CLAIMS

1. A device, comprising:

a coupler device that operates in a first oscillating mode and a second oscillating mode;

a first superconducting qubit coupled to the coupler device based on a first oscillating mode structure corresponding to the first oscillating mode and based on a second oscillating mode structure corresponding to the second oscillating mode, 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 coupler device; and

a second superconducting qubit coupled to the coupler device based on the first oscillating mode structure and the second oscillating mode structure,

wherein the first superconducting qubit and the second superconducting qubit have an equal exchange coupling with the first oscillating mode structure and the second oscillating mode structure based on a critical current of the coupler device, and wherein the equal exchange coupling suppresses ZZ interactions between the first superconducting qubit and the second superconducting qubit over a defined range of qubit frequencies.

2. The device of claim 1, wherein at least one of the first superconducting qubit or the second superconducting qubit comprises at least one of a transmon qubit, a fixed frequency qubit, or a fixed frequency transmon qubit.

3. The device of any one of the preceding claims, wherein the coupler device comprises at least one of a two junction qubit, a fixed frequency coupler, a multimode two junction coupler, a flux tunable coupler, a tunable coupler qubit, a flux tunable coupler qubit, a tunable qubit, a tunable bus, or a flux tunable qubit bus.

4. The device of any one of the preceding claims, wherein the equal exchange coupling facilitates 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.

5. A computer-implemented method, comprising:

generating, by a system operatively coupled to a processor, an exchange coupling of a first superconducting qubit and a second superconducting qubit with a first oscillating mode structure and a second oscillating mode structure of a coupler device, wherein the first oscillating mode structure and the second oscillating mode structure respectively correspond to a first oscillating mode and a second oscillating mode of the coupler device, and 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 coupler device;

producing, by the system, an entangling quantum gate between the first superconducting qubit and the second superconducting qubit; and

generating, by the system, an equal exchange coupling of the first superconducting qubit and the second superconducting qubit with the first oscillating mode structure and the second oscillating mode structure to suppress ZZ interactions between the first superconducting qubit and the second superconducting qubit over a defined range of qubit frequencies.

6. The computer-implemented method of claim 5, wherein at least one of the first superconducting qubit or the second superconducting qubit comprises at least one of a transmon qubit, a fixed frequency qubit, or a fixed frequency transmon qubit.

7. The computer-implemented method of any one of claims 5 to 6, wherein the coupler device comprises at least one of a two junction qubit, a fixed frequency coupler, a multimode two junction coupler, a flux tunable coupler, a tunable coupler qubit, a flux tunable coupler qubit, a tunable qubit, a tunable bus, or a flux tunable qubit bus.

8. The computer-implemented method of any one of claims 5 to 7,

wherein the generating, by the system, an equal exchange coupling of the first superconducting qubit and the second superconducting qubit with the first oscillating mode structure and the second oscillating mode structure facilitates 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 coupler device, the first superconducting qubit, and the second superconducting qubit.

9. A device, comprising:

a coupler device that operates in a first oscillating mode and a second oscillating mode that are indicative of symmetric and antisymmetric combinations of excitations associated with a Josephson Junction and a flux controlled qubit device of the coupler device;

a first superconducting qubit coupled to the coupler device based on a first oscillating mode structure corresponding to the first oscillating mode and based on a second oscillating mode structure corresponding to the second oscillating mode; and

a second superconducting qubit coupled to the coupler device based on the first oscillating mode structure and the second oscillating mode structure,

wherein the first superconducting qubit and the second superconducting qubit have an equal exchange coupling with the first oscillating mode structure and the second oscillating mode structure based on a critical current of the coupler device, and wherein the equal exchange coupling suppresses ZZ interactions between the first superconducting qubit and the second superconducting qubit over a defined range of qubit frequencies.

10. The device of claim 9, wherein at least one of the first superconducting qubit or the second superconducting qubit comprises at least one of a transmon qubit, a fixed frequency qubit, or a fixed frequency transmon qubit.

11. The device of any one of claims 9 to 10, wherein the coupler device comprises at least one of a two junction qubit, a fixed frequency coupler, a multimode two junction coupler, a flux tunable coupler, a tunable coupler qubit, a flux tunable coupler qubit, a tunable qubit, a tunable bus, or a flux tunable qubit bus.

12. The device of any one of claims 9 to 11, wherein the flux controlled qubit device comprises a superconducting quantum interference device loop.

13. The device of any one of claims 9 to 12, wherein the equal exchange coupling facilitates 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.

14. A device, comprising:

a first superconducting qubit;

a second superconducting qubit; and

a coupler device that operates in a first oscillating mode and a second oscillating mode and that comprises:

a first superconducting pad coupled to the first superconducting qubit;

a second superconducting pad coupled to the second superconducting qubit; and

a third superconducting pad coupled to the first superconducting qubit,

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 coupler device,

wherein the first superconducting pad and the third superconducting pad are coupled to the first superconducting qubit based on a first oscillating mode structure corresponding to the first oscillating mode and the second superconducting pad is coupled to the second superconducting qubit based on a second oscillating mode structure corresponding to the second oscillating mode to reduce a direct exchange coupling between the first superconducting qubit and the second superconducting qubit and to suppress ZZ interactions between the first superconducting qubit and the second superconducting qubit.

15. The device of claim 14, wherein at least one of the first superconducting qubit or the second superconducting qubit comprises at least one of a transmon qubit, a fixed frequency qubit, or a fixed frequency transmon qubit.

16. The device of any one of claims 14 to 15, wherein the coupler device comprises at least one of a two junction qubit, a fixed frequency coupler, a multimode two junction coupler, a flux tunable coupler, a tunable coupler qubit, a flux tunable coupler qubit, a tunable qubit, a tunable bus, or a flux tunable qubit bus.

17. The device of any one of claims 14 to 16, wherein the coupling of the first superconducting pad and the third superconducting pad to the first superconducting qubit and

the coupling of the second superconducting pad to the second superconducting qubit facilitates 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.

18. A computer-implemented method, comprising:

coupling, by a system operatively coupled to a processor, a first superconducting qubit to a first oscillating mode structure corresponding to a first oscillating mode of a coupler device;

coupling, by the system, a second superconducting qubit to a second oscillating mode structure corresponding to a second oscillating mode of the coupler device, 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 coupler device; and

detuning, by the system, the coupler device from the first oscillating mode or the second oscillating mode; and

coupling, by the system, the first superconducting qubit to the first oscillating mode structure and the second superconducting qubit to the second oscillating mode structure to reduce a direct exchange coupling between the first superconducting qubit and the second superconducting qubit and to suppress ZZ interactions between the first superconducting qubit and the second superconducting qubit.

19. The computer-implemented method of claim 18, wherein at least one of the first superconducting qubit or the second superconducting qubit comprises at least one of a transmon qubit, a fixed frequency qubit, or a fixed frequency transmon qubit.

20. The computer-implemented method of any one of claims 18 to 19, wherein the coupler device comprises at least one of a two junction qubit, a fixed frequency coupler, a multimode two junction coupler, a flux tunable coupler, a tunable coupler qubit, a flux tunable coupler qubit, a tunable qubit, a tunable bus, or a flux tunable qubit bus.

21. The computer-implemented method of any one of claims 18 to 20,

wherein the coupling, by the system, the first superconducting qubit to the first oscillating mode structure and the second superconducting qubit to the second oscillating mode structure facilitates 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 coupler device, the first superconducting qubit, and the second superconducting qubit.