KEYSIGHT TECHNOLOGIES

NATIONAL HIGH MAGNETIC FIELD LABORATORY

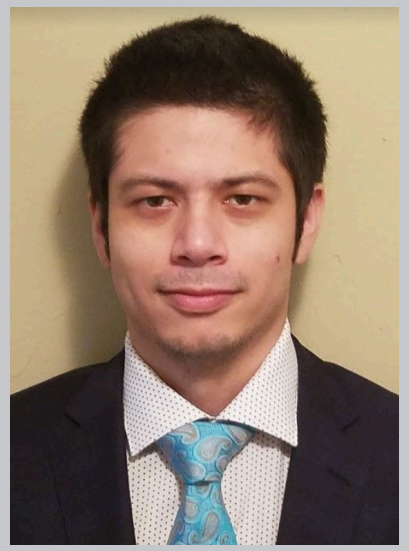
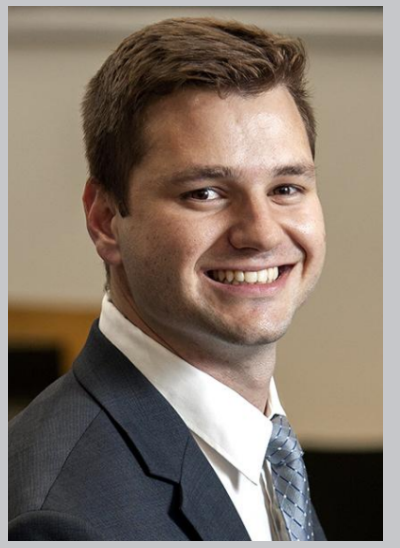
SeniorDesignII

T307

Team 307

Keysight Narrow Band “Oscilloscope” for High Power Tuning of NMR Probes

Introduction

Jonathan Burt	Gabriel De Leon	Emil Lobachev	Asher Rich	Kyle York
Programming Lead Document Lead	**Financial Advisor** Web Master	**Lead ECE** DGR	**Team Leader** Communications Lead	**Research Lead** Circuit & Hardware Assembly Lead
				

Presentation Outline

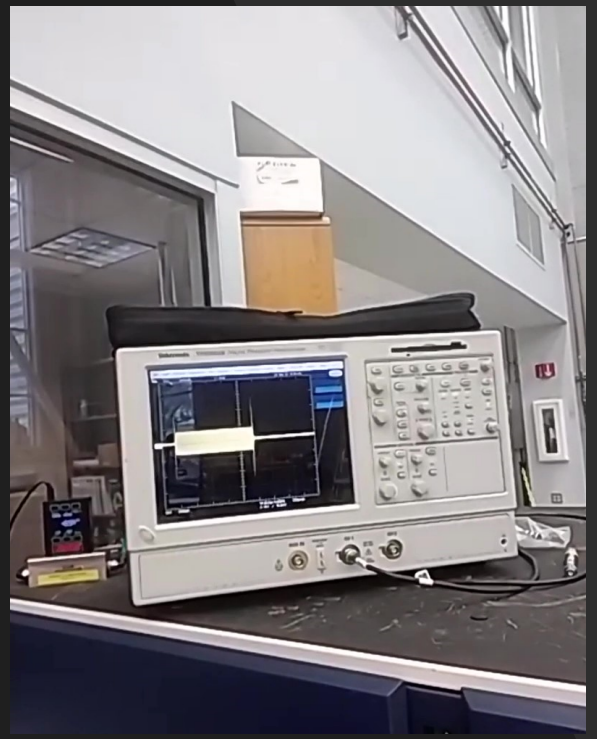
- Introduction
- Abstract
- Customer Needs & Requirements
- Concept Selection
- Old Research
- New Discoveries
- Future Work
- Summary

Abstract

- Project Overview

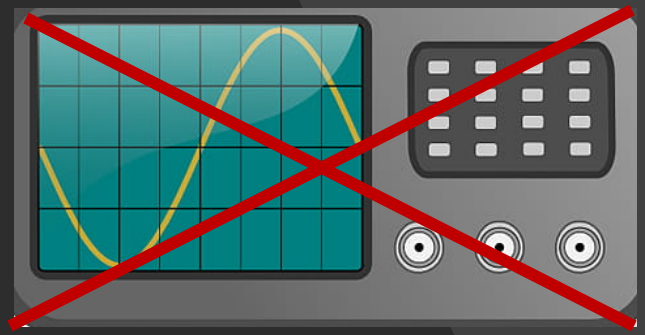
Project Overview

Motivation



Plan

Expectations

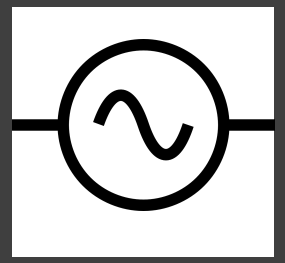
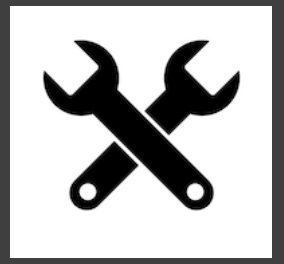


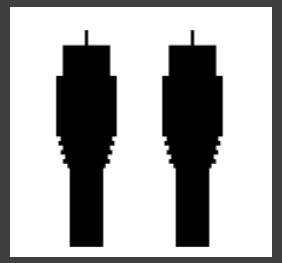
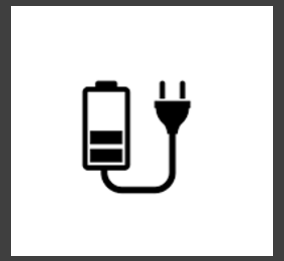
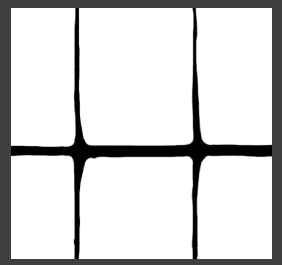
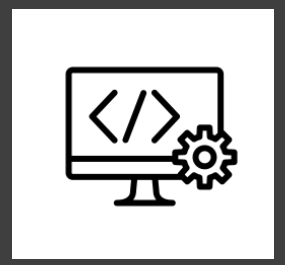
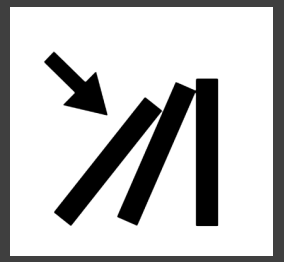
Jonathan Burt

Customer Needs / Requirements

- Needs Synopsis
- Customer Requirements

Needs Synopsis

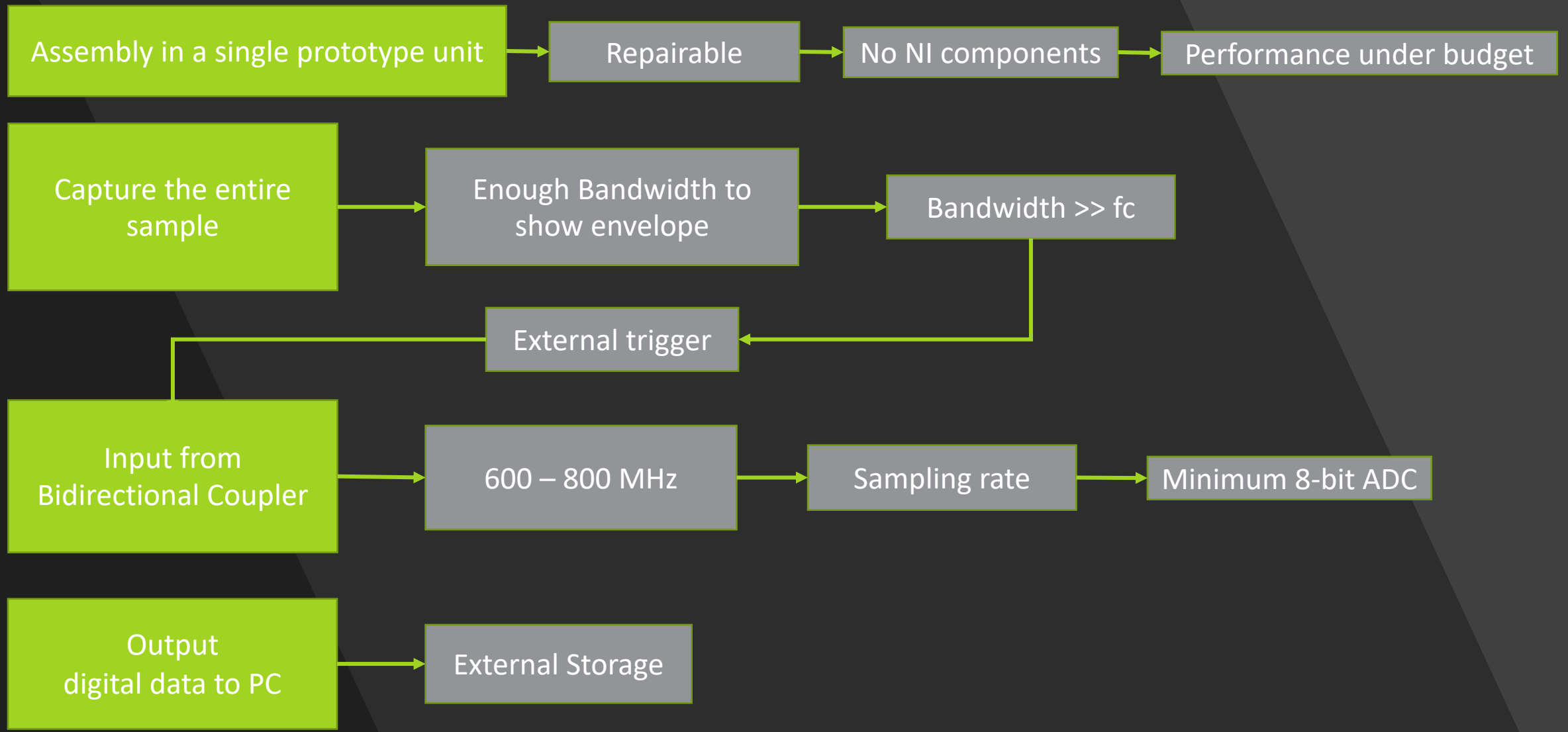







Emil Lobachev

Customer Requirements

Block Diagram

Emil Lobachev



Emil Lobachev

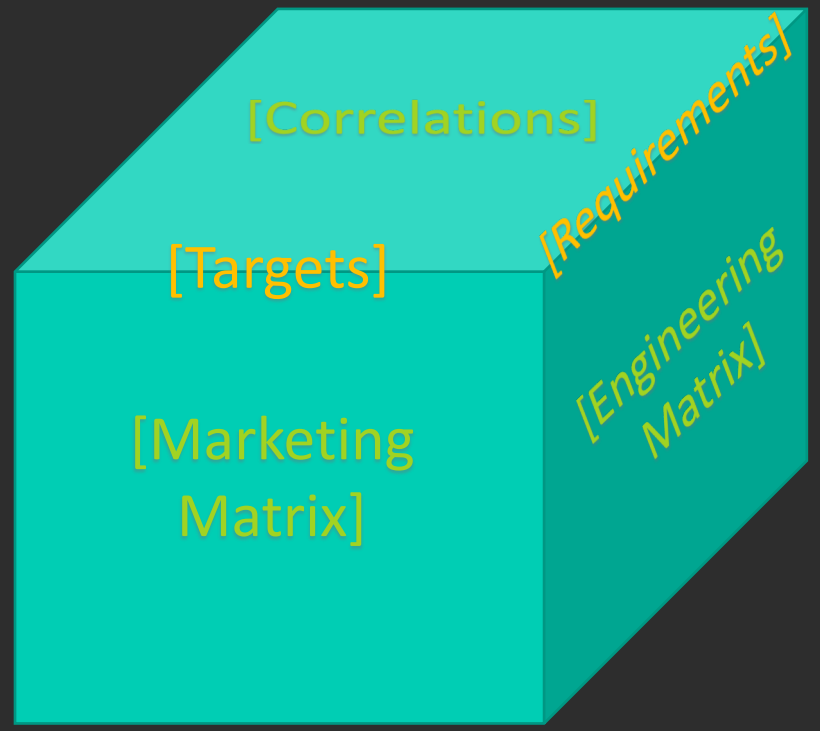
Concept Selection

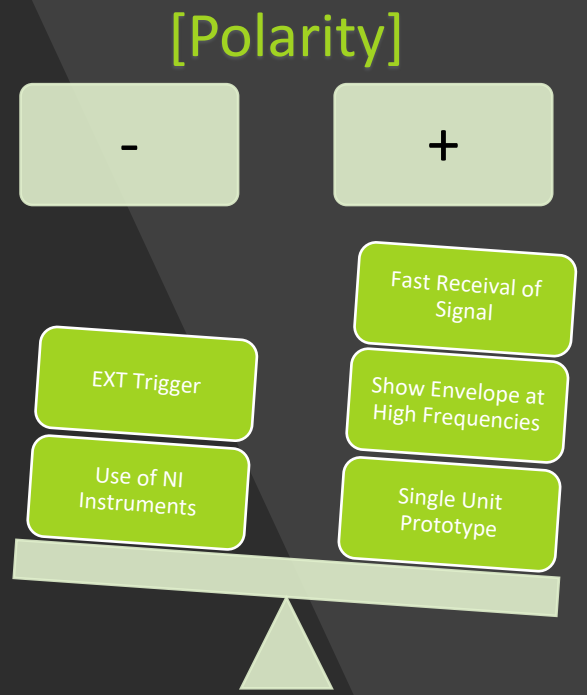
- Technical Work
- Consistency Check
- Analysis
  - Final Design

Asher Rich

Technical Work

- Marketing & Engineering Matrices
- House of Quality
- Pugh Chart





		Option 1	Option 2	Option 3
No National Instruments components or software	7	-	-	-
Output digital signal from prototype will have at least 8-bit resolution	6	-	1	-1
Score		-	-1	-11
Continue?		Yes	No	No

Asher Rich

Consistency Check

- Sorted Weights
- Consistency Variables

Avg of Consis Vector, λ	Consistency Index	Consistency Ratio (n = 14, RI = 1.57)
14.349	0.027	0.0171

Sorted Weights	
No National Instruments components or software	0.197
Output digital signal from prototype will have at least 8-bit resolution	0.112
Range of 600-800MHz for received and reflected signals	0.112
Sampling rate of the SDR will be higher than minimum value for correct scan	0.103
Prototype will have several times the bandwidth of the carrier frequency of the pulse	0.097
Will capture the entire sample (pulse train)	0.094
Quick access to hardware or code in software to run diagnostics on the system in case of failure	0.066
SDR will have enough bandwidth to demonstrate the envelope	0.044
Prototype will be connected to an external trigger	0.042
Transmit data signal to PC for review, analysis, and storage	0.038
Receive experiment output for analysis	0.028
External Storage of received data	0.025
Performs the software and hardware capabilities necessary while staying under budget	0.021
Assembled in a single unit	0.019

Asher Rich

Analysis

- Analytical Hierarchy Process
  - Combination: Pugh Chart & Sorted Weights

	W	Option 1	Option 2	Option 3
Output digital signal from prototype will have at least 8-bit resolution	0.112	0.044	0.075	0.023
Score		0.413	0.371	0.354

Output digital signal from prototype will have at least 8-bit resolution				
Column1	Option 1	Option 2	Option 3	P
Option 1	1	1/2	2	0.39
Option 2	2	1	3	0.67
Option 3	1/2	1/3	1	0.2

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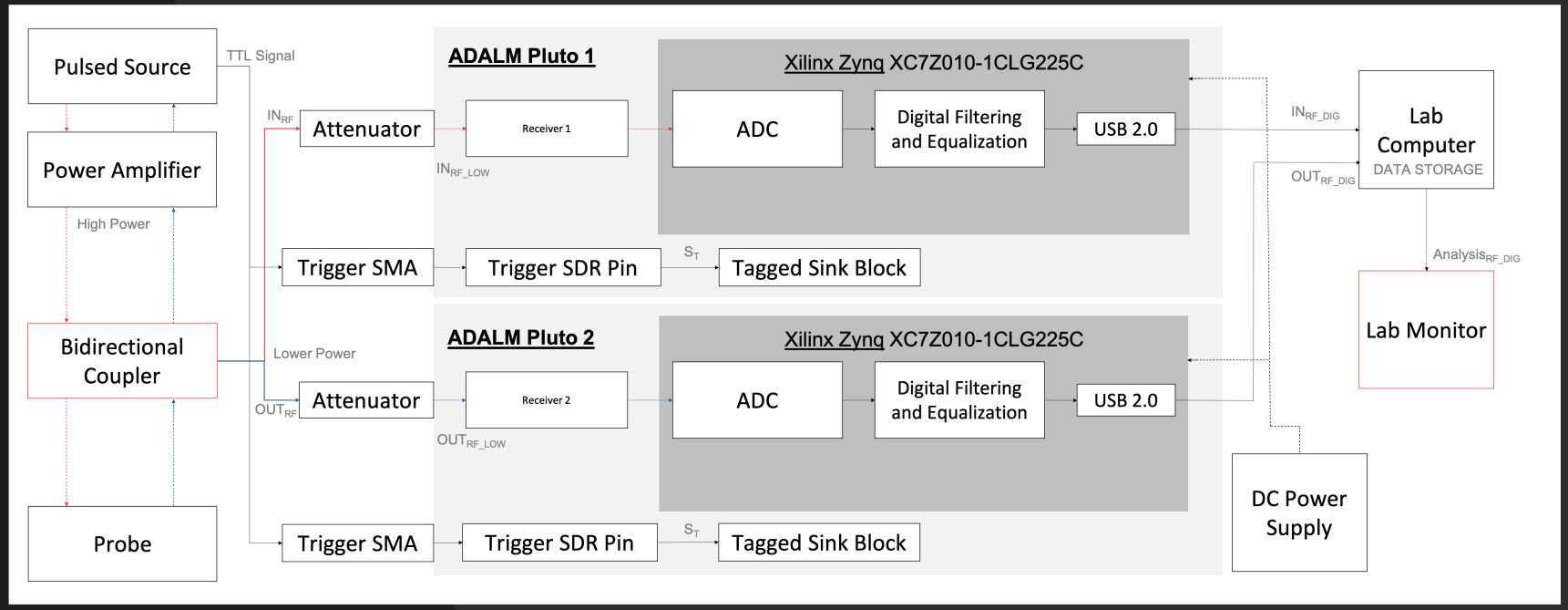
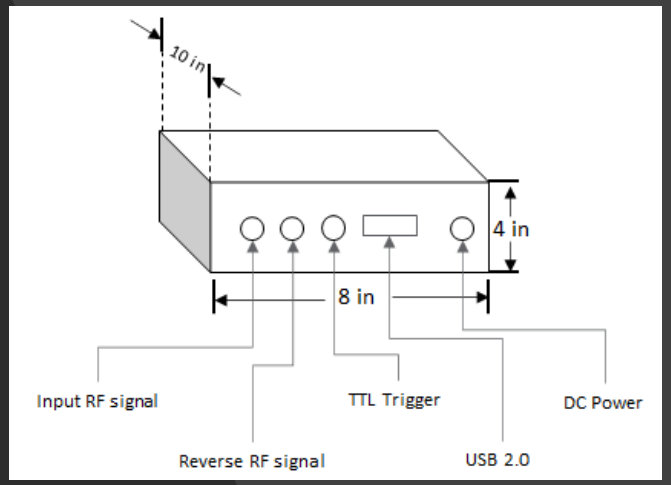
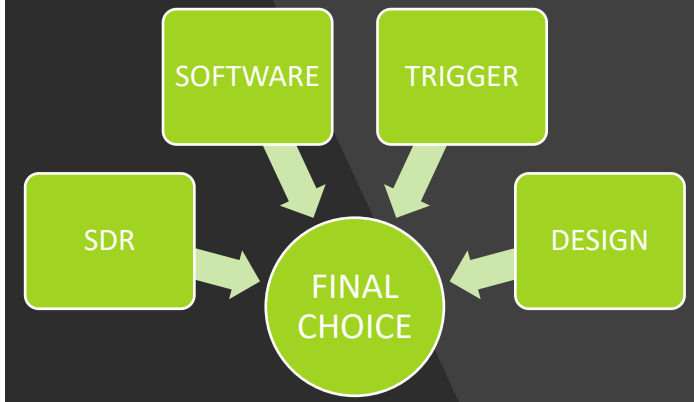
Analysis (continued…)

Final Design







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Old Research

- NMR
- SDR
- SDR Concept
- TTL Trigger

NMR – Nuclear Magnetic Resonance

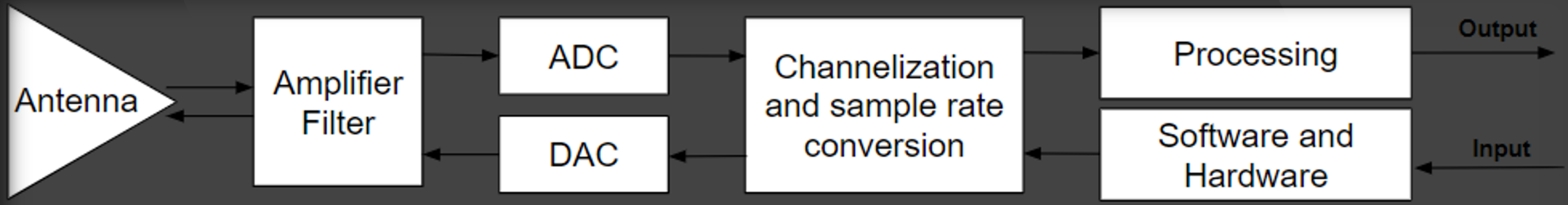
- Spectroscopic Technique
- Produced by RF Pulses Using Excitation
- Shows Structure of Metabolites and Proteins

SDR – Software Defined Radio

- Radio Communication System
- Maps Signals to a Computer
- Hardware Requirement for Project

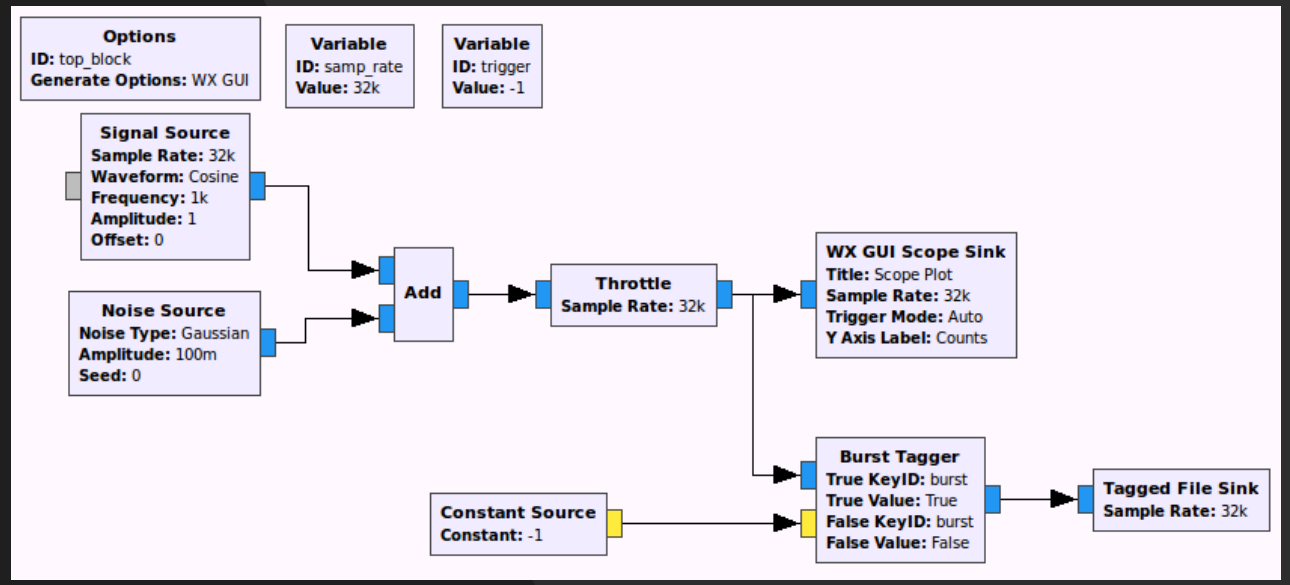
Gabriel De Leon

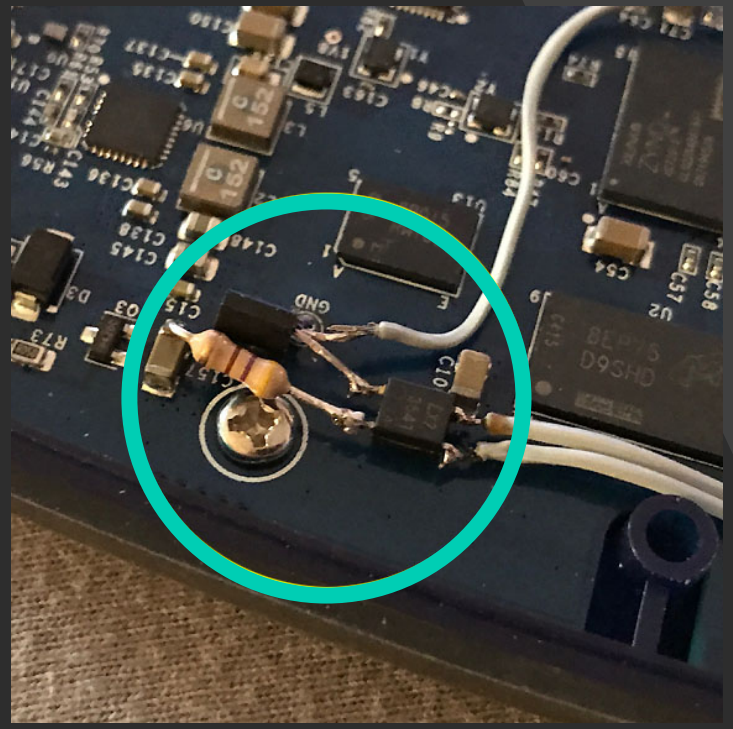
SDR Concept


Antenna
Amplifier
Filter
ADC
DAC
Channelization
and sample rate
conversion
Processing
Software and
Hardware
Output
Input

TTL – Transistor Transistor Logic Trigger

- Soldered Connection
- Triggered by Software





Gabriel De Leon

New Discoveries

- Failures
- Successes
- Discovery Summary

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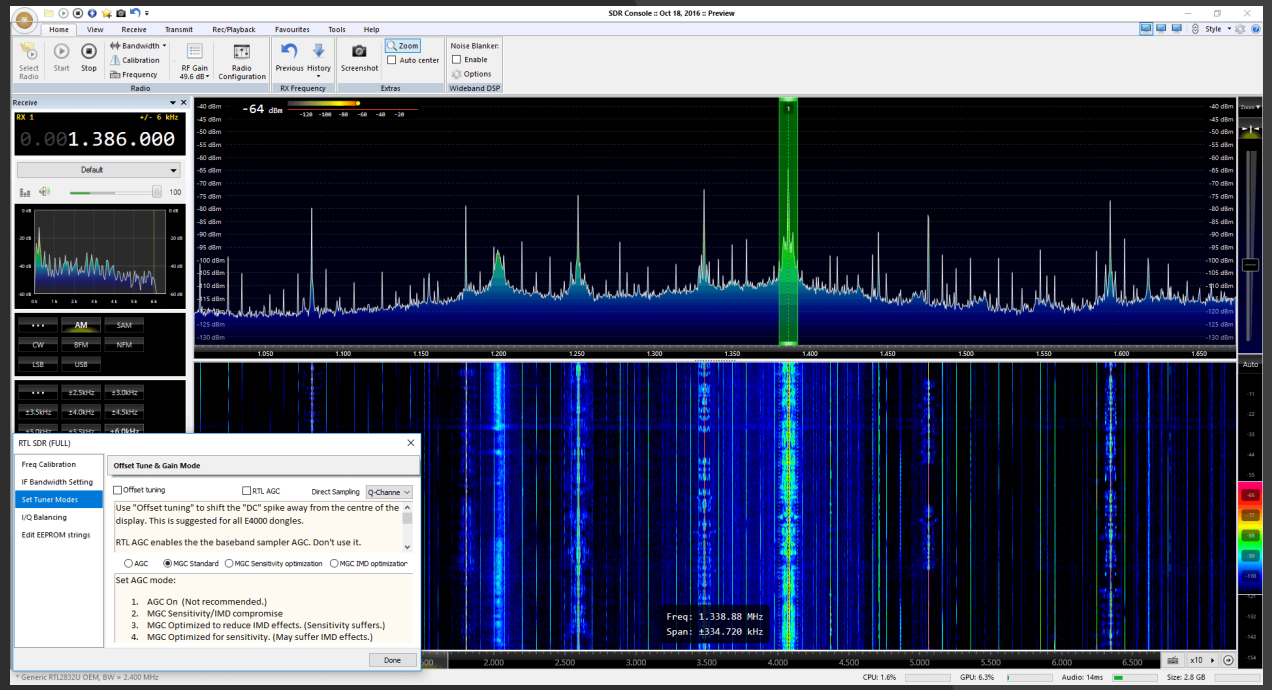
Failures

- SDR Console V3 Failure
- ADI IIO Oscilloscope Failure




```
sudo, sudoedit - execute a command as another user
```

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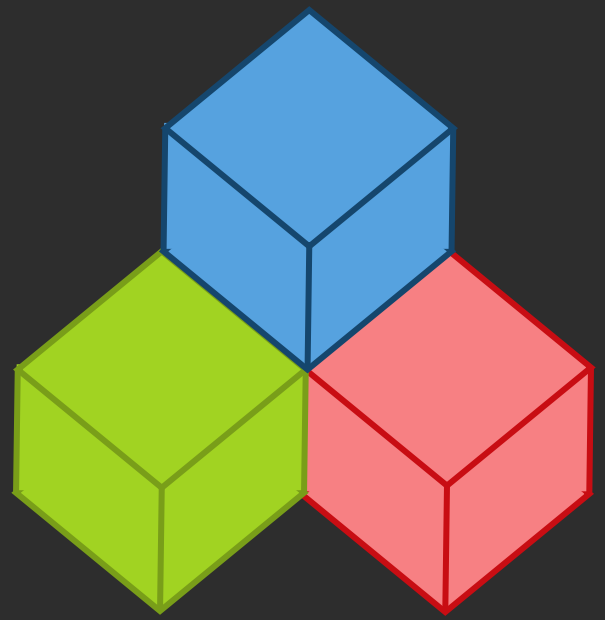
Successes

- MATLAB



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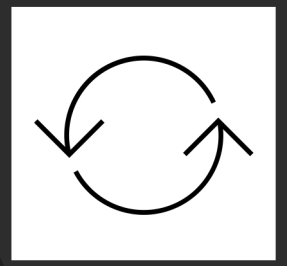
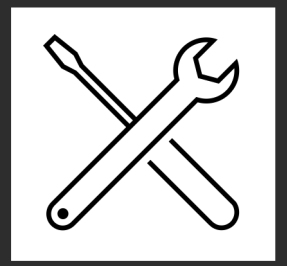
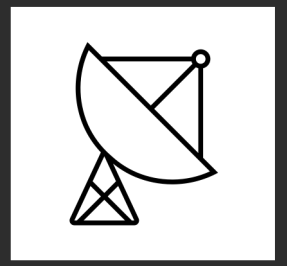
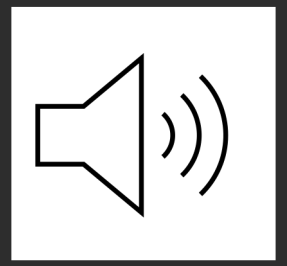
Discovery Summary

- Updating Hardware
- Toolbox Exploration
- First Results

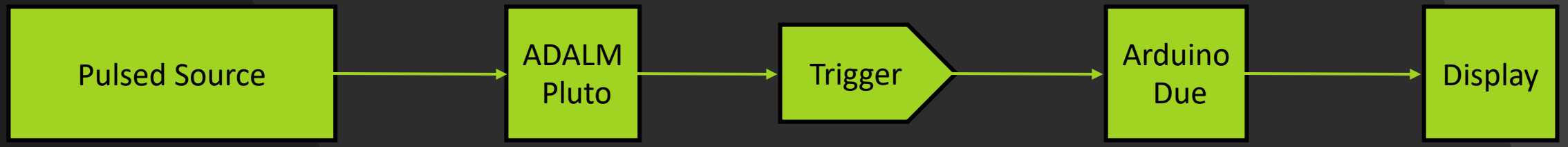
Future Work & Testing

- Hardware
  - ADALM Pluto & Potential Arduino Configurations
- Software
  - MATLAB & Simulink with Prospective Toolboxes
- Hardware & Software Test Benches

Kyle York & Asher Rich

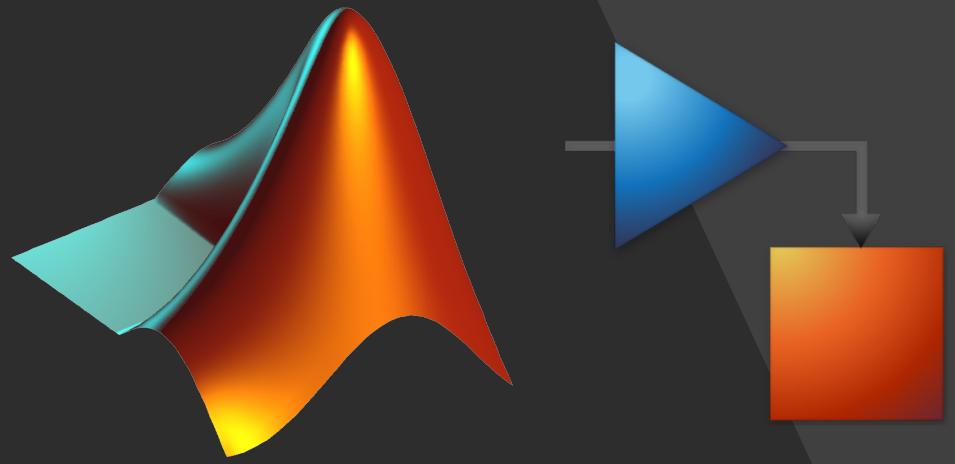
Hardware

- ADALM Pluto
- Possible Addition
  - Arduino Due



Software

- MATLAB & Simulink
- Toolboxes:
  - Communications
  - RF Blockset
  - RF Toolbox
  - Signal Processing
  - DSP System

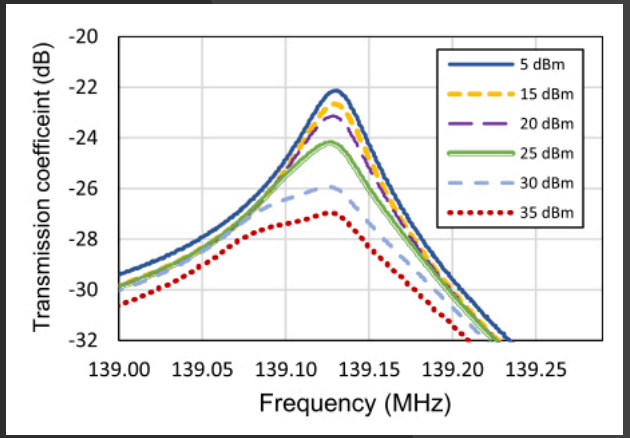


Kyle York

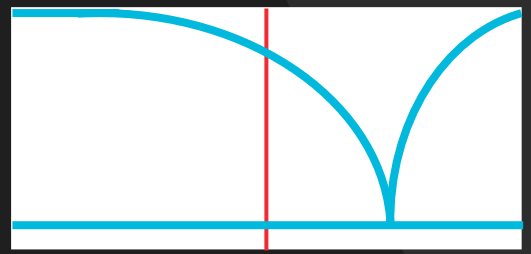
Hardware & Software Test Benches

- Testing Hardware
- Testing Software
- Verification

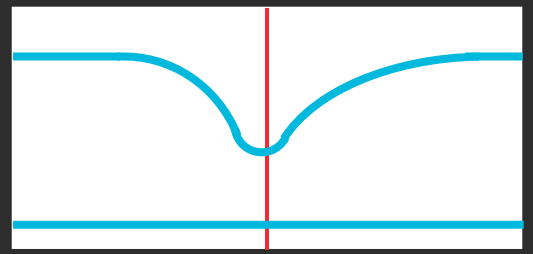
[Transmission Testing]



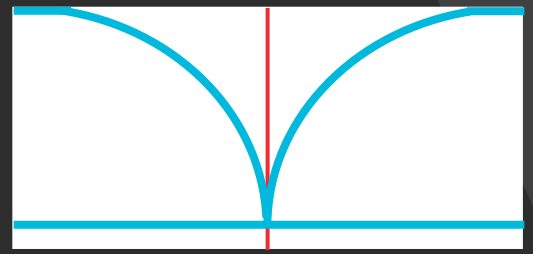
[Probe Tuning and Matching]



[Poorly Tuned but Well Matched]



[Well Tuned but Poorly Matched]



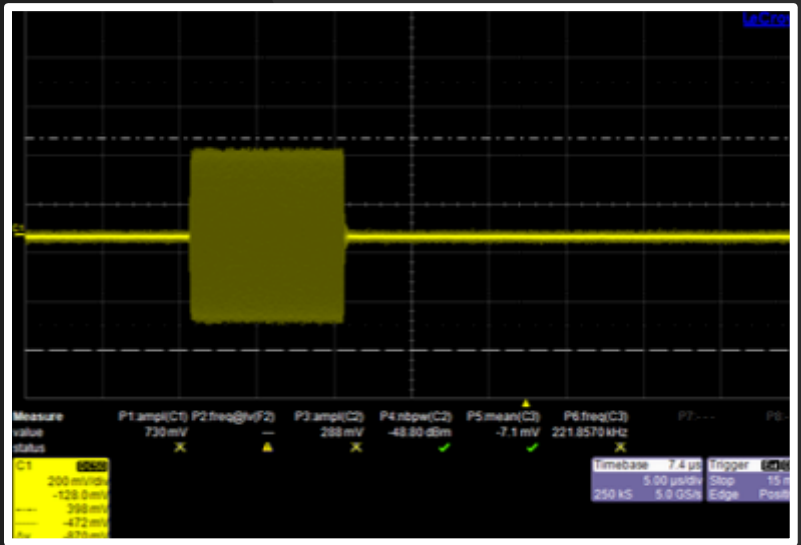
[Well Tuned and Well Matched]

Asher Rich

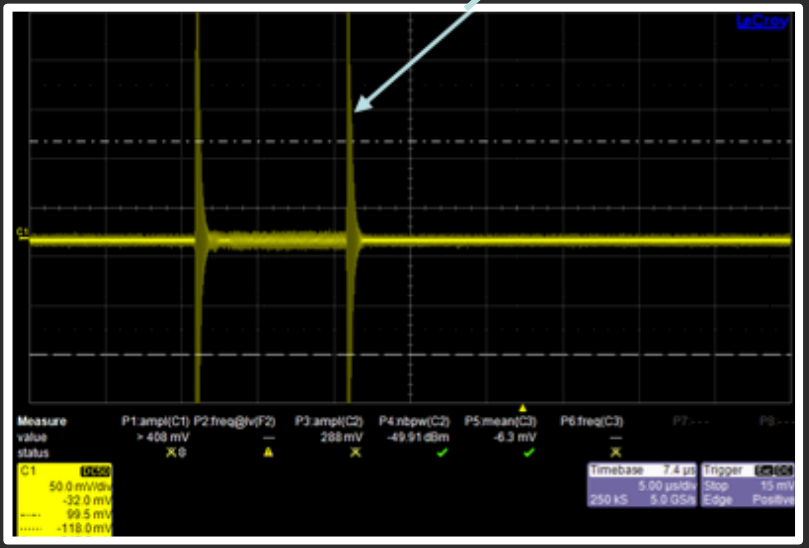
H&S Test Benches (continued…)

$$V(t) = V_o e^{-\omega t/2Q}$$

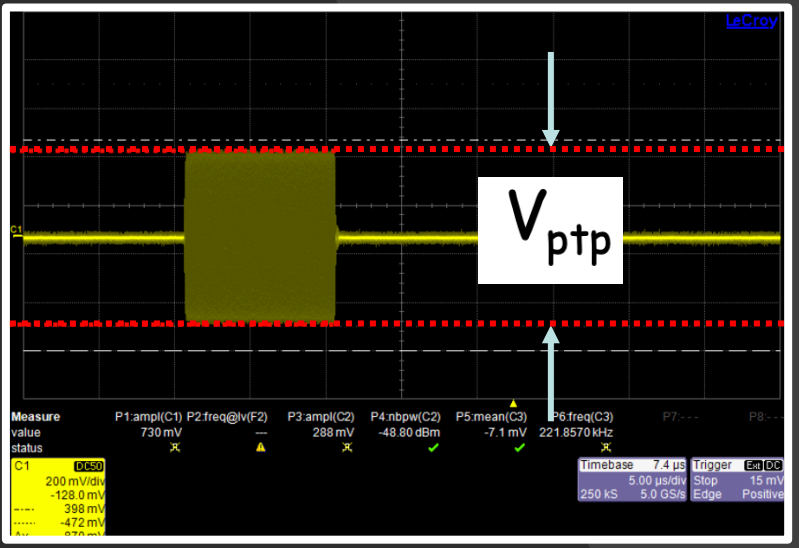
[Probe Testing Under Power]



[Forward Power]



[Reflected Power]



[Peak-to-Peak Voltage]

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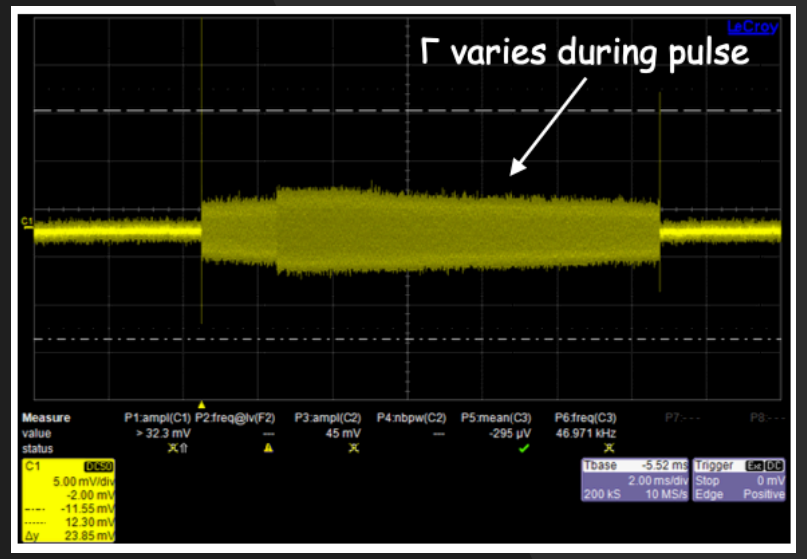
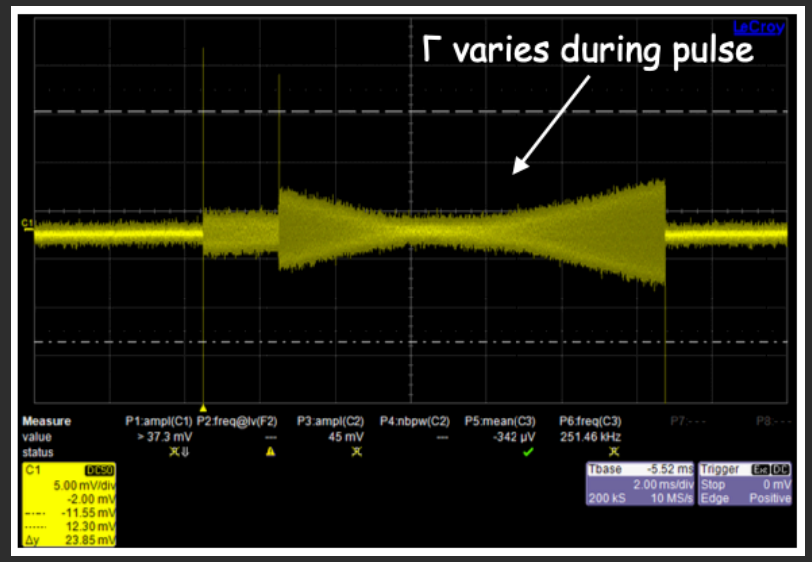
H&S Test Benches (continued…)

L	•Sample •Inductance
C	•Ceramic •Capacitance
R	•Load •Resistance

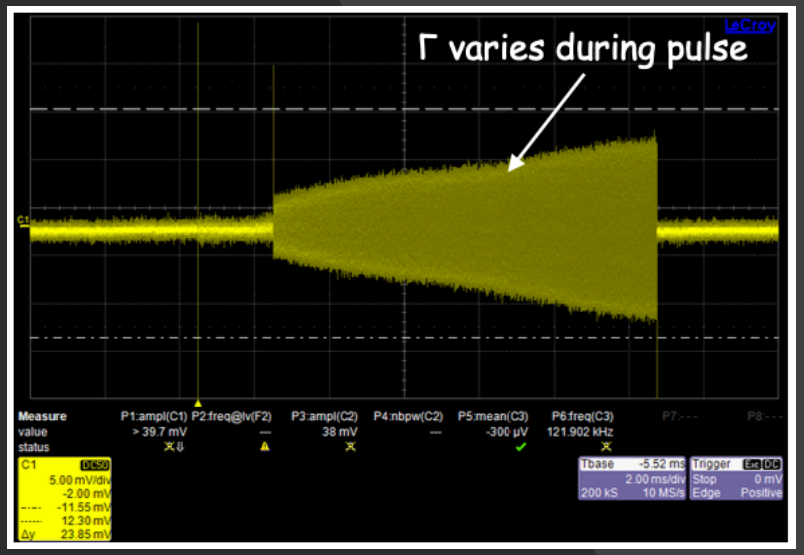
[Sample & RF E-field Interaction During Decoupling]



[L & C Varied]



[R Varied: Under-Tuned]



[R Varied: Over-Tuned]

Asher Rich

Summary

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References

1. “A Narrow Band “Oscilloscope” for High Power Tuning of NMR Probes”, Project Proposal, W. Brey, 2020.
2. “NMR Operation at NYSBC”, NYSBC Solid State NMR Short Course,

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4. G. Amouzandeh, V. Ramaswamy, N. Freytag, A. S. Edison, L. A. Hornak and W. W. Brey, "Time and Frequency Domain Response of HTS Resonators for Use as NMR Transmit Coils," in IEEE Transactions on Applied Superconductivity, vol. 29, no. 5, pp. 1-5, Aug. 2019, Art no. 1102705, doi: 10.1109/TASC.2019.2902522.
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Questions