Building Blocks and Sub-Circuits with Magnetic Field Generators

Team sdmay23-29

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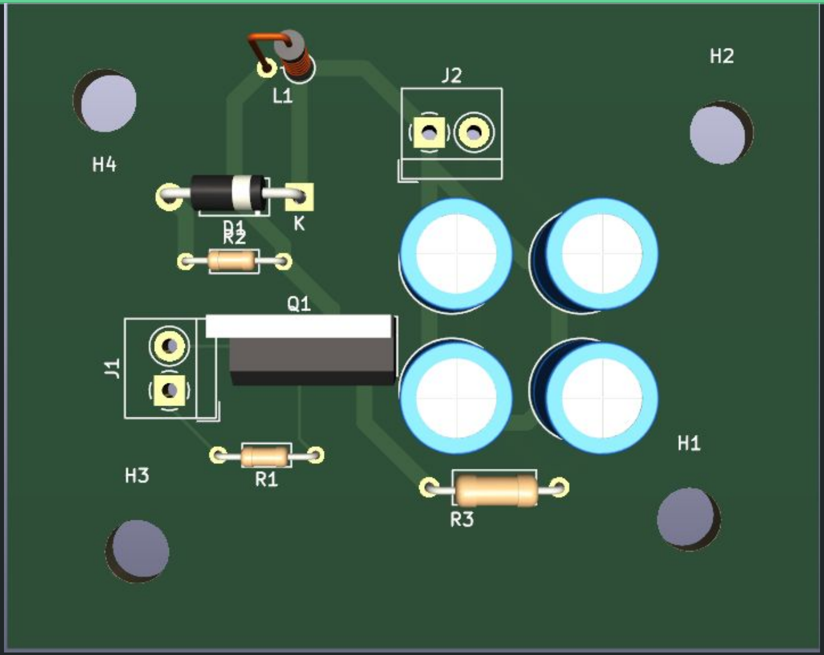
Date: 12/8/22



3D Model of PCB

Project Introduction

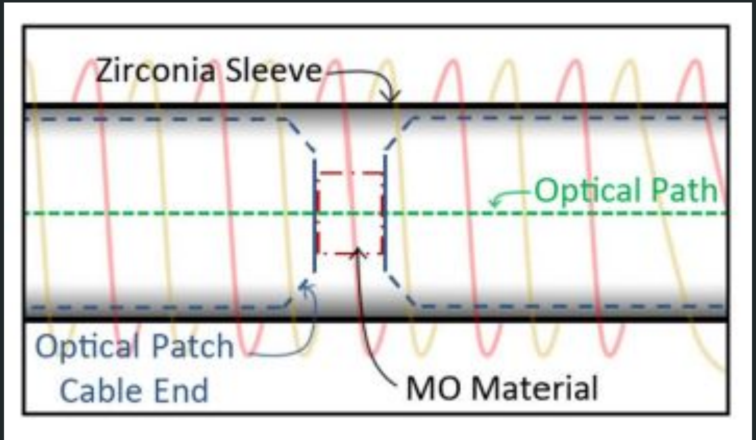
Context

Our project consists of designing a magnetic field generator (MFG) with a focus on optical design/simulation.

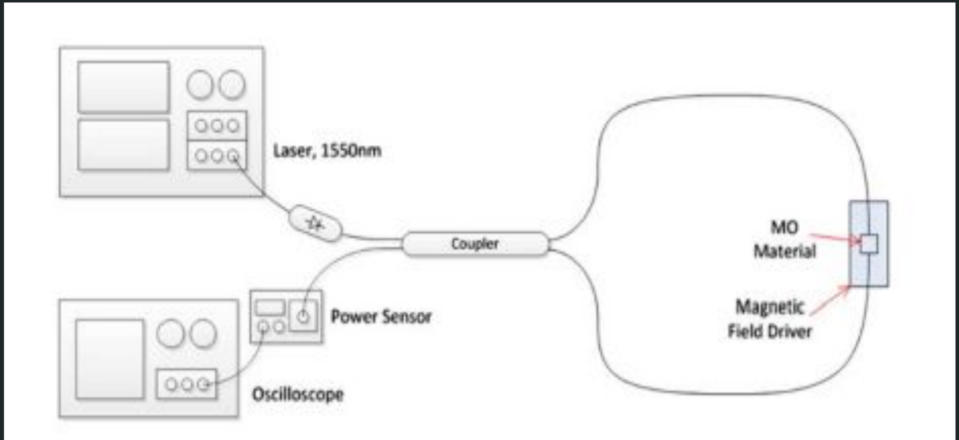
Problem Statement

Our goal is to enhance the MFG circuits of past senior design projects and create our own optical simulation with various softwares.

Optical Simulation



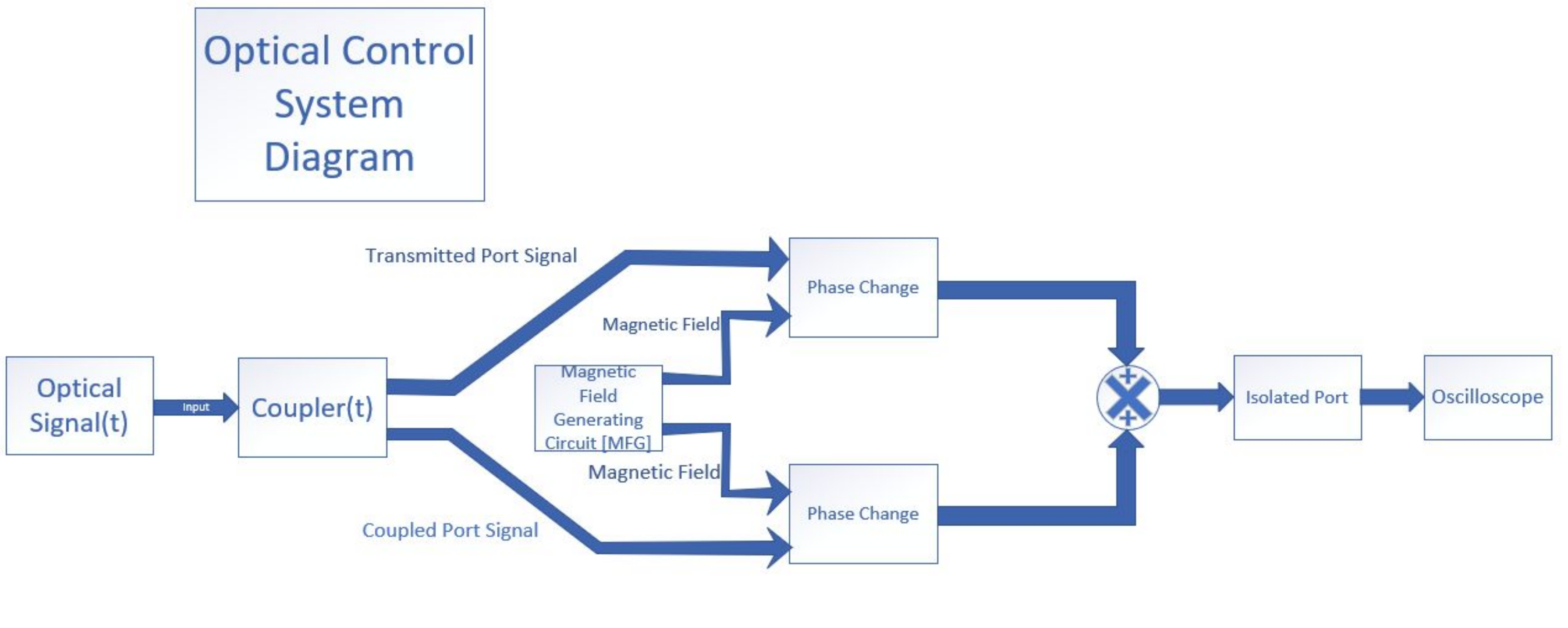
MO material between two optical patch cable ends, fitted within the mating sleeve.



Fiber-based Magneto-Optic (MO) Sagnac interferometer setup.

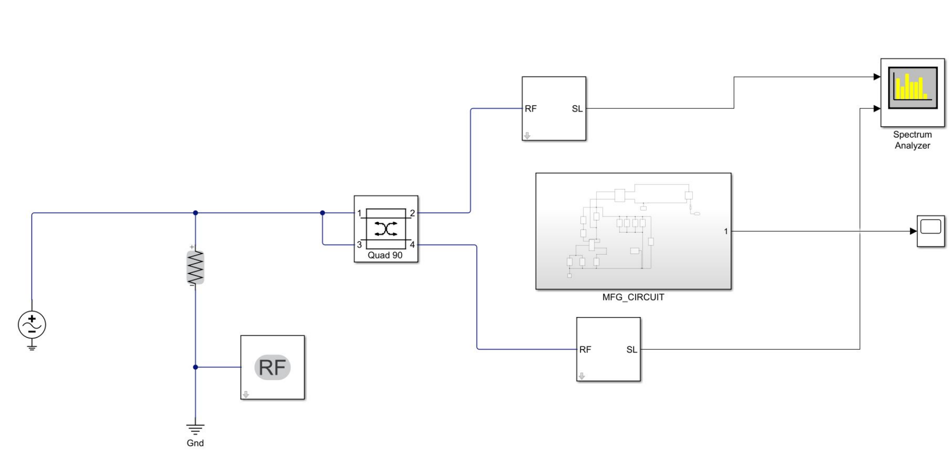
J. W. Pritchard, M. Mina and R. J. Weber, "Improved Switching for Magneto-Optic Fiber-Based Technologies," in *IEEE Transactions on Magnetics*, vol. 48, no. 11, pp. 3772-3775, Nov. 2012, doi: 10.1109/TMAG.2012.2202275.

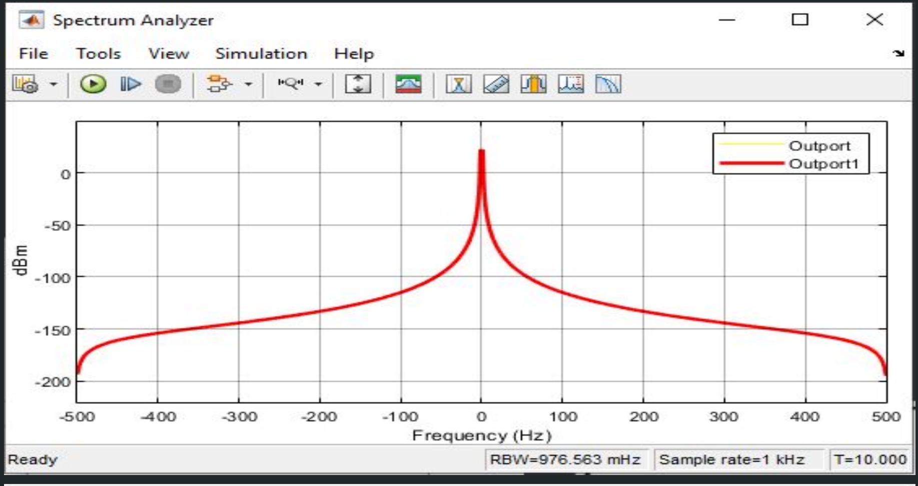
Optical Simulation



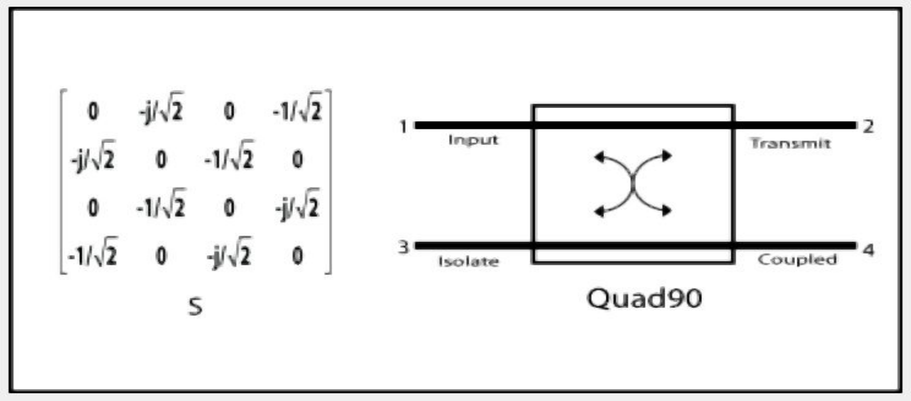
Optical Simulation In MATLAB (Work In Progress)

Overall Optical Simulation





Coupler S Parameters



Inductor Design

$$B = \frac{\mu_0 N I}{\sqrt{l^2 + 4r^2}}$$

$$L = \frac{\mu_0 N^2 \pi r^2}{\sqrt{l^2 + 4r^2}}$$

$N = 4\ turns$

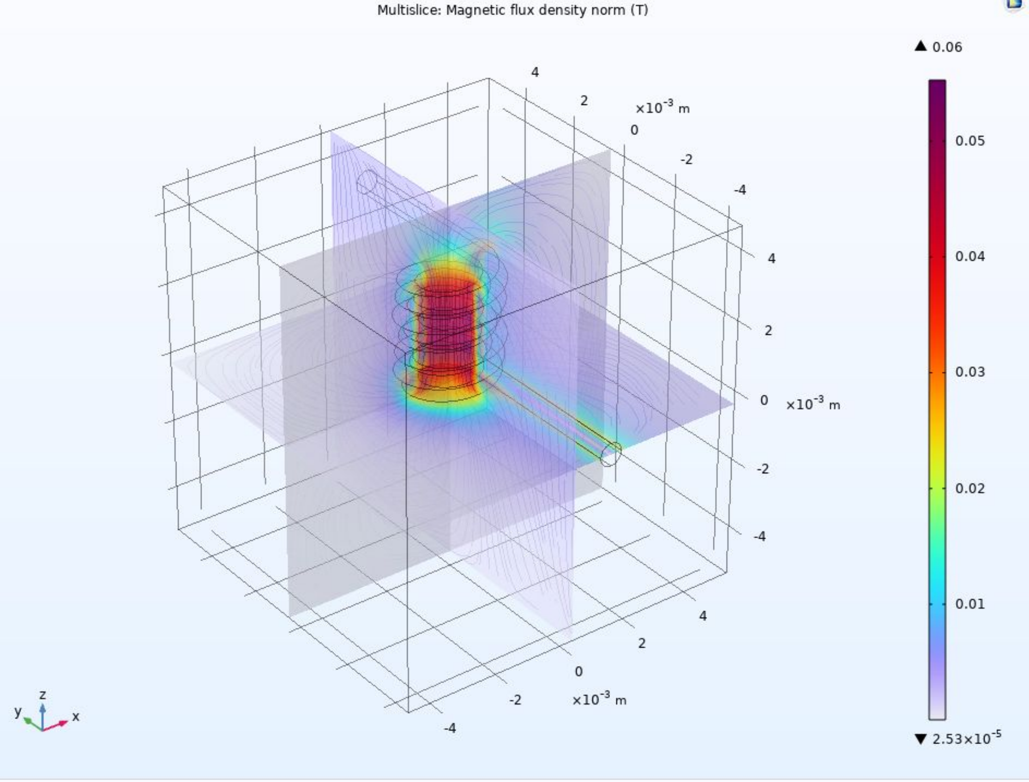
$r = 1.1\ mm$

$l = 3.5\ mm$

$\mu_0 = 4\pi * 10^{-7} H/m$

Calculated Inductance = 20.2 nH

Inductance Calculated in COMSOL = 21.73 nH



Magnetic Flux Density of Inductor in COMSOL

"39 • fast, compact, High Strength Magnetic Pulse Generator," *sdmay22*. [Online]. Available: http://sdmay22-39.sd.ece.iastate.edu/. [Accessed: 05-Dec-2022].

Circuit Design

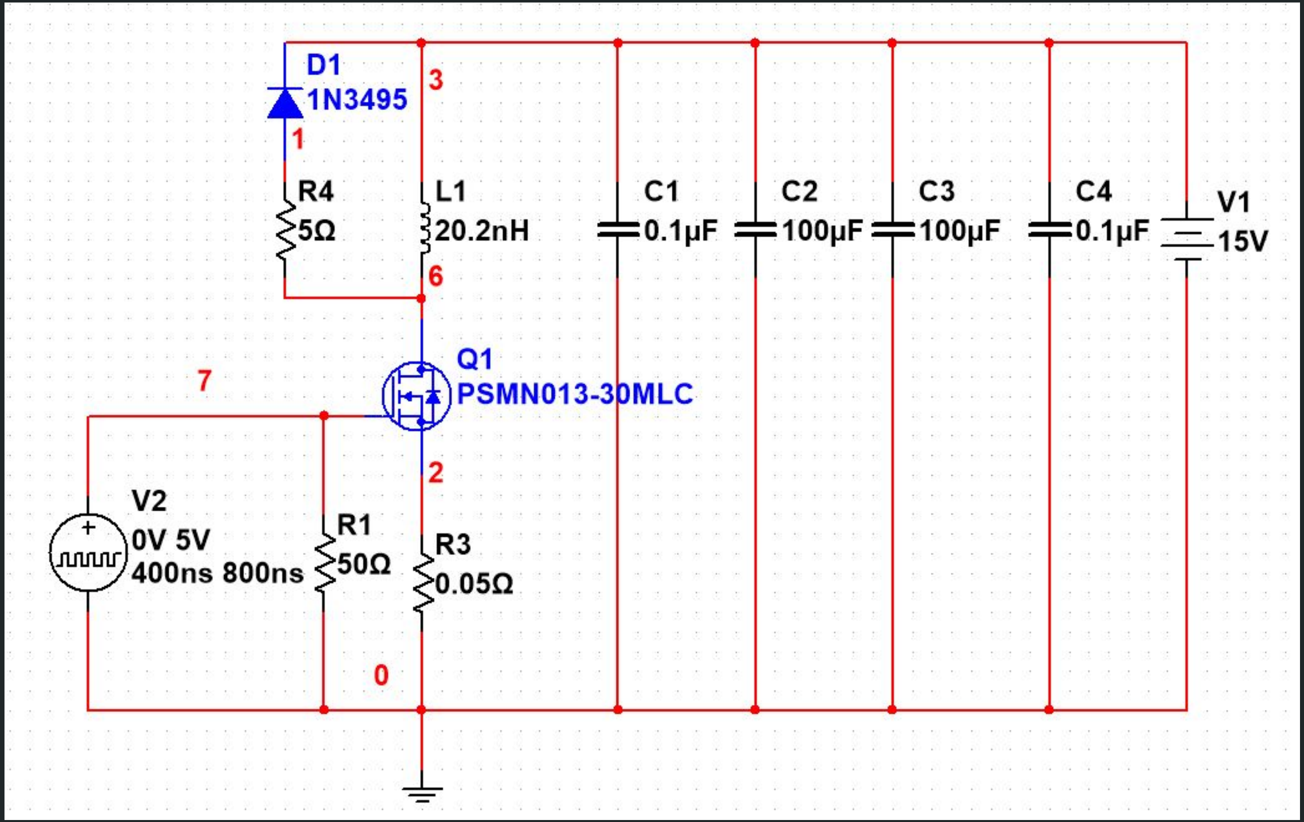
Circuit Specs:

VDC - <= 15V

Flux Density - > 500 G

Rise TIme - < 100 ns

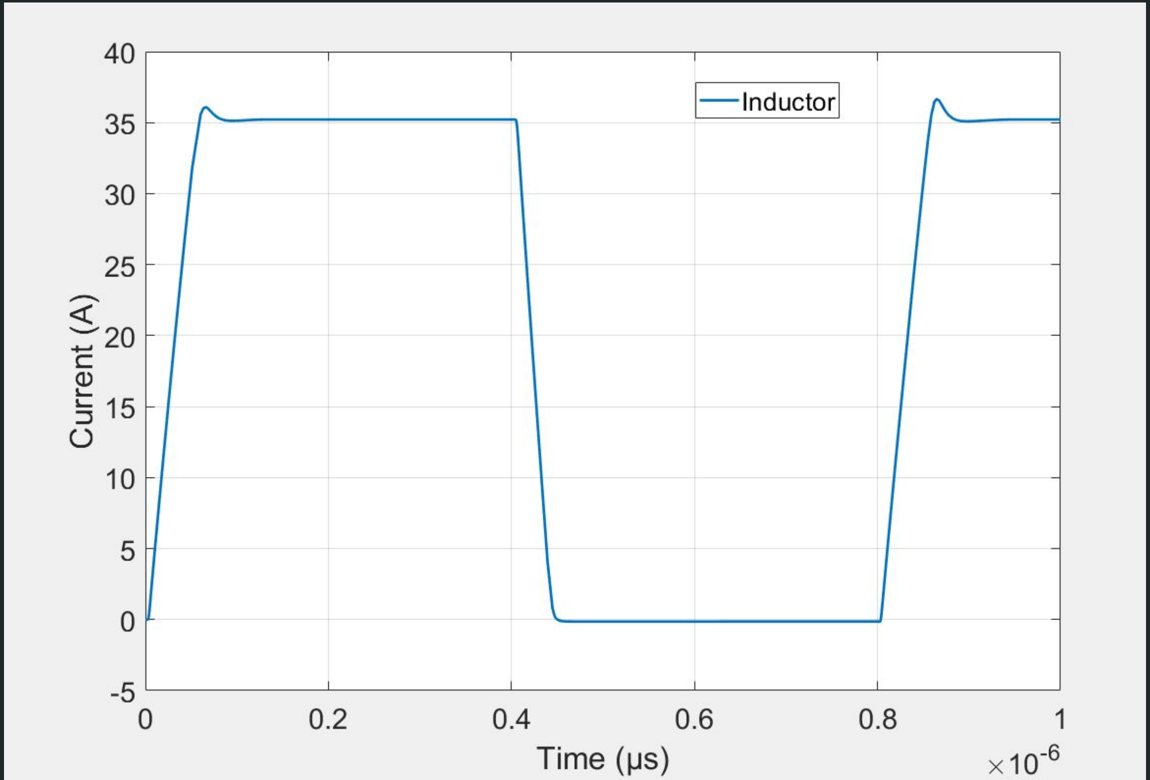
PCB Size - 3.5” x 2”



Schematic of MFG Circuit

Circuit Simulation Results

Rise Time - 42.6 ns



Transient Simulation of MFG Circuit

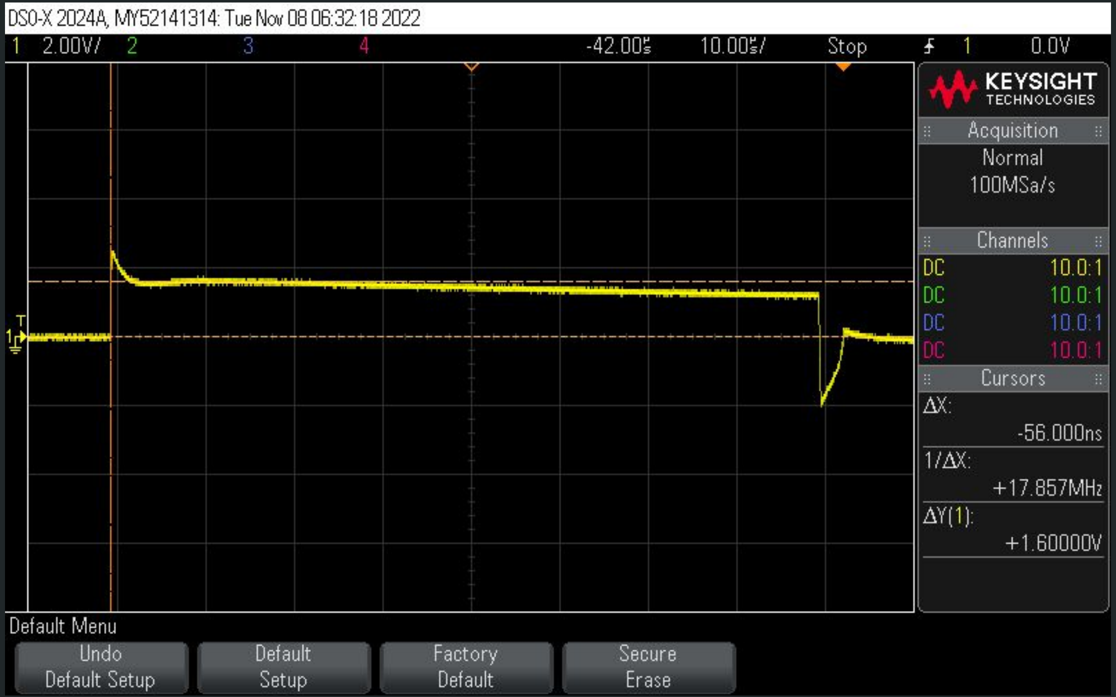
Initial Testing

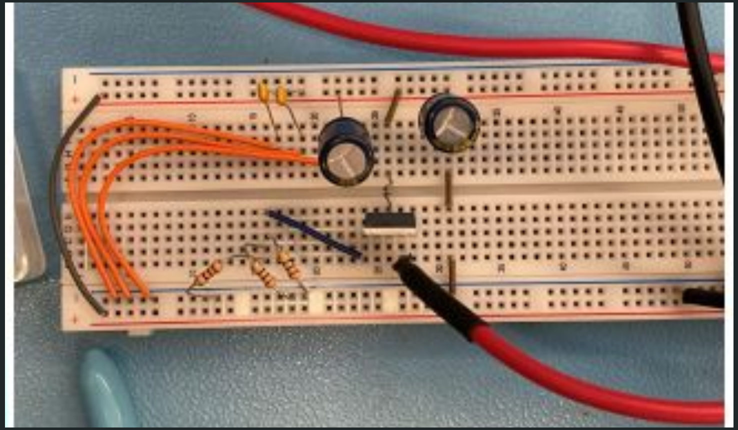
Rise Time - 56 ns

X axis - Time

Y axis - Voltage

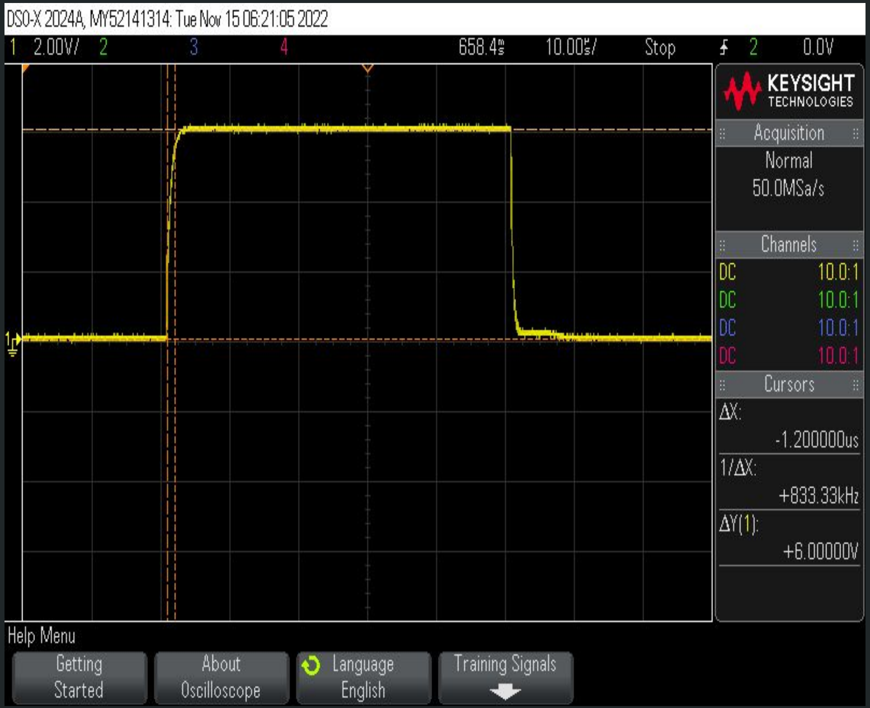
Oscilloscope measurements



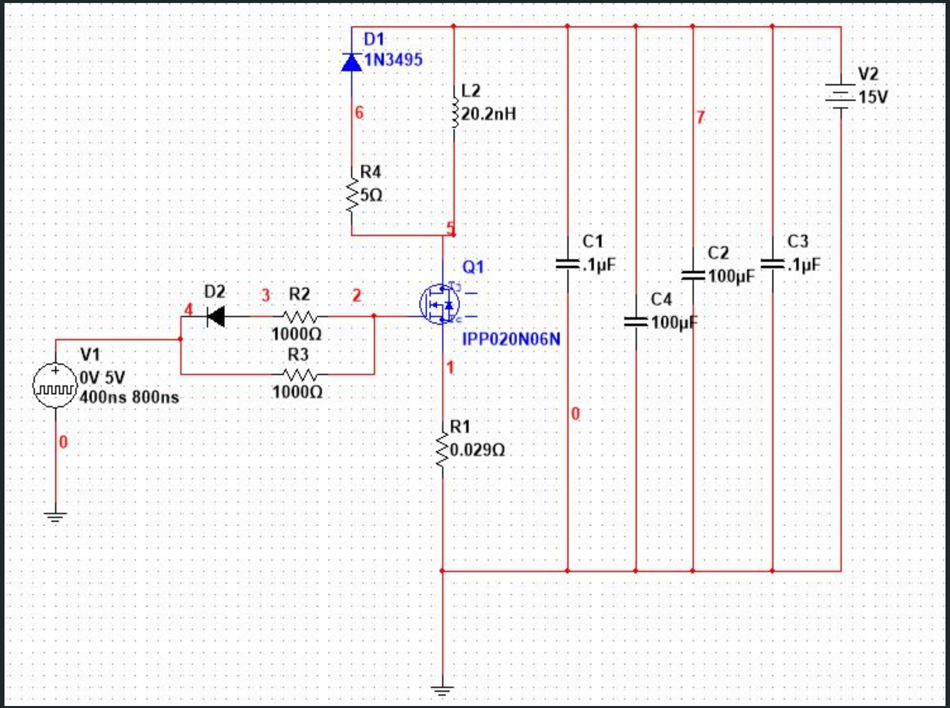


Prototype circuit

Initial Testing



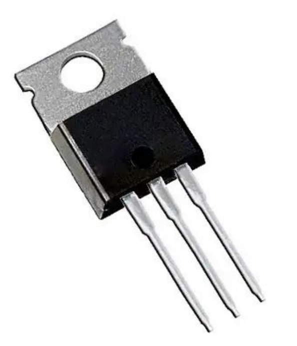
New Oscilloscope measurements



New Schematic of MFG Circuit

MOSFET Figure of Merit

	IRF540 (TH)	PSMN013-30MLC (SM)
V_{DS} (V)	100	30
I_{Pulse} (A)	110	157
C_{IN} (pF)	1700	519
t_{rise} (ns)	44	9.8
Q_{GD} (nC)	32	1
R_{DS} (mΩ)	77	17
R_{DS} x Q_{GD}	2464	17



J. Strydom, "eGaNTM N -Silicon Power Shoot-Out: Comparing Figure of Merit (FOM) ", ed. Power Electronics Technology, 2010

Conclusion

According to our advisors we are on track

Our plan for next semester is the following

- Complete our optical simulation
- Finalized part selection by testing out various components in our circuit design
- Complete and test our PCB design

References

- “39 • fast, compact, High Strength Magnetic Pulse Generator,” *sdmay22*. [Online]. Available: http://sdmay22-39.sd.ece.iastate.edu/. [Accessed: 05-Dec-2022].
- J. Strydom, "eGaNTM N -Silicon Power Shoot-Out: Comparing Figure of Merit (FOM) ", ed. Power Electronics Technology, 2010
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