BIPM Capacity Building & Knowledge Transfer Programme

2021 BIPM - TÜBİTAK UME Project Placement

REPORT

Project Name	Electric power and related quantities. Metrology of Digital Signal Processing Units
Description	AC Power Standard Digital Sampling Wattmeter (DSWM), Frequency Response Analysis of DSWM, Calibration of Resistive Voltage Dividers-RVDs (Ratio & Phase errors up to 5 kHz), Phase Calibrations by using DSWM and RVDs (Phase Standard)
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Motivation & Introduction

Accurate measurements of power and related quantities is required verification of power and energy reference equipment in appropriate laboratories of Metrology Institutes to ensure that measurement techniques and equipment meet appropriate standards.

The main goal of my project was to study with the AC Power Measurement Standard (Digital Sampling Wattmeter - DSWM), because it has been using as the reference for a wide variety of measurements, i.e. AC Power and Energy measurements, Voltage and Current Harmonics, Flicker measurements, Voltage and Current Transformers Ratio and Phase Errors, Voltage and Current Transformer Bridges, Transformer and Reactor Loss Measurement Systems. And, our main aim during my visit was particularly application of digital sampling method for phase measurements of Phase Standard (Clarke-Hess models) up to audio frequencies to show that digital sampling method can be an alternative method to the traditional one known as bridge verification.

Research

DSWM is operated with external triggering of each sampling voltmeters synchronized with the applied signal frequency. The triggering frequency can be set the binary multiplier of signal frequency (f) starting with 8f up to 1024f. İn this particular work the aim was extending the measuring frequency from power frequencies (45 Hz – 65 Hz) up to certain level of audio frequencies within the limits of highest sampling frequency around 50 kHz. Therefore, the software routine was updated to fulfil the requirements of new application by fixing the triggering frequency at 51.2 kHz (50 Hz x 1024). And, certain signal frequencies were selected for best measurement performance: 50 Hz, 100 Hz, 200 Hz, 400 Hz, 800 Hz, 1600 Hz, 3200 Hz, 6400 Hz. All measurements given in the followings were done at these certain frequencies by following step-up verification method.

The First Step: Frequency response of sampling voltmeters were measured by using AC-DC Standard (Fluke 5790A). Three correction formula were applied for each frequency point: one for aperture time correction, one for bandwidth correction and last one for input impedance correction. The target was finding all corrected results within the calibration uncertainties of AC-DC Standard which is not so far from 10-15 ppm at those frequency and amplitude levels. The results proved that the applied correction formulas are successfully working.

The Second Step: Characterization of two channels of DSWM for both ratio error and phase displacement by applying certain voltages within 1 V and 10 V ranges. Both ratio and phase correction values for each frequency and each voltage level were saved to be used in the next verification steps.

The Third Step: In part of work in the laboratory, the resistive voltage dividers (RVD) of DSWM were calibrated. For this work, a set of resistive voltage dividers (4 V to 1000 V) was successfully characterized by applying step-up method and by using two sampling voltmeters; a Labview software and a stable voltage source (Fluke 5520A). Wiring diagram of setup for calibration is shown in Figure 1.

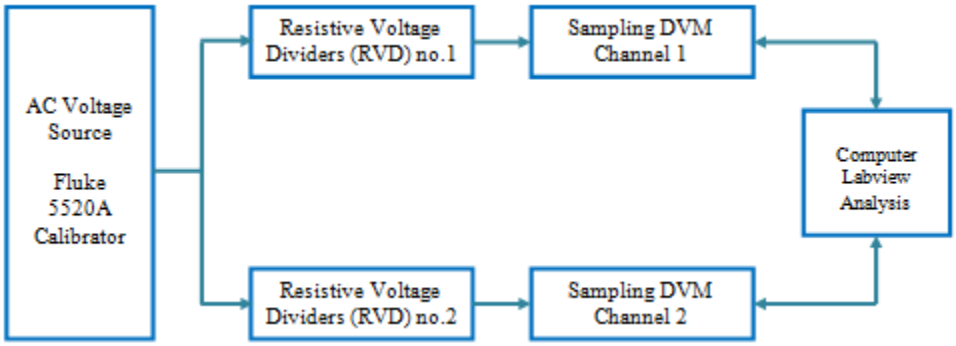

Figure 1. Calibration of resistive voltage dividers of DSWM

The target was to calibrate by step-up method up to 5 kHz and determine the correction of amplitude and phase of the different ratios of dividers. The sequence of connection of dividers during calibration is shown in Figure 2.

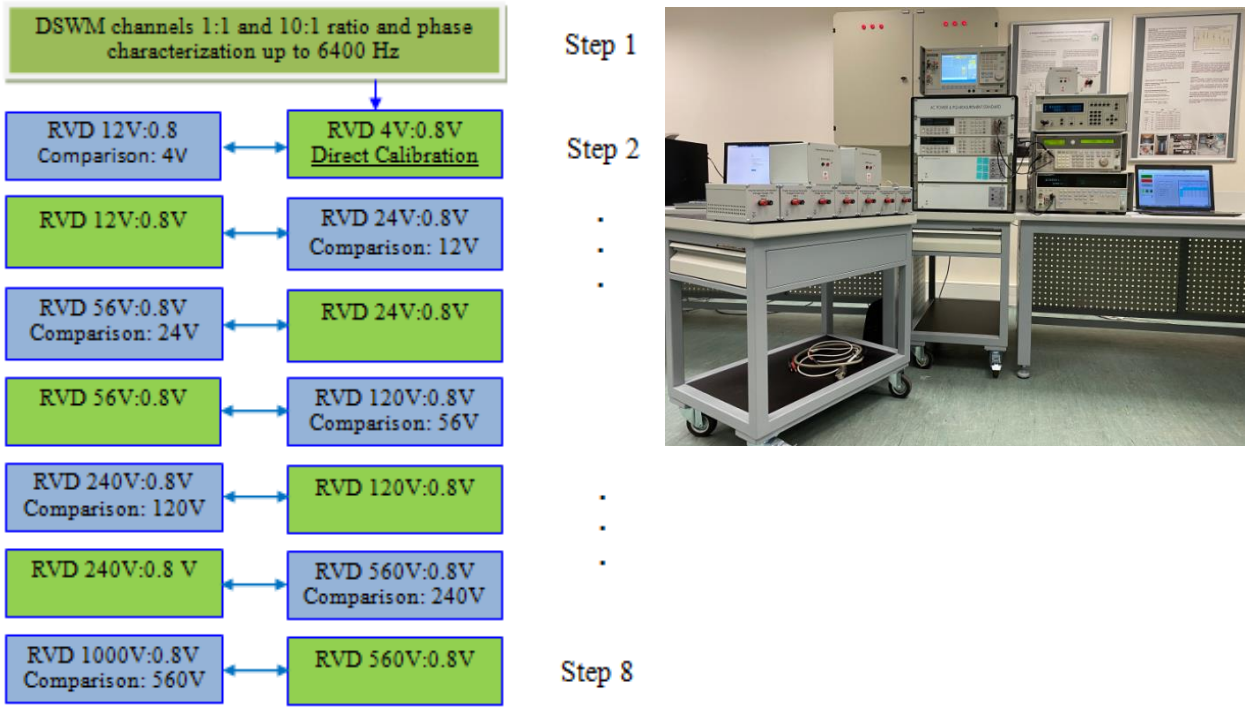

Figure 2. Process of the step-up calibration of RVD set and view of Calibration setup.

Step 1: The first RVD of 4V:0.8V was characterized and calibrated by applying 4V AC signal to both RVD and first channel of DSWM (the first sampling voltmeter which was set to the 10V range), and the output of RVD (0.8V) was connected to the second channel (the second sampling voltmeter which was set to the 1V range). Real ratio and absolute phase of 4V:0.8V RVD were measured then re-calculated with the correction factors of sampling voltmeters and saved for each frequency level.

Step 2: Once the first RVD was characterized the following procedure was direct comparison of two RVDs by applying the lower voltage; Here: 12 V : 0.8 V RVD was compared with the calibrated 4 V : 0.8 V RVD by applying 4 V @ 50 Hz up to 6400 Hz.

Step 3-8: Next steps were similar for all RVDs up to 1000 V : 0.8 V RVD calibration (see Figure 2).

The Fourth Step: Calibration of a Phase Standard (Clarke-Hess) by using calibrated RVD Set and direct measurement with DSWM. Since the highest voltage level of Phase Standard is 120 V, calibration process was kept in the limits of the device by using 4V-12V-24V-56V-120V RVDs only. Calibration results showed that a Phase Standard could be successfully calibrated by this alternative method within the uncertainties of ±1.5° in the worst case (at 6400 Hz) which means not more than 25 μrad (starting with 1 μrad at 50 Hz).

Conclusions and Future Work

During the internship I got information about calibration methods of voltage/current transformers, Power and Power Quality Measurements. I studied on the sampling methods in power measurements (from the articles of laboratory and the book 'Sampling With 3458A') by using AC Power Standard (DSWM). Two sampling voltmeters (DVMs) of the system was characterized up to audio frequencies (up to 6400 Hz). The characterization of ratio of two DVMs was made up to same frequency level. Then, a set of Resistive Voltage Dividers (RVDs) was calibrated by using characterized DSWM by following step-up method. İt started with the calibration of 4 V : 0.8 V RVD then the results were transferred to the 12 V : 0.8 V RVD by direct comparison of two. The step-up method was applied to the rest of the RVD set (24 V - 56 V - 120 V – 240 V – 560 V – 1000 V). The final step of the laboratory work was calibration of a Phase Standard by using the DSWM and the RVD set which were well-characterized up to 6400 Hz.

Except work in laboratory I learned the classroom lectures on the international aspects of metrology and the guidelines on participation in the mechanisms of the CIPM MRA. On classroom lectures I learned more about CIPM MRA, comparisons in the CIPM MRA, quality management system, calibration and measurement capabilities, peer-review of CMCs and metrological traceability. I plan to apply the knowledge and experience gained during the internship in the laboratory of my country.

Acknowledgements

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