

CLAIMS

1. A device, comprising:
 - a superconducting bus resonator;
 - a first superconducting qubit; and
 - a second superconducting qubit, the first superconducting qubit and the second superconducting qubit respectively comprising:
 - a first superconducting pad;
 - a second superconducting pad;
 - a third superconducting pad;
 - a first Josephson Junction coupled to the first superconducting pad and the second superconducting pad; and
 - a second Josephson Junction coupled to the second superconducting pad and the third superconducting pad, wherein the first superconducting pad and the second superconducting pad of the first superconducting qubit and the second superconducting qubit are coupled to the superconducting bus resonator, and wherein the superconducting bus resonator entangles the first superconducting qubit and the second superconducting qubit based on receiving a control signal.
2. The device of any one of the preceding claims, wherein the first superconducting qubit operates in a first oscillating mode and a second oscillating mode.
3. The device of any one of the preceding claims, wherein the second superconducting qubit operates in a first oscillating mode and a second oscillating mode.
4. The device of any one of the preceding claims, wherein at least one of the first superconducting qubit or the second superconducting qubit comprises at least one of a tunable coupler qubit, a two junction qubit, a multimode qubit, a multimode two junction qubit, or a tunable qubit.
5. The device of any one of the preceding claims, wherein the first superconducting pad and the second superconducting pad of the first superconducting qubit and the second superconducting qubit are coupled to the superconducting bus resonator to suppress ZZ interactions between the first superconducting qubit and the second superconducting qubit and to reduce energy loss associated with the superconducting bus resonator, thereby facilitating at least one of: reduced quantum gate errors associated with at least one of the first superconducting

qubit or the second superconducting qubit; increased speed of a quantum gate comprising the first superconducting qubit and the second superconducting qubit; or at least one of improved fidelity, improved accuracy, or improved performance of a quantum processor comprising the device.

6. A computer-implemented method, comprising:
encoding, by a system operatively coupled to a processor, quantum information in a first oscillating mode of a first superconducting qubit and a second superconducting qubit; and
coupling, by the system, a superconducting bus resonator to an oscillating mode structure corresponding to a second oscillating mode of the first superconducting qubit and the second superconducting qubit.
7. The computer-implemented method of claim 6, wherein the first superconducting qubit operates in the first oscillating mode and the second oscillating mode.
8. The computer-implemented method of any one of claims 6 to 7, wherein the second superconducting qubit operates in the first oscillating mode and the second oscillating mode.
9. The computer-implemented method of any one of claims 6 to 8, wherein at least one of the first superconducting qubit or the second superconducting qubit comprises at least one of a tunable coupler qubit, a two junction qubit, a multimode qubit, a multimode two junction qubit, or a tunable qubit.
10. The computer-implemented method of any one of claims 6 to 9, further comprising:
encoding, by the system, the quantum information in the first oscillating mode of the first superconducting qubit and the second superconducting qubit; and
coupling, by the system, the superconducting bus resonator to the oscillating mode structure corresponding to the second oscillating mode of the first superconducting qubit and the second superconducting qubit to suppress ZZ interactions between the first superconducting qubit and the second superconducting qubit and to reduce energy loss associated with the superconducting bus resonator, thereby facilitating at least one of: reduced quantum gate errors associated with at least one of the first superconducting qubit or the second superconducting qubit; increased speed of a quantum gate comprising the first superconducting qubit and the second superconducting qubit; or at least one of improved fidelity, improved accuracy, or

improved performance of a quantum processor comprising the first superconducting qubit, the second superconducting qubit, and the superconducting bus resonator.

11. A device, comprising:
 - a superconducting bus resonator;
 - a first superconducting qubit; and
 - a second superconducting qubit, the first superconducting qubit and the second superconducting qubit respectively comprising:
 - a first superconducting pad;
 - a second superconducting pad;
 - a third superconducting pad;
 - a first Josephson Junction coupled to the first superconducting pad and the second superconducting pad; and
 - a second Josephson Junction coupled to the second superconducting pad and the third superconducting pad, wherein the second superconducting pad of the first superconducting qubit and the second superconducting qubit is coupled to the superconducting bus resonator, and wherein the superconducting bus resonator entangles the first superconducting qubit and the second superconducting qubit based on receiving a control signal.
12. The device of claim 11, wherein the first superconducting qubit operates in a first oscillating mode and a second oscillating mode.
13. The device of any one of claims 11 to 12, wherein the second superconducting qubit operates in a first oscillating mode and a second oscillating mode.
14. The device of any one of claims 11 to 13, wherein at least one of the first superconducting qubit or the second superconducting qubit comprises at least one of a tunable coupler qubit, a two junction qubit, a multimode qubit, a multimode two junction qubit, or a tunable qubit.
15. The device of any one of claims 11 to 14, wherein the second superconducting pad of the first superconducting qubit and the second superconducting pad of the second superconducting qubit are coupled to the superconducting bus resonator to suppress ZZ interactions between the first superconducting qubit and the second superconducting qubit and to reduce energy loss associated with the superconducting bus resonator, thereby facilitating at least one of: reduced

quantum gate errors associated with at least one of the first superconducting qubit or the second superconducting qubit; increased speed of a quantum gate comprising the first superconducting qubit and the second superconducting qubit; or at least one of improved fidelity, improved accuracy, or improved performance of a quantum processor comprising the device.

16. A computer-implemented method, comprising:
encoding, by a system operatively coupled to a processor, quantum information in a data mode of a first superconducting qubit and a second superconducting qubit; and
coupling, by the system, a superconducting bus resonator to a coupling mode structure corresponding to a coupling mode of the first superconducting qubit and the second superconducting qubit.
17. The computer-implemented method of claim 16, wherein the first superconducting qubit operates in the data mode and the coupling mode.
18. The computer-implemented method of any one of claims 16 to 17, wherein the second superconducting qubit operates in the data mode and the coupling mode.
19. The computer-implemented method of any one of claims 16 to 18, wherein at least one of the first superconducting qubit or the second superconducting qubit comprises at least one of a tunable coupler qubit, a two junction qubit, a multimode qubit, a multimode two junction qubit, or a tunable qubit.
20. The computer-implemented method of any one of claims 16 to 19, further comprising:
encoding, by the system, the quantum information in the data mode of the first superconducting qubit and the second superconducting qubit; and
coupling, by the system, the superconducting bus resonator to the coupling mode structure corresponding to the coupling mode of the first superconducting qubit and the second superconducting qubit to suppress ZZ interactions between the first superconducting qubit and the second superconducting qubit and to reduce energy loss associated with the superconducting bus resonator, thereby facilitating at least one of: reduced quantum gate errors associated with at least one of the first superconducting qubit or the second superconducting qubit; increased speed of a quantum gate comprising the first superconducting qubit and the second superconducting qubit; or at least one of improved fidelity, improved accuracy, or improved performance of a

quantum processor comprising the first superconducting qubit, the second superconducting qubit, and the superconducting bus resonator.

21. A device, comprising:

a first superconducting qubit and a second superconducting qubit that operate in a first oscillating mode; and

a superconducting bus resonator coupled to an oscillating mode structure corresponding to a second oscillating mode of the first superconducting qubit and the second superconducting qubit.

22. The device of claim 21, wherein at least one of the first superconducting qubit or the second superconducting qubit comprises at least one of a tunable coupler qubit, a two junction qubit, a multimode qubit, a multimode two junction qubit, or a tunable qubit.

23. The device of any one of claims 21 to 22, wherein the first oscillating mode and the second oscillating mode are indicative of symmetric and antisymmetric combinations of excitations associated with a first Josephson Junction and a second Josephson Junction of the first superconducting qubit and the second superconducting qubit.

24. The device of any one of claims 21 to 23, wherein at least one of the first oscillating mode or the second oscillating mode comprise at least one of a data mode or a coupling mode.

25. The device of any one of claims 21 to 24, wherein the first superconducting qubit and the second superconducting qubit operate in the first oscillating mode and the superconducting bus resonator is coupled to the oscillating mode structure corresponding to the second oscillating mode to suppress ZZ interactions between the first superconducting qubit and the second superconducting qubit and to reduce energy loss associated with the superconducting bus resonator, thereby facilitating at least one of: reduced quantum gate errors associated with at least one of the first superconducting qubit or the second superconducting qubit; increased speed of a quantum gate comprising the first superconducting qubit and the second superconducting qubit; or at least one of improved fidelity, improved accuracy, or improved performance of a quantum processor comprising the device.