European Metrology Research Programme

SI Broader Scope II

An overview of the funded projects from the Targeted Programme SI Broader Scope II.

The aim of these projects is to underpin the development of the SI system of measurement units.

The projects focus on preparations for the implementation of the redefinition of the SI base units, which is likely to take place over the next few years, the development of practical realisations of the redefined units and traceability of measurement results.

Impedance measurements for electrical components

Simple, reliable and cost-effective impedance measurements

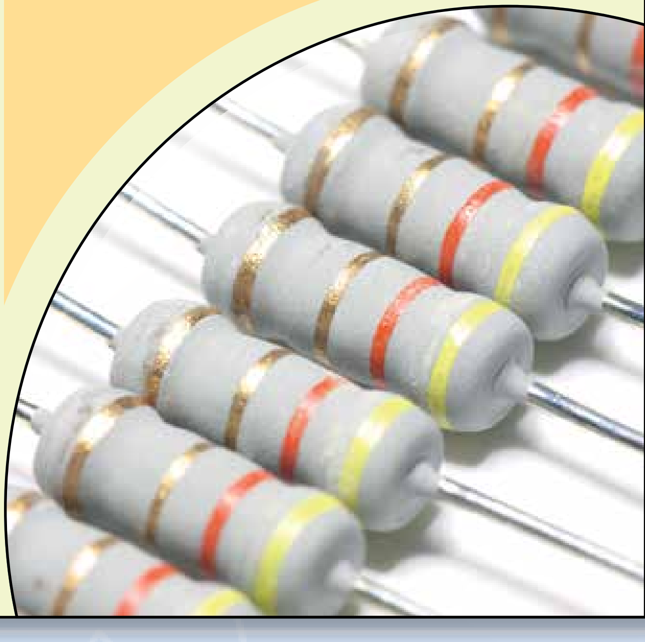
Electrical impedance is used to manufacture passive electronic components, to analyse battery electrolytes, touchscreens and fuel gauges, and to calibrate dosimeters for radiation measurement.

Currently, the lowest uncertainty impedance calibrations use previously defined ratios, with calibrations performed as a comparison with a known impedance. The ratio is normally defined by a purpose-built transformer and many different transformers are required for different impedance ratios. This project aims to replace this large number of individual standards by building a novel programmable impedance simulator.

The project will produce new methods and devices to help establish a reliable impedance scale in the frequency range between 10 Hz and 20 kHz. New traceability routes will also be established where there are currently none, for example, impedance values for nanotechnology. This will bring the costs of impedance calibrations down, benefitting manufacturers of electrical components and users of electrical systems.

Project SIB53: Automated impedance metrology extending the quantum toolbox for electricity

Dr Luis Palafox Gámir, PTB, Germany
+49 531 592 2140 | luis.palafox@ptb.de



Better biological measurements

Removing barriers to traceable measurements in biology

Accurate counting of biological entities such as DNA and cells is vital for the security, healthcare and food sectors, among others. Specific applications include the monitoring of tumour cells in patients, the detection of genetically modified organisms in food and the quality control of tissue engineered products.

This project will use purified calibration materials and counting technologies for biological measurements to bring traceable measurement to biology. It will develop methods to characterise pure biological materials for calibration, while establishing procedures for primary reference measurements of amount of nucleic acid based on single-molecule detection and counting, using digital PCR (polymerase chain reaction).

The project will also focus on monitoring for minimal residual disease, as used in the treatment of leukaemia to determine whether the therapy is successful. The results will reduce some of the most important barriers to adoption of SI traceability for a wide range of biological measurements.

Project SIB54: Traceability for biologically relevant molecules and entities

Helen Parkes, LGC, UK
+44 20 8943 7676 | helen.parkes@lgcgroup.com

Portable quantum resistance standards

Making quantum resistance standards more widely available to industry

While quantum electrical voltage standards are widespread and easily transported, the same cannot be said for quantum resistance standards. The primary resistance standards are only available at national measurement institutes and the resulting calibrations lose precision at every link of their long chain.

Graphene exhibits the quantum Hall effect at lower magnetic fields and closer to room temperature than any other material. The material could therefore help create simple and portable ‘bench-top’ systems which could be deployed more widely and easily than current resistance standards (even into industry). This would reduce the cost and inconvenience of the calibration chain.

This project will use materials science and improved measurement precision to build stable graphene devices that can operate in relaxed conditions of temperature and magnetic field. These will then be used as quantum resistance standards for the electricity community.

Project SIB51:
Quantum resistance metrology based on graphene

Dr Franz Ahlers, PTB, Germany
+49 531 592 2600 | franz.ahlers@ptb.de

www.ptb.de/emrp/graphohm.html

Thermal protection for industry

Building confidence in novel thermal protection materials

Recent advances in thermal protection include the development of polymers, aerogels and fibrous based composite systems. These new materials are thinner, lighter and stronger, and provide a thermal performance several times better, than conventional insulation materials. However, it is difficult to evaluate their performance.

Measurements of thermal conductivity can produce scatter of over 100 % for these new types of material. This leads to a lack of confidence and investment from manufacturers, an inability to demonstrate performance for certification and means that industry has to use costly full-scale testing during the development of aerospace components, fire safety systems and process plants, for example.

This project will establish a framework for measurements of thermal conductivity in order to improve industrial measurement techniques up to 800 °C. This will enable designers of fire engineering and transportation safety systems to select the best performing thermal protection materials, helping to reduce the rate of industrial disasters and, ultimately, to save lives.

Project SIB52:
Metrology for thermal protection materials

Dr Jiyu Wu, NPL, UK
+44 20 8943 6045 | jiyu.wu@npl.co.uk

Preparing for a new second

Demonstrating and comparing next generation optical clocks

Project SIB55: International timescales with optical clocks

Dr Helen Margolis, NPL, UK
+44 20 8943 6113 | helen.margolis@npl.co.uk

projects.npl.co.uk/itoc/

Accurate time underpins many everyday technologies, particularly in the areas of communications and navigation. A redefinition of the second in terms of an optical frequency will help improve accuracy further, but a number of challenges remain before this can be achieved.

Improved methods for comparing the frequencies of optical clocks constructed in different laboratories are needed to help build confidence. Scientists will also need to improve evaluations of the effects of Einstein's theory of general relativity, and in particular the local effects that gravity has on each clock due to the very high levels of stability and accuracy demonstrated by the clocks.

This project will help prepare for a future redefinition of the second, by addressing these challenges, and provide the scientific community with a basis for tests of fundamental physical theories. By demonstrating the performance of optical clocks, it will also benefit fundamental science in space such as the ACES (Atomic Clock Ensemble in Space) mission, due for launch in 2015.

The airborne watt

New measurements of sound power

Project SIB56: Realisation, dissemination and application of the unit watt in airborne sound

Dr Volker Wittstock, PTB, Germany
+49 531 592 1549 | volker.wittstock@ptb.de

www.ptb.de/emrp/soundpwr.html

Sound power is the total amount of sound radiated from a source such as a speaker and is often used to describe the acoustic output of technical products. This definition makes it independent of the environment and of the distance from a source but, in reality, sound power can only be determined from other measurements such as sound pressure at a certain position.

This often results in different procedures to determine the sound power of a particular source producing different results, which leads to uncertainties up to the level of several decibels. This makes it impossible to compare the defined legal requirements for noise protection with measurement results in the field.

This project will establish traceable measurements of sound power and develop a primary standard to realise the unit watt in airborne sound, with a target uncertainty of 0.5 decibels. It will also develop primary sound power sources, from which the unit watt can be disseminated to users.

Light detection

New light detectors for new light sources

Project SIB57:
New primary standards and traceability for radiometry

Dr Maria Luisa Rastello, INRIM, Italy
+39 011 3919 219 | m.rastello@inrim.it

Europe is home to some of the world's largest laser and optics companies but, in order to remain competitive, new research needs to focus on developing more efficient light-detecting instruments, known as photodetectors.

This project will improve photodetector efficiency and result in high level realisations of the radiometric units. It will also develop new primary standards that can be built directly into applications, improving access to the candela, the SI unit of luminous intensity, for calibration and testing laboratories.

The project results will improve quality control in industry and impact on the photodetectors which are integrated into advanced products such as diagnostic devices and the smart imaging technologies used by surveillance cameras and driverless vehicles. To support the uptake of energy efficiency lighting, the new standards will be designed to work with energy efficient solid state lighting technologies such as LEDs.

New angles

Improving angle measurements for science and industry

Project SIB58:
Angle metrology

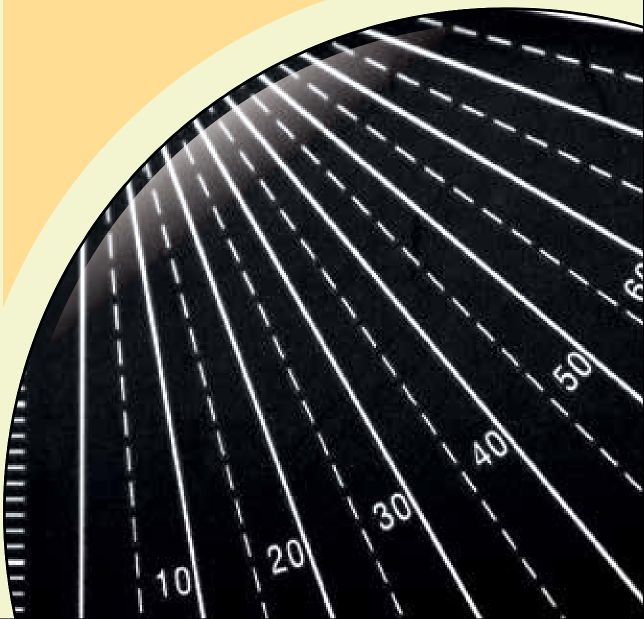
Dr Tanfer Yandayan, TUBITAK, Turkey
+90 262 679 5000 | tanfer.yandayan@tubitak.gov.tr

www.anglemetrology.com/

Many areas of science and industry rely on the accurate measurement of angles. From the precision form measurement of optical surfaces, used at synchrotron radiation beamlines and free electron laser (FEL) centres, to the precision engineering measurements of flatness, straightness and parallelism, used by the automotive and aerospace industries to ensure parts are produced to the correct specifications.

Increasing demands on manufacturing accuracy are raising the need for improvements in the devices used to make these measurements, and in their calibration.

This project will develop prototype devices to realise the radian, the SI unit of angle, to help ensure the reliable and traceable measurement of angles in science and industry. It will also address a wide range of angle measuring devices, such as autocollimators, angle encoders and small angle generators, looking at the applications of these devices and how they perform in challenging measuring conditions.



Electrical traceability

Pushing the boundaries of electrical measurements

The performance of electrical sensors depends on the conversion of analogue and digital signals and, as new products perform at the limits of what is currently possible to measure, the sampling rates of analogue-to-digital convertors and digital-to-analogue converters need to increase.

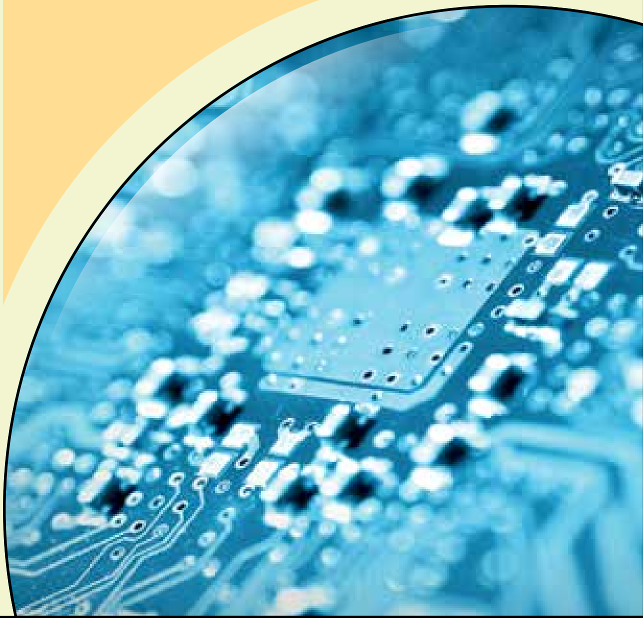
Recent progress in the semiconductor industry, and particularly in precision integrated circuits, has exposed a gap in the direct and traceable voltage measurement for precision devices operating at high frequencies, above 10 MHz. Therefore, new methods for disseminating the volt to non-stationary or alternating waveforms (AC) are needed.

This project will develop a measurement system based on the Josephson effect for the dynamic calibration of the latest generation of analogue-to-digital convertors, according to the current IEC and IEEE standards. It will also improve digital signal processing techniques, while evaluating their contribution to measurement uncertainty, thereby providing direct, traceable measurements within the fast moving electronic sensing sector.

Project SIB59:
A quantum standard for sampled electrical measurements

Dr Johannes Kohlmann, PTB, Germany
+49 531 592 2133 | johannes.kohlmann@ptb.de

www.ptb.de/emrp/sib59-home.html



Large measurements over long distances

Accurate surveying for science and engineering

Many tasks in science and engineering require accurate surveying. Surveillance networks help assess the risk of possible landslides, sinkholes or other tectonic activity, and ensure the safety of local populations and industrial facilities from potential natural disasters. Sea levels are also monitored for both climatologic studies and disaster prevention.

Currently, networks of monitoring devices must measure large distances, of up to several kilometres, with uncertainties of one millimetre or below. Two different measurement techniques are commonly used: optical distance measurement and Global Navigation Satellite Systems (GNSS). However, neither technique can provide traceability to the metre, with the required level of accuracy.

This project will develop optical devices that can measure distances of up to one kilometre in air with an uncertainty of 10^{-7}, as well as improving our understanding of different sources of uncertainty for devices based on high-accuracy GNSS. The results will feed into two different test measurement systems set-up in Sweden and Finland.

Project SIB60:
Metrology for long distance surveying

Dr Florian Pollinger, PTB, Germany
+49 531 592 5420 | florian.pollinger@ptb.de

www.ptb.de/emrp/surveying.html

Nanoscale length measurement

Meeting measurement needs for semiconductors and nanotechnology

Project SIB61: Crystalline surfaces, and self assembled structures, nano-origami as length standards in (nano)metrology

Dr Ingo Busch, PTB, Germany
+49 531 592 6136 | ingo.busch@ptb.de

Nanoscale length measurement standards are currently only available down to 6 nm and 70 nm, for step height and lateral pitch respectively, due to limitations in the technology used to produce them. The development of new dimensional standards which surpass this limit would support the invention of new products for climate change, sustainable energy and life science applications.

This project will develop new types of dimensional standards using crystalline surfaces, self-assembled structures and nano-origami for step height and lateral resolution measurements. These new standards can be used for scanning probe microscopy and interference microscopy and will be tailored to the demands of the semiconductor and nanotechnology industries.

The prototypes will enable manufacturers to make higher resolution measurements and stimulate innovation in the semiconductor market. They will also enable the traceable measurement of nanoparticles and carbon nanotubes, which are of great interest to the environmental and health sectors.

New measurements for emerging electronics

Benchmarking high-performance, energy-efficient electronics

Project SIB62: Metrology for new electrical measurement quantities in high-frequency circuits

Nick Ridler, NPL, UK
+44 20 8943 7116 | nick.ridler@npl.co.uk

A lack of traceable measurements is holding back cutting-edge industrial electronics that operate in the radio frequency, microwave and millimetre-wave areas. This prevents their use in a wide variety of applications such as breast cancer screening, the detection of environmental gases for climate change monitoring and airport security scanners.

This project will develop traceable verification techniques to benefit systems including waveguides, coaxial lines, vector network analysers and printed circuit boards. These techniques will help manufacturers justify performance indicators such as product specifications and help test equipment manufacturers develop new instruments to keep up with advances in new electronics.

The project will also help improve the energy efficiency of components and systems used in mobile communications such as smartphones and base stations, and support emerging technologies such as carbon-based, organic electronics.

Better measurements of larger forces

Measurements to support large mechanical engineering projects

Many industrial and civil engineering applications need force measurement and there is increasing demand for the measurement of larger forces of up to 30 meganewtons (MN). National Measurement Institutes can measure between 1 and 15 MN using a variety of force standard machines and build-up systems can be used for higher forces. However, no standards or guidelines are currently available to calculate their uncertainties.

This project will extend the range of primary force standards up to at least 30 MN with a target uncertainty of 0.05 %. It will also improve transfer standards to help reliably disseminate the unit of force and improve force measurements in industry.

This will result in improved accuracies for mechanical testing with more realistic estimations of measurement uncertainties. This will establish a basis for further developments in mechanical engineering, the aerospace, energy and building industries, and safety and testing.

Project SIB63:
Force traceability within the meganewton range

Dr Rolf Kumme, PTB, Germany
+49 531 592 1200 | rolf.kumme@ptb.de

www.ptb.de/emrp/forcemetrology.html

Moisture in materials

Measuring moisture levels

Maintaining correct moisture levels during the production of products such as pharmaceuticals, foods and paper is vital for ensuring quality and durability, and reducing waste.

Water may be removed from products by evaporation but there is a lack of reliable measurements to determine ‘dryness’. Usually, moisture is determined by weighing a sample before and after drying, and calculating the difference. However, the sample may still contain a certain amount of moisture after drying and so measurement uncertainty often remains unknown.

This project will remove the ambiguity and inconsistency in moisture measurements and calibrations, improving traceability to the SI units, helping science measure moisture more accurately and enabling the development of new products, instruments and services in industry.

Project SIB64:
Metrology for moisture in materials

Dr Martti Heinonen, MIKES, Finland
+358 29 5054 402 | martti.heinonen@mikes.fi

www.metef.net

Dr Duncan Jarvis - EMRP Programme Manager
E-mail: emrp-pm@euramet.org
Phone: +44 20 8943 6707
EURAMET e.V., Bundesallee 100,
38116 Braunschweig, Germany

EMRP
European Metrology Research Programme
Programme of EURAMET

The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

10569/08.13/SEA/0.5k