

CLAIMS

What is claimed is:

1. A method of operating a circuit quantum electrodynamics system that includes a physical qubit dispersively coupled to a quantum mechanical oscillator, the method comprising:
 - applying a first drive waveform to the quantum mechanical oscillator; and
 - applying a second drive waveform to the physical qubit concurrent with the application of the first drive waveform,wherein the first and second drive waveforms are configured to produce a state transition of the circuit quantum electrodynamics system from an initial state to a final state.
2. The method of claim 1, wherein:
 - the physical qubit is in a ground state in the initial and final states of the circuit quantum electrodynamics system, and
 - the quantum mechanical oscillator has a different photon number state in the final state of the circuit quantum electrodynamics system than in the initial state of the circuit quantum electrodynamics system.
3. The method of claim 1, wherein the physical qubit has a state in the final state of the circuit quantum electrodynamics system that depends upon a photon number state of the quantum mechanical oscillator in the initial state of the circuit quantum electrodynamics system.
4. The method of claim 3, wherein the physical qubit is in a ground state in the initial state of the circuit quantum electrodynamics system, and wherein the physical qubit is in either the ground state or in an excited state in the final state of the circuit quantum electrodynamics system.

5. The method of any one of claims 1 through 4, further comprising determining the first and second drive waveforms by optimizing a fidelity of the state transition of the circuit quantum electrodynamics system.
6. The method of claim 5, wherein optimizing the fidelity of the state transition of the circuit quantum electrodynamics system comprises a gradient optimization technique.
7. The method of any one of claims 1 through 4, wherein the first and second drive waveforms are selected, based on the initial state and the final state, from a computer readable medium storing a plurality of previously determined drive waveforms.
8. The method of any one of claims 1 through 4, wherein the state transition is a unitary state change.
9. The method of any one of claims 1 through 8, wherein the quantum mechanical oscillator is a microwave cavity.
10. The method of any one of claims 1 through 9, wherein the physical qubit is a transmon qubit.
11. The method of any one of claims 1 through 4, wherein the dispersive coupling between the physical qubit and the quantum mechanical oscillator has a dispersive shift χ , and wherein a duration of each of the first and second drive waveforms is less than four times $1/\chi$.
12. The method of claim 11, wherein the duration of each of the first and second drive waveforms is less than 1 microsecond.
13. The method of any one of claims 1 through 4, wherein the application of the first drive waveforms begins at substantially the same time as the application of the second

drive waveform begins, and wherein the application of the first drive waveforms ends at substantially the same time as the application of the second drive waveform ends.

14. The method of any one of claims 1 through 4, wherein a plurality of photon number states of the quantum mechanical oscillator are selected as a multi-qubit register, and

wherein the first and second drive waveforms are configured to perform a multi-qubit operation upon the multi-qubit register.

15. A system, comprising:

a circuit quantum electrodynamics system that includes a physical qubit dispersively coupled to a quantum mechanical oscillator;

at least one computer readable medium storing a plurality of drive waveforms, each of the plurality of drive waveforms being associated with an initial state of the circuit quantum electrodynamics system and a final state of the circuit quantum electrodynamics system;

at least one controller configured to select a first drive waveform and a second drive waveform from amongst the stored plurality of drive waveforms based at least in part on a selected final state of the circuit quantum electrodynamics system and the final states associated with the selected first and second drive waveforms; and

at least one electromagnetic radiation source configured to:

apply the first drive waveform to the quantum mechanical oscillator; and

apply the second drive waveform to the physical qubit concurrent with the application of the first drive waveform.

16. The circuit quantum electrodynamics system of claim 15, wherein each drive waveform of the plurality of drive waveforms is configured to transition the circuit quantum electrodynamics system from the initial state associated with the drive waveform to the final state associated with the drive waveform.

17. The circuit quantum electrodynamics system of claim 16, wherein the desired state transition is a unitary state change.

18. The circuit quantum electrodynamics system of claim 15, wherein the plurality of drive waveforms include a first group of drive waveforms configured to be applied to the quantum mechanical oscillator and a second group of drive waveforms configured to be applied to the physical qubit.

19. The circuit quantum electrodynamics system of any one of claims 15 through 18, wherein the quantum mechanical oscillator is a microwave cavity.

20. The circuit quantum electrodynamics system of any one of claims 15 through 19, wherein the physical qubit is a transmon qubit.

21. The circuit quantum electrodynamics system of any one of claims 15 through 18, wherein the dispersive coupling between the physical qubit and the quantum mechanical oscillator has a dispersive shift χ , and wherein a duration of each of the first and second drive waveforms is less than four times $1/\chi$.

22. The circuit quantum electrodynamics system of any one of claims 15 through 21, wherein the at least one controller is further configured to cause the at least one electromagnetic radiation source to:

begin application of the first and second drive waveforms at substantially the same time; and

end application of the first and second drive waveforms at substantially the same time.

23. The circuit quantum electrodynamics system of any one of claims 15 through 18, wherein a duration of each of the first and second drive waveforms is less than 1 microsecond.