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Abstract

The latest results of a new realization of the ohm and farad using the NBS calculable capacitor and associated apparatus will be reported.

Introduction

The NBS representation of the ohm Ω_{NBS} is based on the mean resistance of five Thomas-type, wire-wound resistors maintained in a 25 °C oil bath at NBS Gaithersburg. Similarly, the NBS representation of the farad F_{NBS} is based on the mean capacitance of four fused silica capacitors in a comparable oil bath. By means of the United States calibration hierarchy, measurements of resistance, capacitance, and inductance made throughout the country are generally traceable to these representations.

It is necessary to know Ω_{NBS} and F_{NBS} in SI units for two distinct reasons: First, to ensure that Ω_{NBS} and F_{NBS} are consistent with the SI, thereby ensuring that measurements of these important electrical quantities are themselves consistent with the SI, the unit system used throughout the world; second, to determine in SI units a number of fundamental physical constants of great importance to both physics and electrical metrology. These include the fine-structure constant α , the quantized Hall resistance $R_H = h/e^2$, and the Josephson frequency to voltage quotient $E_J = 2e/h$ (h is the Planck constant, e is the elementary charge). Indeed, it is likely that starting 1st January 1990, representations of the ohm worldwide will be based on a conventional value of R_H and representations of the volt will be based on a new conventional value of E_J , both as consistent with the SI as possible. These values are to be derived from the data available by 15 June 1988 [1].

In order to contribute to the pool of data, NBS, like other national standards laboratories, is carrying out experiments to determine R_H and E_J . Determining Ω_{NBS} in ohms by means of the NBS calculable capacitor, which is equivalent to realizing the ohm, is an important part of the NBS effort. This paper describes our measurements and gives our latest results. Additional aspects of the NBS work to determine R_H and E_J are described in other papers to be presented at the Conference.

Summary

The measurement sequence used in the 1974 ohm and farad determinations [2] has been retained in the present NBS measurements. A 0.5 pF calculable cross capacitor is used to measure a transportable 10 pF

reference capacitor which is carried to the laboratory containing the NBS bank of 10 pF fused silica reference capacitors. A 10:1 bridge is used in two stages to measure two 1000 pF capacitors which are in turn used as two arms of a special frequency dependent bridge for measuring two 100 k Ω resistors. A 100:1 bridge is used to compare each of the two 100 k Ω resistors with a 1000 Ω transportable resistor which is carried to the laboratory containing the NBS bank of 1 Ω resistors where the dc stepdown is made. The ac-dc difference of the 1000 Ω transportable resistor is determined by means of a special 1000 Ω coaxial resistor of negligible ac-dc difference. All ac measurements are carried out at 1592 Hz.

The calculable capacitor [2], ac bridges [3] and standards [4], ac-dc resistance standard [5], and the equipment used to measure transformer ratios [6,7] and voltage dependencies [8] remain basically the same as in the 1974 measurements. The calculable capacitor was partially disassembled in order to realign the electrical and optical axes, clean the optical flats, install larger diameter PTFE rings on the guard tubes, check for microphonic coupling errors [9], and measure the distributed inductances and capacitances used to calculate frequency corrections. All of the ac voltage sources and some of the preamplifiers and phase sensitive detectors have been replaced. A data acquisition system used in the comparison of the calculable capacitor with the 10 pF reference capacitor is presently yielding a standard deviation of 0.003 ppm for the random scatter in one complete measurement requiring about one hour.

Increased accuracy is expected in two areas: (1) the dc stepdown where a variety of new Hamon dividers and scaling techniques have shown consistent results, and (2) the measurement of laser wavelength where an iodine stabilized He-Ne laser [10] is used to provide in situ frequency calibration of the working laser used to illuminate the calculable capacitor interferometer. Other changes in the optical system include an acousto-optic modulator for laser isolation and improved equipment for adjusting the laser beam.

Most of the corrections and possible systematic errors have been reevaluated and it is expected that all of those likely to change with time or as a result of equipment modification will have been examined by June 1988. Preliminary results indicate that the average drift rate of Ω_{NBS} since 1974 is not greatly different from the short term drift rate as determined by repeated NBS quantized Hall resistance measurements during the past few years [11].

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