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

New primary ac power standard

A new primary standard of active power has been developed. The standard comprises a thermal power comparator, an NMIA 1000 V Inductive Voltage Divider and a new multi-range computer-controlled current transformer. The new standard operates at frequencies up to 1 kHz and provides fully automated calibration with uncertainties close to 3 μW/VA (k=2).

Multi-range current transformer

A multi-range current transformer has been constructed. The current transformer has high accuracy and stability, allows full automation through computer control and requires only one 10 Ω shunt to maintain. The primary currents are 0.125, 0.25, 0.5, 1.25, 2.5, 5, 10, 20A (25A, 50 A, 100 A, 200 A with ×10 range extender) and the secondary currents are 3 × 100 mA into three 10 Ω resistors. The frequency of operation has been tested up to 1 kHz. The worst in-phase error is a few μA/A and the worst quadrature error is a few μrad. Improvements on the design aim at a target uncertainty of the current ratio to less than 1 μA/A.

Current shunts

A number of new current shunts have been constructed for frequencies up to 100 kHz. The nominal ranges are 1 mA (with Buffer Amplifier), 10 mA, 20 mA, 50 mA, 100 mA, 200 mA, 500 mA, 1 A, 2 A, 5 A, 10 A, and 20 A. The nominal output voltage is 1 V (1 mA to 10 A) and 0.75 V (20A). The in-phase error is a few μΩ/Ω and the quadrature a few μrad.

Quantum-based calibration of voltage references and digital multimeters

Dc calibration of client instruments is being transferred to a new working standard. The standard uses two AIST programmable Josephson voltage arrays operating in a cryocooler, for voltages up to 10 V, with an addition of a precision resistive divider for voltages up to 1000 V. The new standard has a resolution of less than 100 nV over the entire voltage range. It will replace calibrators as a working standard to calibrate nanovoltmeters, high end digital multimeters and will also be used to calibrate voltage references.

Calibration of wideband power analysers for the measurement of LED power

NMIA has been helping several Australian laboratories to improve the measurements of LED power for the purpose of efficiency analysis. Real LED current waveforms of interest are measured, recreated using digital techniques and used as test current for a precision power measurement system based on a wideband thermal power comparator. Comparisons indicate that the users are able to effectively disseminate the corrections obtained in this way on their power analysers in the testing of LED solid state lights.

Calibration of Phasor Measurement Units

A system has been developed to calibrate phasor measurement units against the new IEC standard. The system is based on sampling techniques using precision digital voltmeters and waveform generators.

New transconductance amplifier to assist calibration of thermal converters against a Josephson array

A new transconductance amplifier is being developed to be used for unloading a Josephson array in the calibration of precision thermal voltage converters against. The new amplifier can generate voltages up to 7 V rms. The influence of a series resistance in the circuit has been greatly reduced, enabling the reduction of loading errors to less than 0.1 μV/V.

IMPEDANCE

Calculable capacitor and precision four-port ac capacitance bridge

A new calculable capacitor and associated impedance measurement chain is being designed and 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.

Polishing of the calculable capacitor electrode bars is now complete. The bars are geometrically accurate to better than 50 nm over the central 370 mm length, easily meeting the target 100 nm required to reduce the error contribution with geometric nosepieces to less than 1 nF/F. The precise alignment of the electrodes in the calculable capacitor, which is critical to achieving the target uncertainty, is underway. A special probe has been made that allows the rotational skew of the bars to be adjusted with a resolution of 1.1 mrad over the central 370 mm length, reducing the skew error to less than 1 nF/F.

Progress has been made on the design and implementation of the calculable capacitor optical system with required measurement accuracy.

Good progress has been made on the precision four-port capacitance ratio bridge. The source, ratio and calibration transformers are complete, as is the precision quadrature source and the low-noise preamplifier. The bridge will be balanced using a relay-controlled in-phase and quadrature balancing network. All 21 transformers for the balancing network have been wound with both the pre-excitation and define windings, and have been mounted in an enclosure together with shields and terminations. The printed circuit board for the relays and drivers, and the development of control software is in progress. A broadband, self-excited transformer has been designed and constructed for use in a range of applications: for active coaxers, for the comparator required in the calibration of the main transformer and as an impedance matching transformer. Tests demonstrated good performance over an extended frequency range.

A set of nine Invar capacitors with values from 5 pF to 50 pF has been completed. The air bath for the Invar capacitor set, as well as the previously completed set of eight fused-silica capacitors with values from 50 pF to 500 pF, is substantially complete except for the control system. Once complete, the air bath will be 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.

HIGH VOLTAGE

Very Fast Transient Measurement System

Good progress has been made in establishing reference measurement systems for fast transients. A reference system for measuring electrical fast transients/bursts for immunity tests as specified in IEC61000-4-4 is now operational. The typical rise time for this type of transients is 5 ns with the peak voltage being up to 4 kV. A reference system for measuring a single impulse up to 10 kV with a rise time down to 50 ns is also being developed.

Resistive switching impulse reference divider

Good progress has also been made in constructing a resistive reference divider for measuring switching impulses with a peak voltage rating of 250 kV. Simulation and measurement of step responses of various designs have been completed. The final design of the divider has been finalised and all components, including resistors and mechanical parts have either been purchased or made.

System for the calibration of Instrument Transformer Testing Sets

The development of a new system for calibrating Instrument Transformer Testing Sets has been completed. Initial verification has demonstrated that the new system provides measurement uncertainties comparable to those of the existing manual system. The new system enables automation and faster calibration times.

Impulse voltage test and calibration system

A new system based on a 12-bit digitiser has been completed for performing impulse tests and calibrations in accordance with various IEC and IEEE standards. A high degree of automation can be achieved using the system software for calibrating a range of artefacts, including dividers, attenuators, digitisers and a complete systems, for their scale factors or voltage errors, errors of time parameters, voltage non-linearity and associated measurement uncertainties.

RADIOFREQUENCY AND MICROWAVE

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 made available for use by accredited laboratories.

A system is being developed to measure phase and gain pattern of GPS antennas in L1 and L2 frequency bands.

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