Introduction

- Tunable couplers have been important in the development of superconducting quantum computers.
- The ability to maintain zero coupling between qubits during operation, a feature of high-fidelity quantum gates, has been shown to be possible with the use of tunable couplers.
- As an example, Sete et al., 2021 (1) showed this was possible with a tunable coupler between transmons (see right): the qubit-coupler and qubit-qubit couplings create a net effective coupling strength between the qubits that can be tuned to zero.

Statement of Purpose

The derivation of an effective coupling strength (see right) between the qubits is quite complex. We propose a simpler method of obtaining this effective coupling with the Born-Oppenheimer approximation.

Methods

- As in the Born-Oppenheimer approximation, we take the tunable coupler and qubits as our fast and slow degrees of freedom, respectively (see Fig. 4). Thus, we replace the qubit creation and annihilation operators with their eigenvalues.
- We rotate the Hamiltonian by the qubit frequencies and apply displacement operators to eliminate the qubit-coupler terms from the Hamiltonian (see Fig. 3).
- We find the propagator to determine the phase and differentiate to yield the coupling strength.

Results and Conclusions

- We achieve a result in Figure 5 which corresponds to the effective coupling term produced by Sete et al., 2021 (1) with the Schrieffer-Wolff transformation (as shown in Figure 1).
- In general, usage of the Schrieffer-Wolff method requires prior knowledge of the generator of the SW transformation, which is hamiltonian-specific.
- Our method is less case-specific, making it a potential framework to determine effective coupling strengths with other hamiltonians.