BIPM Capacity Building & Knowledge Transfer Programme

2020 BIPM - TÜBİTAK UME Project Placement

REPORT

Project Name	[Knowledge Transfer on the electrical quantum standards based on the revised SI]
Description	[The operation and maintenance of the Programmable Josephson Voltage Standard]
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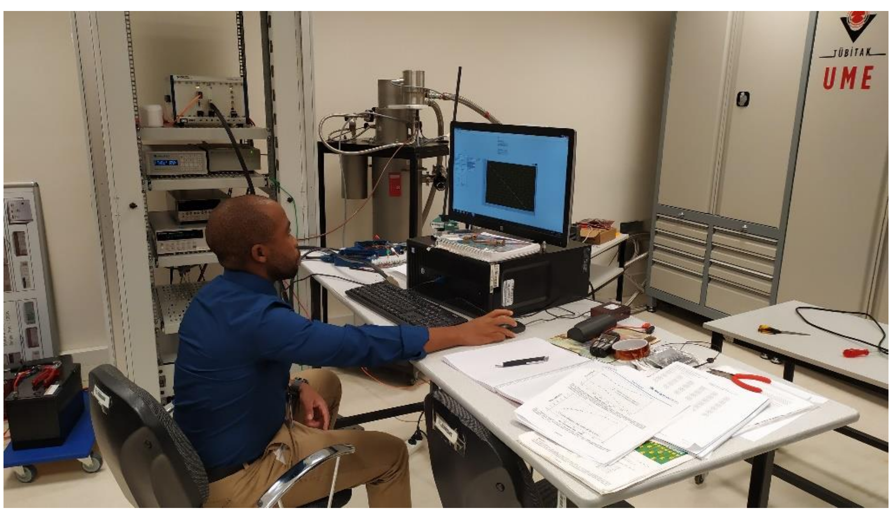
Motivation & Introduction

The Josephson effect occurs in low temperatures in a junction of two weakly coupled superconductors where they are separated by a thin insulating layer. The Josephson voltage standard operates under this phenomenon. Applications of the Josephson Voltage Standard (JVS) is primarily for calibration measurements of electrical instruments. JVS system is utilized for calibrating Zener voltage reference standards. The conventional JVS it is still utilized in some NMIs. Challenges about the conventional Josephson voltage systems lies with the fact that they utilise liquid Helium which is expensive these days. Therefore, this makes it a burden for NMIs to continue operating the systems. In other NMIs the system is operated only once or twice a year in order to cut the costs of operation.

In this project we focus on the new generation of voltage standard known as Programmable Josephson Voltage Standard (PJVS). These kinds of systems are cost effective since most are dry systems, their operation depends on electricity or power supply, cryocooler and a compressor unit. The main objectives of the project were to obtain skills to disseminate traceability of voltage using the PJVS and learn about uncertainty contributors of the PJVS to the final value.



Research

The method used in this project is standard method implying that they are well known in the field of electrical metrology. A detail description of the in-house developed PJVS at TÜBITAK UME. The array chip is enclosed with two chambers, before closing the chambers the array chip is covered with mylair foil to prevent heat transfers such as conduction, convection and radiation from the surrounding. Attached to the outer chamber is a temperature sensor to detect the temperature of the cold finger. The cold finger and the array chip are coupled in a way that we can assume that the temperature of the cold finger is the same as the temperature of the array chip. Then the system is air evacuated by using a turbo pump to create a vacuum, then air cooling compressor unit is used to cool down the system to desirable temperatures. Any temperature below the boiling point of liquid helium is bset for PJVS system operation. Once the system reaches desirable temperatures the system performance test can commence. Checking the following about the system viz, critical current, width of the voltage step, bias current and the microwave power. When all these important features are satisfactory then the system can be prepared for running calibrations. This is being done by entering all the required information on a LabVIEW program which is used for data acquisition developed at TÜBITAK UME.

The main findings of the research focused on the factors that influences the cryocooled PJVS system. The first factor is vacuum, it plays an important role in the system without a good vacuum the system will not perform as intended. Temperature is another factor; it must be low enough so that the array chip can be used to realize voltage plateaus. The Josephson voltage used for calibration should be stable the stability depends on the microwave frequency used to irradiate the array chip. The Josephson junction's stability and the microwave distribution should be uniform across active segments of the array chip. The uniformity of the microwave distribution is due the non-hysteric behavior of the superconductor-normal metal-superconductor (SNS) Josephson junctions. The outcomes of the project will be implemented by learning more about the cryocooled PJVS system. Operating the system for calibration, checking the importance features of the system to avoid the Josephson voltage to deviate from the value recommended by International Committee for Weights and Measures (CIPM). Acquiring more knowledge about the sources of uncertainty related to the system. We were not able to acquire measurement results and do calibrations of secondary voltage standards. The system was still giving us problems such trapping of the magnetic flux, not obtaining the desired voltage step and the output voltages of some active segments were not the expected values. The output voltage might be led by the non-uniformity of the microwave distributions since the Josephson voltage depends the stability of the microwave frequency irradiated on the array chip.

Conclusions and Future Work

The PJVS system is of importance for electrical metrology and the Kibble Balance for mass measurements. I have learnt a lot about the important features that are more crucial to the optimum operation of the PJVS system. Few objectives were achieved such as how the system works, important features about the system and individual instruments or parts that make-up the system. To overcome the difficulty of not getting results more research on how to reduce the factors restricting the performance of the overall PJVS system needs to be done.

Acknowledgements

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