

## Self shunted flux type superconducting quantum circuit element

Realization of high performance, highly integrated quantum computer by increased coherence time, anharmonicity, and reduced footprint of qubit

### Overview

The superconducting quantum bit is composed of a single or multiple superconducting tunnel junctions (Josephson junctions). Research and development of typical charge type and magnetic flux type qubits are active. The current mainstream of high integration is Transmon, a modified version of the charge type, which has advantage of long coherence time, but has disadvantage of small anharmonicity, which can cause error. On the other hand, the magnetic flux type has advantage of large anharmonicity, but has disadvantage of short coherence time. Adding a shunt capacitor to increase coherence time causes increased footprint (the area occupied by a single qubit).

This invention solves above problem, and it is about a technology that can achieve high integration with a small footprint while maintaining a practically tolerable coherence time and anharmonicity.

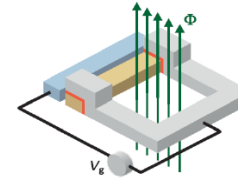
### Product Application

- High performance and highly integrated quantum computer (quantum gate method, quantum annealing method)

### IP Data

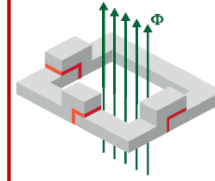
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Charge type  
(Transmon)



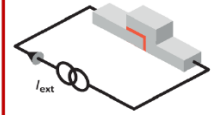
- Current mainstream type
- Leakage, etc. due to small anharmonicity

Magnetic flux type



- High anharmonicity
- Improved coherence time/yield due to capacitor shunting

Phase type



### Increased anharmonicity, reduced footprint, excellent noise tolerance

#### Designed models by full Hamiltonian

This invention	Model	$f_{01}$ [GHz]	$f_{\text{anharm}}$ [MHz]	Shunt capacitor	Anharmonicity (larger is better)  The rest of this table is unpublished as the application is not yet publicly available. Technical information and commercialization opportunities are available after concluding a contract that includes a confidentiality clause.
	SSFQ-A	4.3	403	0	
	SSFQ-B	3.3	1049	0	
	SSFQ-C	4.2	606	0	
	C-shunt [1]	4.3	830	200x300 $\mu\text{m}^2$	
	Mergemon [2,3]	4-5	200-400	0	

[1] F. Yan *et al.*, *Nat. Commun.* **7**, 12964 (2016).

[2] R. Zhao *et al.*, *Phys. Rev. Appl.* **14**, 064006 (2020).

[3] H. J. Mamin *et al.*, *Phys. Rev. Appl.* **16**, 024023 (2021).

### Related Works

<https://www.youtube.com/watch?v=MrAq03tHtoM&list=TLGGLIs3opvq4UQxNjA2MjAyMw&t=851s>

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