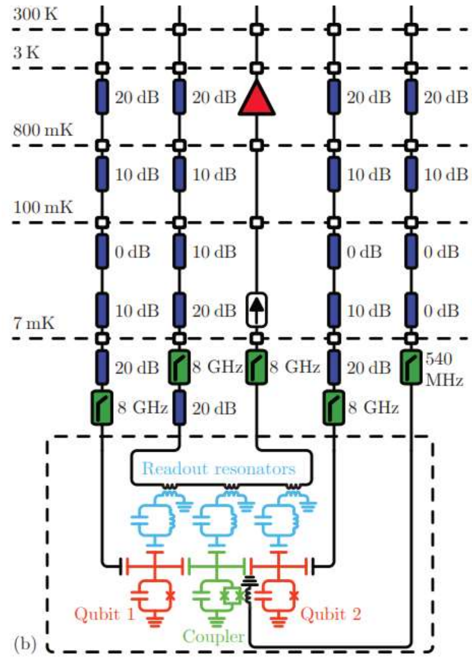
WACQT | Wallenberg Centre for Quantum Technology

Carbon Nanotube Filters for Quantum Computing Applications

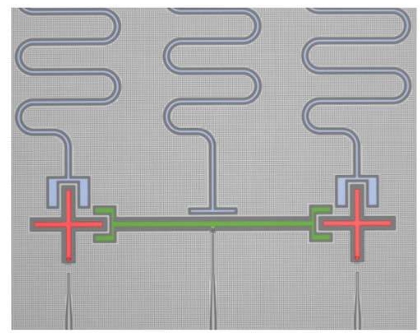


Background

Quantum computing aims to harness the power of quantum mechanical effects to speed up certain classes of computational problems. While the theoretical side has made plenty of progress, it still comes down to experimentalists to build the equipment which can implement these quantum algorithms.

One of the major hurdles in building scalable quantum hardware is these devices are extremely sensitive to noise. Most implementations of quantum computing exist at extremely low temperatures of approximately 10 mK. To address these devices, we send in signals from equipment working at room temperature through cables thermalized and attenuated at different temperature stages to limit the noise coming from the laboratory environment.

Problem description



Our systems using superconducting qubits work in a band of 4-8GHz whereas this high frequency noise exists above 18GHz where much of the high frequency equipment is transparent. There are several proposed ways of removing this high-frequency noise. One is to use iron-based materials, which act as a lossy dielectric, and to make a filter that is absorptive across all frequencies [1]. However, this material is under tight import controls due to its military and aerospace applications. An alternative was realized using bundled carbon nanotubes, which provide a cheap and comparably easier way to make these 'black' filters [2]. These have a variety of applications as their filtering profile is independent of temperature and could be used within a variety of applications, such as satellite, MRI, and various other cryogenic applications.

Workflow

In this project you will, design the filter box to obtain a frequency cutoff for our lab's specifications, develop the process for fabricating the filters and filling them with the lossy material, and characterize the cryogenic performance of these filters and measure their performance in quantum computing experiments with superconducting qubits.

Team size

3-6 students.

Student background

Electrical Engineering, Engineering Physics

Literature

[1] D F Santavicca, D E Prober. Impedance-matched low-pass stripline filters. Measurement Science and Technology, V19, 8. (2008)

[2] M V Moghaddam, C. W. Chang, I, Nsanzineza, A. M. Vadiraj, C. M. Wilson. Carbon nanotube-based lossy transmission line filter for superconducting qubit measurements. Appl. Phys. Lett. 115, 213504. (2019).

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