National Physical Laboratory

News from NPL for the CCEM, 14-15 April 2021

New Quantum Programme

As part of the UK National Quantum Technologies Programme (NQTP), NPL has initiated its own quantum programme. This wide-ranging NPL programme will focus on the many ways in which NPL, as the UK's National Metrology Institute, can contribute to the national endeavour to build economic growth for the UK, based on new products and services for a range of quantum technologies.

The new NPL quantum programme consists of multiple elements, each using different aspects of NPL capability. NPL will work closely with the UK EPSRC-funded quantum technology hubs, groups of UK research-leading universities focussed on a specific technology area. NPL is already a key partner in several of these hub programmes, for example in the field of atomic clocks or quantum communications. However, there are many other areas in which NPL capability could enhance the outputs from the hubs in sensing, imaging and quantum computing.

Through its new programme, NPL will lead on the creation of a comprehensive capability to test and evaluate prototypes and new products based on quantum technologies for the UK. This will involve the design and construction of new test facilities. The collaboration with partners around the UK is an important aspect of this programme. This programme will involve aspects of skills and training, giving access for industry to test facilities, and work on establishing new methods and protocols which could contribute to new international standards.

Quantum electrical standards

NPL is measuring the current from a silicon single electron pump at frequencies up to 2 GHz (generating 320 pA), with typical uncertainties less than 0.1 ppm for a 10-hour measurement. All measurements are performed with the pump at a temperature of 4 K in zero magnetic field. A blind protocol is implemented to avoid experimenter bias until after the measurement campaign has finished.

A collaboration between the NPL Quantum Electrical Metrology and Nuclear Metrology groups is studying the feasibility of measuring the half-life of long-lived radionuclides by directly measuring the decay in current from an ionisation chamber using precision techniques. A proof of concept study on carbon-14 has been running since 2019. The results are sufficiently promising (the approximately 1 fA per week current decay can be resolved over 2-3 weeks) that following a recent review, the experiment will continue with improved data logging and environmental control.

NPL is continuing its development of compact QHR standards and is currently delivering its first commercial contract for a system. We have also successfully switched our routine resistance traceability for measurement services to a graphene QHR running cryogen-free at 5 T and 4 K.

NPL is also upgrading its programmable Josephson junction array system from 1V to 10 V. The system will be used for both dc measurements and for waveform synthesis up to kHz frequencies.

5G Millimeter-wave facility

NPL has set up a 5G Millimeter-Wave Fully-Connected Hybrid Beamformer with a Large Antenna Array at the University of Surrey in a joint laboratory. The facility operates around the 24-32 GHz window (TBC) has several applications from beam-formation to hazard assessment.

As part of our strategic partnership with the University of Surrey, we are also a member of the 5G Innovation Centre (5GIC), now the largest UK academic research centre dedicated to the development of the next generation of mobile and wireless communications, and we jointly run the Nonlinear Microwave Measurement and Modelling Laboratories (n3m-labs), helping to develop the next generation of super-efficient electronic devices. More information is available here: https://www.npl.co.uk/digital/ensuring-the-5g-revolution-is-a-success

Kibble Balances

A team at NPL, led by Ian Robinson, is producing a small number of Kibble Balances in collaboration with NMISA (South Africa) and RISE (Sweden). The balances employ a seismometer-like mechanism with bifilar windings to allow single-mode, two-phase, operation. The mechanics and electronics for the balances are in the final phases of production and we expect to ship the first collaboration balance to South Africa by the end of the year. The Swedish balance will follow soon afterwards. The balances will measure masses in the 200 g region and the long-term aim of the collaboration is to achieve an uncertainty equal to, or better than, 2 parts in 10^8.

Measurement for Recovery

NPL launched the Measurement for Recovery (M4R) programme in July 2020 to ensure measurement science was available to UK industry during the Covid-19 crisis when businesses were facing multiple challenges including cash flow, job security and investment in innovation. Working with our partner laboratories that make up the National Measurement System, M4R was designed to address and solve the challenges by matching businesses with world-leading measurement scientists and engineers, techniques and technologies, and providing up to 20 days specialist science and engineering expertise free of charge.

Over 300 projects have been agreed across a wide range of physical measurements including exploitation microwave and THz technologies. Some example projects are summarised here: https://www.npl.co.uk/measurement-for-recovery#impact

Accreditation of measurement services

The annual UKAS audit of all the measurement services provided by the ElecMeas group at NPL (covering all DC&LF, RF and Microwave and Fibre Optic areas) was successfully completed in September 2020. There were no major issues reported by the auditors, and an extension of NPL's UKAS scope to cover frequency extensions in microwave S-parameter and power was approved.

As the audit was conducted as a remote desk-based exercise, due to COVID restrictions, there was an enhanced focus on documentation and record keeping aspects of the quality system. A follow up exercise with video and live-streaming of laboratory activities is planned for Q1 2021.

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