

National Measurement Institute, Australia
Report on Research and Development Activities in Electricity and Magnetism
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DC and LOW FREQUENCY

New Quantum voltage standards

A new pulse-driven Josephson voltage array, developed by NIST, has been installed into the NMIA Arbitrary Josephson Waveform Synthesiser (JAWS), extending the available voltage to 0.45 V. The assistance of NIST, particularly Dr Sam Benz is gratefully acknowledged.

Ac-dc transfer measurement up to 10 KHz confirmed agreement with conventional NMIA standards well within their uncertainty. Work is continuing on several applications of the new JAWS system, including:

- Linking the Australian ac scale to the JAWS with the help of the NMIA Precision Transconductance Amplifier
- Extending the voltage range to hundreds of volts using the NMIA 1000 V Inductive Voltage Divider
- Using the JAWS to provide traceability to complex measurement instruments

Transconductance amplifier to enable calibration of thermal converters against a Josephson array

A Mark III transconductance amplifier to unload a Josephson array for the calibration of precision thermal voltage converters and other loads has been developed. The new amplifier has been optimised for use with 1 V JAWS. The influence of a series resistance in the circuit has been greatly reduced, enabling the reduction of loading errors to less than 0.1 $\mu\text{V/V}$. The operation of the new amplifier has been verified using the new JAWS.

Ac power and energy standards

The NMIA ac power standard, comprising a thermal power comparator, an NMIA 1000 V Inductive Voltage Divider and a multi-range computer-controlled current transformer, has been extended by means of a sampling digital power comparator developed by VNIIM. The sampling software operates two digital multimeters without modification to their design or external synchronisation. The thermal and digital power comparators have been extensively compared, resulting in a maximum deviation of 5×10^{-6} . This allowed the use of the digital system as a working standard, greatly improving productivity.

A measurement capability for phase angle between voltages up to 1000 V and currents up to 200 A at frequencies up to 1 kHz for the fundamental and 10 kHz for harmonics has been established. The uncertainties start at 1 μrad .

NMIA multi-range current transformer – extension of frequency range

A system has been developed to compare the NMIA multi-range current transformer with current shunts over the range of currents up to 100 A and frequencies from 10 Hz to 10 kHz. The measurements have shown the suitability of the multi-range current transformer for an automated working ac current standard over this frequency range.

NMIA 1000 V Precision Inductive Voltage Divider

A new batch of NMIA 50 Hz to 1 kHz 1000 V Precision Inductive Voltage Dividers of unprecedented accuracy is being constructed. Several further improvements are being implemented.

IMPEDANCE

A new calculable capacitor and associated impedance measurement chain is being built at the NMIA. All components in the chain will be configured as four-port devices and measured at frequencies from 199 Hz to 1990 Hz.

Preliminary alignment of the electrodes in the calculable capacitor has been completed using a special probe that allows the rotational skew of the bars to be adjusted with a resolution of 1.1 mrad over the central 370 mm length. Skew error will therefore result in an uncertainty in the calculable capacitance of no more than 1 nF/F.

The determination of the (very small) frequency correction to the calculable capacitance has also been completed. In earlier calculable capacitors including NMIA's existing calculable capacitor, lumped-component models were used to estimate the frequency correction. It rapidly became clear that even a sophisticated lumped-component model would introduce an unacceptably high uncertainty. Instead, a novel experimental technique was developed. It has been determined that the frequency correction is less than 0.01 $\mu\text{F}/\text{F}$, with an uncertainty of better than 0.001 $\mu\text{F}/\text{F}$. This result is directly applicable to other calculable capacitors of the same geometry.

The calculable capacitor optical system has been designed, and aspects of its performance evaluated. Further implementation of the optical system is awaiting the final assembly of the calculable capacitor, which is currently in progress.

Many elements of the precision four-port capacitance ratio bridge are complete or nearing completion. The source and ratio transformers are complete, as is the precision quadrature source and the low-noise preamplifier. The quad power amplifier and active coaxers are progressing and the programmable injector/detectors and balancing IVD are close to completion. Ongoing collaboration with NIM is assisting with this work. Recently, Dr Yan Yang visited NMIA to work on the PCB design and layout for the programmable injector/detectors.

A set of nine Invar capacitors with values from 5 pF to 50 pF, and eight fused-silica capacitors with values from 50 pF to 500 pF, was completed some time ago. A dedicated air bath capable of maintaining the temperature stability of the capacitors to a level that will not introduce more than 1 nF/F capacitance variation during the measurement has been designed and constructed. Dr Luis Palafox-Gamir is currently visiting NMIA to work on the control system for the air bath.

Calibration of the main ratio transformer will be achieved using a new four-port calibration facility based on Thompson's method. The calibration (or "bootstrap") transformer is complete. Dr Carlos Sanchez of NRC is working on the design of the zero-admittance voltage comparator and the calibration signal transformer.

The assistance and support of NIM, PTB and NRC are gratefully acknowledged.

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HIGH VOLTAGE

Measurement systems for very fast transients

Design and construction of a fast impulse generator of single-pulse fast impulses have been completed. The generator is capable of producing impulses with a maximum peak voltage of

10 kV (both voltage polarities), three different nominal front times (50 ns, 100 ns and 200 ns) and a tail time of 50 μ s. A fast impulse voltage divider for measuring the same type of impulses has also been completed. The generator and the divider will be used for the calibration of fast impulse measurement systems.

System for calibrating Voltage Transformers

The development of a new method for automated calibration of voltage transformers based on digitisers and capacitive dividers is close to completion. The new method will provide faster calibration, a possibility of working in a wider voltage range and lower uncertainties compared to the previously established manual method.

Reference resistive dividers for impulse voltages

NMIA is working on improving the design of its reference dividers for lighting impulse and switching impulse voltages. The work mainly aims at improving the transportability of the dividers for on-site calibration.

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RADIOFREQUENCY AND MICROWAVES

In August 2013 NMIA closed its radiofrequency and microwave project and voluntarily greyed out its calibration and measurement capabilities in this area. However the facilities have been preserved and are being made available for use by accredited laboratories.

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