



GULFMET.EM.S8

Comparison of Calibration of Multimeter

Technical Protocol

**Version 4
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1. INTRODUCTION

The technical basis of the Mutual Recognition Arrangement (MRA) is a set of results obtained in a course of time through key and supplementary comparisons carried out by the Consultative Committees (CCs) of the CIPM, the BIPM and the Regional Metrology Organizations (RMOs). As part of this process, the GULFMET Technical Committee for Electricity and Magnetism decided at its June 2020 meeting to carry out the RMO supplementary comparison GULFMET.EM-S8. The Emirates Metrology Institute (EMI) agreed to act as pilot laboratory with support from Standards and Calibration Laboratory (SCL).

The scope of the comparison is calibration of 8½ digit multimeter for the following quantities:

- DC Voltage
- AC Voltage
- DC Current
- AC Current
- DC Resistance

The measurement points were chosen to be the same as used in EURAMET Project No 1341.

The comparison will be carried out according to the requirement of Measurement comparisons in the CIPM MRA Guidelines for organizing, participating and reporting CIPM MRA-G-11 [1] and Gulf Association for Metrology (GULFMET) Guidelines on Conducting Comparisons. GULFMET 02 [2].

2. TRAVELING STANDARD

2.1. Travelling Standard Description

The travelling standard is an 8½ digit Fluke 8508A Reference Multimeter (Figure 1), supplied by EMI. This DMM was chosen for its high accuracy and stability in time on DC Voltage, AC voltage, DC current, AC current and resistance measurement functions. It can be remotely operated by means of an IEEE 488 interface. The general specifications of 8508A are given in Table 1.

Full descriptions, manuals and specifications for the transfer standard can be found at:

https://us.flukecal.com/products/obsolete-products/8508a-85-digit-reference-multimeter?quicktabs_product_details=2



Figure 1 The travelling standard

Table 1 The general specifications of the travelling standard

Power	Power supply	100 v to 120V or 200 V to 240 V rms $\pm 10\%$ @ 47 Hz to 63 Hz
	Consumption	< 80 VA
Dimensions	Height	88 mm
	Width	427 mm
	Depth	487 mm
Weight		11.5 kg
Environment	Specified Operation	5 °C to 40 °C
Temperature	Storage	-20 °C to 70 °C
Relative Humidity	Operating	5 °C to 40 °C < 90 %rh
	Storage	0 °C to 70 °C < 95 %rh
Warm Up Time		4 hours to full uncertainty specification
Measurement Ranges	DC Voltage:	200 mV, 2 V, 20 V, 200 V, 1000 V
	AC Voltage:	200 mV, 2 V, 20 V, 200 V, 1000 V (1 Hz to 1 MHz)
	DC Current:	200 μ A, 2 mA, 20 mA, 200 mA, 2 A, 20 A
	AC Current:	200 μ A, 2 mA, 20 mA, 200 mA, 2 A, 20 A (1 Hz to 100 kHz)
	Resistance:	2 Ω , 20 Ω , 200 Ω , 2 k Ω , 20 k Ω , 200 k Ω , 2 M Ω , 20 M Ω , 200 M Ω , 2 G Ω , 20 G Ω

2.2. Quantities to be measured

The quantities to be measured are DC voltage, DC current, AC voltage, AC current and DC resistance. The measurement points for each quantity, the settling time and the configuration of the Fluke 8508A, during the comparison measurements are given in Table 2

Table 2 Measurement quantities, points and conditions

Quantity	Measurement Point	Range of 8508A	Settling Time of 8508A	Configuration of 8508A
DC Voltage	100 mV	200 mV	5 min	Resolution 7
	10 V	20 V	5 min	Filter ON
	100 V	200 V	5 min	Fast OFF
	1000 V	1000 V	10 min	Front Input
DC Current	100 μ A	200 μ A	5 min	Resolution 7
	10 mA	20 mA	5 min	Filter ON
	1 A	2 A	30 min	Fast OFF Front Input
AC Voltage	100 mV @ 55 Hz [†]	200 mV	5 min	Resolution 6
	100 mV @ 1 kHz		5 min	Transfer ON
	10 V @ 55 Hz [†]	20 V	5 min	AC Coupled
	10 V @ 1 kHz		5 min	RMS Filter 100 Hz
	10 V @ 100 kHz		5 min	([†] RMS Filter 40 Hz at 55 Hz)
	100 V @ 55 Hz [†]	200 V	5 min	Front Input
	100 V @ 1 kHz		5 min	
AC Current	10 mA @ 300 Hz	20 mA	5 min	Resolution 6
	10 mA @ 1 kHz		5 min	AC Coupled
	1 A @ 300 Hz	2 A	30 min	RMS Filter 100 Hz
	1 A @ 1 kHz		30 min	Front Input
DC Resistance	10 Ω	20 Ω	5 min	True Ω
	10 k Ω	20 k Ω	5 min	Resolution 7
				4-Wire
				Low Current OFF
				Fast OFF
				Front Input
	10 k Ω	20 k Ω	5 min	True Ω
				Resolution 7
				4-Wire
				Low Current ON
				Fast OFF
				Front Input
	1 M Ω	2 M Ω	5 min	Normal Ω
				Resolution 7
				4-Wire
				Low Current OFF
				Filter ON
				Fast OFF
				Front Input

2.3. Calculation of the Comparison Reference Value (CRV)

The Comparison Reference Value (CRV) for each measurement point will be calculated as the weighted mean of the results of the institutes corrected for the time dependence of the travelling standard. The time dependence of the travelling standards during the comparison period will be characterized using the results from the Pilot Laboratory. Any result identified as inconsistent will be excluded from the determination of the CRV.

3. ORGANIZATION

3.1. Coordinator and members of the support group

The Emirates Metrology Institute (EMI) will coordinate the comparison, monitor the stability of the standard and report the measurement results.

Pilot Institute:	Emirates Metrology Institute (EMI)
Coordinator:	Mr Jon Bartholomew Tel: +971 50 386 2676 E-mail: jon.bartholomew@qcc.gov.ae

Support group:

Institute:	Standards and Calibration Laboratory (SCL)
Coordinator:	Dr Steven Yang Tel: +852 2829 4833 Fax: +852 2829 4865 E-mail: steven.yang@itc.gov.hk

3.2. Participants

A list of participating institutes with contacts of responsible person and shipping address is listed in Appendix A.

3.3. Time schedule

The comparison schedule is given in Appendix B. The comparison will begin in October 2021 and is scheduled to be completed within less than 2 years. Because of customs practices in the UAE the circulation of the travelling standard will be organized as a series of loops between the pilot laboratory and one participant. The pilot laboratory will monitor the performance of the travelling standard after each loop. The period between measurements by each participant is six weeks. This allows two weeks for measurements, and 4 weeks for shipping to the pilot laboratory. Should a participant require more time for shipping to the next participant, the measurement time must be shortened.

If unforeseen circumstances prevent a laboratory from carrying out the measurements within the allocated time, the original schedule should be followed by sending the standards to the pilot laboratory without delay. The laboratory may be allowed to carry out additional measurements after the completion of the original schedule and before the end of this comparison.

4. TRANSPORTATION

4.1. Transportation

Each participant is responsible for arranging transport and insurance from their institute to the pilot laboratory. **Arrangements and documentation with their local customs and the pilot laboratory's customs must be prepared in advance.**

Arrival and departure of the standards must be communicated with the pilot laboratory by E-mail using the forms available in Appendix D of this protocol

- When the package arrives at your laboratory, fill in the “Receiving form” in Appendix D and send the form to the pilot laboratory by E-mail.
- When preparing the package for shipment, fill in the “Shipping checklist” in Appendix D and send the checklist to the pilot laboratory by E-mail.
- When the package is shipped, fill in the “Dispatch form” in Appendix D and send the checklist to the pilot laboratory by E-mail.

Please resend any forms that are not acknowledged. If any delay due to transportation is expected, the sender and/or the receiver should promptly contact the pilot laboratory.

4.2. Transport Case

The travelling standard is packed in a transport case of size (80.5 x 53.0 x 32.5) cm and a total weight of 20 kg. The transport case can easily be opened for customs inspection. HS Code is 903031. Insurance Value 20000 USD

On receipt of the case, the device should be unpacked carefully and checked for any damage.

The content of the transport case is given below:

1. Fluke 8508A Reference Multimeter (Serial No: 218865629)*
2. 4 wire shorting device

* The multimeter will be supplied without input leads.

Please refer to Appendix E for illustration of the shipping package.

4.3. Self-Test on Receipt

On receipt of the case, the device should be unpacked carefully and checked for any damage. The correct functioning of the 8508A shall be confirmed by initiating the “Self-Test” (See details in 8508A Reference Multimeter Users Manual [3]):

1. Ensure that the mains voltage setting is applicable to the local supply
2. Allow the Multimeter to warm-up under power at least 10 minutes.
3. Press the CLEAR key, select “Pwr Up Dflt” to restore the power up default configuration and display the DCV menu.
4. Press the “Test” key and select “Std” to initiate a self-test.

4.4. Failure of Travelling Standard

In case of any damage or malfunction of the standards, the participating laboratory must report to the pilot laboratory immediately

4.5. Financial aspects

Each participant institute is responsible for its own costs for the measurements, transportation to the pilot laboratory and insurance of the shipment to the pilot laboratory.

Each participant institute is responsible for paying any customs charges, duties, deposits or surcharges within its country.

Each participant institute is responsible for any damage that may occur within its country.

The overall costs for the organisation of the comparison are covered by the pilot institute. The pilot institute has no insurance for any loss or damage of the travelling standard.

5. MEASUREMENT INSTRUCTIONS

5.1. Before the measurements

Ensure that the mains voltage setting is applicable to the local supply, and check that the instrument is functioning correctly.

The instrument should be allowed to stabilize in a temperature and humidity-controlled environment for at least 24 hours before commencing measurements.

5.2. Measurement Conditions

1. The standard ambient conditions for measurement are:
Temperature: $(23 \pm 1) ^\circ\text{C}$
Relative humidity: $(50 \pm 10) \% \text{rh}$
2. The ambient temperature and humidity conditions during the measurements must be measured and reported.
3. The reference multimeter shall not be adjusted during the comparison measurements.
4. The reference multimeter shall be allowed to warm-up under power at least 4 hours.
5. The reference multimeter should be used in the configurations given in Table 2.
6. The measurement points required are given in Table 2.
7. The front input terminals of the reference multimeter shall be used for all measurements.
8. A single “earth” connection should be used in the measurement setup to avoid “earth” loops.
9. Before each DC measurement point, a “zero” input shall be applied and the instrument “Input Zero” shall be executed.
10. Sufficient settling time shall be allowed for each measurement.
11. Any standard method may be used for calibrating the reference multimeter.
12. The measurement result shall be reported as the relative error of the reference multimeter and calculated by:

$$\text{Relative Error} = \frac{\text{Indicated Value} - \text{Applied Value}}{\text{Applied Value}}$$

6. MEASUREMENT UNCERTAINTY

The measurement uncertainty shall be evaluated in accordance with the JCGM 100:2008 – Evaluation of Measurement Data – Guide to the Expression of Uncertainty in Measurement [1][4] for a 95% level of confidence.

In uncertainty evaluations, all uncertainty components taken into account should be included. The coverage factor and the effective degrees of freedom should be reported.

The contributions to the uncertainty are specific to the participant's measurement system and the measurement method used, however it may be useful to consider some of the possible uncertainty sources given below.

1. The measurement standard used e.g.:
 - a Multifunction calibrator for all or some of the measurements
 - b Reference voltage standard for DC voltage measurements
 - c Standard resistor for resistance measurements
 - d DC current shunt for DC current measurements
 - e AC/DC transfer standard for AC voltage measurements
 - f AC/DC current shunt for AC current measurements
2. Thermal electromotive force (emf) for low DC voltage measurements
3. Drift of the measurement standard used e.g. due to time, temperature, loading etc.
4. Finite resolution of the reference multimeter
5. Repeatability of the measurement

7. MEASUREMENT REPORT

7.1. File Format

The participant's report must be submitted electronically to the pilot laboratory within **one month** from the completion of the measurements, using the following file format:

- Word 2003 or later version for the report including the participant's results
- Excel 2003 or later version for the raw data and detailed uncertainty budget

7.2. Contents of report

The report must contain:

- **Details of participating institute,**
- **The date of the measurements**
- **Detailed description of the method of measurement**
- **The measurement standards used in the comparison measurements,**
- **A statement of traceability for the measurements**
- **Temperature and humidity in the laboratory during the measurement**
- **The results of the measurement**
For each reported value the information must be provided in Excel using the template attached in Appendix C.
- **Uncertainty budget and calculation**
The uncertainty analysis should include a list of all sources of Type B uncertainty, together with the associated standard uncertainties as well as their evaluation method. For clarity, it is recommended to present the uncertainty budget in the form of a table. For each reported value, the expanded uncertainty and the coverage factor k must be given for confidence level of approximate 95 %.

8. FINAL REPORT OF THE COMPARISON

At the conclusion of circulation of the standards, the pilot laboratory will prepare the draft A report within 4 months. In the case of any outliers, the results will not be communicated until the participants concerned have been contacted to ensure that no arithmetic, typographical or transcription errors are present. The draft A report is confidential and will be sent to all participants for review and discussion.

The participants will have two months for comments on the draft A report. In the case of results that are discrepant with the reference value or are not consistent with their published CMCs, the rules given in [1] will be followed.

On the basis of the comments received, the pilot laboratory will prepare the second draft (draft B), where the withdrawn results will be removed. The draft B report will be submitted to the GULFMET TC-EMTF for approval.

Once approved by the GULFMET TC-EMTF the report will be sent to the CCEM WGLF for editorial review. On the basis of the comments received the pilot laboratory will prepare the Final Report. The Final Report will form the basis for the publication of results.

9. REFERENCES

- [1] Measurement comparisons in the CIPM MRA. Guidelines for organizing, participating and reporting. CIPM MRA-G-11.
<https://www.bipm.org/documents/20126/43742162/CIPM-MRA-G-11.pdf/9fe6fb9a-500c-9995-2911-342f8126226c>
- [2] Gulf Association for Metrology (GULFMET) Guidelines on Conducting Comparisons. GULFMET 02, Issue 1, 20/ 02 /2012
<https://www.gulfmnet.org/document-and-guidelines>
- [3] 8508A Reference Multimeter Users Manual. PN 1673798, July 2002. Rev. 6, 3/13
<https://us.flukecal.com/literature/product-manuals/8508a-reference-multimeter-users-manual>
- [4] JCGM 100:2008 – Evaluation of measurement data – Guide to the expression of uncertainty in measurement, September 2008
<https://www.bipm.org/en/publications/guides>

APPENDIX A: List of Participants

No	Country / Economy	Acronym of Institute	Name of Institute	Shipping Address	Contact Person
1.	United Arab Emirates	EMI	Emirates Metrology Institute	Emirates Metrology Institute Abu Dhabi Quality and Conformity Council (QCC) Kryptolabs Building, Masdar City Abu Dhabi, UAE	Mr Waleed Al Kalbani w.alkalbani@qcc.gov.ae Tel: +971 50 889 0080
2.	Hong Kong, China	SCL	Standards and Calibration Laboratory	Standards and Calibration Laboratory 36/F Immigration Tower, 7 Gloucester Road, Wan Chai, Hong Kong	Dr Steven Yang steven.yang@itc.gov.hk Tel.: +852 2829 4833
3.	Saudi Arabia	SASO-NMCC	Saudi Standards, Metrology and Quality Organization National Measurement and Calibration Center	Saudi Standards, Metrology and Quality Organization (SASO)-National Measurements & Calibration Center PO. B 3437 Riyadh- Al Muhammadiyah – in front of King Saud University (Bldg. # 4, NMCC) 11471 Riyadh Kingdom of Saudi Arabia	Mr. Ahmed AlAyali a.ayli@saso.gov.sa
4.	Qatar	QGOSM	Qatar General Organization for Standards and Metrology	Qatar General Organization for Standards and Metrology P.O. Box: 23277, Doha - Qatar	Ms Nany S. Al-Kuwari nsalkwary@mme.gov.qa
5.	Bosnia and Herzegovina	IMBIH	Institute of Metrology of Bosnia and Herzegovina	Laboratory for electrical quantities and time and frequency Institute of metrology of Bosnia and Herzegovina Dolina 6 71 000 Sarajevo Bosnia and Herzegovina	Mr Srdjan Calija srdjan.calija@met.gov.ba Tel: +387 (0)33 568 924

No	Country / Economy	Acronym of Institute	Name of Institute	Shipping Address	Contact Person
6.	Uzbekistan	UzNIM	Uzbek National Institute of Metrology of Uzstandard Agency	Department of Electr and magnetic measurements 1000049, Farobiy street, 333A, Tashkent city, Uzbekistan	Mr Kamoliddin Makhamatov k.makhamatov@nim.uz Tel: +99878 150 26 03 +99897 773 37 22 Or Sardor Ikramov, s.ikramov@nim.uz Tel: +99878 150 26 03 +99897 704 44 21

APPENDIX B: Measurement Schedule

Measurement Dates	Country / Economy	Acronym of Institute
3 October to 15 October 2021	United Arab Emirates	EMI
9 December to 15 December 2021	Saudi Arabia	SASO-NMCC
23 December to 24 February 2022	United Arab Emirates	EMI
24 April to 17 May 2022*	Qatar	QGOSM
13 June to 24 June 2022	United Arab Emirates	EMI
25 July to 5 August 2022	Bosnia and Herzegovina	IMBIH
5 September to 16 September 2022	United Arab Emirates	EMI
17 October to 28 October 2022	Hong Kong	SCL
28 November to 16 December 2022*	United Arab Emirates	EMI
16 January to 27 January 2023	Uzbekistan	UzNIM
27 February to 10 March 2023	United Arab Emirates	EMI

*Period extended to allow for public holiday

APPENDIX C: Measurement Results

DC Voltage

Range of 8508A	Nominal Value	Applied Value	Indication of 8508A	Error of 8508A	Expanded Uncertainty
200 mV	+ 100 mV				
20 V	+ 10 V				
200 V	+ 100 V				
1000 V	+ 1000 V				

DC Current

Range of 8508A	Nominal Value	Applied Value	Indication of 8508A	Error of 8508A	Expanded Uncertainty
200 μ A	+ 100 μ A				
20 mA	+ 10 mA				
2 A	+ 1 A				

DC Resistance

Range of 8508A	Mode of 8508A	Nominal Value	Applied Value	Indication of 8508A	Error of 8508A	Expanded Uncertainty
20 Ω	True Ω	10 Ω				
20 k Ω	True Ω	10 k Ω				
	True Ω LoI	10 k Ω				
2 M Ω	Normal	1 M Ω				

AC Voltage

Range of 8508A	Nominal Value		Applied Value	Indication of 8508A	Error of 8508A	Expanded Uncertainty
	Voltage	Frequency				
200 mV	100 mV	55 Hz				
	100 mV	1 kHz				
20 V	10 V	55 Hz				
	10 V	1 kHz				
	10 V	100 kHz				
200 V	100 V	55 Hz				
	100 V	1 kHz				

AC Current

Range of 8508A	Nominal Value		Applied Value	Indication of 8508A	Error of 8508A	Expanded Uncertainty
	Voltage	Frequency				
20 mA	10 mA	300 Hz				
	10 mA	1 kHz				
2 A	1 A	300 Hz				
	1 A	1 kHz				

APPENDIX D: Forms for Transportation

GULFMET.EM.S8 COMPARISON Receiving Form

(Send this form to the pilot laboratory as soon as you have received the standard)

Arrival Date & Time	Date: _____ Time: _____	
Is the package damaged?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
	Comments:	
Is the standard damaged?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
	Comments:	
Are all materials listed in the packing list available in the package?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
	Comments:	

The transport case was received by:

(Please fill in your contact information)

Institute	
Contact Person	
E-mail Address	
Telephone No	

GULFMET.EM.S8 COMPARISON Dispatch Form

(Send this form to the pilot as soon as the standard is shipped.)

The dispatch date of transport case	Date: _____ Time: _____
The travelling standards are in working condition?	Yes <input type="checkbox"/> No <input type="checkbox"/>
Comments on the behaviour of the standards:	
Method of Shipment	Courier Name: Tracking No: <i>Airline (if available):</i> <i>Flight No (if available):</i>
Informed courier about documentation requirement of ATA carnet. (if applicable)	Yes <input type="checkbox"/> No <input type="checkbox"/>
Shipping to (Participant Name & Address)	

The transport case was dispatch by:

(Please fill in your contact information)

Institute	
Contact Person	
E-mail Address	
Telephone No	

APPENDIX E: Shipping package

