BIPM Capacity Building & Knowledge Transfer Programme

FUTURE NEEDS FOR METROLOGY Summer School
and METAS Project Placement

REPORT

Project Name	DC Resistance Metrology
Description	Theoretical and practical knowledge on resistance measurement techniques
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Motivation & Introduction

I currently work as a scientist/engineer in the electrical DCLF laboratory at the National Metrology Institute of South Africa (NMISA), where I am responsible for the maintenance of the national resistance measurement standards, secondary multifunctional standards and dissemination of traceability from these standards to industry through calibration of industrial instruments.

The purpose of my placement at METAS was to gain in-depth theoretical and practical knowledge on resistance measurements. Particularly, the realisation of Ohm through quantum Hall resistance standard (QHRS) and the operation of DC cryogenic current comparator (CCC) in dissemination traceability to resistance working standards.

The outcome of this placement is to enable me to contribute towards knowledge and expertise for the realisation of Ohm at NMISA.

Activities

I started by attending module II and III at the "Future needs for metrology summer school" in Varenna, Italy from the 12th-18th July 2025. The topics covered for the two modules are:

Module II: Fundamentals of metrology and the digital transformation of measurement

This module provided insight on the origin and evolution of international system of units (SI). The 7 base units were thoroughly explained together with the fundamental constants that are used to realize them. The SI redefinition process was also explained and its impact to the metrology community. The evaluation of measurement uncertainties was also covered.

The module also covered the need for digital transformation of measurement to enhance efficiency, quality, reduced turnaround time and errors. The opportunities for the digital transformation of metrology were also presented with a focus on strategy, process, governance, technology and capabilities.

Module III: Physical and quantum metrology

This module covered a background of various metrological fields from electrical, thermometry, mass metrology, time and frequency and photometry

The topics covered are:

- Link from quantum standards to power and energy
- Metrology for future grids & energy transition
- Principles of photometric and colorimetric measurements
- Waves to particles (Optics)
- Thermometry – Thermodynamic temperature
- Kilogram – Planck's constant
- Atomic clocks

The ongoing research and developments undertaken in these fields were also highlighted.

I presented a poster on **"Environmental factors on DC resistance standards"** during one of the poster sessions and got an opportunity to interact with other colleagues about the technical developments in their areas of work.

METAS PLACEMENT:

My placement was focused on DC resistance metrology under the supervision of Alessandro Mortara.

- Upon my arrival, I was taken on a lab tour in the DCLF laboratories. The lab tour allowed me to explore the different systematic facilities and capabilities available at METAS (i.e. DC&AC resistance, DC&AC voltage, AC/DC voltage and current, Impedance)
- The realization and traceability of the Ohm through the quantum Hall resistance standard (QHRS) was explained and demonstrated.
- I witnessed the demonstration of the CCC setup and operation (theoretical and practical)
- The systematic upgrades and modifications on CCC that is used for traceability dissemination from the QHRS were explained
- The precautionary measures required for the high-level precision operation of the CCC were outlined.
- We carried out the calibration of high value DC resistors, discussed and evaluated associated uncertainty contributors (sources of errors), studied their behavior and updated maintenance records.

- We continued with the different setups of the CCC to calibrate different makes of resistors (from high to low values), discussed the associated uncertainty contributors and updated maintenance records.
- We conducted diagnostic and intermediate checks on various components of the CCC
- I have also learnt about the use of CCC in calibrating calculable resistors which are used to transfer traceability from DC resistance to impedance (capacitance and inductance)

Lastly, I got an opportunity to visit the electrical power and energy laboratories to explore their systems and capabilities.

Conclusions and Future Work

I have gained valuable knowledge through participation in the Varenna Metrology summer school and placement at METAS. The knowledge acquired from the school will help me stay abreast of emerging developments in the broader metrology field.

The placement at METAS enhanced my knowledge and skills in DC resistance measurements. The enhanced knowledge will contribute towards the improvement of expertise at NMISA in the field of DC resistance metrology.

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