Justervesenet

Report on Electromagnetic Metrology Activities at JV, Norway Prepared for the 32st Meeting of the CCEM 2021

Staff

Dr. Helge Malmbekk – **ACI/ACV** – Group leader – hma@justervesenet.no
Dr. Ilia Kolevatov – **DCV/DCI**, DC and AC Josephson – iko@justervesenet.no
Mr. Tore Sørsdal – **Resistance**, QHR, CCC – tsr@justervesenet.no
Dr. Bjørnar Karlsen – **Power and Energy,** AC Josephson – bka@justervesenet.no
Mr. Kristian Ellingsberg – Power and Energy – kbe@justervesenet.no

Bjørnar Karlsen defended his PhD-Thesis in on **"Design of optically controlled AC Josephson arrays and voltage dividers for high precision voltage metrology "**. The work was closely linked to the work in the EMPIR project QuADC, and demonstrated LHe operation of InGaAs photo diodes, generating fast current pulses used for operation of Josephson junction arrays. Mach-Zehnder modulation of a continuous-wave laser has been performed to generate photo-current pulse widths (full-width-at-half-maximum) as short as 62 ps in the bipolar module, and peak heights up to 16 mA for wider pulses in the unipolar module. A mode-locked laser has been used to generate photo-current pulse widths as short as 37 ps in the bipolar module, and with peak heights up to 6.34 mA. The work was a collaboration with PTB, NPL, VTT and the University of South-Eastern Norway (USN).

Dr. Helge Malmbekk visited NPL for a 3 month research visit as part of the EMPIR project DIG-AC. He work on a technique for **phase locking a freely drifting AC voltage source** to a Programmable Josephson Voltage Standard. By measuring the differential signal between the two signals, and monitoring the phase component of the error signal a continual phase alignment was achieved by varying the frequency of the master clock used in the Josephson standard.

Our old DC Josephson system has been replaced by a new 10 V PJVS system and during 2020 the system was upgraded with a **pulse tube cryostat** for continuous operation. The cryostat will be used for both PJVS and JAWS, with a testbed for optical generation of current pulses based on the work of Dr. Bjørnar Karlsens PhD thesis. In the future, we plan to start investigating if a QHE standard based on Graphene could be operated inside the cryostat as well.

In 2020 we started the EMPIR project QuantumPower, coordinated by Dr. Helge Malmbekk, where the overall objective of the project is to develop a **quantum sampling standard for electrical power** which is open to the whole Metrology community and provides direct traceability to the new quantum SI. The use of quantum standards in sampling of electrical power enables direct traceability not only for power measurements, but also for PQ and phasors. The project will develop an open-source hardware multiplexer that will be synchronised with the sampling system. It will be able to switch the input of the analogue-to-digital convertors (ADCs) between the voltage, current and PJVS channels, in order to provide real-time calibration of the ADCs and substantially decrease the uncertainties of the power measurements. The multiplexer will enable using a single PJVS chip for measurement of both current

and voltage components of the electric power using differential sampling, or to provide calibration of ADCs before and after the direct sampling of electric power.

As part of the EMPIR project ADVENT, we have developed an **active current shunt for measuring on low power devices** without disrupting the current flow in the system. The device is intended for measurement of current with in the nA- and µA-range and high frequency up to 1 MHz with negligible impact on the circuit. An introduction of the developed active shunt into the current path does not result in distortion of signals of the test circuit. This makes the active shunt suitable for low current in-circuit measurement.

In the EMPIR project MeterEMI, we have conducted on-site measurements of current waveforms in residential building to investigate if these waveforms causing **electromagnetic interference on static electricity meters**. Investigations have shown that some current sensors commonly used in static electricity meters can cause large errors if the current peaks have a sharp and short rise time.

During the last few years we have been discussing technical solutions for calibration and control of fast DC charging of electrical vehicles. A Nordic cooperation on the legal metrology issues related to this and a EURAMET project has been initiated to investigate the issues related to fair and correct billing of **electrical vehicle charging**.

During 2020/2021 Dr. Bjørnar Karlsen conducted a visit to VSL as an RMG in the EMPIR project TrafoLoss. The main technical objective of this RMG is to achieve **primary sampling power measurements** with a measurement uncertainty that is better than 10 µW/VA at low power factors, and to provide a thorough overview of all the factors that affect this uncertainty. An optimised design of a primary sampling power measurement system by will be produced by reviewing the various options for the realisation of its three key components: digitizers, voltage scaling and current scaling. The research visit was heavily affected by the pandemic, but hopefully the last past can be finished this summer.

Publications

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