CLAIMS

1. A quantum coupler device, comprising:

a tunable coupler coupled between terminals of a same polarity of a first qubit and a second qubit, the tunable coupler configured to control a first coupling between the first qubit and the second qubit;

a capacitor device coupled to terminals of an opposite polarity of the first qubit and the second qubit, the capacitor device configured to provide a second coupling that is opposite in sign relative to the first coupling; and

wherein the capacitor device provides the second coupling based on a resonant frequency of the tunable coupler being smaller than a resonant frequency of both the first qubit and the second qubit.

2. The quantum coupler device according to claim 1, wherein the tunable coupler comprises at least one of 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.

3. The quantum coupler device according to any of the preceding claims, wherein at least one of the first qubit or the second qubit comprises at least one of a fixed frequency qubit, a tunable qubit, a transmon qubit, a fixed frequency transmon qubit, or a tunable transmon qubit.

4. The quantum coupler device according to any of the preceding claims, wherein the capacitor device comprises at least one of a differential capacitor or a bypass capacitor.

5. A computer-implemented method of quantum coupling, comprising:

providing, by a system operatively coupled to a processor, a tunable coupling between terminals of a same polarity of a first qubit and a second qubit;

providing, by the system, a capacitive coupling between terminals of opposite polarity of the first qubit and the second qubit; and

tuning, by the system, a resonant frequency associated with the tunable coupling,

wherein the capacitive coupling generates a coupling that cancels the tunable coupling when the resonant frequency associated with the tunable coupling is smaller than a resonant frequency of both the first qubit and the second qubit.

6. The computer-implemented method according to the preceding claim, further comprising:

decoupling, by the system, the first qubit from the second based on the coupling that cancels the tunable coupling when the resonant frequency associated with the tunable coupling is smaller than the resonant frequency of both the first qubit and the second qubit.

7. The computer-implemented method according to any of the two preceding claims, further comprising:

eliminating, by the system, coherent rotations on at least one of the first qubit or the second qubit based on the coupling that cancels the tunable coupling when the resonant frequency associated with the tunable coupling is smaller than the resonant frequency of both the first qubit and the second qubit, thereby facilitating at least one of: reduced quantum gate errors associated with at least one of the first qubit or the second qubit; increased speed of a quantum gate comprising the first qubit and the second qubit; improved performance of a quantum processor; or improved fidelity of the quantum processor.

8. The computer-implemented method according to any of the three preceding claims, wherein at least one of the first qubit or the second qubit comprises at least one of a fixed frequency qubit, a tunable qubit, a transmon qubit, a fixed frequency transmon qubit, or a tunable transmon qubit.

9. A quantum coupler device, comprising:

a tunable coupler coupled between a first qubit and a second qubit; and

a capacitor device coupled between the first qubit and the second qubit,

wherein the capacitor device generates a coupling that is opposite in sign to a coupling from the tunable coupler based on a resonant frequency of the tunable coupler being smaller than a resonant frequency of both the first qubit and the second qubit.

10. The quantum coupler device according to the preceding claim, wherein the capacitor device comprises a first terminal and a second terminal, the first terminal and the second terminal cross coupled between the first qubit and the second qubit, and wherein the tunable coupler is directly coupled between the first qubit and the second qubit.

11. The quantum coupler device according to any of the two preceding claims, wherein the tunable coupler is coupled between terminals of a same polarity of the first qubit and the second qubit, and wherein the tunable coupler is configured to control a coupling between the first qubit and the second qubit.

12. The quantum coupler device according to any of the three preceding claims, wherein:

the tunable coupler is coupled between terminals of a same polarity of the first qubit and the second qubit;

the tunable coupler is configured to control a first coupling between the first qubit and the second qubit;

the capacitor device is coupled to terminals of an opposite polarity of the first qubit and the second qubit; and

the capacitor device is configured to provide a second coupling that is opposite in sign relative to the first coupling.

13. The quantum coupler device according to the preceding claim, wherein the tunable coupler is configured to control the first coupling and the capacitor device is configured to provide the second coupling to eliminate coherent rotations between the first qubit and the second qubit, thereby facilitating at least one of: reduced quantum gate errors associated with at least one of the first qubit or the second qubit; increased speed of a quantum gate comprising the first qubit and the second qubit; improved performance of a quantum processor comprising the quantum coupler device; or improved fidelity of the quantum processor comprising the quantum coupler device.

14. The quantum coupler device according to any of the preceding claims 9 to 13, wherein the tunable coupler comprises at least one of 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.

15. The quantum coupler device according to any of the preceding claims 9 to 14, wherein at least one of the first qubit or the second qubit comprises at least one of a fixed

frequency qubit, a tunable qubit, a transmon qubit, a fixed frequency transmon qubit, or a tunable transmon qubit.

16. The quantum coupler device according to any of the preceding claims 9 to 15, wherein the capacitor device comprises at least one of a differential capacitor or a bypass capacitor.

17. A device, comprising:

a first tunable coupler coupled between terminals of a same polarity of a first qubit and a second qubit, the first tunable coupler configured to control a first coupling between the first qubit and the second qubit;

a first capacitor device coupled to terminals of an opposite polarity of the first qubit and the second qubit, the first capacitor device configured to provide a second coupling that is opposite in sign relative to the first coupling;

a second tunable coupler coupled between terminals of a same polarity of the second qubit and a third qubit, the second tunable coupler configured to control a third coupling between the second qubit and the third qubit; and

a second capacitor device coupled to terminals of an opposite polarity of the second qubit and the third qubit, the second capacitor device configured to provide a fourth coupling that is opposite in sign relative to the third coupling.

18. The device according to the preceding claim, wherein the first capacitor device provides the second coupling based on a resonant frequency of the first tunable coupler being smaller than a resonant frequency of both the first qubit and the second qubit, and wherein the second capacitor device provides the fourth coupling based on a resonant frequency of the second tunable coupler being smaller than a resonant frequency of both the second qubit and the third qubit.

19. The device according to any of the two preceding claims, wherein the first tunable coupler or the second tunable coupler is configured to respectively control the first coupling or the third coupling and the first capacitor device or the second capacitor device is configured to respectively provide the second coupling or the fourth coupling to respectively eliminate coherent rotations between the first qubit and the second qubit or between the second qubit and the third qubit, thereby facilitating at least one of: reduced

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

20. The device according to any of the three preceding claims, wherein:

at least one of the first tunable coupler or the second tunable coupler comprises at least one of 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;

at least one of the first qubit, the second qubit, or the third qubit comprises at least one of a fixed frequency qubit, a tunable qubit, a transmon qubit, a fixed frequency transmon qubit, or a tunable transmon qubit; and

at least one of the first capacitor device or the second capacitor device comprises at least one of a differential capacitor or a bypass capacitor.

21. A computer-implemented method of quantum coupling, comprising:

providing, by a system operatively coupled to a processor, a first tunable coupling between terminals of a same polarity of a first qubit and a second qubit, and a second tunable coupling between terminals of a same polarity of the second qubit and a third qubit;

providing, by the system, a first capacitive coupling between terminals of opposite polarity of the first qubit and the second qubit, and a second capacitive coupling between terminals of opposite polarity of the second qubit and the third qubit; and

tuning, by the system, a first resonant frequency associated with the first tunable coupling, and a second resonant frequency associated with the second tunable coupling,

wherein the first capacitive coupling comprises a first coupling that cancels the first tunable coupling when the first resonant frequency is smaller than a third resonant frequency of both the first qubit and the second qubit, and wherein the second capacitive coupling comprises a second coupling that cancels the second tunable coupling when the second resonant frequency is smaller than a fourth resonant frequency of both the second qubit and the third qubit.

22. The computer-implemented method according to the preceding claim, further comprising:

decoupling, by the system, at least one of the first qubit from the second qubit or the second qubit from the third qubit based on at least one of the first tunable coupling or the second tunable coupling, respectively, wherein at least one of the first qubit, the second qubit, or the third qubit comprises at least one of a fixed frequency qubit, a tunable qubit, a transmon qubit, a fixed frequency transmon qubit, or a tunable transmon qubit.

23. The computer-implemented method according to any of the two preceding claims, further comprising:

eliminating, by the system, coherent rotations on at least one of the first qubit, the second qubit, or the third qubit based on at least one of the first tunable coupling or the second tunable coupling, thereby facilitating at least one of: reduced quantum gate errors associated with at least one of the first qubit, the second qubit, or the third qubit; increased speed of a quantum gate comprising the first qubit and the second qubit or the second qubit and the third qubit; improved performance of a quantum processor; or improved fidelity of the quantum processor.