# National Measurement Institute, Australia
# Report on Research and Development Activities in Electricity and Magnetism
# CCEM Meeting, April 2021

## *DC AND LOW FREQUENCY*

### *New method to calibrate dc resistive voltage dividers and dc voltage calibrators up to 1000 V*

A new method has been developed to calibrate resistive voltage dividers and dc voltage calibrators, taking advantage of the combination of:

an inductive voltage divider (IVD) with an ultimate life-time stability of its ac voltage ratio,

a resistive voltage divider (Transfer RVD) with low and stable ac-dc difference but relatively large voltage dependence and modest long-term stability of the dc ratio,

a programmable Josephson voltage standard

The target uncertainty of dc voltage ratio is 1 x $10^{-7}$ at voltages up to 1000 V.

### *Josephson Arbitrary Waveform Synthesizer as a Reference Standard for the Calibration of Lock-in Amplifiers*

A Josephson arbitrary waveform synthesizer (JAWS) utilizes the accuracy of the ac Josephson effect to produce voltages calculated from first principles at frequencies up to several megahertz. We have extended the use of a Josephson arbitrary waveform synthesizer to the voltage range from 1 µV to 1 mV, at frequencies from 60 Hz to 1 kHz, to provide traceability to lock-in amplifiers. This offers a convenient and intrinsically accurate alternative to conventional methods for the calibration of lock-in amplifiers, such as those based on the generation of low voltages by means of a calibrated semiconductor source and a calibrated inductive voltage divider. The uncertainty contribution from the JAWS system is better than 45 nV for 1 mV at 1000 Hz, k=2.0.

### *Calibration of Precision Current Transformers and AC Resistors by Comparison using Two Sampling Digital Voltmeters*

NMIA has developed a new highly efficient technique for the calibration of a current transformer, loaded by a precision shunt resistor, by comparison with a reference transformer - resistor combination. Two sampling digital voltmeters are used to measure the voltage output of each combination. The errors of the transformer and the resistor are measured without knowing the voltmeter errors. The new technique has significantly simplified the calibration chain and has enabled complete automation. It has also provided for comparisons between NMIA reference current transformers and current shunts. The calibration uncertainty is a few parts in $10^{-6}$ for both in-phase and quadrature errors at frequencies up to 1 kHz.

## *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 NMIA with a target accuracy below 0.005 µF/F. All components will be configured as four-port devices, and measured at ten frequencies from 200 Hz to 2 kHz.

The calculable capacitor is in the final stages of assembly. Recent upgrades to the system provide in-situ alignment of the upper guard electrode and the lower mirror, as well as an improved mechanism for the alignment of the lower guard electrode. These improvements will facilitate the implementation of the interferometry system.

Most of the components for the associated capacitance ratio bridge have now been completed. The source, ratio and calibration transformers, the precision quadrature source, the low-noise preamplifier, the active coaxers and the quad power amplifier are all complete. The bridge-balancing network and the programmable injector/detectors are in advanced stages of construction, and the design of the signal generator is complete.

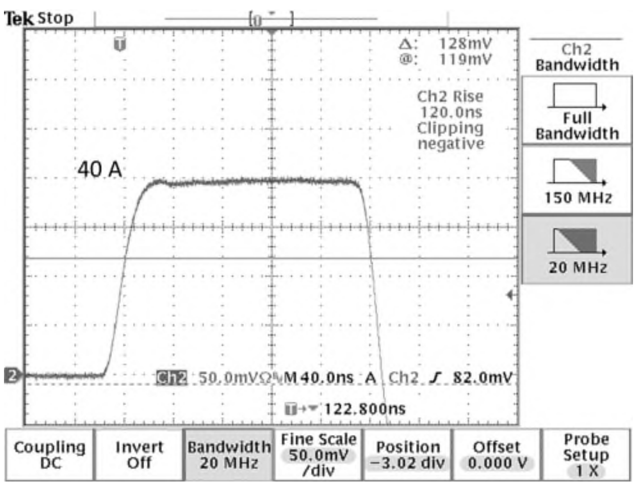
## *HIGH VOLTAGE*

### *Development of a wideband on-site high-voltage current transformer calibration system*

NMIA is performing laboratory tests on reference current transformers to be used in an on-site calibration system for calibrating high-voltage current transformers at the power frequency as well as at frequencies up to 10 kHz. The development is a part of the Global Linkage Project, Power Quality of Future Electricity Networks, that involves 5 Australian power utilities, 3 Australian Universities, Tsinghua University in China, National Measurement Institute Australia, National Institute of Metrology China, ARCMesh Australia and SMA Solar Technology AG Germany.

### *Development of step current generators*

NMIA has completed some experiments of generating step currents using coaxial cables. The current step generators are to be used for measuring the dynamic performance of reference resistive impulse current shunts for lightning impulse currents with a standard waveform of 8 µs front time and 20 µs tail time. A stable step current with a rise time of less than 100 s has been achieved.




*Step current produced from discharging a 20 m long coaxial cable*

***Comparison of standard high-voltage capacitors and comparison of high-voltage dielectric dissipation factor standards***

NIM China and NMI Australia have started a comparison program to compare the high-voltage capacitance and dielectric dissipation factor (DDF), with transfer devices provided by NIM China. The transfer devices include a 100 kV standard gas capacitor, a 10 kV DDF standard and a 750 V standard capacitor. NIM China has completed the first set of measurements and devices have arrived at NMI Australia. An ambitious objective of the program is to achieve unprecedented agreements in the absolute capacitance values at high voltage by carefully controlling and measuring the gas pressure and the ambient temperature. The 100 kV capacitor have to be de-gassed for transport and re-gassed before the next set of measurements.

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