specifications of the manufacturer, and according to a fully documented procedure.

Only in the case of an uncertainty claim better than this extrapolation result, a special review in the RMO is necessary.

APMP TCTF Guidelines for CMC

Guidelines for Filling the Calibration and Measurement Capabilities Appendix C (Ver. 4)

Asia-Pacific Metrology Programme (APMP)

Technical Committee for Time and Frequency (TCTF)

This document provides guidelines on the Appendix C of the Calibration and Measurement Capabilities (CMC). The purpose of the guidelines is to harmonize the data submitted on the CMC.

Generally, the field of time and frequency is divided into three categories of measurement services – frequency, time interval, and time scale difference. Relevant parameters in the CMC table are described below.

APMP TCTF Guidelines for CMC

Guidelines for Filling the Calibration and Measurement Capabilities Appendix C (Ver. 4)

Asia-Pacific Metrology Programme (APMP)
Technical Committee for Time and Frequency (TCTF)

This document provides guidelines on the Appendix C of the Calibration and Measurement Capabilities (CMC). The purpose of the guidelines is to harmonize the data submitted on the CMC.

Generally, the field of time and frequency is divided into three categories of measurement services – frequency, time interval, and time scale difference. Relevant parameters in the CMC table are described below.

Column 1

Specify the quantity to be calibrated or measured. Examples are "Frequency", "Time interval', or "Time scale difference".

Column 2

.
.
.
.
.

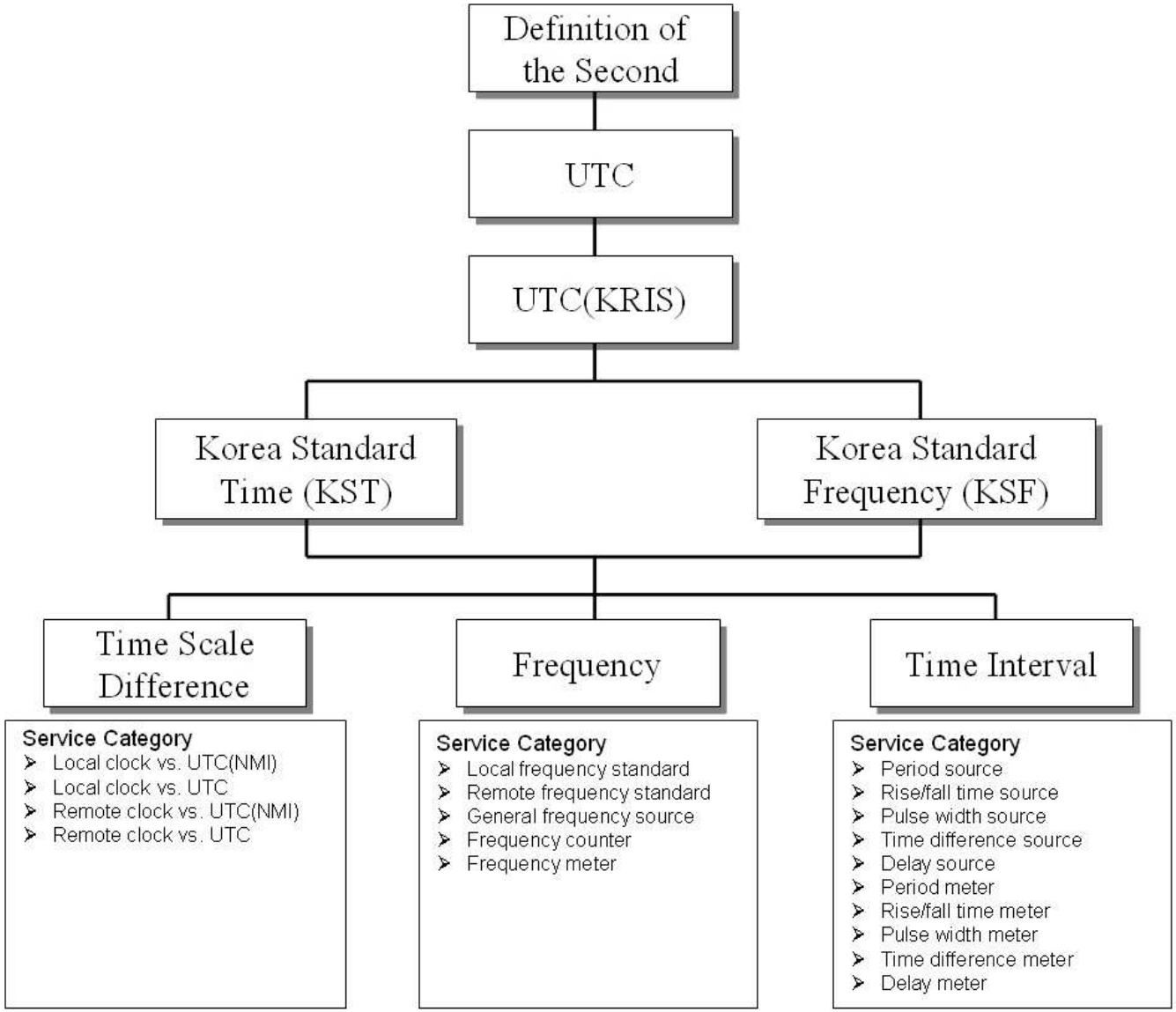
Column 22

Comment on the review to be given by WG MRA. Results of assessments are classified into two groups – Accepted or Not accepted.

Contact Person (bottom of the table)

Information of a contact person of the submitting NMI (name of country) and his/her email address.

Example: KRISS system



KRISS

Extrapolation

Traceability of KST and KSF based on the data of BIPM Circular-T and uncertainty of reference frequency.

Korea Standard Time, (UTC(KRIS) + 9 h)	• [*UTC – UTC(KRIS)*] = 0 ns • standard uncertainty = 100 ns
Korea Standard Frequency	• relative frequency offset = 1.0×10^{-14} • relative standard uncertainty = 3.5×10^{-14} (for measurement time of 10^5 s)
Reference Frequencies (1 MHz, 5 MHz, 10 MHz)	• relative frequency offset = 1.0×10^{-14} • relative standard uncertainty = 3.5×10^{-14} (for measurement time of 10^5 s)

Uncertainty of the reference frequency for DMTD measurement.

Reference Frequency	• relative frequency offset : calculated • relative standard uncertainty = 1.8×10^{-14} (for measurement time of 3 days)

The uncertainties are obtained by extrapolating the 5-day results in the Circular-T for the measurement time and by considering the effects of all parts of the measurement system

Sample CMC

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUT's Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale difference	Local clock vs. UTC(KRIS)	Direct time interval measurement	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K1.1.1	1.1.1	KRISS		
Time scale difference	Local clock vs. UTC	Direct time interval measurement	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	200	ns	2	95%	No	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K1.1.2	1.1.2	KRISS		
Time scale difference	Remote clock vs. UTC(KRIS)	GPS common-view time transfer	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	22	ns	2	95%	No	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K1.2.1	1.2.1	KRISS		new
Time scale difference	Remote clock vs. UTC	Direct time interval measurement	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	210	ns	2	95%	No	Cesium beam frequency standard	BIPM	CCTF-K001.UTC	Excluded	K1.2.2	1.2.2	KRISS		new
Frequency	Local frequency standard	Dual mixer time difference measurement	5	5	MHz	Measurement time	3 d	4E-14	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

- **Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr**

KRISS

Sample CMC – column 1

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUT's Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency	KRISS	CCTF-K001.UTC	Excluded		1.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
Frequency	Local frequency standard								Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Column 1

Specify the quantity to be calibrated or measured. Examples are "Frequency", "Time interval', or "Time scale difference".

Frequency

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

KRISS

Sample CMC – column 2

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service	Measurand Level or Range	Measurement Conditions / Independent Variable	Expanded Unce

Column 2

Describe the instrument or artifact under calibration (or measurement) tabled in the CCTF WGMRA Guideline 1 Rev.20021209.

Time scale difference	Remote clock vs. UTC(KRIS)	GPS common-view time transfer	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	22	ns	2
Time scale difference	Remote clock vs. UTC	Direct time interval measurement	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	210	ns	2
Frequency	Local frequency standard	Dual mixer time difference measurement	5	5	MHz	Measurement time	3 d	4E-14	Hz/Hz	2
						Amplitude	>0.5 V (50 Ω)			
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2
						Number of measurements	100			
						Amplitude	>0.5 V (50 Ω)			
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2
Frequency	Local frequency standard	Direct frequency measurement								2
						Number of measurements	100			
						Amplitude	>0.5 V (50 Ω)			
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2
						Amplitude	>0.5 V (50 Ω)			
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2
						Amplitude	>0.5 V (50 Ω)			

Local frequency standard

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

1. Time scale difference 2(4)
   - 1.1 Local clock
     - 1.1.1 Local clock vs. UTC(NMI)
     - 1.1.2 Local clock vs. UTC
   - 2.1 Frequency standard
     - 2.1.1 Local frequency standard
     - 2.1.2 Remote frequency standard
   - 2.2. General frequency source
     - 2.2.1 General frequency source
   - 2.3 Frequency meter
     - 2.3.1 Frequency counter
     - 2.3.2 Frequency meter
3. Time Interval 3(10)
   - 3.1 Period source
     - 3.1.1 Period source
   - 3.2 Time Interval source
     - 3.2.1 Rise/fall time source
     - 3.2.2 Pulse width source
     - 3.2.3 Time difference source
     - 3.2.4 Delay source
   - 3.3 Period meter
     - 3.3.1 Period meter
   - 3.4 Time Interval meter
     - 3.4.1 Rise/fall time meter
     - 3.4.2 Pulse width meter
     - 3.4.3 Time difference meter
     - 3.4.4 Delay meter

Sample CMC – column 3

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUT's Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock vs	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency	KRISS	CCTF-K001.UTC	Excluded		1.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	1									Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Column 3

Describe the instruments (or method) employed in the calibration (or measurement). Examples are direct frequency measurement, phase comparison, direct time interval measurement, stop watch calibrator, time interval counter, etc.

Direct frequency measurement

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Sample CMC – column 4 and 5

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUT's Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded		1.1.1	KRISS		

Column 4 and 5

The minimum and maximum value of a measuring range shall be in column 4 and 5, respectively. If the measured value is discrete, it shall be in both the column 4 and column 5. Data shall be entered as a scientific number (e.g., 1.20E-10) and/or integer number (e.g., 1, 5, 10).

Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate							Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Numb measu															
						Ampl															
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

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Sample CMC – column 6

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUT's Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency	KRISS	CCTF-K001.UTC	Excluded		1.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements															
						Amplitude															
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time								KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

MHz

Column 6

Specify the unit of the measured quantity. Examples are s, ns, etc. in the field of time, and Hz, MHz, etc. in the field of frequency.

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Sample CMC – column 7

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service	Measrand Level or Range	Measurement Conditions / Independent Variable	Expanded Uncertainty	Reference Standard used in calibration	List of Comparisons supporting this measurement / calibration service	DUT's Effect or Comments	APMP TCTF Service Administration													

Column 7

State parameters that have an influence on the measurement. Examples are measurement time, amplitude, trigger level, gate time, etc. Temperature and relative humidity shall be omitted from this column. "Measurement time" indicates the total measurement time when the time interval measurement method or the phase comparison method is used for the calibration and measurement. "Gate time" is used when frequency counters or the direct frequency measurement method is used for the calibration and measurement.

Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz									2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13										2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz									2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz									2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Gate time

Number of measurement

Amplitude

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Sample CMC – column 8

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement / calibration service	DUT's Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock us	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency	KRISS	CCTF-	Excluded		1.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Fre					MHz	Gate time	1000 s	2E-13							CCTF-01.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Fre					MHz	Gate time	1000 s	2E-13							CCTF-01.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Fre					MHz	Measurement time	1 d	2E-13							CCTF-01.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Fre					MHz	Measurement time	1 d	2E-13							CCTF-01.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Column 8

Specify values, or a range of values, of the influencing parameters applicable to the measurement. These values shall have appropriate units.

Gate time

Number of measurement

Amplitude

1000 s

100

> 0.5 V (50 Ω)

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

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Sample CMC – column 9

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUTs Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency	KRISS	CCTF-	Excluded		1.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz							ed	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz												new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz												new
						Amplitude	>0.5 V (50 Ω)														

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

Column 9

Specify the best measurement capability (BMC) by extrapolation taking into account the properties of Reference Standard (See CCTF WGMRA Guideline 3 Rev.20021210),

2E-13

$2 \times 10^{-13} \rightarrow$ 2E-13

2.35E-13 → 2.4E-13
(in one or two significant figures)

(ref. JCRB documents and GUM)

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Sample CMC – column 10

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement / calibration service	DUT's Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	s	2	95%	No	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded					
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		new
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		new
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		new
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Column 10

Specify the unit of the BMC in Column 9. An example of uncertainty in frequency is Hz. If the uncertainty is a relative one, this column should be blank.

CCTF WGMRA
should be "Hz/Hz" or "s/s"

Hz/Hz

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

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Sample CMC – column 11

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measurand Level or Range			Measurement Condition / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUT's Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specification	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classification of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency	KRISS	CCTF-	Excluded		1.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%							.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Column 11

Coverage factor, k. Normally, k = 2.

2

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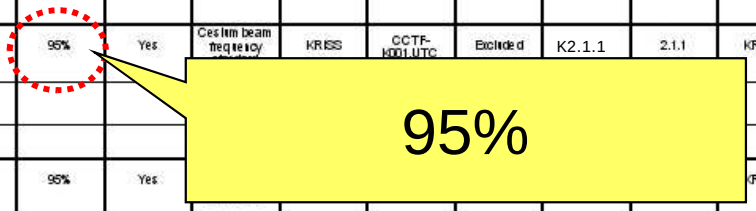
Sample CMC – column 12

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUTs Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency	KRISS	CCTF-K001.UTC	Excluded		1.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes							KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Column 12

Level of confidence associated with the uncertainty. Uncertainties are normally evaluated at a level of confidence of 95%.



- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

KRISS

Sample CMC – column 13

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUTs Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock vs	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded		1.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard								
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Column 13

If the BMC is a relative uncertainty, this column should be "Yes", if not, "No".

Yes

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

KRISS

Sample CMC – column 14

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUTs Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency	KRISS	CCTF-	Excluded		1.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS							
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Column 14

Reference standard employed in transferring or assigning the measured value(s) to the measurand. An example of frequency measurements, examples are cesium beam frequency standard, hydrogen maser, rubidium frequency standard, or quartz oscillators.

Cesium beam frequency standard

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

KRISS

Sample CMC – column 15

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement calibration service	DUTs Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded					
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC						
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2											
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Column 15

An organization transferred the measured value(s) to the reference standard stated in Column 14. If the reference standard is **traced to the UTC(*k*) within the NMI *k* submitting the CMC**, **then the NMI shall state itself as the source of traceability**. Otherwise, an external organization, such as another NMI or the BIPM, shall be identified

KRISS

The cesium beam frequency standard being used as the reference standard at KRISS *is traced to the* UTC(KRIS) *with in the* KRISS.

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

KRISS

Sample CMC – column 16

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service	Measrand Level or Range	Measurement Conditions / Independent Variable	Expanded Uncertainty	Reference Standard used in calibration	List of Comparisons supporting this measurement/ calibration service	DUT's Effect or Comments	APMP TCTF Service Administration					
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s						Cesium beam	RISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s							RISS	CCTF-K001.UTC	Excluded		2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d												KRISS		new
						Amplitude	>0.5 V (50														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d												KRISS		new
						Amplitude	>0.5 V (50														

Column 16

If, as stated in Column 15, a NMI employed its own standard for traceability, it shall then provide information on international comparison(s) involving that standard. It may state, for example, the **reference number(s) used by the organizers such as the BIPM, CCTF or an RMO to identify the comparison(s).**

In cases where an external organization provides the source of traceability, the NMI shall instead state the reference **number(s) of relevant calibration certificates** in Column 16.

CCTF-K001.UTC

The KC *number of* **CCTF-K001.UTC** *is being used instead of* CCTF-K2001.UTC *from March, 2007 in the BIPM KCDB.*

(refer the report of the 17th CCTF *meeting)*

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

KRISS

Sample CMC – column 17

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUT's Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock us	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency	KRISS	CCTF-K001.UTC	Excluded		1.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Column 17

Write "Excluded DUT's Effect" if the uncertainty is estimated for the hypothetical case, "Included DUT's Effect" if it is estimated for actual DUT effect. And state comments here if necessary on entries in Column 1 to 16.

Excluded

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

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Sample CMC – column 18 and 19

Calibration and Measurement Capability (1/3)

Column 18 and 19

Specify the Category Number of Classification of Services (See CCTF WGMRA Guideline 1 rev. 20021209) like "3.2.1", not a Category Name.

2. Frequency 3(5)
- 2.1 Standard frequency source
  - 2.1.1 Local frequency standard
  - 2.1.2 Remote frequency standard
- 2.2. General frequency source
  - 2.2.1 General frequency source
- 2.3 Frequency meter
  - 2.3.1 Frequency counter
  - 2.3.2 Frequency meter

3. Time Interval 3(10)
- 3.1 Period source
  - 3.1.1 Period source
- 3.2 Time Interval source
  - 3.2.1 Rise/fall time source
  - 3.2.2 Pulse width source
  - 3.2.3 Time difference source
  - 3.2.4 Delay source
- 3.3 Period meter
  - 3.3.1 Period meter
- 3.4 Time Interval meter
  - 3.4.1 Rise/fall time meter
  - 3.4.2 Pulse width meter
  - 3.4.3 Time difference meter
  - 3.4.4 Delay meter

No	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K1.2.1	1.2.1	KRISS	new
No	Cesium beam frequency standard	BIPM	CCTF-K001.UTC	Excluded	K1.2.2	1.2.2	KRISS	new
Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS	new
Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS	
					K2.1.1	2.1.1	KRISS	
Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS	new
Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS	new

KRISS *category number of services*

K2.1.1

2.1.1

KRISS

Sample CMC – column 20

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUTs Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
Time scale	Local clock	Direct time interval	-1	1	s	1 PPS amplitude	>0.5 V (50 Ω)	2	ns	2	95%	No	Cesium beam frequency	KRISS	CCTF-	Excluded		1.1.1	KRISS		
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%							2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	10	10	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														
Frequency	Remote frequency standard	GPS Common-view time transfer	5	5	MHz	Measurement time	1 d	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.2	2.1.2	KRISS		new
						Amplitude	>0.5 V (50 Ω)														

Column 20

Name of the submitting NMI, such as CRL, NIM, NML, etc.

KRISS

- Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

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Sample CMC – Contact Person

Calibration and Measurement Capability (1/3)

Calibration or Measurement Service			Measrand Level or Range			Measurement Conditions / Independent Variable		Expanded Uncertainty					Reference Standard used in calibration		List of Comparisons supporting this measurement/ calibration service	DUT's Effect or Comments	APMP TCTF Service Administration				
Quantity	Instrument or Artifact	Instrument Type or Method	Minimum Value	Maximum Value	Units	Parameter	Specifications	Value	Units	Coverage Factor	Level of Confidence	Relative	Standard	Source of Traceability			NMI service identifier	Classifications of Service	NMI	Review Status	Review Comment
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12	Column 13	Column 14	Column 15	Column 16	Column 17	Column 18	Column 19	Column 20	Column 21	Column 22
							>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	10	10	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	5	5	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
						Amplitude	>0.5 V (50 Ω)														
Frequency	Local frequency standard	Direct frequency measurement	1	1	MHz	Gate time	1000 s	2E-13	Hz/Hz	2	95%	Yes	Cesium beam frequency standard	KRISS	CCTF-K001.UTC	Excluded	K2.1.1	2.1.1	KRISS		
						Number of measurements	100														
Frequency	Remote frequency standard																				new
Frequency	Remote frequency standard												standard								new
						Amplitude	>0.5 V (50 Ω)														

Contact Person (bottom of the table)

Information of a contact person of the submitting NMI (name of country) and his/her email address.

- Contact person: Dr. Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

• Contact person: Dr.Taeg Yong Kwon (KOREA), tykwon@kriss.re.kr

KRISS

Column 21

An entry to be given by WG MRA.

Column 22

Comment on the review to be given by WG MRA. Results of assessments are classified into two groups – Accepted or Not accepted.

Contents

- Review
  - CCTF Guidelines
  - TCTF Guidelines
  - making CMCs in accordance with the CCTF and TCTF guidelines
- **Discussion**
  - **Review Comments**
- Summary
  - Things to be considered for making CMCs
- JCRB documents
  - Procedure for modifying CMCs in Appendix C of the KCDB website

Review comments

- "BMC is too small" or "BMC is too big"
  - *The NMI submitting CMCs should explain how they estimated the BMCs.*
- column ## Is in blank
  - *All columns from 1 to 20 of in the CMC sheet table should be filled in.*
- Mistyping

  Ex) It seems that "Yes" in column 13 of row 5 is mistyping of "No".

Review comments on Time scale difference

- Column 3 in the services of “Local clock vs. UTC” and “Remote clock vs. UTC”

  make it clear whether predicted UTC *or post-processed* UTC *is used*

  Example)

  “Direct time interval measurement”

  → “Comparison against predicted UTC”

Review comments on Frequency

- State the measurement conditions clearly
  - gate time, number of measurement, measurement time, and so on

Example) “measurement time =100 s”

It is unclear whether it means

“gate time=100 s and number of measurement is not stated”,

or

“100 s is the total measurement time (= gate time times number of measurement)”.

Contents

- Review
  - CCTF Guidelines
  - TCTF Guidelines
  - making CMCs in accordance with the CCTF and TCTF guidelines
- Discussion
  - Review Comments
- **Summary**
  - **Things to be considered for making CMCs**
- JCRB documents
  - Procedure for modifying CMCs in Appendix C of the KCDB website

Summary

Things to be considered for making CMCs.

- The CCTF WGMRA and TCTF guidelines for CMC entries
- JCRB document
  - It requires that NMI use the Excel files for CMC sheet.
  - Procedure for modifying CMCs in Appendix C

Contents

- Review
  - CCTF Guidelines
  - TCTF Guidelines
  - making CMCs in accordance with the CCTF and TCTF guidelines
- Discussion
  - Review Comments
- Summary
  - Things to be considered for making CMCs
- **JCRB documents**
  - **Procedure for modifying CMCs in Appendix C of the KCDB website**

Procedure for modifying CMCs in Appendix C

DOCUMENT JCRB-8/10_rev 9 November 2004

Modifications of a published CMC usually arise for reasons falling into one of three categories:

a) material or editorial errors and improvements to the explanatory text for a quantity, instrument, method etc.;

b) increase of the uncertainty or reduction in scope, decided by the NMI or following a comparison result;

c) change of the method of measurement or reduction of the uncertainty or increase in scope.

Modifications under category a)

a) material or editorial errors and improvements to the explanatory text for a quantity, instrument, method etc.;

- Modifications do not change the essence of the CMC (instrument, range of the quantity and of the parameters, method, uncertainty, traceability)

❑ For this category of modifications,

- the internal and the inter-RMO reviews are unnecessary.

- The NMI will send its proposal for change to the Technical Committee (TC) chairperson of its RMO, who will contact the coordinator of the BIPM database.

Modifications under category b)

b) increase of the uncertainty or reduction in scope, decided by the NMI or following a comparison result;

- Modifications may be requested, for example, by an NMI wanting to reduce its engagement in the particular measurement activity or they may follow from a comparison result showing a significant unresolved deviation from the key comparison reference value.

- For this category of modifications,
  - the internal and the inter-RMO reviews are unnecessary.
  - The NMI will send its proposal for change to the Technical Committee (TC) chairperson of its RMO, who will contact the coordinator of the BIPM database.
  - *in case that the change was originated by a comparison result*,
    - ✓ the TC chairperson should verify that the reduction in scope or the increase of the uncertainty is sufficient to assure the equivalence of the measurements.

Modifications under category c)

c) change of the method of measurement or reduction of the uncertainty or increase in scope.

- For this category of modifications,
  - should follow the full procedure of internal and inter-RMO review, as if they were new CMCs.

Notes:

Modifications must be made only on the Excel files available from the link. "Get published CMCs", located in the Summary box of the JCRB Website (http://www.bipm.org/JCRBCMCs/).

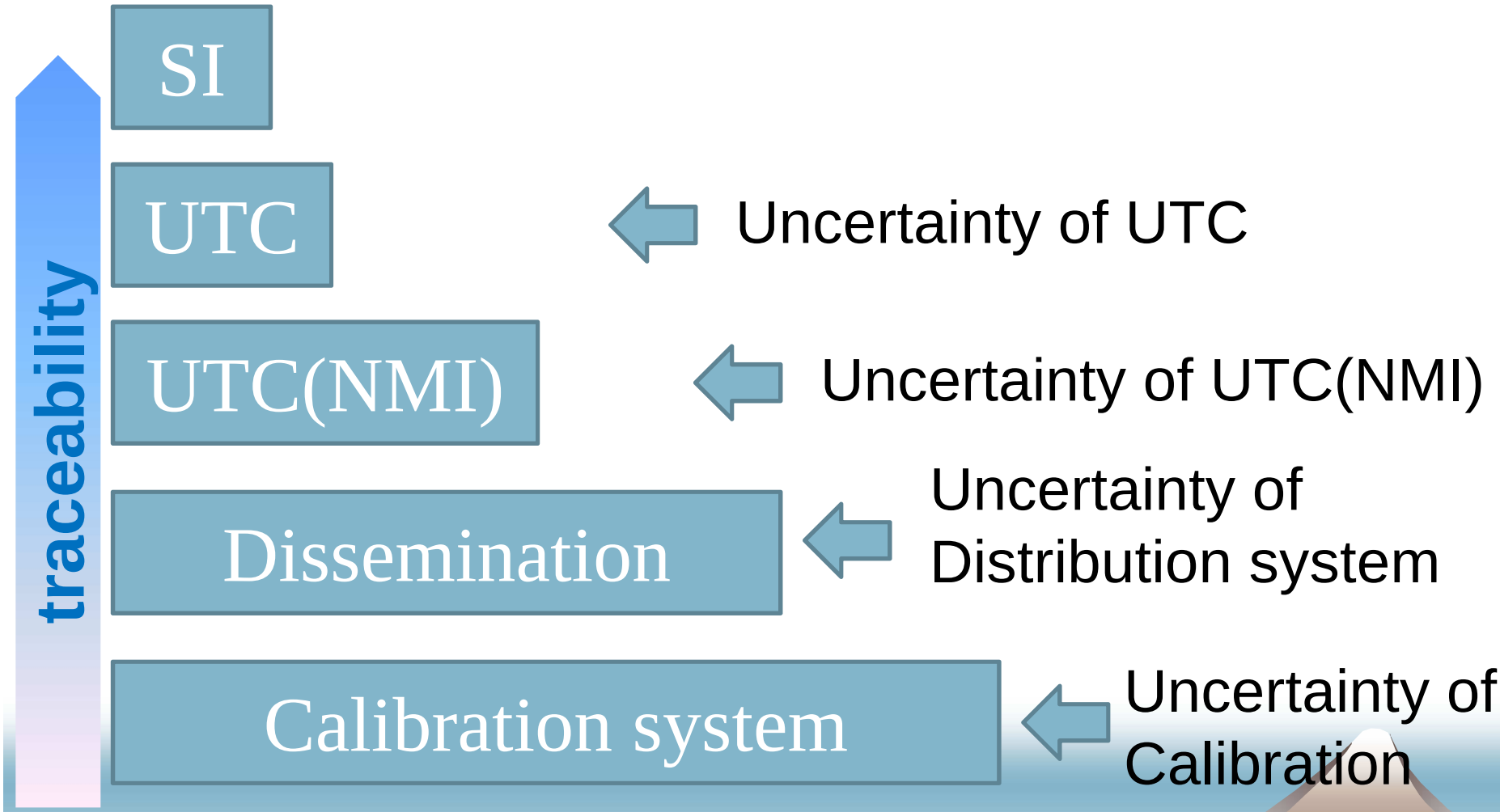
Uncertainty budget

Frequency area

Contents

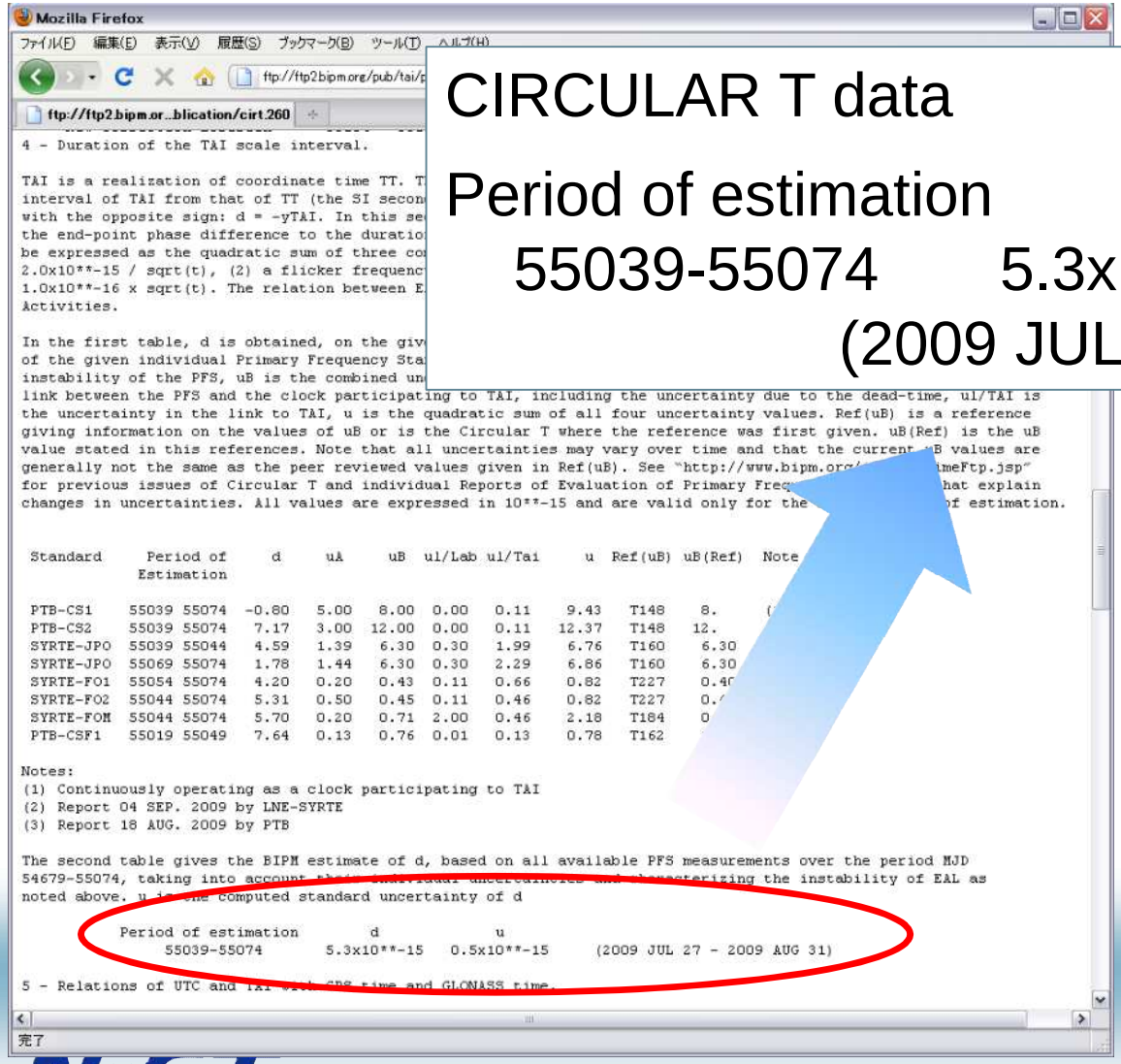
- Uncertainty
  - Uncertainty of UTC
  - Uncertainty of UTC(NMI)
  - Uncertainty of UTC(NMI) distribution system
  - Uncertainty of calibration method

Uncertainty



NiCT

Uncertainty of UTC



CIRCULAR T data

Period of estimation d u

55039-55074 5.3x10**-15 0.5x10**-15

(2009 JUL 27 - 2009 AUG 31)

the worst value in a period

Uncertainty of UTC

Uncertainty of UTC(NMI)

- Uncertainty of UTC(NMI) consists of

  - Uncertainty of UTC(NMI) in CIRCULAR-T

    ⇨ The worst value of u_A in a period

  - Prediction of UTC(NMI) Uncertainty for 1 M
    - CIRCULAR-T is published 1 month later

    ⇨ Frequency stability of the source clock &
    System noise of the regulator (ex. AOG)

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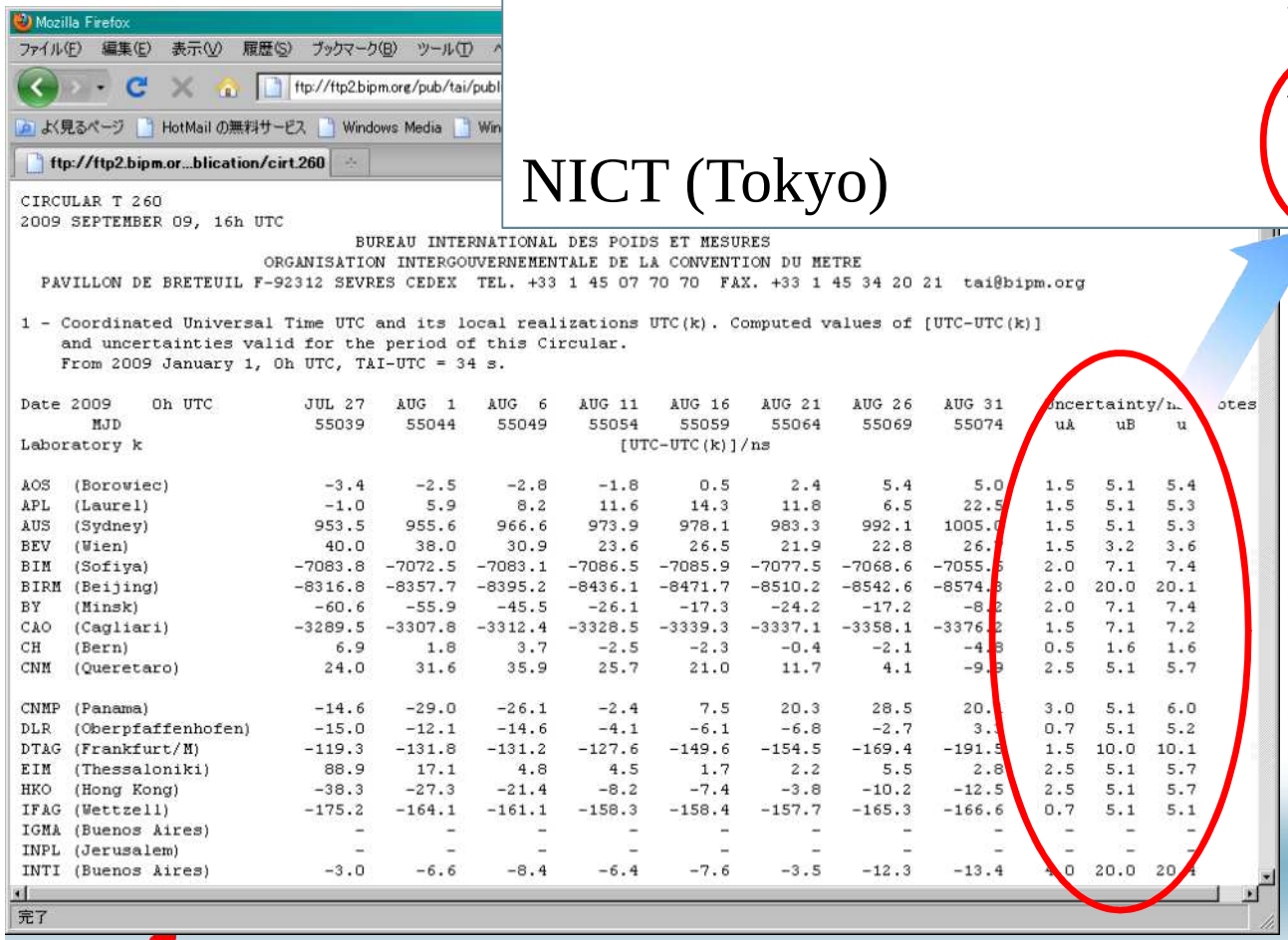
Uncertainty of UTC(NMI) in CIRCULAR-T

CIRCULAR T data

NICT (Tokyo)

Uncertainty/ns

uA	uB	u
0.7	4.6	4.7



Mozilla Firefox

ftp://ftp2.bipm.org/pub/tai/publ

ftp://ftp2.bipm.or...blication/cirt.260

CIRCULAR T 260
2009 SEPTEMBER 09, 16h UTC

BUREAU INTERNATIONAL DES POIDS ET MESURES
ORGANISATION INTERGOUVERNEMENTALE DE LA CONVENTION DU METRE
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1 - Coordinated Universal Time UTC and its local realizations UTC(k). Computed values of [UTC-UTC(k)]
and uncertainties valid for the period of this Circular.
From 2009 January 1, 0h UTC, TAI-UTC = 34 s.

Date 2009 0h UTC	JUL 27	AUG 1	AUG 6	AUG 11	AUG 16	AUG 21	AUG 26	AUG 31	Uncertainty/n		otes
MJD	55039	55044	55049	55054	55059	55064	55069	55074	uA	uB	u
Laboratory k	[UTC-UTC(k)]/ns										
AOS (Borowiec)	-3.4	-2.5	-2.8	-1.8	0.5	2.4	5.4	5.0	1.5	5.1	5.4
APL (Laurel)	-1.0	5.9	8.2	11.6	14.3	11.8	6.5	22.5	1.5	5.1	5.3
AUS (Sydney)	953.5	955.6	966.6	973.9	978.1	983.3	992.1	1005.0	1.5	5.1	5.3
BEV (Wien)	40.0	38.0	30.9	23.6	26.5	21.9	22.8	26.7	1.5	3.2	3.6
BIM (Sofiya)	-7083.8	-7072.5	-7083.1	-7086.5	-7085.9	-7077.5	-7068.6	-7055.5	2.0	7.1	7.4
BIRM (Beijing)	-8316.8	-8357.7	-8395.2	-8436.1	-8471.7	-8510.2	-8542.6	-8574.8	2.0	20.0	20.1
BY (Minsk)	-60.6	-55.9	-45.5	-26.1	-17.3	-24.2	-17.2	-8.2	2.0	7.1	7.4
CAO (Cagliari)	-3289.5	-3307.8	-3312.4	-3328.5	-3339.3	-3337.1	-3358.1	-3376.2	1.5	7.1	7.2
CH (Bern)	6.9	1.8	3.7	-2.5	-2.3	-0.4	-2.1	-4.8	0.5	1.6	1.6
CNM (Queretaro)	24.0	31.6	35.9	25.7	21.0	11.7	4.1	-9.9	2.5	5.1	5.7
CNMP (Panama)	-14.6	-29.0	-26.1	-2.4	7.5	20.3	28.5	20.1	3.0	5.1	6.0
DLR (Oberpfaffenhofen)	-15.0	-12.1	-14.6	-4.1	-6.1	-6.8	-2.7	3.1	0.7	5.1	5.2
DTAG (Frankfurt/M)	-119.3	-131.8	-131.2	-127.6	-149.6	-154.5	-169.4	-191.5	1.5	10.0	10.1
EIM (Thessaloniki)	88.9	17.1	4.8	4.5	1.7	2.2	5.5	2.8	2.5	5.1	5.7
HKO (Hong Kong)	-38.3	-27.3	-21.4	-8.2	-7.4	-3.8	-10.2	-12.5	2.5	5.1	5.7
IFAG (Wettzell)	-175.2	-164.1	-161.1	-158.3	-158.4	-157.7	-165.3	-166.6	0.7	5.1	5.1
IGMA (Buenos Aires)	-	-	-	-	-	-	-	-	-	-	-
INPL (Jerusalem)	-	-	-	-	-	-	-	-	-	-	-
INTI (Buenos Aires)	-3.0	-6.6	-8.4	-6.4	-7.6	-3.5	-12.3	-13.4	4.0	20.0	20.4

完了

the worst value in a period

1 day averaged uncertainty

$=u_A/86400/5x\sqrt{5}$

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Prediction of UTC(NMI) Uncertainty for 1 month

- Frequency stability of the source clock
  - Frequency stability for 1 month

    Ex. 5071A (agilent teck.) is 1.0E-14

    H-maser (Anritu) is <= 1.0E-14

- System noise of the regulator
  - System noise for 1 month

    Ex. AOG is 3E-13/86400/30

Uncertainty of Distribution

- Uncertainty of Distribution consists of

  - System noise of distribution amplifiers for UTC(NMI)

    ⇨ Stability of amplifiers (ex. Catalog data)

  - System noise of the cable for disseminating UTC(NMI)

    ⇨ Thermal noise, exogenous noise, and so on

    (ex. Catalog data, measured data)

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Uncertainty of Calibration

- Uncertainty of calibration methods
  - Ex. Method of Time interval measurement,
    Method of Frequency direct measurement,
    etc.
    - Factors for uncertainties
      - Gate time
      - Measurement number of times
      - Ability of using counters

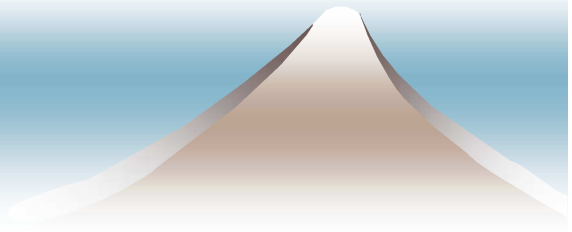
      and so on

Total uncertainty

- Total uncertainty is combined by the above data
  - Total uncertainty is a square-root of sum of squares of the above data

- Expanded uncertainty computed by multiplying the total uncertainty by k (coverage factor =2)

Thank you for your attention



Budget of Uncertainty : Time Interval Measurement Mode

Standard Uncertainty Component $u(x_i)$	Source of Uncertainty	Value of Standard Uncertainty $u(x_i)$		actual value	remarks	$\lvert\partial\gamma_i/\partial\xi_i\rvert$	$\upsilon(P_i)=\lvert\partial\gamma_i/\partial\xi_i\rvert\upsilon(\xi_i)$
Calibration System							
u (UTC)	UTC Uncertainty	8.00E-16	☆	8.00E-16	Circular-T Worst value in 2008	1	8.00E-16
u (UTC(NICT)) *u(UTC-UTC(NICT))*	UTC(NICT) Uncertainty	3.62E-15	☆ 3.62E-15	0.7 ns	Circular-T uA Worst value in 2008	1	3.62E-15
u (UTC(NICT)) *u(UTC-UTC(NICT)*	UTC(NICT) Predictin Uncertainty (30d Stability of UTC(NICT)	1.08E-14	☆ 4.00E-15	4.00E-15	Circular-T 2008 data	1	1.08E-14
u(Source)	Source atomic clock Uncertainty Anritsu RH401A		☆ 1.00E-14	1.00E-14	Frequency stability Stability of 30days		
u(AOG)	Stability of AOG		□ 6.68E-20	3.00E-13	manual data (1s) 30days		
u (Amplifier) u (Mult & Amp)	Distribution amplifier Uncertainty Multiplier & Amplifier HPDA15-RM-C-MOD	4.09E-17	□ 1.67E-17 Temp. coefficient Temp. variation Averaging time	5.00 ps/deg. 0.50 K 24 hours	manual data ± 24 hours	1	4.09E-17
u (Amp.1)	Amplifier 1 HPDA15-RM-C		□ 1.67E-17 Temp. coefficient Temp. variation Averaging time	5.00 ps/deg. 0.50 K 24 hours	manual data ± 24 hours		
u (Amp.2)	Amplifier 2 HPDA15-RM-C		□ 3.34E-17 Temp. coefficient Temp. variation Averaging time	5.00 ps/deg. 1.00 K 24 hours	manual data ± 24 hours		
u (Cable)	Cable Uncertainty Andrew FSJ1-50A	7.22E-17	□ 7.22E-17 Temp. coefficient length Temp. variation Averaging time	0.04 ps/deg. 60.00 m 5.00 K 24 hours	manual data ± 24 hours	1	7.22E-17
u (Count) *u(Counter)*	Counter Uncertainty SR620	5.20E-15	□ 5.18E-15 Measurement error Measurement interva Number of sample	100.00 ps. 1440 s 60	manual data	1	5.20E-15
u(Source)	Source atomic clock Uncertainty Anritsu RH401A		☆ 5.16E-16 Frequency stability Number of sample	4.00E-15 60	1440 s		

$u_c^2(R_i) = \sum u_i^2(R_i) =$ 1.57E-28

Relative combined uncertainty $u_c(R_i) =$ 1.25E-14

Expanded uncertainty(k=2) $u =$ 2.50E-14

5.00E-14

☆ : Normal Distribution Type A ◇ : Normal Distribution Type B □ : Rectangular Distribution Type B

averaging time 24 hours 24 hours

Budget of Uncertainty : Direct Frequency Measurement Mode

Standard Uncertainty Component $u(x_i)$	Source of Uncertainty	Value of Standard Uncertainty $u(x_i)$		actual value	remarks	$\lvert c_i \rvert \equiv \lvert \partial f / \partial x_i \rvert$	$u(R_i) = \lvert c_i \rvert u(x_i)$
Calibration System							
u(UTC)	UTC Uncertainty	8.00E-16	☆	8.00E-16	Circular-T Worst value in 2008	1	8.00E-16
u(UTC(NICT)) *u(UTC-UTC(NICT))*	UTC(NICT) Uncertainty	3.62E-15	☆ 3.62E-15	0.7 ns	Circular-T uA Worst value in	1	3.62E-15
u(UTC(NICT)) *u(UTC-UTC(NICT* *u(Source)* *u(AOG)*	UTC(NICT) Predictin Uncertainty (30d Stability of UTC(NICT) Source atomic clock Uncertainty Anritsu RH401A Stability of AOG	1.08E-14	☆ 4.00E-15 ☆ 1.00E-14 ☐ 6.68E-20	4.00E-15 1.00E-14 3.00E-13	Circular-T 2008 data Frequency stability Stability of 30days manual data (1s) 30days	1	1.08E-14
u(Amplifier) u(Amp.1)	Distribution amplifier Uncertainty Amplifier 1 HPDA15-RM-C	4.09E-17	☐ 1.67E-17 Temp. coefficient Temp. variation Averaging time	5.00 ps/deg. 0.50 K 24 hours	manual data ± 24 hours	1	4.09E-17
u(Amp.2)	Amplifier 2 HPDA15-RM-C		☐ 1.67E-17 Temp. coefficient Temp. variation Averaging time	5.00 ps/deg. 0.50 K 24 hours	manual data ± 24 hours		
u(Amp.3)	Amplifier 3 HPDA15-RM-C		☐ 3.34E-17 Temp. coefficient Temp. variation Averaging time	5.00 ps/deg. 1.00 K 24 hours	manual data ± 24 hours		
u(Cable)	Cable Uncertainty Andrew FSJ1-50A	7.22E-17	☐ 7.22E-17 Temp. coefficient length Temp. variation Averaging time	0.04 ps/deg. 60.00 m 5.00 K 24 hours	manual data ± 24 hours	1	7.22E-17
u(Count) u(Counter)	Counter Uncertainty SR620	6.35E-13	☐ 2.17E-13 Measurement error Measurement interva Number of sample	350.00 ps. 10 s 8640	manual data	1	6.35E-13
u(Freq. Drift)			☆ 5.97E-13		measured		
u(Ref. Freq. Drift)			☆ 4.84E-13		measured		
u(Source)	Source atomic clock Uncertainty Anritsu RH401A		☆ 3.23E-16 Frequency stability Number of sample	3.00E-14 8640	10 s		
					$u_c^2(R_i) = \Sigma u_i^2(R_i) =$		4.04E-25
					Relative combined uncertainty $u_c(R_i) =$		6.35E-13
					Expanded uncertainty(k=2) $u =$		1.27E-12
							2.50E-12

☆ : Normal Distribution Type A ◇ : Normal Distribution Type B ☐ : Rectangular Distribution Type B

averaging time	24 hours	24 hours

Budget of Uncertainty : Remote Frequency Measurement Mode S.A. = maximum

Distance of two stations = 1000km

c= 2.9979E+08 m/s

Standard Uncertainty Component $u(x_i)$	Source of Uncertainty	Value of Standard Uncertainty $u(x_i)$		actual value	remarks	$\|c_i\| \equiv \|\partial f/\partial x_i\|$	$u(R_i) \equiv \|c_i\|u(x_i)$
GPS link							
u(Receiver)		1.04E-13				1	1.04E-13
u(PR)	Pseudorange Uncertainty	4.63E-14					
u (rec)	Receiver noise and resolution		☆ 3.27E-14	8.00 ns	measured		
			Number of sample	16	two sessions data		
			Averaging time	24 hours	24 hours		
u(Range)	Range Uncertainty	9.36E-14					
u (Ephem)	Ephemeris error		□ 7.88E-14	5.00 m	no relation for CV		
u (ant)	Antenna Coordinate Error		□ 3.15E-14	1.00 m			
u (multipath)	multipath		□ 3.94E-14	2.50 m			
			Averaging time	24 hours	24 hours		
u(Source)	Source atomic clock Uncertainty	5.27E-16	◇ 5.27E-16		manual data		
	Anritsu RH401A		Frequency stability	5.00E-15	16 min		
			Number of sample	90			
u(Propagation)		1.52E-13				1	1.52E-13
u (Tion)	Delay error of Ionosphere	1.50E-13	□		D=1000km		
	Difference between 2 sites		1.50E-13	22.50 ns			
			Averaging time	24 hours	24 hours		
u (Ttrop)	Delay error of Atmosphere	2.00E-14	□				
	Difference between 2 sites		2.00E-14	3.00 ns			
			Averaging time	24 hours	24 hours		
Calibration System							
u (UTC)	UTC Uncertainty	8.00E-16	☆	8.00E-16	Circular-T	1	8.00E-16
					Worst value in 2008		
u (UTC(NICT))	UTC(NICT) Uncertainty	3.62E-15				1	3.62E-15
u(UTC-UTC(NICT))			☆ 3.62E-15	0.7 ns	Circular-T uA		
					Worst value in 2008		
u (UTC(NICT))	UTC(NICT) Predictin Uncertainty (30day	1.08E-14				1	1.08E-14
u(UTC-UTC(NICT	Stability of UTC(NICT)		☆ 4.00E-15	4.00E-15	Circular-T		
					2008 data		
u(Source)	Source atomic clock Uncertainty		☆ 1.00E-14	1.00E-14	Frequency stability		
	Anritsu RH401A				Stability of 30days		
u(AOG)	Stability of AOG		□ 6.68E-20	3.00E-13	manual data (1s)		
					30days		
u (Amplifier)	Distribution amplifier Uncertainty	4.09E-17				1	4.09E-17
u (Amp.1)	Amplifier 1		□ 1.67E-17				
	PD10-RM-B		Temp. coefficient	5.00 ps/deg.	manual data		
			Temp. variation	0.50 K	±		
			Averaging time	24 hours	24 hours		
u (Amp.2)	Amplifier 2		□ 1.67E-17				
	PD10-RM-B		Temp. coefficient	5.00 ps/deg.	manual data		
			Temp. variation	0.50 K	±		
			Averaging time	24 hours	24 hours		
u (Amp.3)	Amplifier 3		□ 3.34E-17				
	PD10-RM-B		Temp. coefficient	5.00 ps/deg.	manual data		
			Temp. variation	1.00 K	±		
			Averaging time	24 hours	24 hours		
u (Cable)	Cable Uncertainty	7.22E-17	□ 7.22E-17			1	7.22E-17
	Andrew FSJ1-50A		Temp. coefficient	0.04 ps/deg.	manual data		
			length	60.00 m			
			Temp. variation	5.00 K	±		
			Averaging time	24 hours	24 hours		
u (Source)	Source atomic clock Uncertainty	5.16E-15	◇ 5.16E-15			1	5.16E-15
			Frequency stability	4.00E-14	24 hours		
			Number of sample	60			

$u_c^2(R_i) = \Sigma u_i^2(R_i) =$	3.41E-26
$u_c(R_i) =$	1.85E-13
Relative combined uncertainty(k=2)	3.69E-13
Expanded uncertainty(k=2)	5.00E-13

☆ : Normal Distribution Type A ◇ : Normal Distribution Type B □ : Rectangular Distribution Type B

averaging time 24 hours 24 hours