Breaking the Linearity Barrier: The bi-SQUIPT from Concept to Quantum-Ready Device

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Abstract: We present the bi-SQUIPT, a superconducting flux-to-voltage transducer with an intrinsically linear response. Its differential dual-loop design suppresses nonlinearities, achieving up to 60 dB SFDR with ultralow power for scalable, high-performance cryogenic quantum electronics.

Superconducting interferometers are the workhorses of ultra-sensitive magnetometry and cryogenic signal processing, but their full potential is held back by one key flaw: a highly nonlinear flux-to-voltage response. This work introduces a new theoretical concept [1] designed to break that limitation at its root: the bi-SQUIPT, an intrinsically linear flux-to-voltage transducer. The bi-SQUIPT builds on the superconducting quantum interference proximity transistor (SQUIPT), where magnetic flux reshapes the quasiparticle density of states in a proximitized weak link via the superconducting proximity effect. By coupling two SQUIPT elements in a dual-loop, three-terminal, differentially read-out configuration, the bi-SQUIPT cancels nonlinear terms directly at the device level. The resulting transfer function is predicted to be clean and quasi-triangular, delivering a spurious-free dynamic range (SFDR) approaching ~60 dB [1], while maintaining ultra-low power dissipation and robust performance against fabrication spread.

The follow-up experimental work reports the first realization of this concept and confirms the proposed linearization mechanism [2]. The fabricated Al/Cu hybrid bi-SQUIPT (see Fig. 1) shows a voltage swing of about 120 µV and an SFDR up to 60 dB, fully consistent with theory. Crucially, the differential architecture suppresses nonlinearities without relying on external feedback schemes such as flux-locked loops, simplifying circuitry and preserving bandwidth. Operating at femtowatt-level power dissipation and remaining stable up to ~600 mK [2], the bi-SQUIPT is tailored for scalable cryogenic quantum electronics. Together, these results position the bi-SQUIPT as a powerful platform for next-generation superconducting transducers that are simultaneously low-noise, low-dissipation, and highly linear, bringing SQUID-class sensitivity closer to the scalability requirements of emerging quantum technologies.

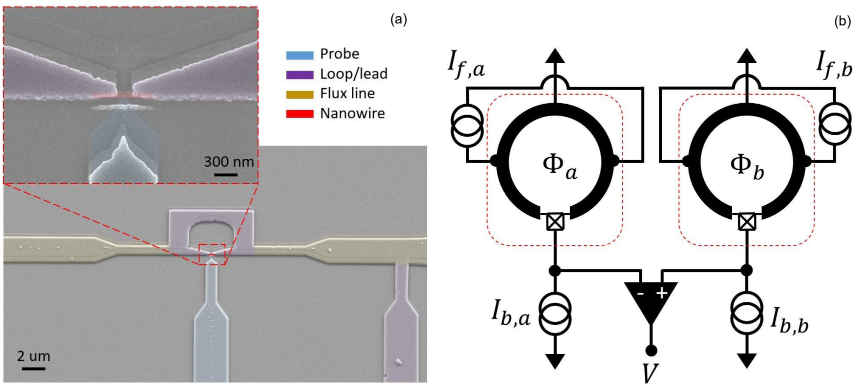

Fig. 1 (a) False-color micrograph of a superconducting quantum interference proximity transistor (SQUIPT) showing a tunnel-probe electrode (blue), magnetic flux lines (yellow), a superconducting loop and ground electrode (purple), and a proximitized nanowire (red). (b) Circuit schematic of a bi-SQUIPT, where two SQUIPTs are connected in parallel, grounding the loop and allowing measurement of the voltage difference between their tunnel probes.

References

[1] G. De Simoni and F. Giazotto, “Ultra linear magnetic flux-to-voltage conversion in superconducting quantum interference proximity transistors”, Phys. Rev. Applied 19, 054021 (2023).

[2] A. Greco, G. De Simoni, and F. Giazotto, “Highly-linear flux-to-voltage transducer based on superconducting quantum interference proximity transistors”, arXiv:2602.24075 (submitted, 2026).