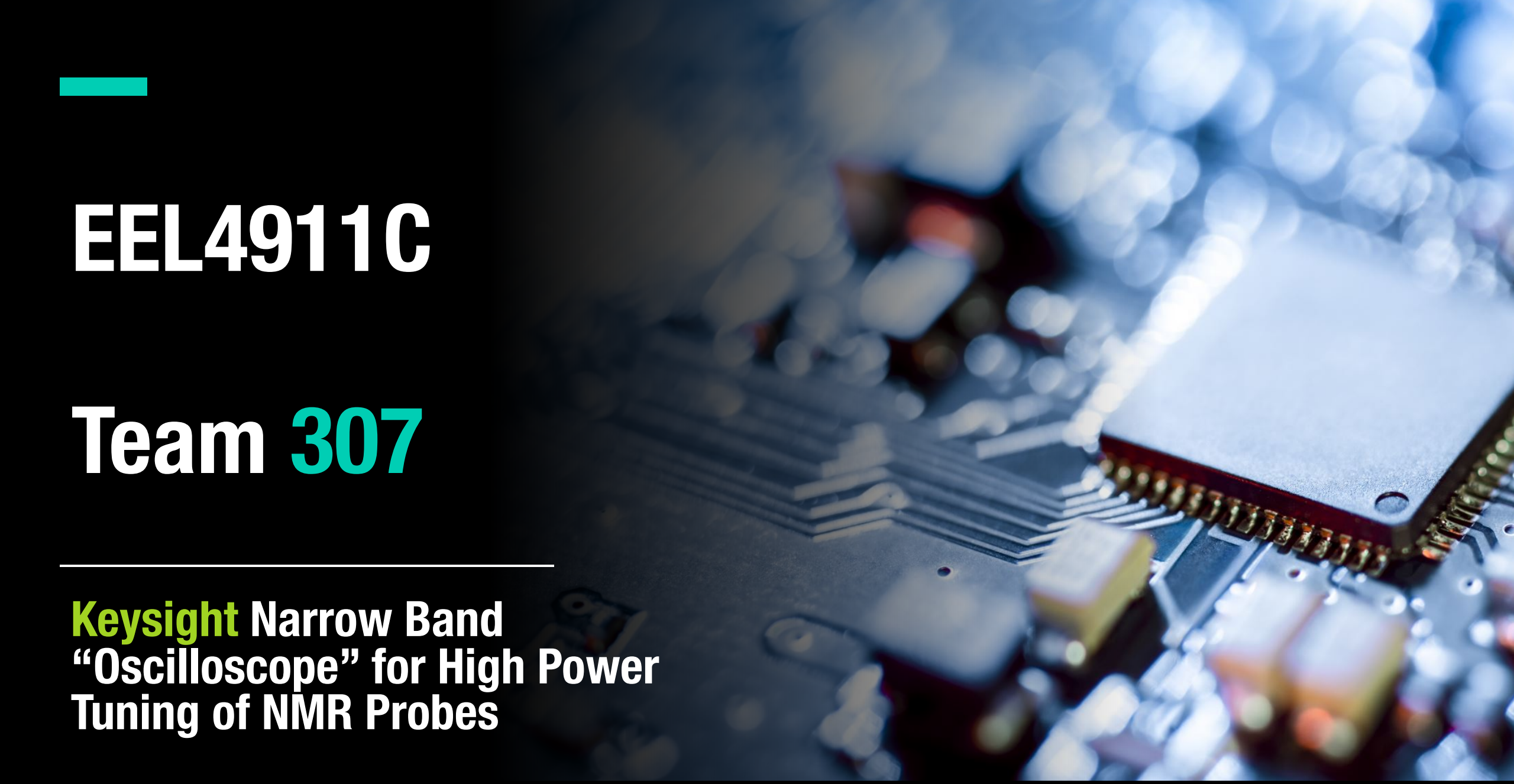
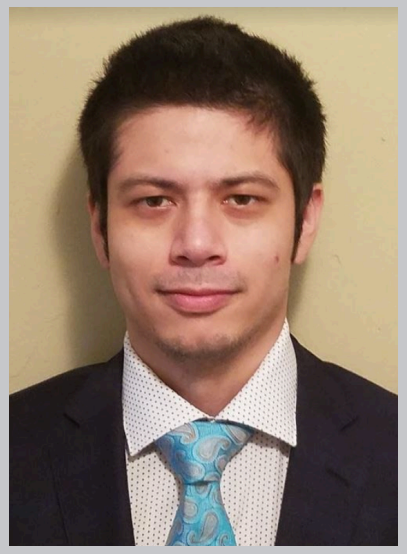
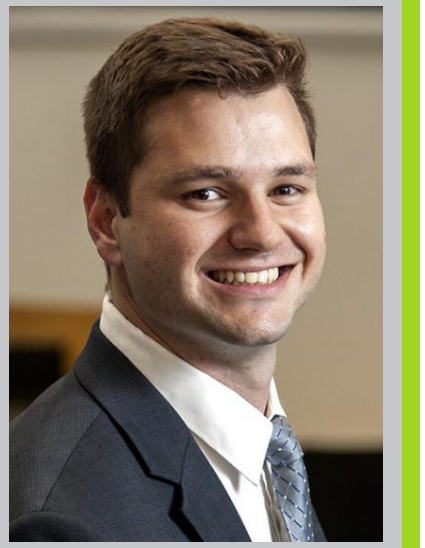
EEL4911C

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** Circuit & Hardware Assembly Lead	**Lead ECE** DGR	**Team Leader**	**Research Lead**
				

Presentation Outline

- Introduction
- Project Scope
- Customer Needs / Requirements
- Targets
- Concept Generation
- Concept Selection
- Bill of Materials
- Summary

Project Scope

- Project Description
- Key Goals
- Markets
  - Stakeholders

Project Description

- Software Defined Radio
- Trigger
- Radio Frequency (RF)
- Reflected Power

Key Goals

- Design/Produce Working Prototype
- Reduce Cost of Envelope Detection
- Display Sweep Length and Control Frequency

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Market

- Magnetic Laboratories
- Tech-based Companies
- Government & Defense
- Service Providers
- Researchers

Stakeholders

- National High Magnetic Field Laboratory
- Keysight
- Researchers

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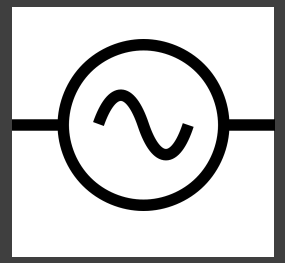
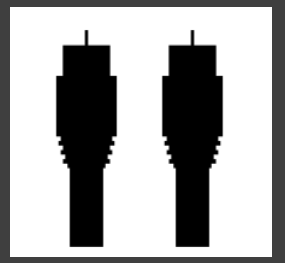
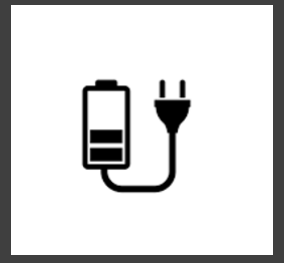
Customer Needs / Requirements

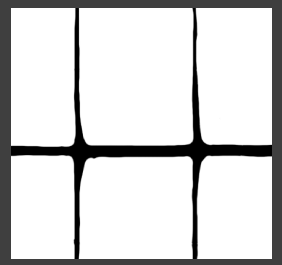
- Needs Synopsis
- Customer Requirements

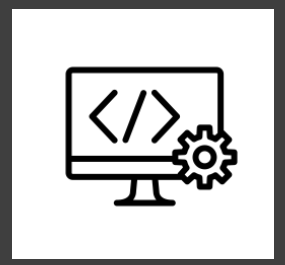
Needs Synopsis

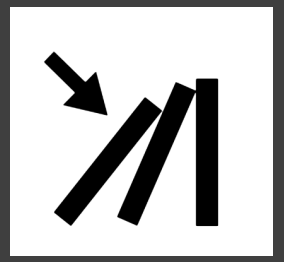












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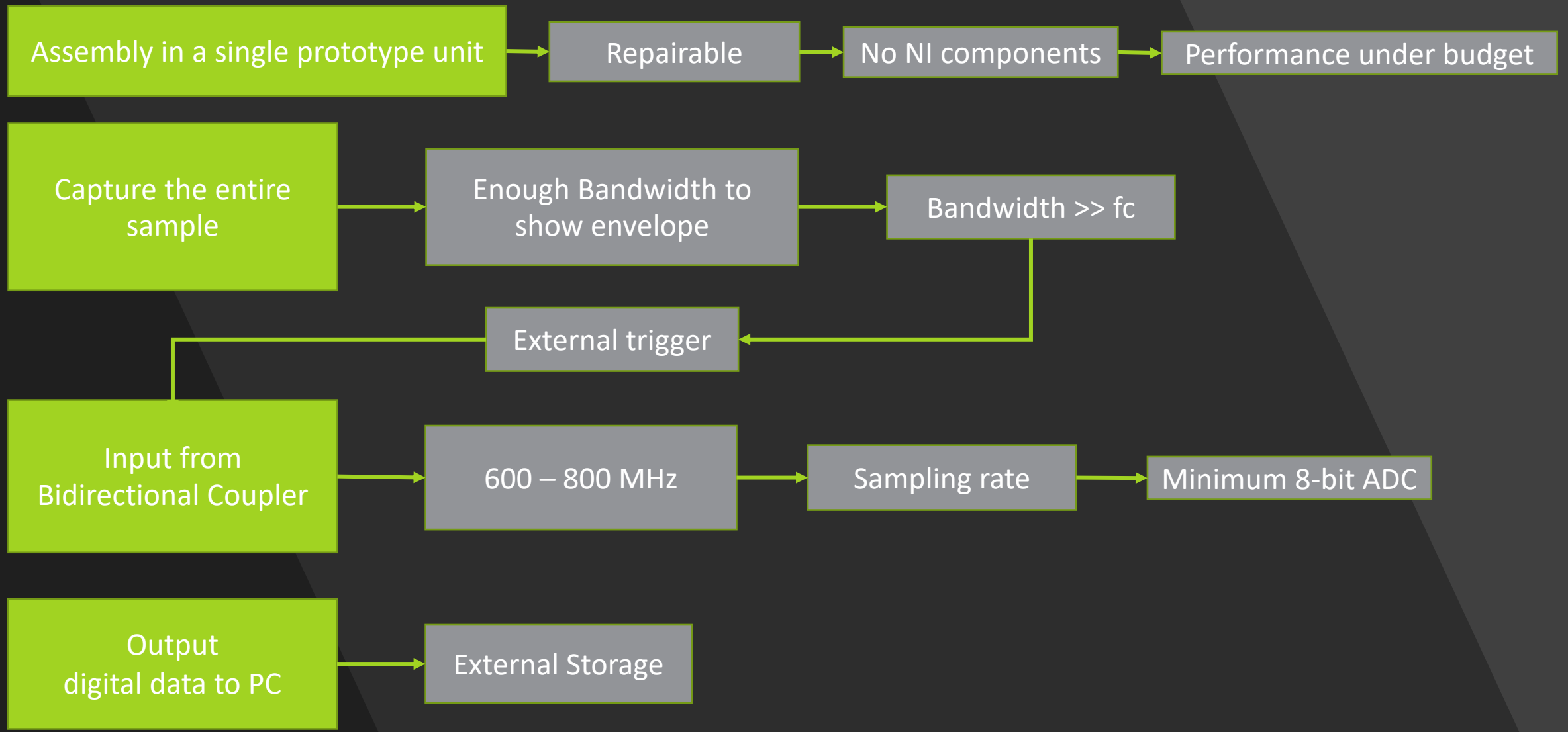
Customer Requirements

Block Diagram



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Targets

- Metrics
- Overview

Metrics

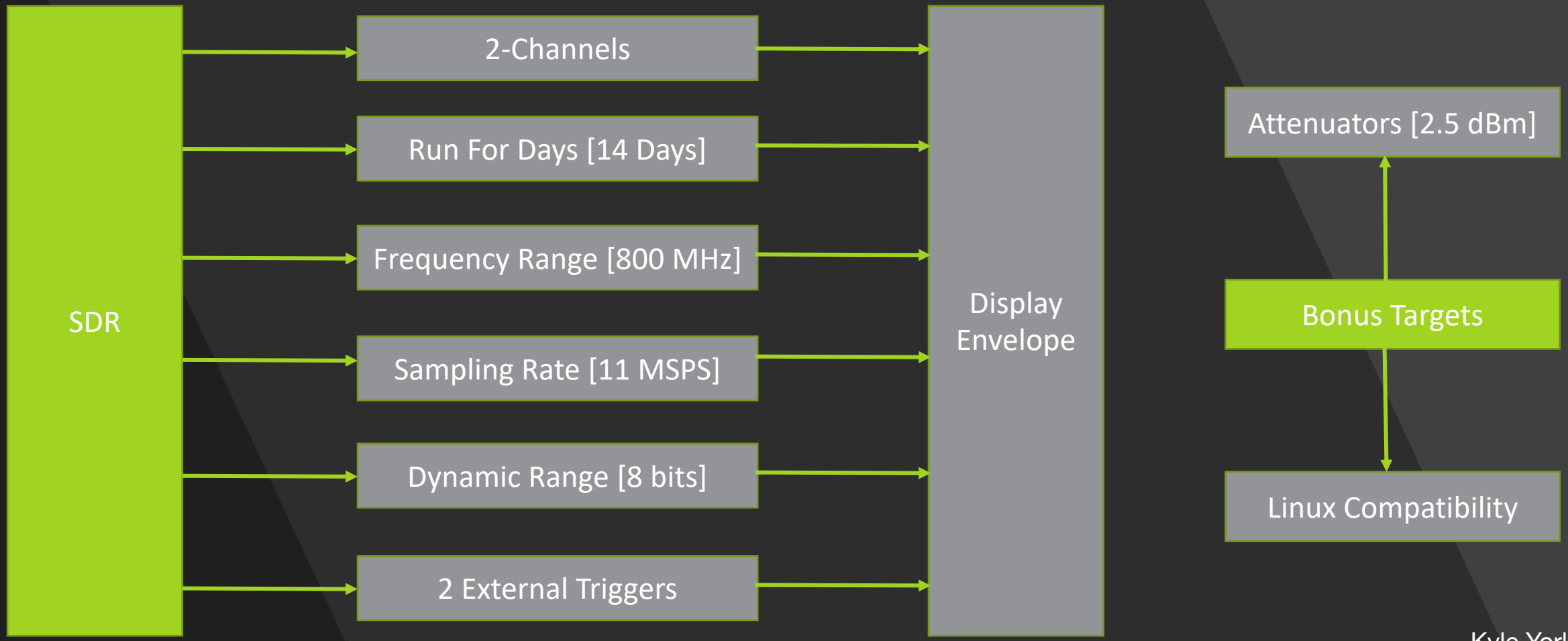
- Why targets are helpful
- List Format

Metric Number	Need	Metric	Importance	Units	Marginal Value	Ideal Value

- Target Report
  - Validates the targets
    - Tools
    - Instruments
    - Measurements

Kyle York

Target Overview



Kyle York

Concept Generation

- Concept Metrics
- Generation Methods
  - Morphological Chart
  - Biomimicry
  - Anti-Problem
- Design Options

Asher Rich and Gabriel De Leon

Concept Metrics

- External Search
- Internal Search

Asher Rich

Generation Methods

- Morphological Chart
- Biomimicry
- Anti-Problem

Asher Rich

Generation Methods

Morphological Chart

Chart I

Attenuation	On SDR	On Bi-Directional Coupler	On Box to SDR
Trigger	Digital Interpreter (DI) Circuit	Soldered Connection	Input Connection
Interface	Keyboard	Switches	Buttons
Software	SDRuno	Simulink	SDRangel
Display	PC Monitor	In-Lab Monitor Device	CRT

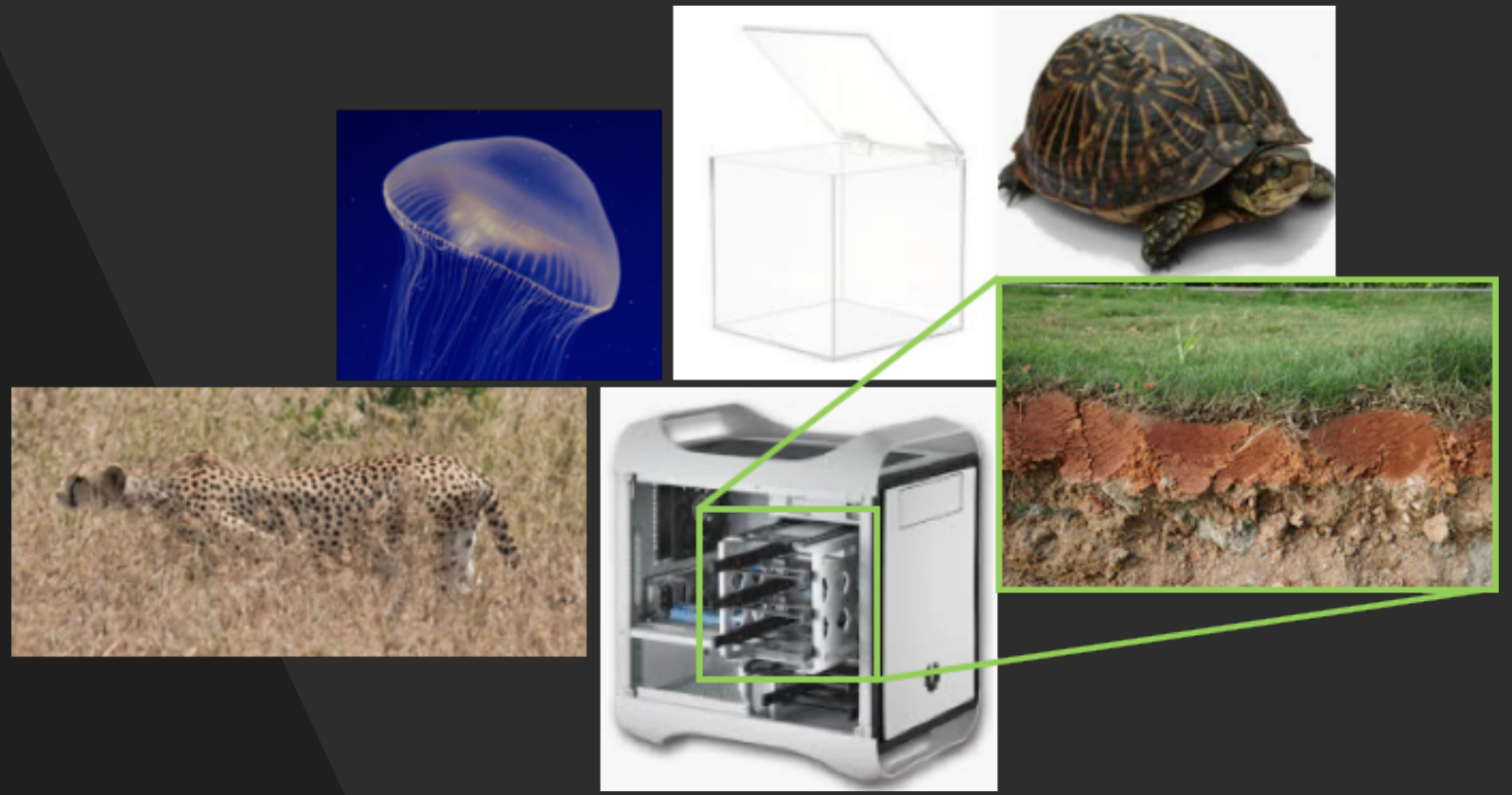
Chart II

Number of SDRs	One (two receiver ports)	Two (one receiver port)	Two (two receiver ports)
SDR	Adalm Pluto	HackRF One	SDRplay DUO
Power	Battery	DC Power	USB Power
Storage	Internal SDR Memory	External (PC or Hard Drive)	Cloud
Trigger Implementation	ADC Control (DMA Recording)	Tagged Sink Block	Separate Circuit PCB Design

Asher Rich

Generation Methods

Biomimicry



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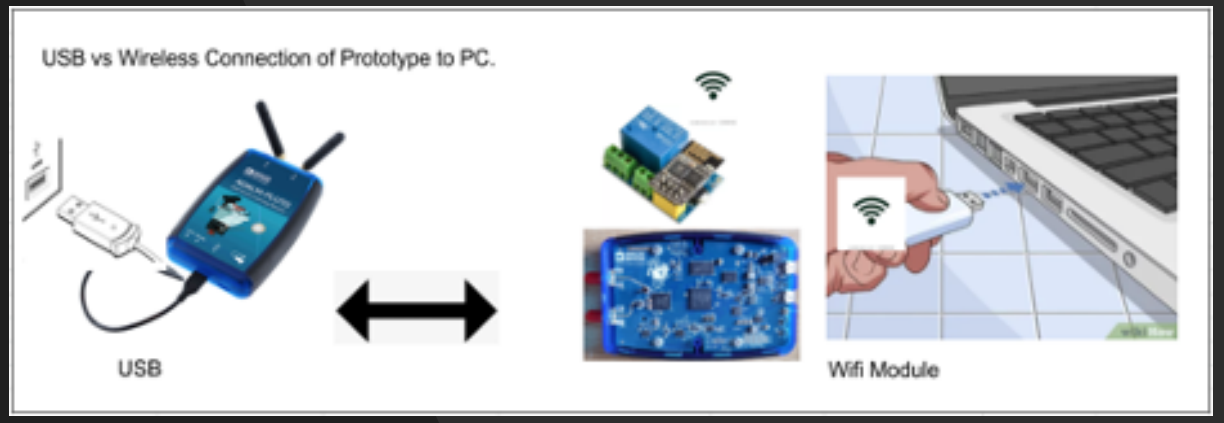
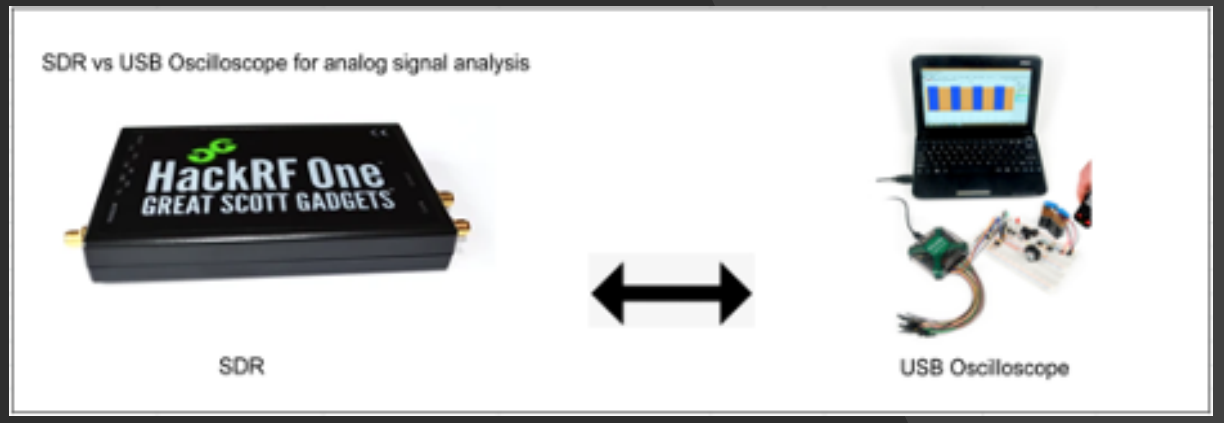
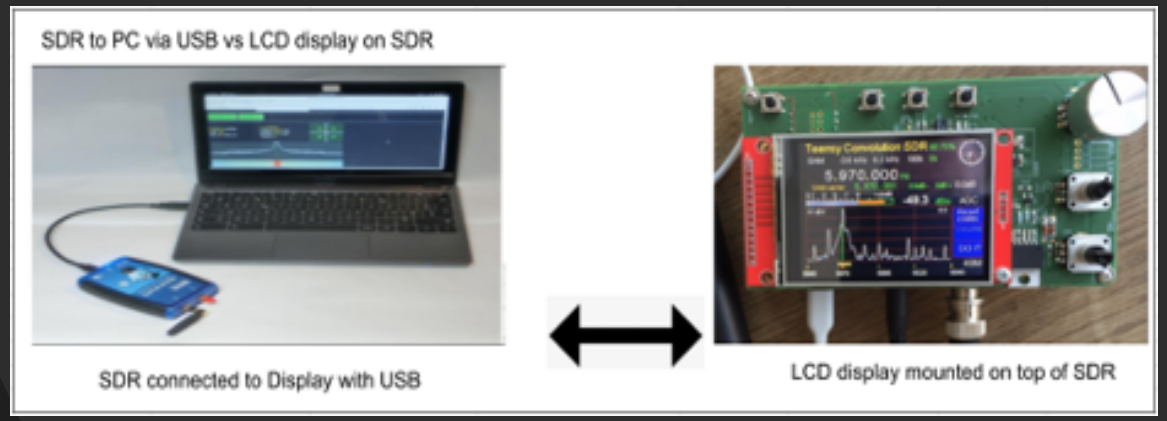
Generation Methods

Anti-Problem



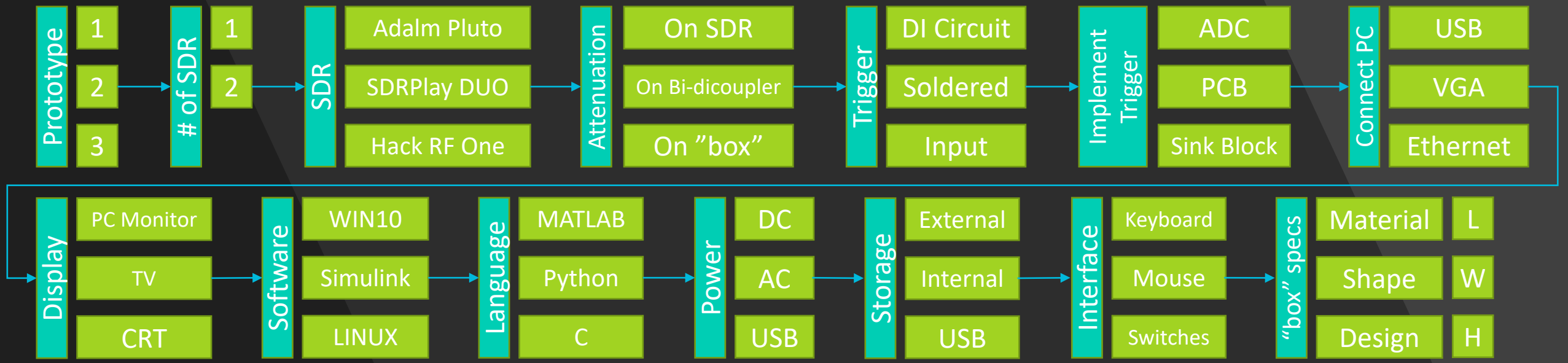




Gabriel De Leon

Design Options

High Fidelity Concepts



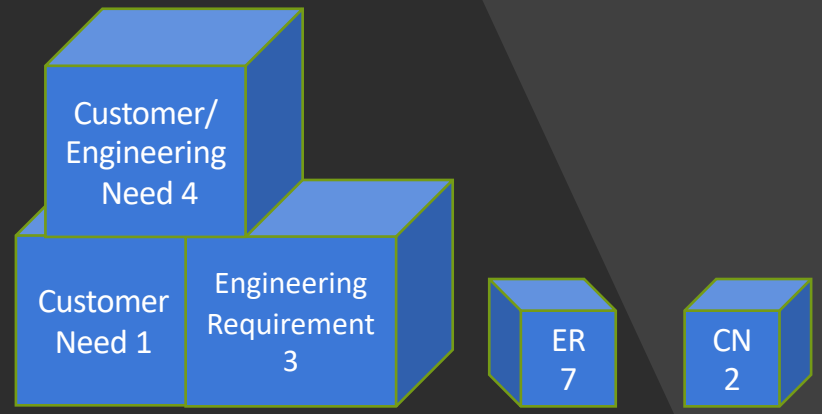
Asher Rich

Concept Selection

- Marketing and Engineering Matrix
- House of Quality
- Pairwise and Consistency
- Analytical Hierarchy Process
- Pugh Chart
- Initial detailed design

Marketing and Engineering Matrix

Customer Needs and Requirements correlations



	Engineering Requirements	Assembly in a single unit	Connected to an external trigger
Customer Need	**Polarity**	+	+
Prototype of a single unit	+	↑↑	↓
Reparability in case of failure	+	↑	↓

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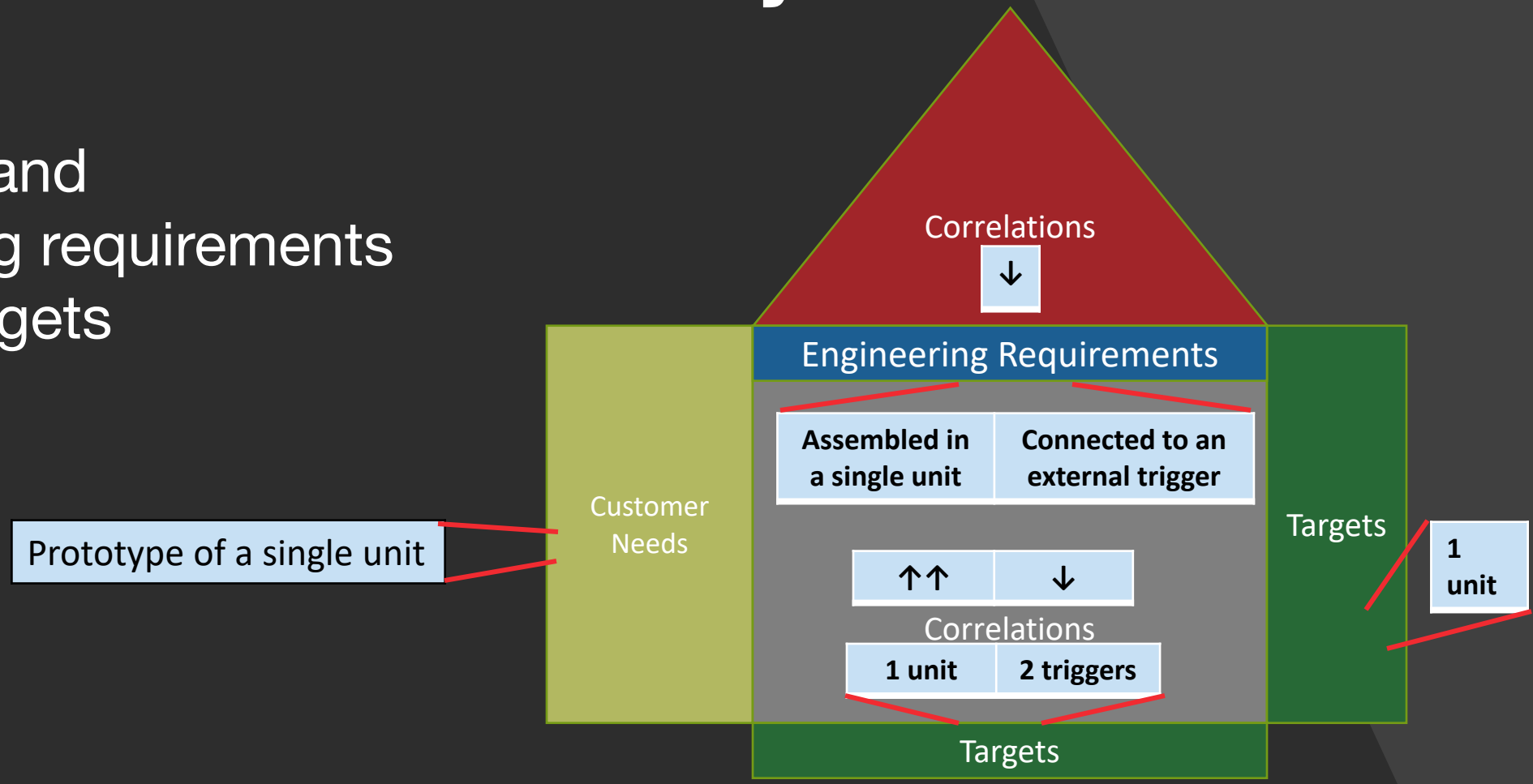
House of Quality

- Customer and Engineering requirements against Targets



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Pairwise Comparison and Consistency Check

- Compared on

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 600MHz-800MHz for received and reflected signals	0.112
Sampling rate of the SDR will be higher than required minimum	0.103
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 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
Stays under budget	0.021
Assembled in a single unit	0.019

- Equal to very important

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

- CR < 0.1

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Analytical Hierarchy Process

Pairwise Comparison Weights

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

	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

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Pugh Chart

- Basic Comparison
- Integer Weighting

	Weight	Option 1	Option 2	Option 3
Output digital signal will have at least 8-bit resolution	6	-	-	-
Connected to an external trigger	3	-	1	-1
Score		-	-1	-11
Continue?		Combine	Combine	No

	Weight	Option 1 & 2	Option 1
Output digital signal will have at least 8-bit resolution	6	-	-
Connected to an external trigger	3	-	-1
Score		-	-3
Continue?		Yes	No

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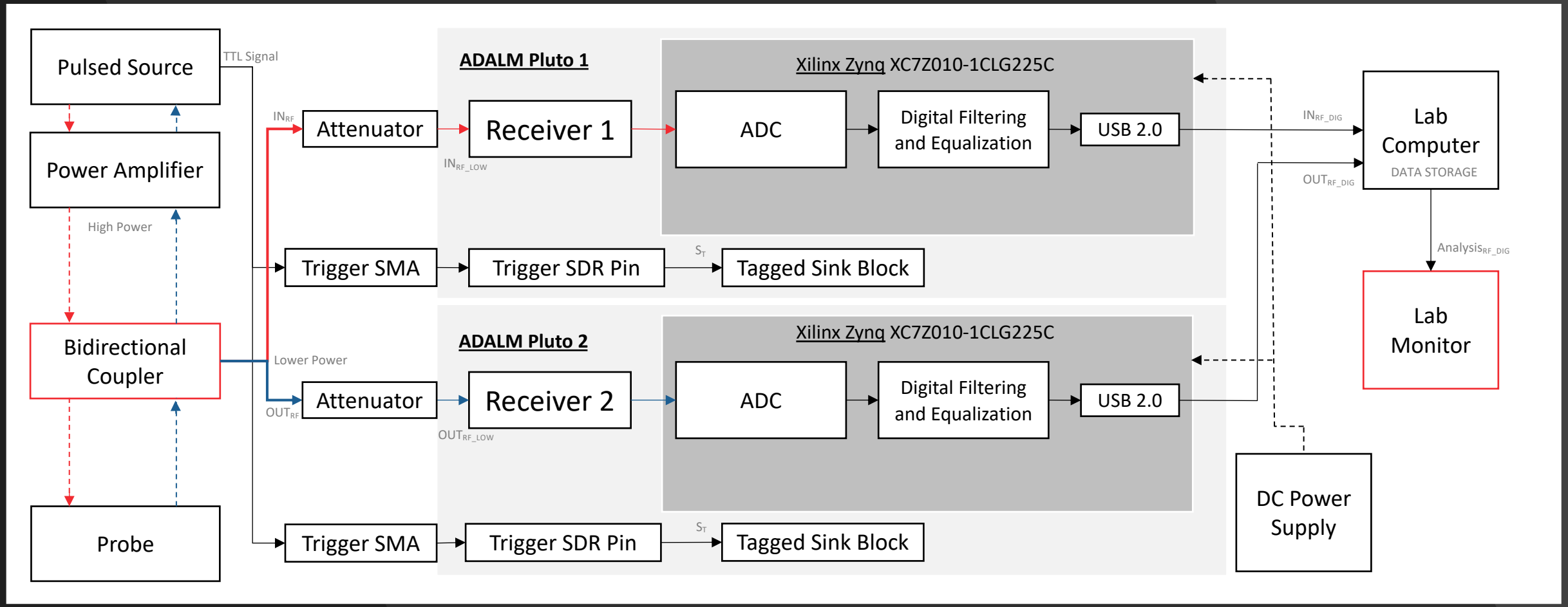
Selected Design Concept

- Original Concepts
- Merged Concepts

Number	Concept	Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9	Column10	Column11	Column12	Column13	Column14	Column15	Column16	Column17
1	Prototype 1	Number of SDR	SDR	Attenuation	Trigger	Trigger implementation	Connection to PC	Display	Software	Language	Power	Storage	Interface	Prototype Box Material	Prototype Box Shape	Prototype Box Design	Prototype Box Size (LxWxH)	Biomimicry
		Two (one receiver port)	ADALM Pluto	On SDR	Soldered connection	Tagged Sink Block	USB 2.0	PC monitor	Windows 10 Simul ink	MATLAB Python	USB Power	External (PC Hard Drive)	Keyboard	ABS Plastic (3D Printing)	Cubical	Closed and accessible	Medium (10x8x4 in)	Solid construction

Detailed Signal Flow Analysis Block Diagram



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SDR Choice

Specification	Value
RF coverage	325 MHz to 3800 MHz
ADC resolution	12-bit ADC
ADC Sample Rate	65.2 kSPS to 61.44 MSPS
Software Support	MATLAB, Simulink
Features	GNU Radio sink and source blocks
Language Support	C, C++, C# and Python API
Power	USB 2.0, Optional DC Power

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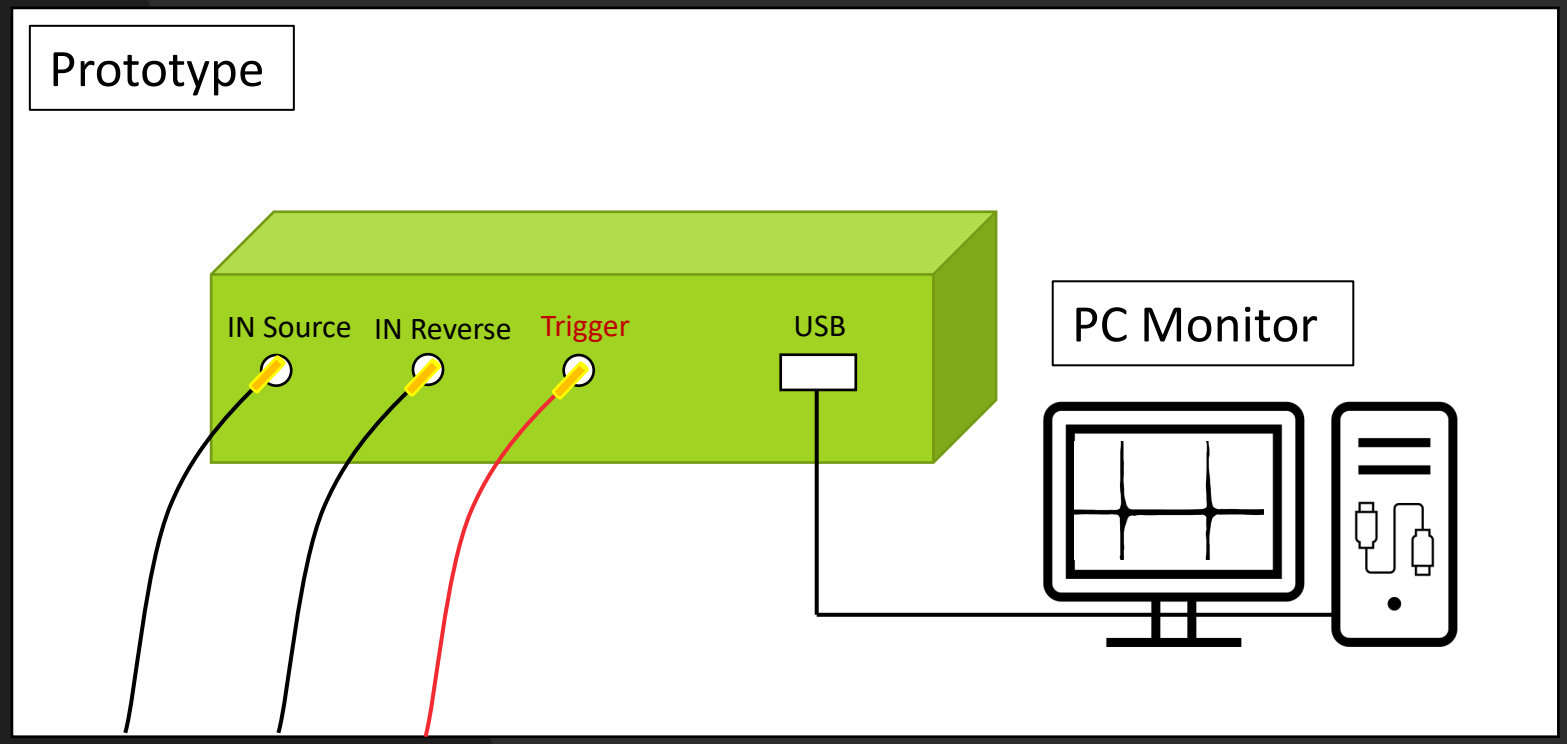
Data Inputs and Output



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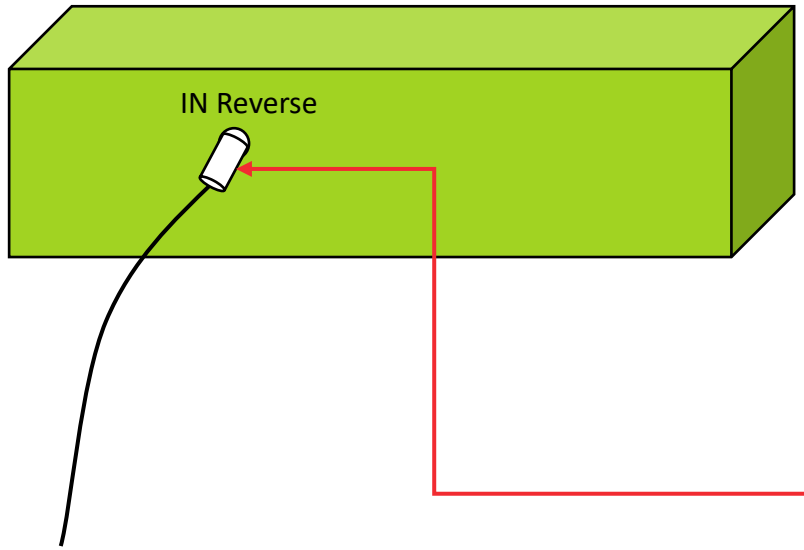
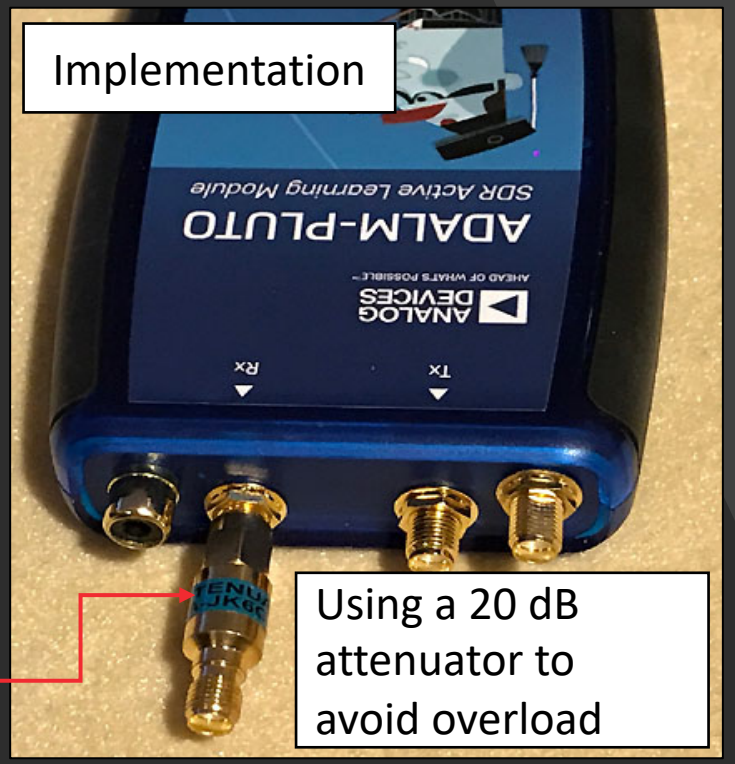
Input 1 and 2: Attenuators

Schematic



Attenuator

Implementation



Using a 20 dB attenuator to avoid overload

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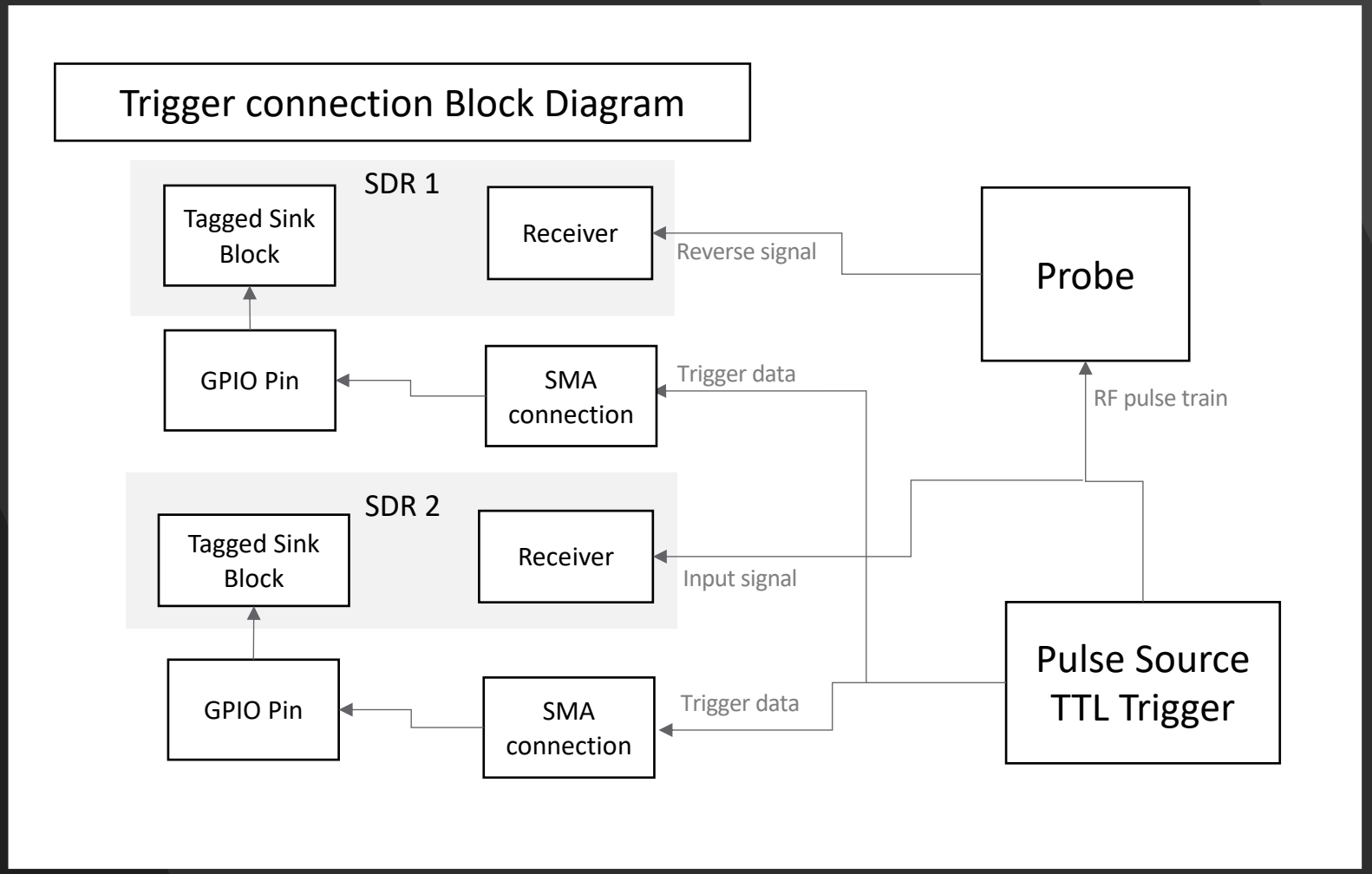
Input 3: Trigger



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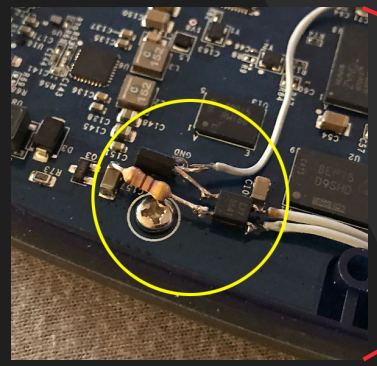
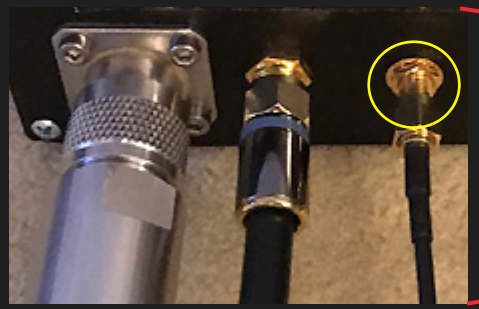
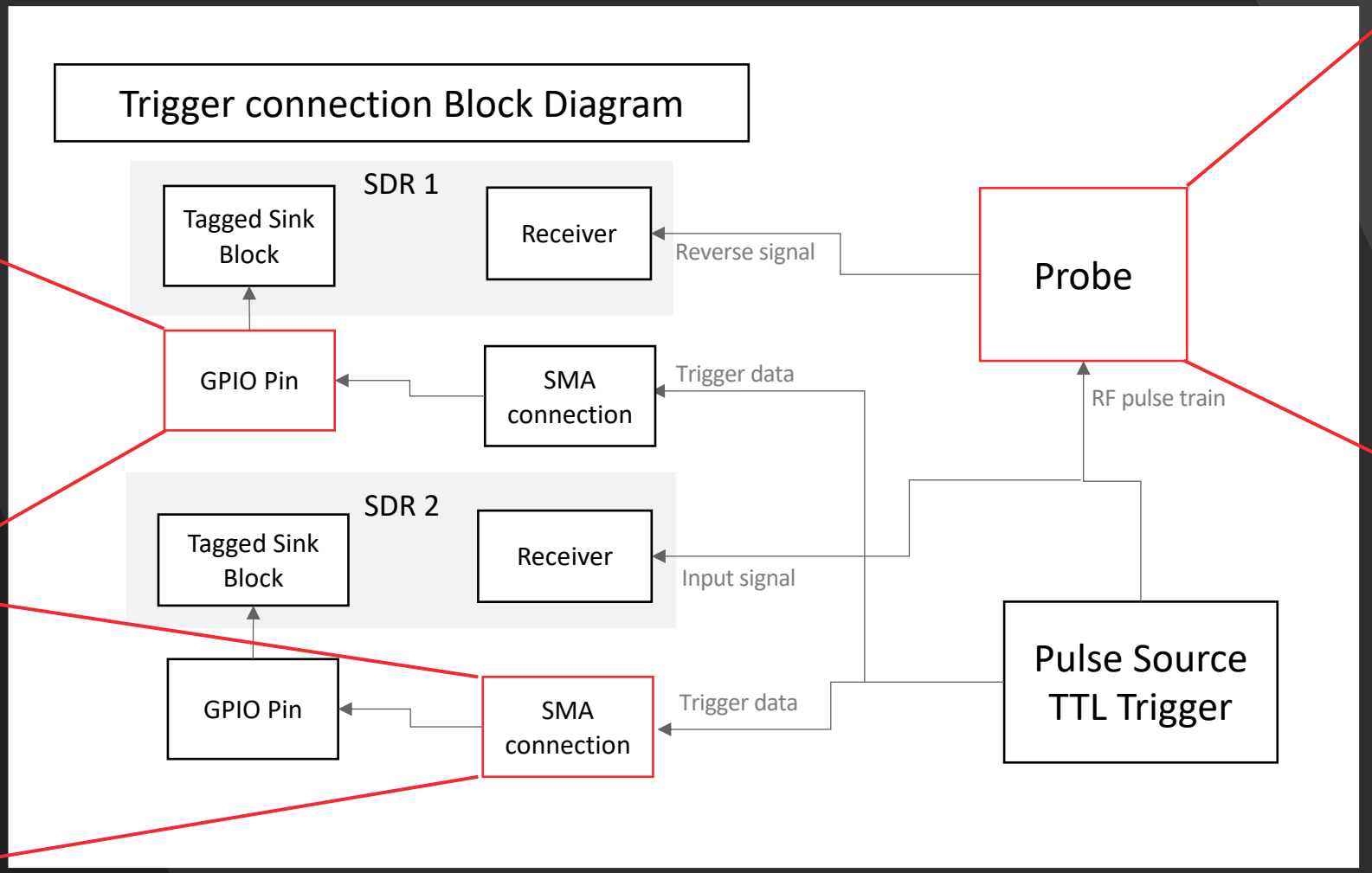
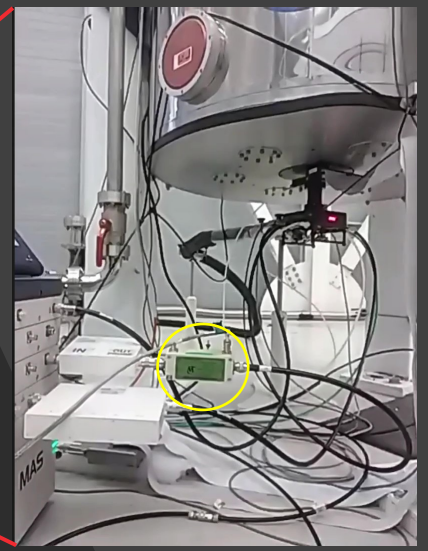
Trigger









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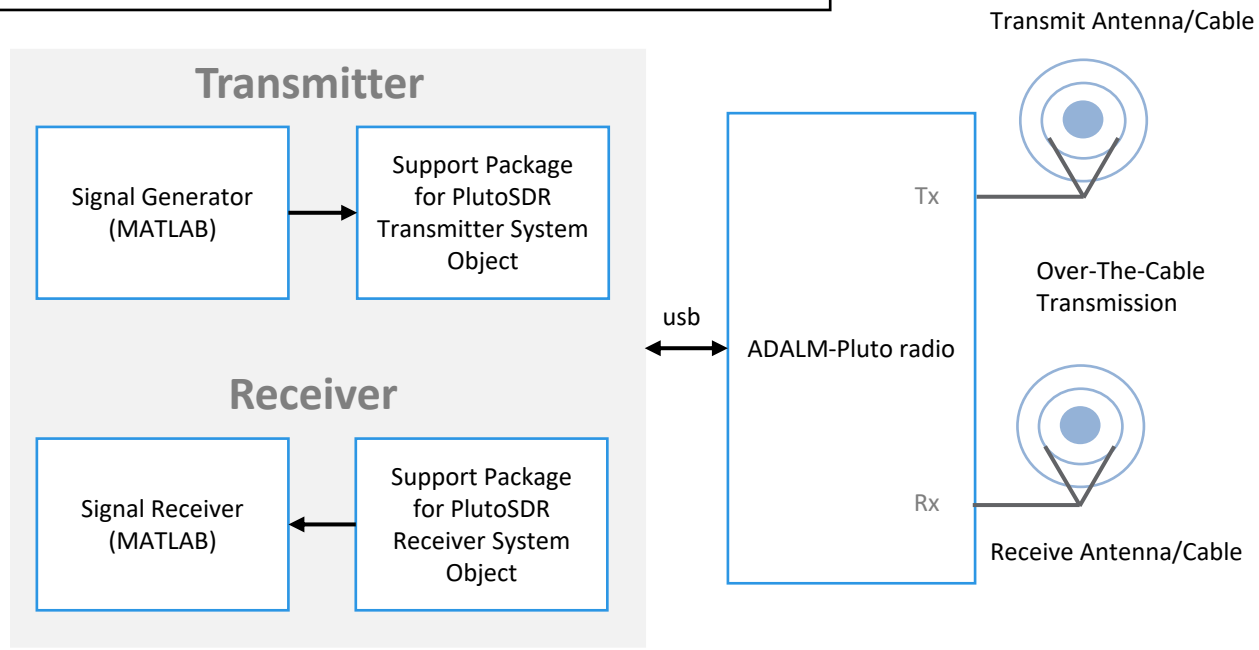
MATLAB Support

Simplified MATLAB Support Block Diagram



- Only Receive Cable MATLAB integration will be used
- MATLAB Simulink software blocks
- Software used for Data Analysis and Storage

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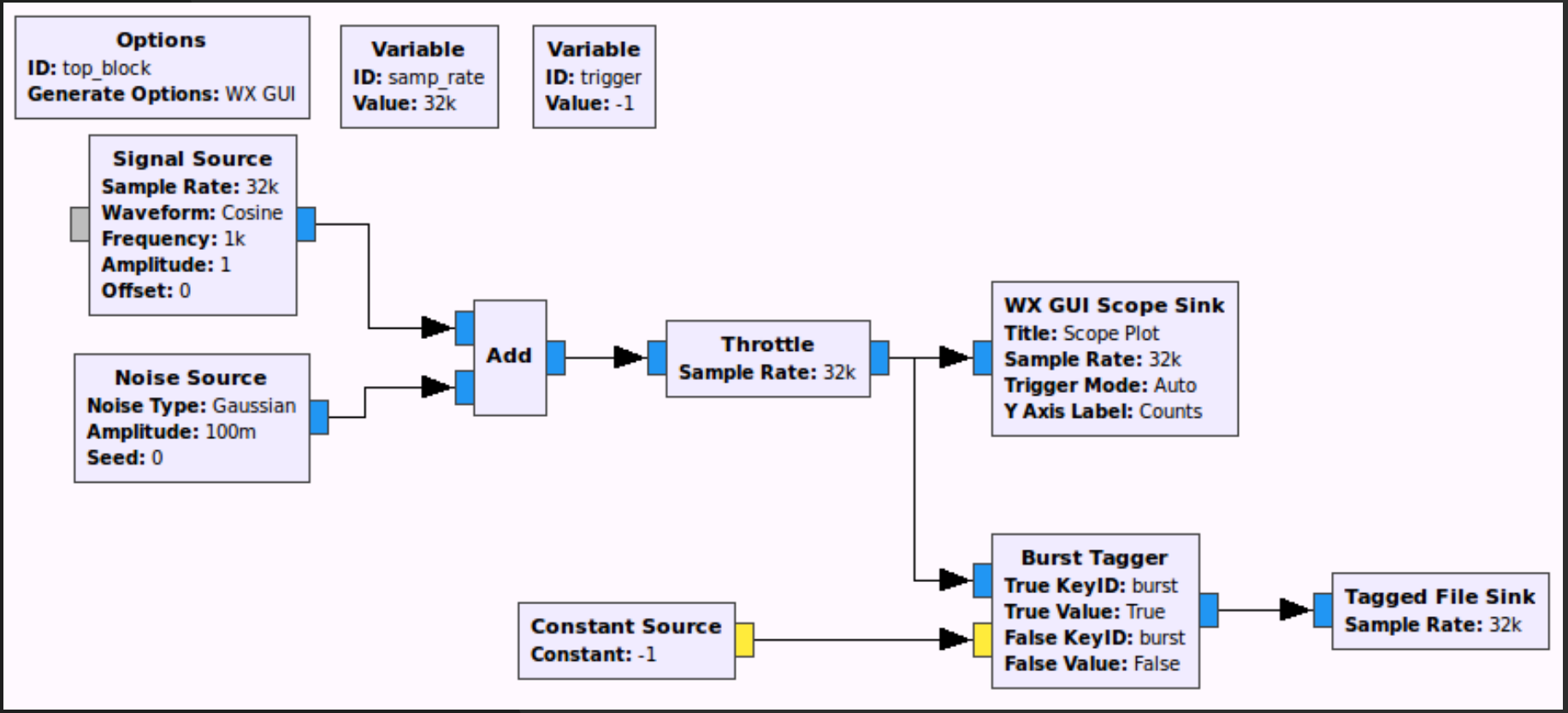
Trigger MATLAB implementation



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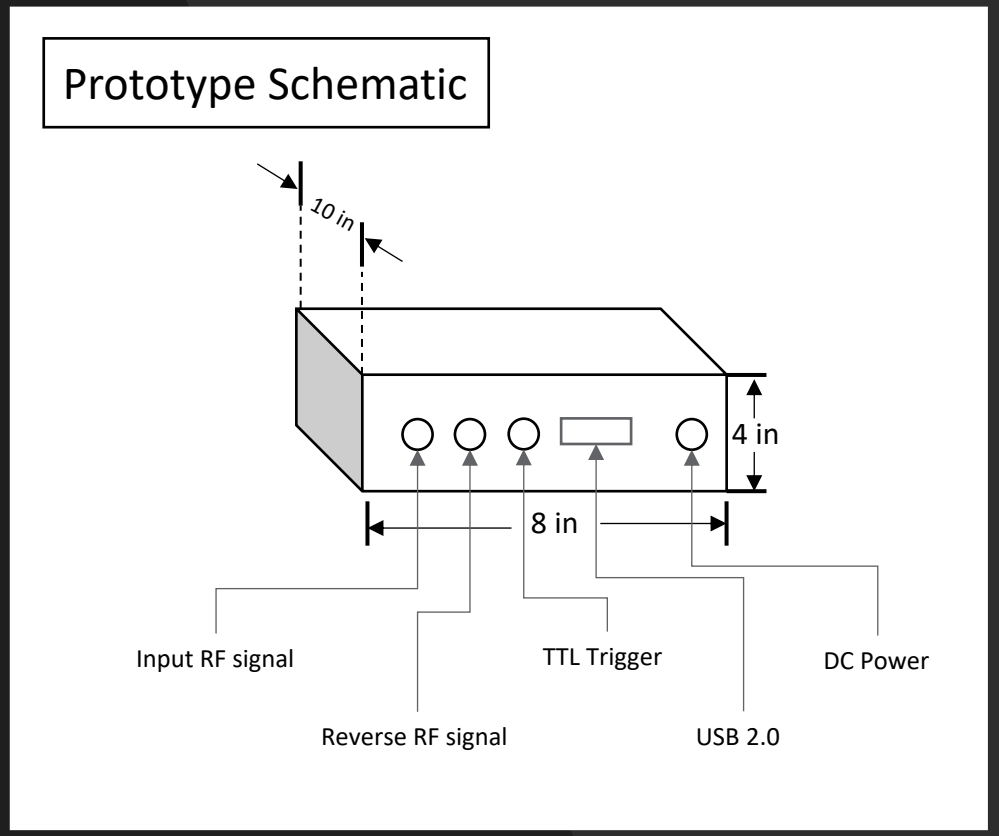
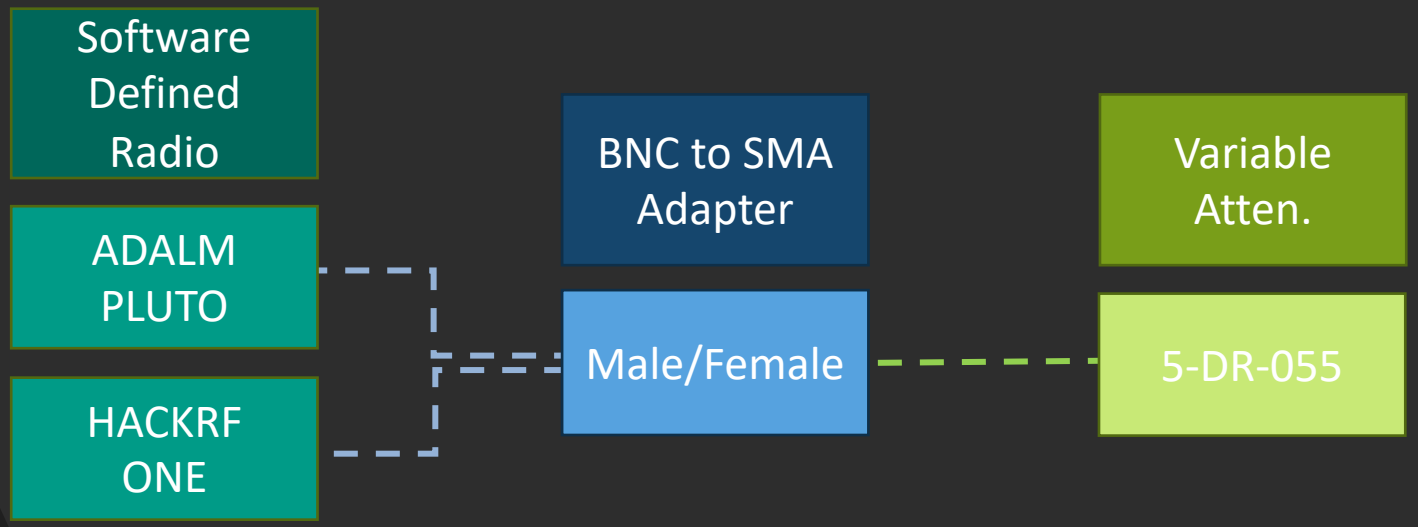
Prototype Unit



Bill of Materials

- BOM Structure
- BOM information
- Purchasing

BOM Structure



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BOM Information

- Item Reference Number
- Description of Item
- Quantity
- Item Cost
- Total Cost

Item Ref #	Item	Qty	Item Cost	Total Cost
1	ADALM PLUTO SDR	2	150	310.69
2	HACKRF SDR	1	299.95	299.95
3	JFW 50DR-055 ATTENUATOR	2	40.00	80.00
4	BNC to SMA ADAPTER	1	6.75	6.75

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BOM Information

- Item Reference Number
- Description of Item
- Quantity
- Item Cost
- Total Cost

Item Ref #	Item	Qty	Item Cost	Total Cost
1	ADALM PLUTO SDR	2	150	310.69

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Purchasing

- Vendors
- Websites

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Summary

- Introduction
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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,

   http://comdnmr.nysbc.org/comd-nmr-educ/comd-nmr-lecture-notes/lecture-notes/solidstateNMRcourse.pdf
3. “Design, Care and Feeding of NMR Probes” tutorial presented by Kurt Zilm at the 2011 ENC

   http://www.enc-conference.org/Portals/0/Probes_2011_Part_I.pps
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.

Questions