P550 - Quantum Devices I

Fall 2024

Professor: Rogério de Sousa

Number of UVic units: 1.5

Target audience

Graduate students in Science and Engineering at all levels, who want to obtain conceptual and prac cal understanding of quantum hardware for quantum compu ng and sensing applica ons. Part I of the course will cover devices based on superconduc ng circuits; Part II will cover quantum photonic circuits, emphasizing the similarity between both.

Prerequisites

Knowledge of quantum theory and electrical circuits at the undergraduate level. Some knowledge of quantum informa on science/technology.

Attendance of the QuantumBC-CMC workshop on superconduc ng circuit and qubits is OPTIONAL. In this workshop students will be able to apply their knowledge to build their own superconduc ng quantum circuit. The workshop will take place in Calgary from Nov. 18 to 22, 2024. For more informa on, check out the workshop website: https://fabricinnova on.ca/workshop-build-your-own-superconduc ng-quantum-device-2024/

Course date/ me/loca on:

September 5 - December 3, 2024.

Tuesdays and Thursdays from 2:30 pm - 4:00pm Pacific me.

The course is hybrid with in-person lectures and synchronous virtual lectures via zoom.

Overview

Building quantum computers is a great challenge and involves concepts and technology that have similari es and differences with those in conven onal “classical” computers. It involves cryogenic electronics and in the currently most advanced approach it relies on superconduc ng and quantum circuits that display quantum effects. The topic of this course is superconduc ng and photonic quantum devices and circuits for quantum computers and sensors.

Learning objec ve

To become proficient in using models to predict the performance and behaviour of superconduc ng and photonic devices and circuits.

We will achieve this by teaching:

1. Fundamentals of superconductivity and its application to electrical circuits.
2. Quantum theory of electrical circuits made of superconducting wires and Josephson junctions. How to use them to make resonators, SQUIDs, qubits, quantum annealers, quantum amplifiers, etc.
3. Fundamentals of quantum optics and its application to photonic chips.
4. Introduction to the basics of photonic circuits and how to use them to make qubits and sensors.

Course evaluation/assessment

Class participation (30% of final grade)

Final course project (70% of final grade)

Class participation

Credit will be given for students that ask questions in class, and participate in discussions. Also for students that post questions in the BrightSpace forum, and answer questions posed by other students.

Final course project

There are three options for the final presentation: Students can present either (1) a recent paper from the literature; (2) a classic paper from the literature, describing a groundbreaking discovery; (3) a review paper or a book chapter, describing an important topic not covered in class. The deadline for choosing the paper or topic is October 22nd. Students are welcome to discuss possibilities with the instructor, and I am glad to suggest papers or topics.

Lecture materials

All lecture materials and assignments are available in the course's Brightspace:

https://bright.uvic.ca/d2l/home/359976

In particular, the lecture boards used in class and my handwritten notes will be made available online. These can be found under "Lecture boards" and "Lecture notes" in the content link.

Office hour

Wednesdays, 2:00-3:00 pm in-person at Elliott 117 and by Zoom at my personal Zoom office:

https://uvic.zoom.us/j/3056080360?pwd=OFJBS3VXY1J0bEVldnVjeHpSQ3J4QT09

Textbook

For superconducting devices, we will use selected chapters of the book we are writing, “Superconducting Circuits and Quantum Devices”, edited by Rogério de Sousa and Reza Molavi. For photonic circuits, we will use a selection of review articles (to be determined).

Final letter grade: UVic's percentage grading system

A+	90-100	Exceptional performance.
A	85-89	Outstanding performance.
A-	80-84	Excellent performance.
B+	77-79	Very good.
B	73-76	Good.
B-	70-72	Solid.
C+	65-69	Satisfactory.
C	60-64	Minimally satisfactory.
D	50-59	Marginal performance.
F	0-49	Unsatisfactory performance.

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