



State Enterprise “All-Ukrainian state research and production center
of standardization, metrology, certification consumers’ right protection”
(SE “Ukrmeterteststandard”)

TECHNICAL PROTOCOL
on Supplementary Comparison of
Precision Measuring Systems for Phase Shift Angle
(GULFMET.EM-S9)

Oleh Velychko, Yulia Kulish

Pilot laboratory: SE “Ukrmetrteststandard”
4, Metrologichna Str., 03143, Kyiv, Ukraine
E-mail: velychko@ukrcsm.kiev.ua

Coordinator of comparison: Oleh Velychko

December 2021
Kyiv, Ukraine

Table of Content

| | |
|---|----|
| 1 Introduction | 3 |
| 2 Participants and time schedule of the comparison | 3 |
| 3. Financial aspects and insurance | 4 |
| 4. Travelling standards and measurement instruction | 4 |
| 4.1. Description of the travelling standards | 4 |
| 4.2 Handling of travelling standards | 5 |
| 5. Description of the method of measurement | 7 |
| 5.1 Operations before measurements | 7 |
| 5.2 Measurements | 7 |
| 5.3 Measurement uncertainties | 7 |
| 6. The measurement report | 8 |
| 6.1 General information | 8 |
| 6.2 Measurement results | 9 |
| 7. The report on comparison | 10 |
| References | 10 |

1 Introduction

The GULFMET Supplementary Comparison (SC) of phase shift angle standards (comparison identifier – GULFMET.EM-S9) will be in the framework of GULFMET project from December 2021 to June 2022.

This project for comparing of national phase shift angle standard will be between countries which are member laboratories of GULFMET and COOMET regional metrology organizations. In this comparison take part two national metrology institutes (NMI): SE “Ukrmetrteststandard” (UMTS, Ukraine); SASO-NMCC (Saudi Arabia).

The State Enterprise “All-Ukrainian State Scientific and Production Center of Standardization, Metrology, Certification and Protection of Consumer” (SE “Ukrmetrteststandard”), Ukraine was selected as the pilot laboratory. Dr. Oleh Velychko will be the comparison coordinator. The pilot laboratory is responsible for providing the travelling standards, coordinating the schedule, collecting and analyzing the comparison data, preparing the draft report, etc.

2 Participants and time schedule of the comparison

Each participant is given 2 weeks to perform the measurements of the travelling standard and 1 week to transfer standards to the pilot laboratory. The NMI participants and the time schedule of the comparison are given in Table 1 and Table 2. There are three NMI participants in this comparison. Participants should have the traveling standard delivered to the address of the participant scheduled to perform measurements after themselves according to the schedule.

Table 1 List of NMI participants of the comparison

| No | NMI | Abbreviation of NMI | Address | Contact person | e-mail, phone, fax |
|----|--|---------------------|--|----------------|--|
| 1 | State Enterprise “All-Ukrainian state research and production center of standardization, metrology, certification consumers’ right protection” (SE “Ukrmetrteststandard”) – pilot | UMTS | 4, Metrologichna Str., 03143, Kyiv, Ukraine | Oleh Velychko | velychko@ukrcsm.kiev.ua Tel./Fax: +38 044 526 0335 |
| 2 | Saudi Standards, Metrology and Quality Organization of The Kingdom of Saudi – National Measurements and Calibration Center | SASO-NMCC | Front king Saud University Riyadh 11471, P.O. Box 3437 Kingdom of Saudi Arabia | Saad Bin Qoud | s.qoud@saso.gov.sa Tel: +966 56 902 7551 |

Table 2 List of dates of measurements

| Abbreviation of NMI | Dates of measurements | Dates of delivery |
|---------------------|-----------------------|-------------------|
| UMTS | 01–24.01.2022 | - |
| UMTS | 04–22.04.2022 | 25.04.2022 |
| SASO-NMCC | 09–20.05.2022 | 23.05.2022 |
| UMTS | 01–10.06.2022 | - |

3. Financial aspects and insurance

Each NMI participant of comparison should be at their own expense to perform all the measurements and send travelling standards back to the pilot laboratory (including transportation costs, insurance costs and customs).

In addition, each NMI participant of comparison should be at their own expense to cover all costs from the moment of arrival the travelling standard in the country, up to the moment of sending back to the pilot laboratory.

Expenses may include (but are not limited to): charges at check travelling standard (customs fees, brokerage services, transportation within the country) and the costs of returning the standard to the pilot laboratory.

4. The travelling standard and measurement instruction

4.1. Description of the travelling standard

The selected travelling standard is Model 6000A Clarke Hess Phase Meter (Figure 1).



Figure 1 The travelling standard Model 6000A Phase Meter

Main characteristics of the travelling standard:

| | |
|------------------------------|---|
| - resolution | 0.001° |
| - accuracy for 5 Hz to 2 kHz | 0.02° |
| - frequency response | 5 Hz to 1 MHz |
| - phase ranges | 0° to 360° or ±180° user selectable |
| - amplitude range | 10 mV to 630 VRMS |
| - input impedance | 1 MΩ in parallel with 100 pF |
| - response time | less than 6 sec. to specified accuracy |
| - frequency accuracy | ± 0.01 % |
| - optional DC output | +1.80 V to -3.60 V DC |
| - digital interface | IEEE-488.2 and USB |
| - temperature range | 0° TO 40 °C operating 23 ± 5 °C within specification |
| - input power | 90 to 264 VAC, 47 to 63 Hz, 20 VA |
| - dimensions | 17.3” W X 3.5” H X 13” D |

4.2 Handling of travelling standards

The travelling standard will be transported in two transport boxes which are designed for safe transportation. Upon arrival the participants must check transport boxes to make sure that all the parts are present according to the list. The travelling standard will be neatly stacked in a transport box (Figure 2). Linear dimensions of the transport box are: 710x620x300 mm. Weight of this transport box (together with the content) is about 17 kg.



Figure 2 Transport box

If the damage of any transport box is found the travelling standard must be packed in new transport box which will provide the necessary protection during transporting.

Travelling standard must be carefully removed from the transport box. Opening the corpus of travelling standards is strictly prohibited. If noticed any malfunction of travelling standards, the NMI participants should immediately notify the pilot laboratory by fax or email. If travelling standards are needed to be repaired the NMI participant must send travelling standards to the pilot laboratory.

NMI participants must inform the pilot laboratory by fax or e-mail about the arrival of travelling standards by using the form shown on Figure 3.

| Confirmation note for receipt | | |
|-------------------------------|----------------------------------|--------------------------------------|
| Date of arrival | | |
| NMI | | |
| Name of responsible person | | |
| The travel standard | <input type="checkbox"/> Damaged | <input type="checkbox"/> Not Damaged |
| Additional notes: | | |

Figure 3 Sample form for the information of arrival of travelling standards

The NMI participants should inform the pilot laboratory about departure of the travelling standard by using the form shown on Figure 4.

| Confirmation note for dispatch | |
|--|--|
| Date of shipment | |
| NMI | |
| Name of responsible person | |
| Shipment information (company name etc.) | |
| Additional notes: | |

Figure 4 Sample form for the information of departure of the travelling standard

After the measurements, NMI participant of comparison must send the travelling standard to the pilot laboratory. NMI participants in the comparison are responsible for arranging shipment of the travelling standard to the pilot laboratory.

5. Description of the method of measurement

5.1 Operations before measurements

After power up of the travelling standard in NMI participant it will be stabilizing for 2 days.

To connect the travelling standard NMI participants can use any adapters but participants should take into account all relevant adjustments. Before the measurements, it is necessary to familiarize design features and work principles of the travelling standard by using technical description.

5.2 Measurements

Measurements must be performed under the following conditions:

- temperature: $23\text{ °C} \pm 3\text{ °C}$;
- relative humidity: from 30 % to 70 %;
- supply frequencies: $50\text{ Hz} \pm 0.5\text{ Hz}$ or $60\text{ Hz} \pm 0.6\text{ Hz}$ with a sinusoidal waveform.

The participants should inform the pilot laboratory if the above conditions cannot be met.

The data to be recorded at each measurement:

- date of measurement;
- air temperature and relative humidity environment.

If measurements are carried out within a few days, then measured value together with the measurement date shall be given for each measurement day.

Comparison of national standards is provided by means of measuring of the travelling standard metrological characteristics.

Measurements are performed at the values of phase shift angle φ 0° , 30° , 60° , 90° , 120° , 180° , 270° for electrical voltage 1V, 10 V, 100 V at frequency of 1 kHz.

The measurement scheme is shown in Figure 5.

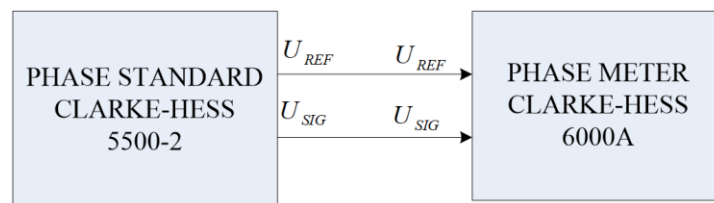


Figure 5 – Scheme for measurements

U_{REF} – reference signal; U_{SIG} – variable signal, the phase of which changes relative to the reference.

Each NMI participant provides up to ten observations at each operation current. Each NMI participant presents arithmetical mean of ten observations and uncertainty in measurements as a result of measurement.

5.3 Measurement uncertainties

Uncertainty of the measurements should be calculated according to the GUM – Guide to the expression of uncertainty in measurement JCGM 100:2008 [1] (GUM 1995 with minor corrections). With the results of measurements should be given a model that describes how the measurement result was obtained considering all influencing quantities.

For each of the influencing quantities should be given the description of the source of uncertainty and an assessment of this uncertainty. All influencing quantities, their uncertainties, influencing coefficients, degrees of freedom and levels of confidence should be given in the budget of the uncertainty.

The budget of the uncertainty (Table 6) should include such number of influencing quantities and their uncertainties, which ensures the high-level measurements for the laboratory.

Table 6 Uncertainty budget

| i | Quantity (unit) | Distribution | x_i | $u(x_i)$ | ν_i | c_i | $u_i(y)$ |
|------------------------|--------------------------------|--------------|-------|----------|---------|-------|----------|
| 1 | | | | | | | |
| ... | | | | | | | |
| ... | | | | | | | |
| ... | | | | | | | |
| y | Std uncertainty of measurement | | | | | | |
| Confidential level = | | | | | | % | $k =$ |
| Expanded uncertainty = | | | | | | | |

The components of the uncertainty budget should be expressed as standard uncertainties. The main components of the uncertainty budget are:

- standard uncertainty obtained as a result of an experiment from N independent measurements;
- uncertainty of the standard of the NMI laboratory, by means of which the value of the travelling standard is determined;
- uncertainty caused by the corrections.

Participants in the comparisons may include additional sources of uncertainty.

6. The measurement report

6.1 General information

Each NMI participant of the comparisons shall provide a report within six weeks from the date of departure travelling standards to the pilot laboratory. For quick detection of possible problems with the travelling standards a brief report shall be sent immediately after the measurements.

The report shall be sent to the coordinator of comparison by e-mail: velycho@ukrcsm.kiev.ua

The report shall include:

- description of measurement method(s);

- description of the measurement circuit and used the standard possibilities;
- confirmation of the metrological traceability (if NMI participant has its own units playback system, or -
- must provide proof of traceability from another laboratory).
- temperature and humidity in the laboratory during the measurement;
- measurement results;
- values of the respective standard uncertainties;
- detailed budget of uncertainty, which will be included in a report on the comparisons.

If the corrections affecting the measurement result were applied, then they must be described in the report.

If between the measurements of any NMI participant, provided the pilot laboratory and preliminary comparisons reference value is detected a significant difference, it will be reported to the appropriate party. No other information on the measurement results will not be reported.

If any NMI laboratory has difficulties in fulfilling one or more of the requirements listed in this protocol, instead of not taking part in the comparison, this NMI laboratory is recommended to contact the coordinator of the comparisons and find a way out of this situation.

6.2 Measurement results

GULFMET.EM-S9 comparison.

Name of NMI participant: _____

Country: _____

Dates of measurements: from _____ to _____.

Table – Measurement results

| Phase shift angle φ , ° | Frequency, 1 kHz | | |
|---------------------------------|------------------|------|-------|
| | 1 V | 10 V | 100 V |
| 0 | | | |
| 30 | | | |
| 60 | | | |
| 90 | | | |
| 120 | | | |
| 180 | | | |
| 270 | | | |

7. The report on comparison

Preliminary and final reports on the results of comparison will be prepared by the pilot laboratory. The report will be prepared by the pilot laboratory within 1 month after the end of the measurement, and sent to the NMI participants. The report is only for the NMI participants of comparisons and is confidential.

Notes. The report should be directed to the pilot laboratory for 1 month from the date of distribution of the Draft A. Comments will be considered in the Draft B. Draft B will be completed within 1 month after the end of the measurement. The final report will be prepared within 1 month from the receipt of the comments on the Draft B.

References

[1] JCGM 100:2008 Evaluation of measurement data – Guide to the expression of uncertainty in measurement.