TOWARDS SCALABLE READOUT IC‘S FOR SEMICONDUCTOR QUANTUM DOTS

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1. INTRODUCTION

- Trade-of between power and sensitivity
  → higher scalability means lower sensitivity
  → Develop new multiplexing techniques
- Pay for scalability by sensitivity
  → OK, if readout fidelity > qubit fidelity

TWO OPERATING MODES:

HIGH SPEED, LOW RESOLUTION (OPERATION):
- 1-bit output to detect $|1\rangle$ and $|0\rangle$
- Short readout maximizes number of operations
- Read a large number of qubits simultaneously

LOW SPEED, HIGH RESOLUTION (TUNING):
- RT ADC for high resolution digitization
- Cryogenic transimpedance amplifier to minimize noise
- Slow time-multiplexed readout

2. CONCEPT

CORRELATED DOUBLE SAMPLING

- Lower temperature → increase of 1/f noise
- Cancelling of low-frequency-noise required

OPERATION

1. Reference sample while quantum dot is an defined state
2. quantum dot operations
3. If required: spin-to-charge conversion
4. Second sample of all quantum dots simultaneously (signal-level depends on final state)
5. Compare both samples
6. If difference greater than comparator threshold → positive output → $|1\rangle$
7. Repeat procedure

MEASUREMENTS – ANALOG READOUT

LOW SPEED, HIGH RESOLUTION (TUNING):

Input Referred Noise:	188 pA RMS (Integrated 10 Hz to 1MHz)
Analog Power:	183 µW
Temperature:	6 K

MEASUREMENTS – 1-BIT READOUT

HIGH SPEED, LOW RESOLUTION (OPERATION):

Digital Power:	41 µW
Analog Power:	33.6 µW / SET
Input Referred Noise:	223 pA RMS @ 1µs Sample Time
Temperature:	6 K

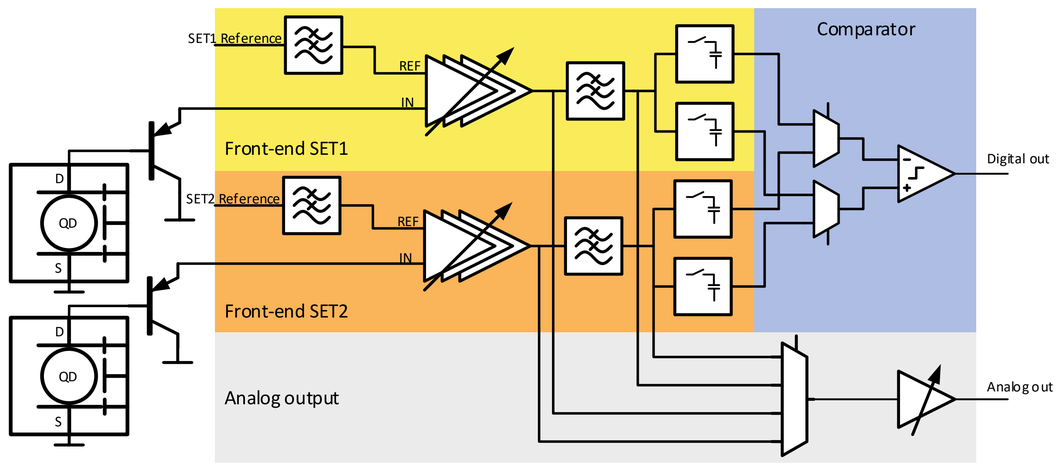

Fig. 1: Simplified block level schematic of QuoccaSET ES1 for readout of two SETs

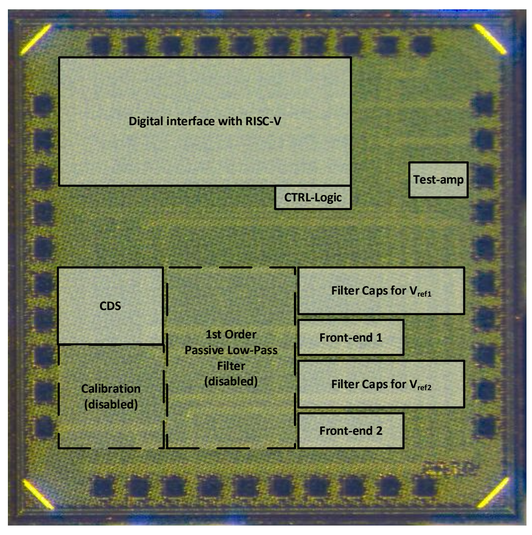

Fig. 2: DIE-shot of the Quocca.SET IC without bond-wires. Size is 1.25 x 1.25 mm².

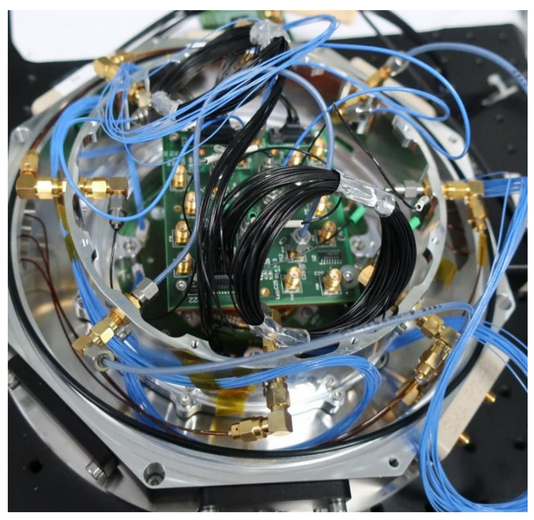

Fig. 3: Measurement setup for characterizing Quocca.SET at 10K inside attocube’s attoDRY800xs

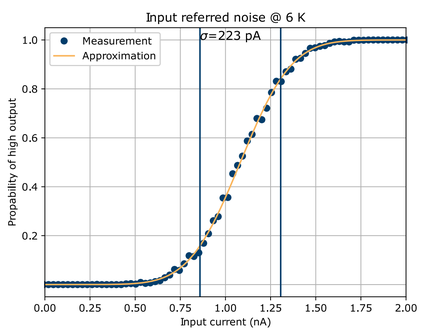

Fig. 4: Measurement of input referred noise at 6 K for 1-bit readout

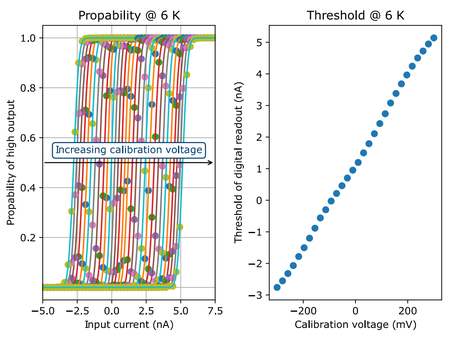

Fig. 5: Measurement of SET‘s offset calibration at 6 K

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