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Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

Proposal for Thesis Research in Partial Fulfillment
of the Requirements for the Degree of
Masters of Engineering

Title: Defect Identification in Superconducting 2-Terminal Devices

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Expected Date of Completion: May 2022

Laboratory: Quantum Nanostructures and Nanofabrication under the Research Laboratory for Electronics

Supervision Agreement:

The program outlined in this proposal is adequate for a Master's thesis. The supplies and facilities required are available, and I am willing to supervise the research and evaluate the thesis report.

K. K. Berggren, Prof. of Elec. Eng.

Contents

1	Introduction	3
1.1	Non-linearity in superconducting nanowires	3
1.2	Nanowire Elements	3
1.2.1	NSPDs	3
1.2.2	NSPIs	3
1.2.3	Tapers	3
1.2.4	hTron	3
1.3	Problems Simulating Nanowires	3
2	SPICE	3
2.1	QNN SPICE	3
2.2	Dynamic Models	3
2.3	Generating Noise	3
2.4	Arbitrary S_{xy} models	3
2.4.1	2-port model	3
2.4.2	n-port model	3
2.5	Postprocessing	4
3	Model Stability	4
3.1	Stability in F.D.M.	4
3.1.1	Stability in LTSpice	4
3.2	Malicious Circuits	4
3.2.1	Proof of Equivalence to Stability	4
3.3	Better nanowire models	4
3.3.1	Current nanowire model	4
3.3.2	S.A. of current nanowire model	4
3.3.3	Different Integrator	4
3.3.4	1 Element Models	4
3.3.5	0 Resistance Models	4
4	Efficient Simulation	4
4.1	Tline Model	4
4.1.1	Equivalent Circuit	4
4.1.2	Kernel	4
4.1.3	GPU	4
4.2	Harmonic Balance	4
4.2.1	TD Assist	4
4.3	Device Symmetries	4
4.4	Coupling Diff. Eq. (or Thermal Model?)	4
4.4.1	TDC	5
4.4.2	NSPI coupling	5
4.5	Precomputation	5
4.6	ML Optimization	5
4.6.1	Symbolic Solver	5
4.6.2	Tapers	5
4.6.3	Differentiable Simulator	5
4.6.4	Inverse design	5

4.6.5	Monte Carlo Simulation	5
5	Time Domain Reflectometry	5
5.1	Idea	5
5.2	Optimal Search Theory	5
5.3	Simulation	5
5.4	Experimental Setup	5
5.5	Results	5
5.6	Future Ideas	5

1 Introduction

1.1 Non-linearity in superconducting nanowires

1.2 Nanowire Elements

1.2.1 SNSPDs

1.2.2 SNSPIs

1.2.3 Tapers

1.2.4 hTron

1.3 Problems Simulating Nanowires

2 SPICE

spice-daemon and qnn-spice

2.1 QNN SPICE

2.2 Dynamic Models

E.g. Tapers

2.3 Generating Noise

2.4 Arbitrary S_{xy} models

2.4.1 2-port model

E.g. Tapers!

2.4.2 n-port model

E.g. Bias Tee

2.5 Postprocessing

3 Model Stability

3.1 Stability in F.D.M.

3.1.1 Stability in LTSpice

3.2 Malicious Circuits

Why? How? (tline timestepping with half res?)

3.2.1 Proof of Equivalence to Stability

3.3 Better nanowire models

3.3.1 Current nanowire model

Layout of in-depth model

3.3.2 S.A. of current nanowire model

3.3.3 Different Integrator

3.3.4 1 Element Models

3.3.5 0 Resistance Models

4 Efficient Simulation

Julia simulator

4.1 Tline Model

4.1.1 Equivalent Circuit

4.1.2 Kernel

4.1.3 GPU

4.2 Harmonic Balance

4.2.1 TD Assist

4.3 Device Symmetries

4.4 Coupling Diff. Eq. (or Thermal Model?)

Maybe sections should be separate. Phonon-Electron transport.
Complex electric coupling

4.4.1 TDC

4.4.2 SNSPI coupling

4.5 Precomputation

4.6 ML Optimization

4.6.1 Symbolic Solver

4.6.2 Tapers

Note on resistive groups? -¿ Sonnet?

4.6.3 Differentiable Simulator

4.6.4 Inverse design

4.6.5 Monte Carlo Simulation

5 Time Domain Reflectometry

5.1 Idea

5.2 Optimal Search Theory

5.3 Simulation

5.4 Experimental Setup

5.5 Results

5.6 Future Ideas