CLAIMS

1. A device, comprising:

a control qubit coupled to a first mode-selective coupler and a second mode-selective coupler;

a first target qubit coupled to the first mode-selective coupler, wherein the first mode-selective coupler allows A-mode coupling between the control qubit and the first target qubit, and prevents B-mode coupling between the control qubit and the first target qubit; and

a second target qubit coupled to the second mode-selective coupler, wherein the second mode-selective coupler allows the B-mode coupling between the control qubit and the second target qubit, and prevents the A-mode coupling between the control qubit and the second target qubit.

2. The device according to claim 1, wherein the control qubit, the first target qubit, and the second target qubit are two-junction transmon qubits.

3. The device according to claim 2, wherein the first mode-selective coupler comprises a capacitor that capacitively couples a middle capacitor pad of the control qubit to a middle capacitor pad of the first target qubit.

4. The device according to claim 3, wherein the capacitor has a capacitance that is less than shunting capacitance values of the control qubit and less than shunting capacitance values of the first target qubit.

5. The device according to claim 2, wherein the second mode-selective coupler comprises a first capacitor that capacitively couples an end capacitor pad of the control qubit to an end capacitor pad of the second target qubit and comprises a second capacitor that capacitively couples the end capacitor pad of the control qubit to a middle capacitor pad of the second target qubit.

6. The device according to claim 5, wherein the first capacitor has a first capacitance that is less than shunting capacitance values of the control qubit and less than shunting capacitance values of the second target qubit, and wherein the second capacitor has a second capacitance that is half the first capacitance.

7. The device according to any of the preceding claims, wherein the first target qubit and the second target qubit are degenerate targets.

8. The device according to claim 7, wherein the first target qubit entangles with the control qubit when the control qubit is driven by a first microwave tone corresponding to an A-mode excitation frequency of the degenerate targets, and wherein the second target qubit entangles with the control qubit when the control qubit is driven by a second microwave tone corresponding to a B-mode excitation frequency of the degenerate targets.

9. A method, comprising:

providing a control qubit;

coupling the control qubit to a first target qubit by a first mode-selective coupler that allows A-mode coupling between the control qubit and the first target qubit, and prevents B-mode coupling between the control qubit and the first target qubit; and

coupling the control qubit to a second target qubit by a second mode-selective coupler that allows the B-mode coupling between the control qubit and the second target qubit, and prevents the A-mode coupling between the control qubit and the second target qubit, wherein the second mode-selective coupler couples an end capacitor pad of the control qubit to a middle capacitor pad of the second target qubit.

10. The method according to claim 9, wherein the control qubit, the first target qubit, and the second target qubit are two-junction transmon qubits.

11. The method according to claim 10, wherein the first mode-selective coupler comprises a capacitor that capacitively couples a middle capacitor pad of the control qubit to a middle capacitor pad of the first target qubit.

12. The method according to claim 11, wherein the capacitor has a capacitance that is less than shunting capacitance values of the control qubit and less than shunting capacitance values of the first target qubit.

13. The method according to claim 10, wherein the second mode-selective coupler comprises a first capacitor that capacitively couples an end capacitor pad of the control qubit to an end capacitor pad of the second target qubit and comprises a second capacitor that capacitively couples the end capacitor pad of the control qubit to a middle capacitor pad of the

second target qubit.

14. The method according to claim 13, wherein the first capacitor has a first capacitance that is less than shunting capacitance values of the control qubit and less than shunting capacitance values of the second target qubit, and wherein the second capacitor has a second capacitance that is half the first capacitance.

15. The method according to any of the preceding claims 9 to 14, wherein the first target qubit and the second target qubit are degenerate targets.

16. The method according to claim 15, further comprising:

driving the control qubit with a first microwave tone corresponding to an A-mode excitation frequency of the degenerate targets, thereby entangling the first target qubit with the control qubit; and

driving the control qubit with a second microwave tone corresponding to a B-mode excitation frequency of the degenerate targets, thereby entangling the second target qubit with the control qubit.

17. An apparatus, comprising:

a control qubit;

a first mode-selective coupler that allows A-mode coupling between the control qubit and a first target qubit, and prevents B-mode coupling between the control qubit and the first target qubit; and

a second mode-selective coupler that allows the B-mode coupling between the control qubit and a second target qubit, and prevents the A-mode coupling between the control qubit and the second target qubit, wherein the second mode-selective coupler couples an end capacitor pad of the control qubit to a middle capacitor pad of the second target qubit.

18. The apparatus according to claim 17, wherein the first mode-selective coupler comprises a capacitor that couples a middle capacitor pad of the control qubit to a middle capacitor pad of the first target qubit, wherein a capacitance of the capacitor is less than shunting capacitance values of the control qubit and less than shunting capacitance values of the second target qubit.

19. The apparatus according to any of the preceding claims 17 to 18, wherein the second

mode-selective coupler comprises a first capacitor that couples an end capacitor pad of the control qubit to an end capacitor pad of the second target qubit and comprises a second capacitor that couples the end capacitor pad of the control qubit to a middle capacitor pad of the second target qubit, wherein a first capacitance of the first capacitor is less than shunting capacitance values of the control qubit and less than shunting capacitance values of the second target qubit, and wherein a second capacitance of the second capacitor is half the first capacitance.

20. The apparatus according to any of the preceding claims 17 to 19, wherein the first target qubit and the second target qubit are degenerate targets, wherein the first target qubit entangles with the control qubit when the control qubit is driven by a first microwave tone corresponding to an A-mode excitation frequency of the degenerate targets, and wherein the second target qubit entangles with the control qubit when the control qubit is driven by a second microwave tone corresponding to a B-mode excitation frequency of the degenerate targets.