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23 November 2017

Quantised Hall Standard Resistor

Serial No. 1794-16-11

for

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Quantised Hall Standard Resistor
Serial No. 1794-16-11

This resistor is constructed from a chip of GaAs/AlGaAs heterostructure wafer with annealed tin ball contacts. It is mounted on a plastic header using epoxy, and the ball contacts are connected to the header pins using 2 mil gold wire, wedge-bonded in place. The device requires careful mechanical and electrical handling as it is easily damaged. It must be kept dry at all times, as moisture on the surface can lead to the formation of etch pits which are known to degrade the device performance. This must be taken into account particularly during removal of the device from the cryostat. A schematic of the device is illustrated in Figure 1.

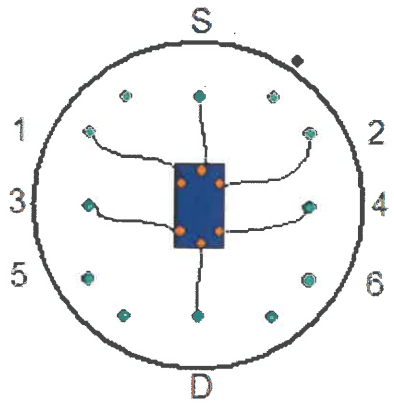

Figure 1. Schematic of the Quantised Hall Standard Resistor, sample 1794-16-11.

There are six wire bonds to the device. In use the current is normally fed through the source and drain contacts (S and D) and the Hall and longitudinal contacts are used for the potential measurements. The device has been tested with this in mind.

The orientation is referenced to a mark on black ink on the edge of the header in the "top right" position. The numbering scheme shown for the contacts is that used at NRC. On this device only S and D and potential contacts 1,2,3,4 are connected to header pins. The rest of the pins are open circuit.

The device was been tested in the laboratories of the Electrical Standards Team, Measurement Science and Standards in Ottawa, in September 2017. During the test it was cooled in zero magnetic field over several hours to approximately 1.3

K, in pumped ^{4}He. The magnetic field was then swept to 8.3 T at a rate of 0.25 T per minute, whilst measuring the Hall voltages $V_{xy\ 1\text{-}2}$ and $V_{xy\ 3\text{-}4}$ and the longitudinal voltages $V_{xx\ 1\text{-}3}$ and $V_{xx\ 2\text{-}4}$. The data from this device is shown on Figure 2.

The data obtained as described was then used to locate the approximate center of the $i = 2$ plateau, 7.62 T in this case. Users should note that since magnetic fields are in general not precisely calibrated, and since the carrier density may fluctuate a little with cool-down, the plateau field center must be determined each time the device is cooled.

With the magnetic field set for the $i = 2$ plateau center the contact resistance for all contacts was checked to be less than 0.3 Ω. In the case of the contacts S and D this was done at a current of 77 μA, and for the other four at a current of 20 μA.

A 77 μA current was supplied between S and D while measurements were made of the longitudinal resistance R_{xx} between contacts 1-3 and then 2-4 using an EM N11 nanovoltmeter. In each case the value of R_{xx} was found to be $< 3 \times 10^{-9}\ R_H$, where R_H is the Hall resistance on the $i = 2$ plateau.

It is considered that these tests show this device to be suitable for use as a Quantised Hall resistance standard at a temperature of approximately 1.3 K and at currents up to 77 μA. However, because of the way in which the two-dimensional electron gas reforms during each cool-down, and because the device may be subject to long-term degradation over which we have no control, NRC cannot guarantee that on each cool-down the device will behave exactly as described here. When used as a resistance standard for metrological purposes it is essential that the user verify, on each occasion, plateau center, contact resistance and longitudinal resistance, and check that the R_H values are the same for the two possible Hall resistance measurements.

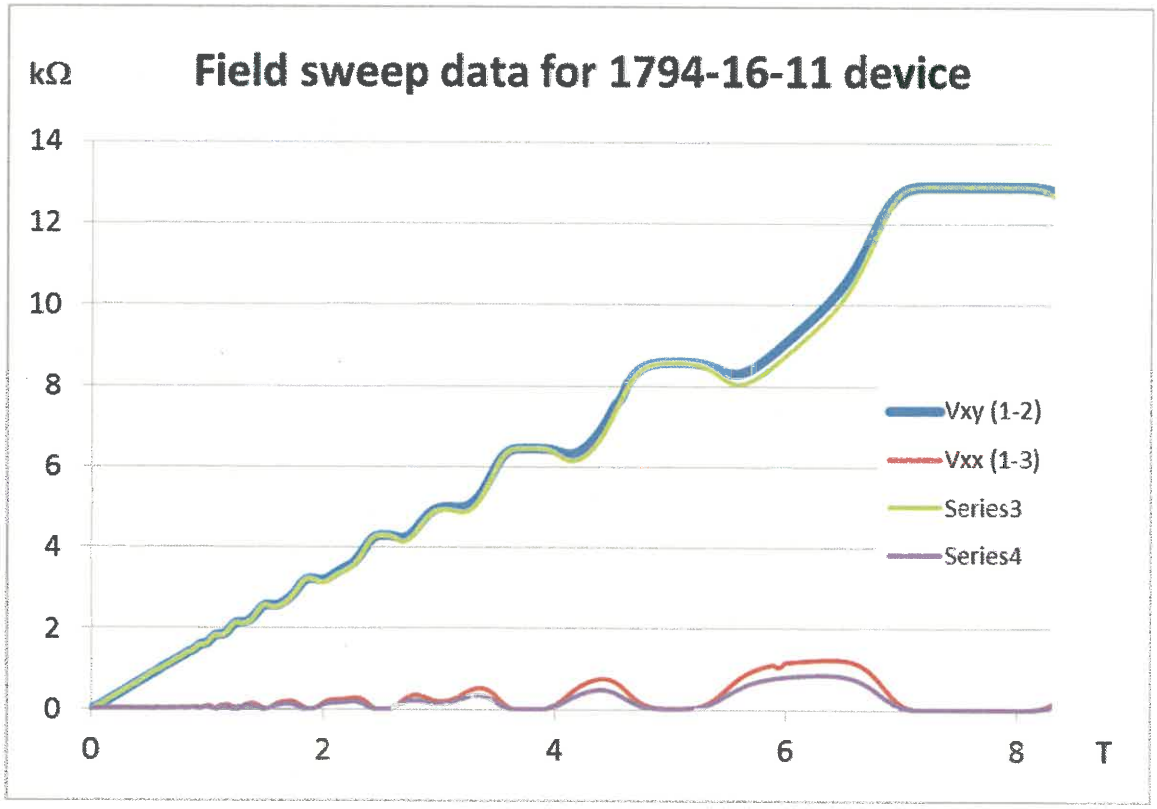

Figure 2. Field sweep for 1794-16-11, at approximately 1.3 K. Field is swept at 0.25 T min^{-1}.