LabVIEW Implementation of Optically Detected Magnetic Resonance

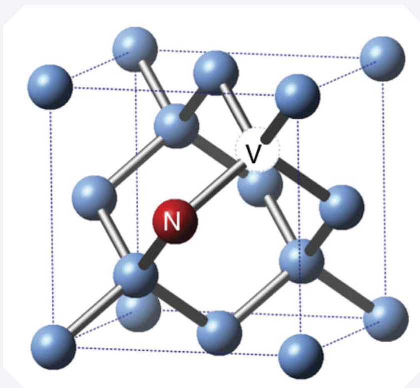
Maya Dunn

UNIVERSITY of WASHINGTON

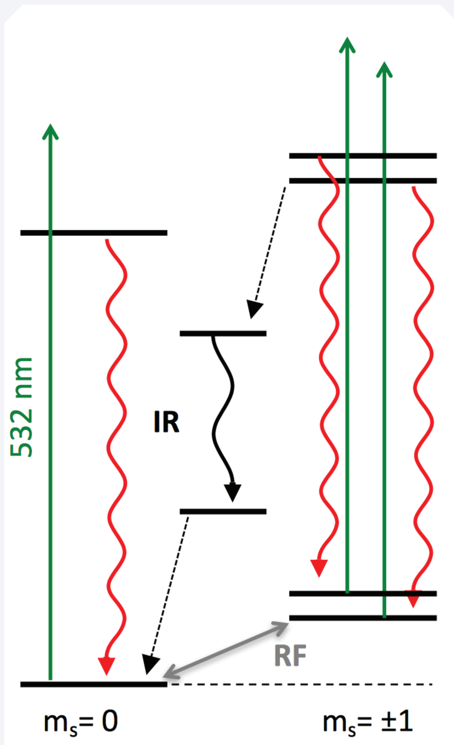
Background

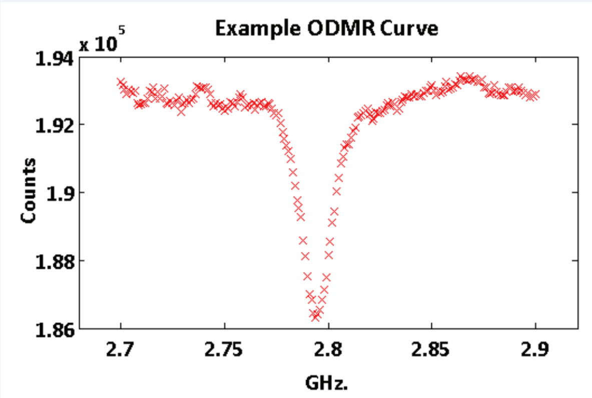
Diamond magnetometry uses optically detected magnetic resonance (ODMR), a technique which combines radio frequency magnetic fields with optical excitation to control an NV center spin.

A nitrogen vacancy (NV) center is a point defect in diamond where a nitrogen atom takes the place of a carbon, creating spin states that can be read out with a laser.



During ODMR, the diamond sample is optically excited with 532 nm light and produces photoluminescence at 630-750 nm. The radio frequency is swept through a resonance.





The resonance dip in an ODMR curve corresponds to the dark (IR) transition, which has a higher occurance rate at the resonant frequency.

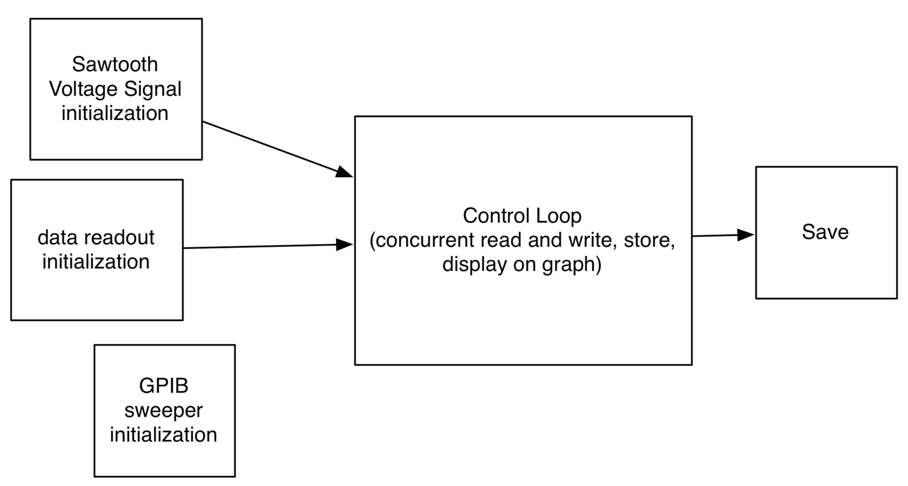
Due to Zeeman splitting, the resonant frequency offset is proportional to applied magnetic field.

Motivation

Diamond magnetometry enables the measurement of small-scale magnetic fields using nitrogen vacancy (NV) defect centers in diamond.

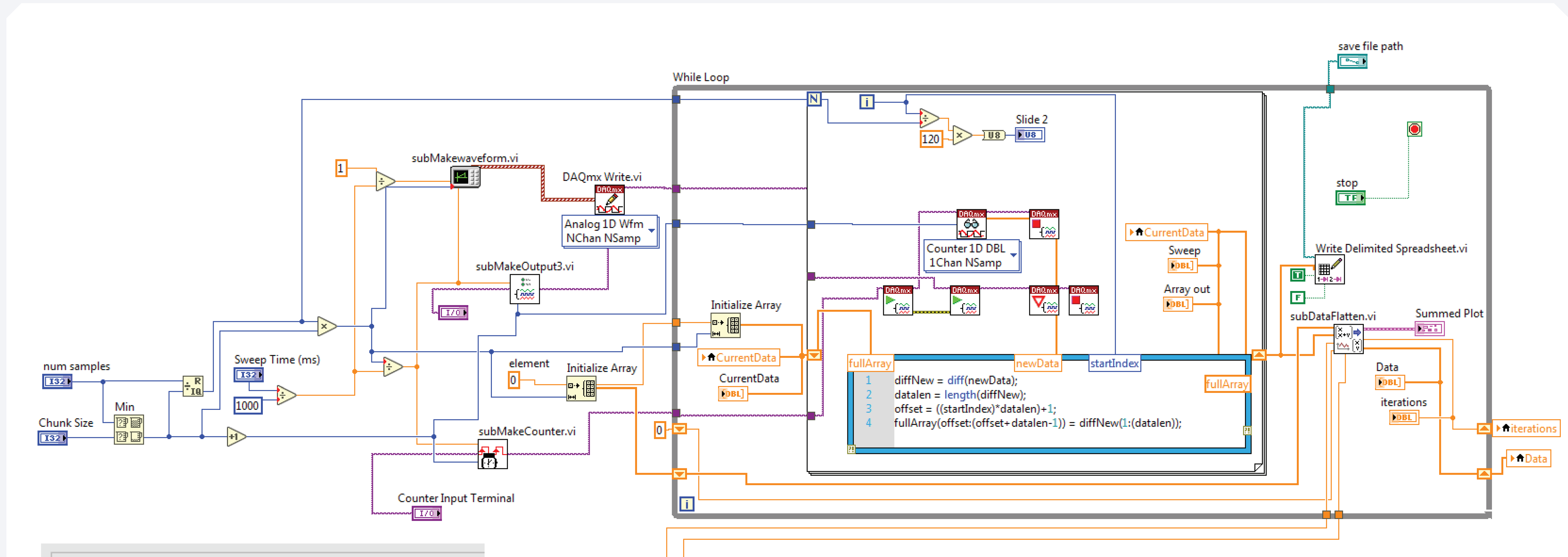
Nanoscale magnetic field detection has a range of applications in biology and chemistry, such as imaging of magnetically-tagged molecules for the study of biological processes.

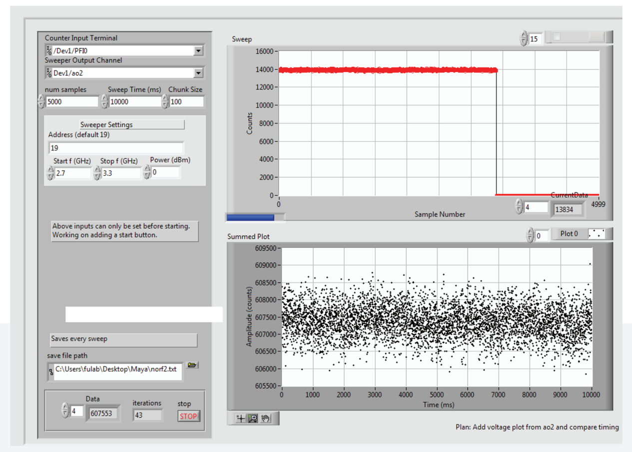
The goal of this project is to implement ODMR in LabVIEW to enable future experiments using with a pulsed readout.

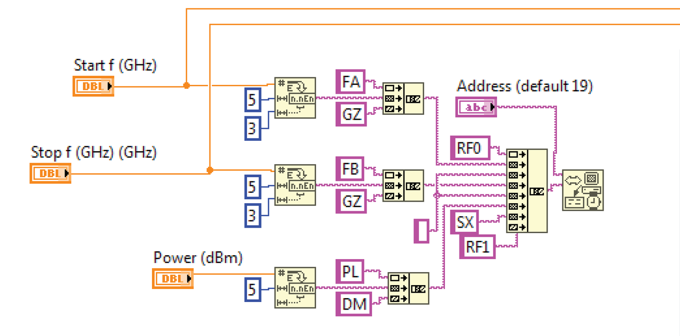


Simplified program model

Software





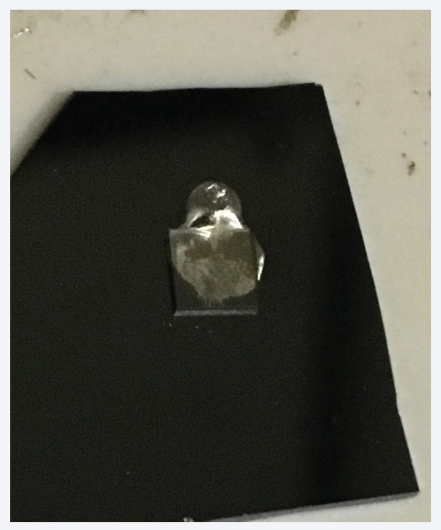


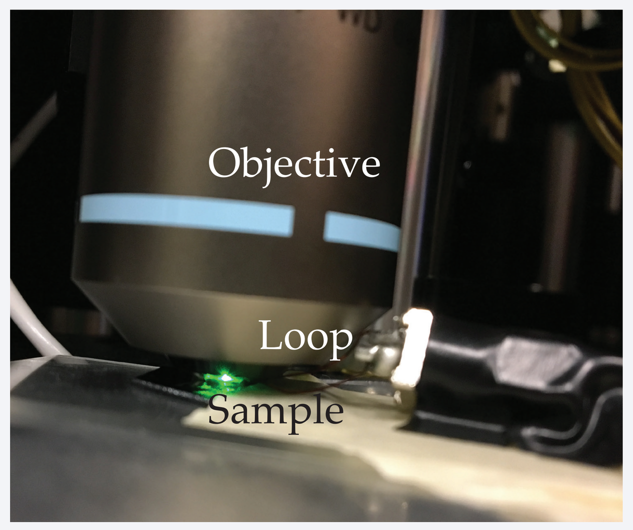
Parameters (Sweep size, sweep time, RF power, and frequency range) are modified through the interface.

The program has three functions:

1. To produce a sawtooth voltage to drive the microwave sweeper from 2.7 to 3.3 GHz.
2. Timing and reading in photoluminescence data.
3. Save data after each sweep.

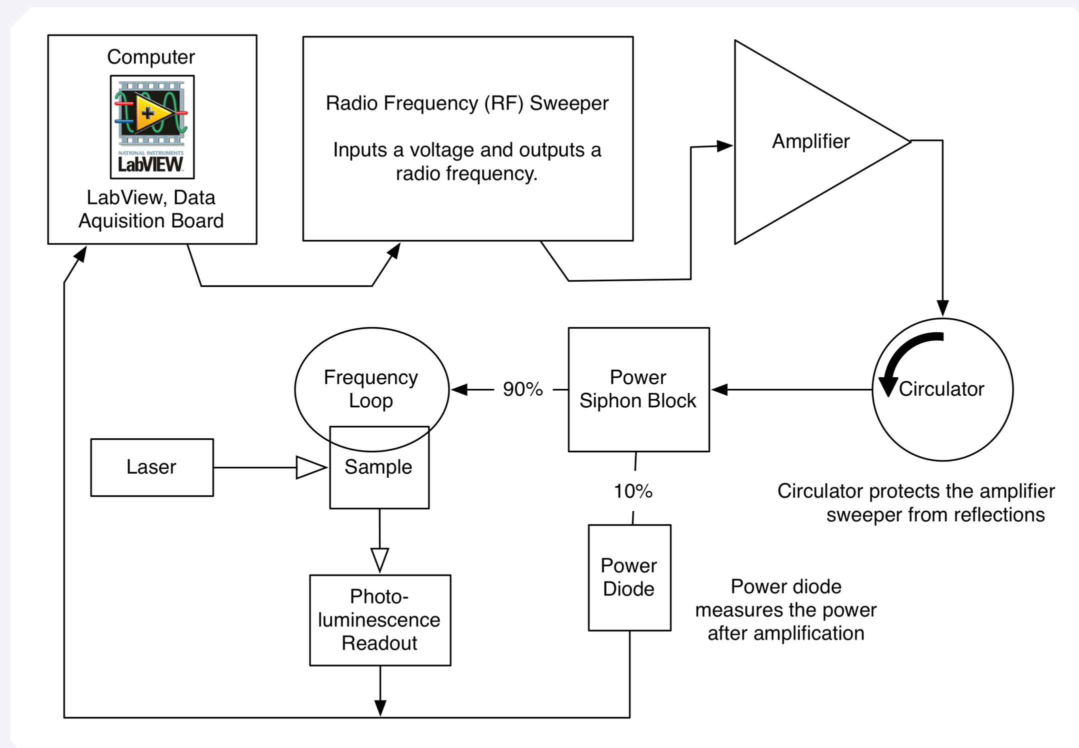
Experimental Setup



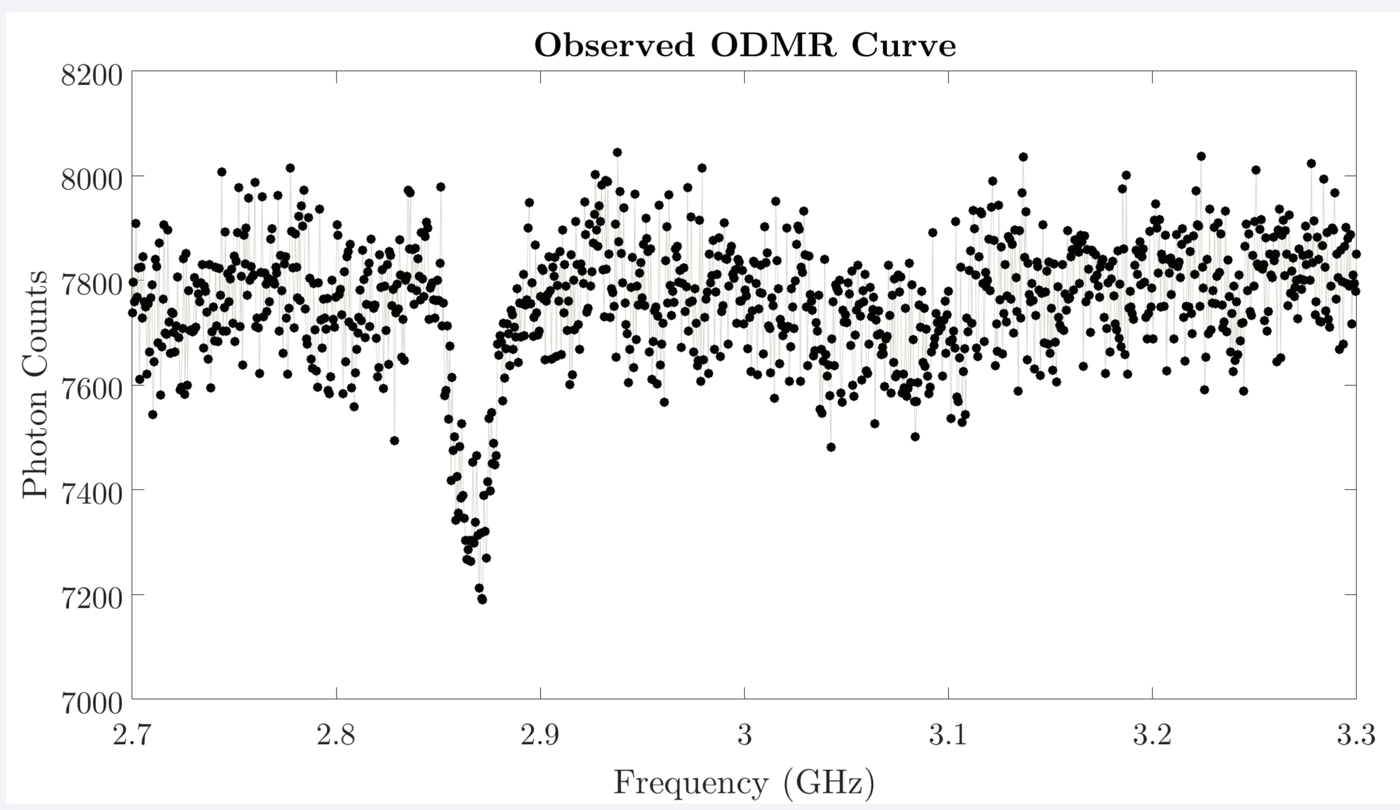


The diamond sample was attached to a piece of silicon with indium.

The frequency loop generates the required microwave field.



Results

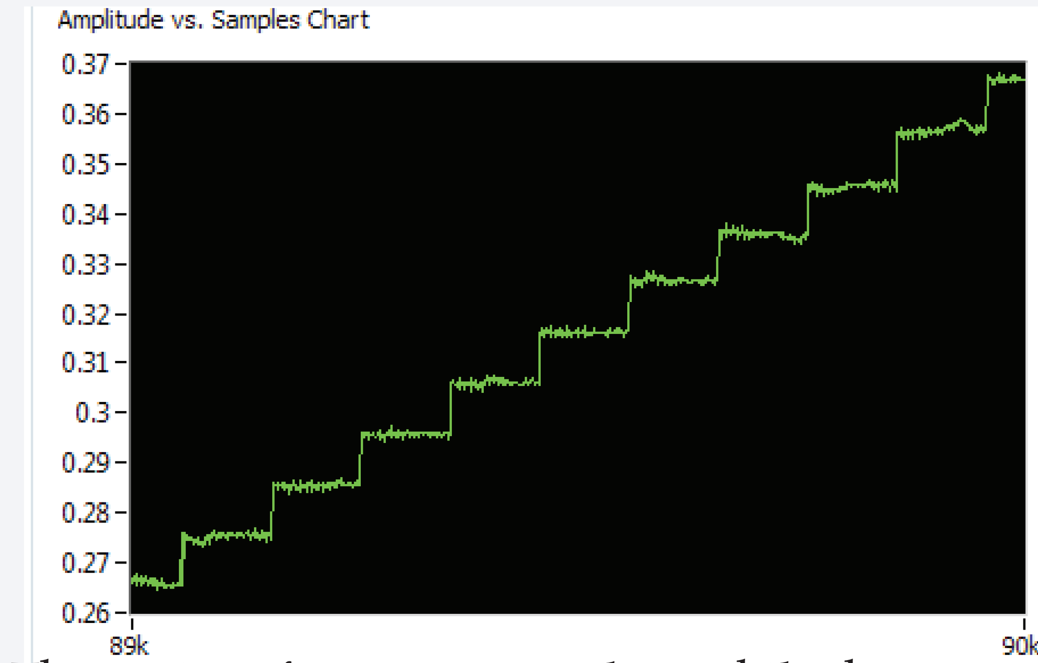


This graph is the sum of 8 sweeps over the 2.7-3.3 GHz frequency range. Each sweep was one second long and was sampled every millisecond.

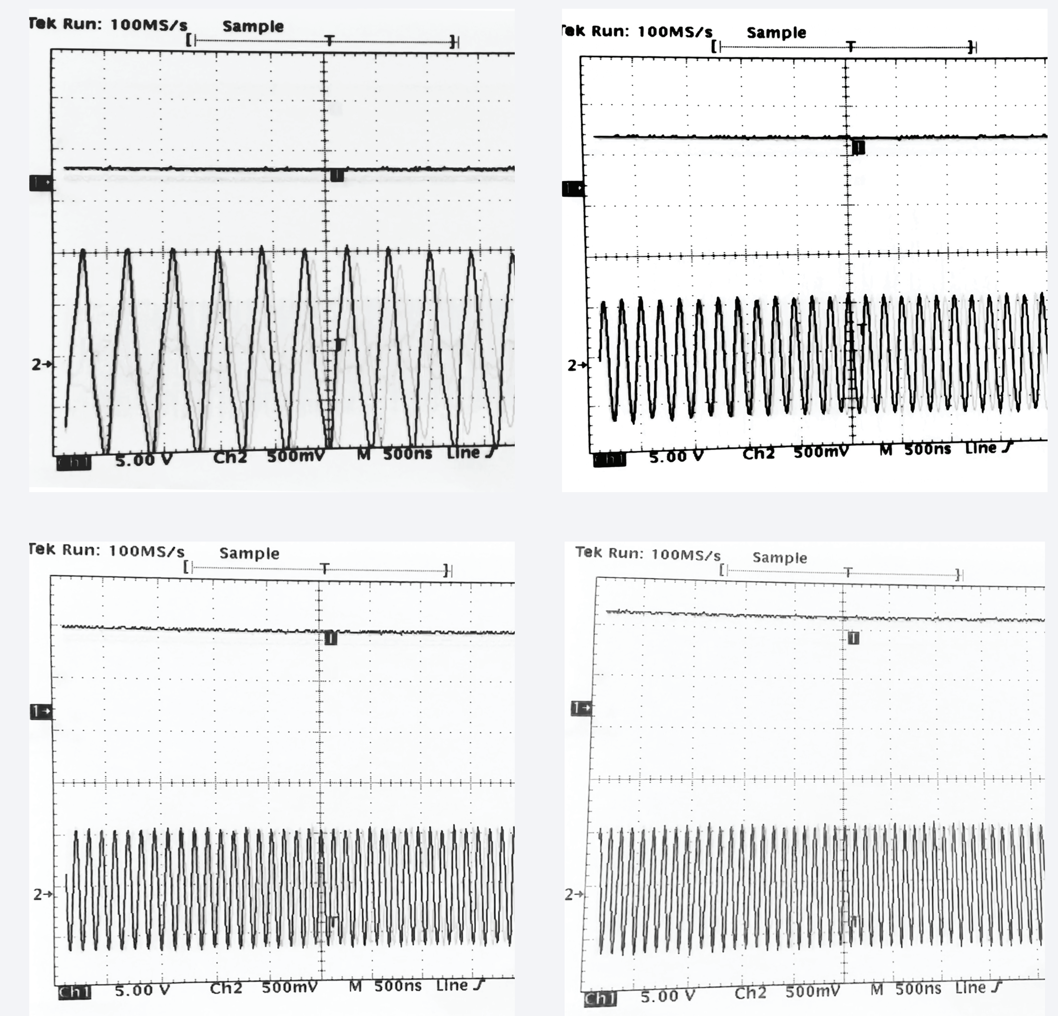
The resonance dip is centered around 2.869 GHz, which matches the expected value of ~2.87 GHz.

Frequency Sweeping

The radio frequency sweeper is driven by a sawtooth voltage signal created by the computer. The sweeper maps voltage linearly to frequencies in a predetermined range.



This series of images was taken while the sweeper was sweeping between 1 and 10 MHz. The control voltage (Ch. 1) and the frequency of the sweeper signal (Ch. 2) rise together.



Outlook

The immediate next step is reaching better RF power stabilization and more consistent voltage output. Changes in radio power are creating uncertainty in the data taken.

Looking forward, this work will be used to create a system in which optical and radio excitation are pulsed and staggered. This will narrow the resonance dip.

Acknowledgments

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