A Kelvin bridge for resistance calibrations based on a graphene quantum Hall resistance standard: preliminary implementation

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We present here a first implementation of a quantum Hall Kelvin bridge based on the design proposed in [1] that allows the direct calibration of standard resistors operating at room temperature. The bridge operates in deflection mode and is composed of a graphene quantum Hall resistance array with superconducting multiple connections (figure 1) working at a temperature of 1.6 K and a magnetic field of 9 T. The bridge excitation and detection are provided by commercial instrumentation. The implemented bridge is applied to the calibration of a standard resistor (NIST SP036) with a nominal value of 12 906 Ω operating in a temperature-controlled oil bath at 25 °C, obtaining a relative uncertainty of about 6×10^{-9}. This level of uncertainty is comparable to that of cryogenic current comparator bridges, but the quantum Hall Kelvin bridge can be implemented in a single cryogenic environment, possibly in a small-size dry cryocooler. The above result is validated by comparison with a calibration of SP036 performed with a cryogenic current comparator against a 100 Ω standard resistor, in turn calibrated against a GaAs quantum Hall resistance standard.

The measurement model of the Kelvin bridge and the detailed uncertainty budget are presented and discussed. We also discuss the extension of the Kelvin bridge to the calibration of standard resistors with, for instance, decadal resistance values by using quantum Hall array resistance standards.

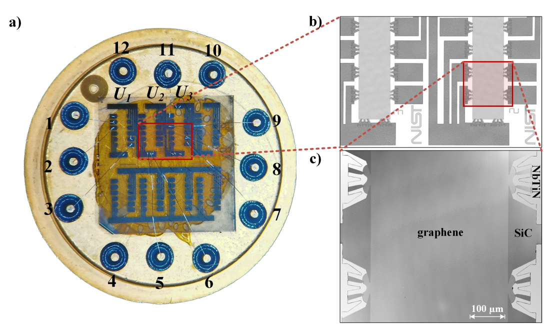

Figure 1. Photograph of the device (a) with details of the superconducting crossover-free series connection (b,c).

[1] M. Marzano et al., "A quantum Hall effect Kelvin bridge for resistance calibration," in *Conference on Precision Electromagnetic Measurements*, Paris (2018).