

# Establishment of Reference Power Standard at SASO NMCC and GULFMET Bilateral Comparison

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**Abstract** — A well-known 3458A based digital sampling wattmeter was established for power and harmonics measurements at SASO NMCC. Its compact design and synchronized to the power source makes the standard unique for the calibrations needed by nationwide laboratories and industry. 40 ppm and 200 ppm are the first estimations in measurement uncertainties for power and harmonics, respectively. And, the first power comparison was organized under GULFMET.EM-S2 in order to evaluate the performance of the standard.

**Index Terms** — Active power, bilateral comparison, calibration standard, harmonics, measurement uncertainty.

## I. INTRODUCTION

An automatic power calibration standard, a compact version of the system designed and evaluated by TUBITAK UME, has been established at SASO NMCC within last three years [1]. The accuracy of the standard is ensured by investigation of all probable error sources from the system components, and by testing its performance in a bilateral comparison.

A comparison was organized in the frame of the project of “Development and Realization Measurement and Calibration System for the National Measurement and Calibration Center (NMCC) at Saudi Standards, Metrology and Quality Organization (SASO)”. And, it was approved by the regional metrology organization as a supplementary comparison under GULFMET.EM-S2. Draft report showed a good agreement between the results and estimated uncertainties [2].

## II. MEASUREMENT SETUP

Operating principle of the standard is based on the use of two sampling voltmeters synchronized to the power source, fig. 1 below. Sinusoidal voltage and current signals or with steady-state harmonics are generated by the phantom power source and applied to the relevant input terminals of the voltage and current measurement units. Regulated voltages are then applied to the voltmeters for sampling with the help of triggering synchronized to the power source.

Ratio and phase angle errors from the voltage and current measurement units are corrected within the software. And, amplitudes of both signals, the phase angles between them and calculated results are displayed during the measurements.

To be ensured of distorted waveforms and to display the harmonic components however, DFT is used on the software.

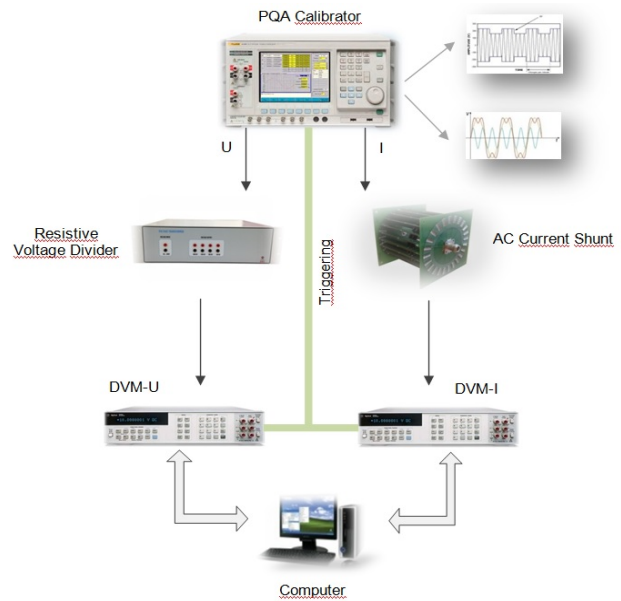


Fig.1. Block diagram of reference power standard.

### A. Voltage and Current Measurement Units

A set of resistive voltage dividers with input ranges of 60 V, 120 V and 240 V is installed into the voltage unit. And, a set of current shunts with input ranges of 0.25 A, 1 A and 5 A is installed into the current measurement unit. Both measurement units have 0.8 V outputs for all voltage and current ranges.

### B. Power Source and Triggering Unit

Fluke 6105A Calibrator is used as the phantom power source. And, its “sample ref output” is used for synchronized measurements by generating pulse-trains upto 1024 S/period via a binary multiplier in triggering unit.

### C. System Control and Software

The system is completely controlled with NI-TestStand and LabView based software including any data analysis. Simultaneous usage of Test Stand and Lab view enable many advantages for the user.

### III. EVALUATION OF THE SYSTEM ACCURACY

A well-known travelling standard (HEG C1-2) was provided by the pilot laboratory and comparison measurements were performed at several AC power values according to the technical protocol, Table 1 below. And, pilot lab. was responsible for monitoring standard performance during the circulation and the evaluation and reporting of the comparison results. Measurements, evaluation and reporting of the comparison results were carried out in accordance with the CCEM guidelines and GUM [3, 4].

Comparison schedule was planned for a very short circulating time between the participants to eliminate the long-term drifts and any other behavior of it. The measurand and the parameters (voltage, current, power factor, and frequency) were selected carefully to be able compare each participant's measurement capabilities as wider as possible.

Table 1. Differences between the measurement results.

Nominal Value				Difference between UME and NMCC
Voltage (V)	Current (A)	Power Factor	Frequency (Hz)	$\Delta P$ ( $\mu W/(V \cdot A)$ )
120	5	1	53	6
120	5	0.8i	53	-1
120	5	0.8c	53	3
120	5	0.5i	53	5
120	5	0.5k	53	0
120	5	0.25i	53	5
120	5	0.25c	53	-4
120	5	0.01i	53	9
120	5	0.01c	53	-4
120	1	1	53	1
120	1	0.5i	53	1
120	1	0.5c	53	4
60	5	1	53	-6
120	5	1	60	-11
120	5	0.5i	60	5
120	5	0.5c	60	-11
120	1	1	60	-6
120	1	0.5i	60	14
120	1	0.5c	60	6

The results for each measurement points are found very close to each other and show a good agreement with the given uncertainties. Both measurement standards used by the participants are based on the digital sampling method with minor differences in the hardware. In this point of view, this comparison might have a meaning of a direct check of two similar primary power measurement standards.

The following sample table (Table 2) shows a typical uncertainty budget used by TUBITAK UME in the calculation of its uncertainty values. And, uncertainty budgets of both sides for 53 Hz and 60 Hz measurements are given in Table 3.

Table 2. Sample calculation of measurement uncertainty.

Source of Uncertainty (At PF= 1)	Standard uncertainty ( $\mu W/VA$ )	Probability distribution	Sensitivity coefficient	Uncertainty Contribution ( $\mu W/VA$ )
Voltage meas.	6.0	Normal	1	6.0
Current meas.	10.0	Normal	1	10.0
Phase meas.	7.5	Normal	0	0.0
Meas. setup	2.5	Rectangula	1	2.5
Std. uncertainty	3.0	Normal	1	3.0
<b>Combined Uncertainty</b>				<b>12.3</b>
<b>Expanded Uncertainty (k=2)</b>				<b>24.6</b>

Table 3. Each participant's uncertainty budgets.

Voltage (V)	Current (A)	Frequency (Hz)	$U_{UME}$ ( $\mu W/(V \cdot A)$ )	$U_{NMCC}$ ( $\mu W/(V \cdot A)$ )
60, 120	1, 5	53	25	40
120	1, 5	60	28	40

### IV. FUTURE WORK

Current and voltage measurement units will be re-evaluated for better measurement uncertainties and for their traceability to the national standards.

### V. CONCLUSION

An AC power measurement standard has been established at SASO NMCC. Performance of the system was tested with a bilateral comparison. Reported results were found in good agreement with the estimated measurement uncertainties. Further research work is planned for improvement in the measurement uncertainties.

### REFERENCES

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