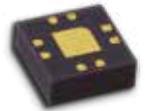


Towards fault tolerant quantum computing with precision magnetic sensing

3-axis magnetic sensor for cryogenic temperatures

As quantum computing advances beyond 1,000 qubits, continuous monitoring of an increasingly complex environment at cryogenic temperature is critical. Paragraf can provide cryogenic magnetic field measurement solutions for error mitigation on the path to fault tolerance. Graphene-based Hall effect sensors (GHS) can be used to map and verify shielding integrity at multiple points in dilution refrigerators to ensure no unexpected magnetic fields impact qubit operations. The presence of these sensors can identify damage caused to shields during maintenance, and eliminate guesswork:

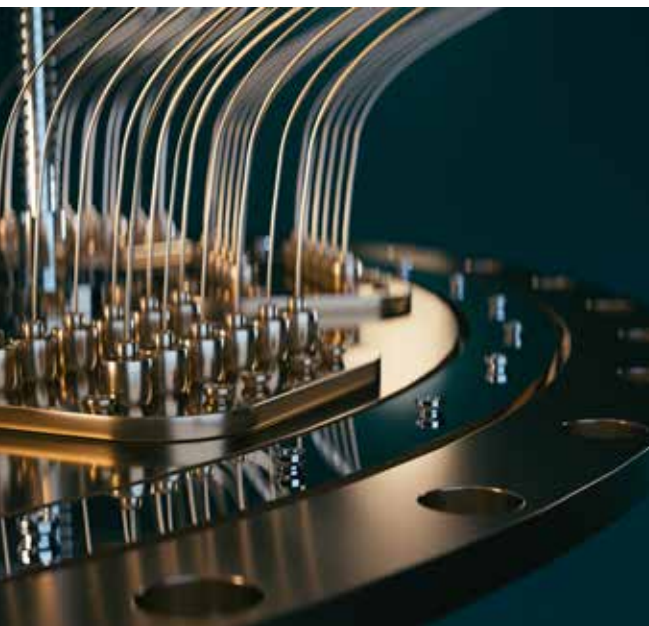
- Real-time continuous or pulse magnetic field measurement from room temp down to 10 mK with minimal impact on the cold-bore environment.
- High-sensitivity, 3-axis, pin-point measurements with $\sim 1 \text{ mm}^3$ sensing volume enabling close-proximity measurement to quantum processing unit (QPU) within the magnetic shielding cylinder.



Graphene Hall sensor (GHS)



3-axis probe with 3 x GHS



- Precision magnetic field measurements in close proximity to the QPU
- Multiple sensors map magnetic fields inside shielding
- Magnetic field mapping along cylindrical shielding could enable new QPU placement options
- Purpose-built data acquisition unit
- Sensor die available for more flexible integration options (e.g. measurement closer to QPU)

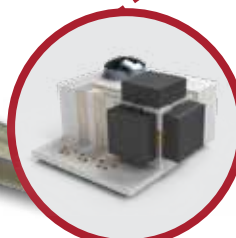
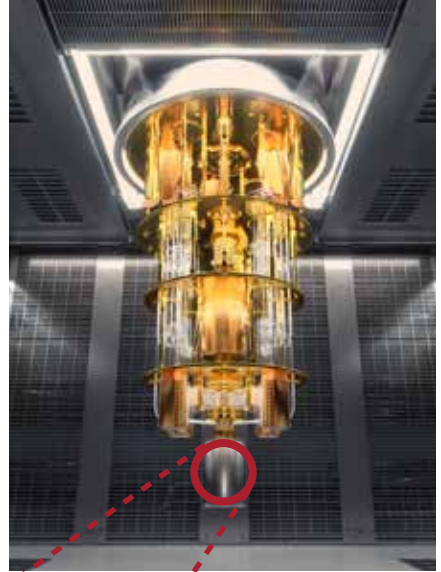
Complete magnetic field measurement system

The MiST (Multi Sensor Test Unit) has been purpose built for our sensors, allowing easy tuning of data acquisition and signal processing.

The MiST provides an easy, intuitive way to measure and log magnetic field fluctuations wherever the sensors are placed.

Key features of Paragraf's 3-axis probe:

- Operating from room temperature down to 10 mK in the cold bore
- Power dissipation <math>< 1 \mu\text{W}</math>
- Sensitivity > 800 V/AT
- Probe package size <math>< 10.3 \times 5.7 \times 10 \text{ mm}</math>



Set-up showing position of 3-axis probe in a dilution refrigerator, with data collected by Paragraf MiST.



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