High Speed Magnetic Pulse Generator

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Introduction

Project Context

Utilizing magnetic field properties for magneto-optic (MO) switching in fiber optic network routing[1] . In current fiber optic routing, optical-electrical conversions cause a data bottleneck in the transmission process. The goal of this project is to utilize MO properties to speed up this conversion process and, consequently, limit transmission bottlenecks.

Problem Statement

Previous work on the MO switching circuit has led to satisfactory switching characteristics. However, we believe there is much work left to be done in further optimization, especially in improving rise time and measurement accuracy.

Design Requirements

Functional

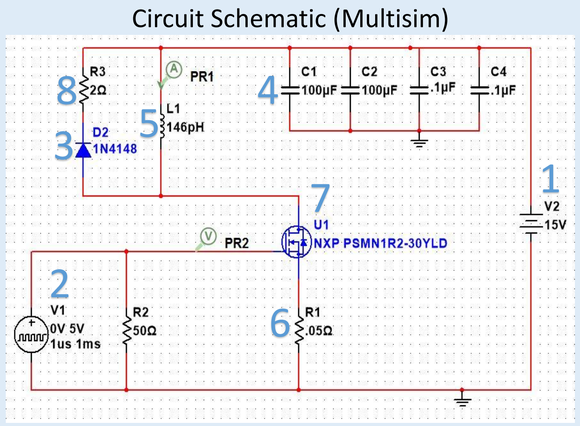
- Less than 100 ns rise time
- Pulse magnitude at least 500 Gauss
- Coil fitted for fiber optic cable

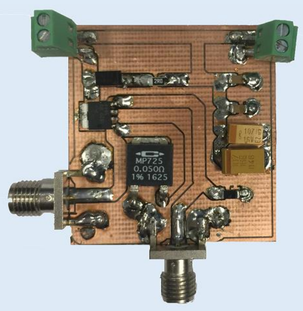
Non-Functional

- Consistent output
- Quality fabrication
- Footprint less than 3.5" x 2"

Fundamental Design

Circuit Schematic (Multisim)





Note: much of the circuit design circuit has been done by past senior design and undergraduate research teams[2][3]

1. DC power supply charges capacitors when MOSFET is turned off
2. Pulse source controls gate of MOSFET to switch on/off
3. Diode protects discharge resistor when MOSFET is on
4. Capacitor bank releases stored charge through inductive coil
5. Current through inductive coil generates magnetic field
6. Current through coil is measured through current sense resistor
7. NMOS MOSFET acts as switch that allows high current to flow through coil
8. Extra charge from coil is dissipated as heat through resistor when MOSFET is off

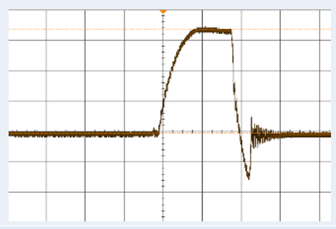
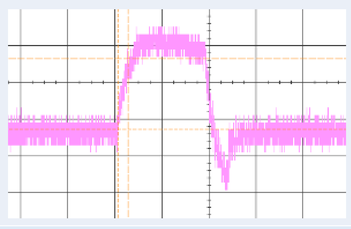
References

1. Pritchard, John W., Mani Mina, and Robert J. Weber. "Magnetic Field Generator Design for Magneto-Optic Switching Applications." IEEE Trans. Magn. IEEE Transactions on Magnetics 49.7 (2013): 4242-244. Web.
2. "Magnetic Pulse Generator. – Design Document 2" N.p., n.d. Web. http://dec1622.sd.ece.iastate.edu/
3. "May15-30." May15-30. N.p., n.d. Web. 19 Feb. 2016. 11 <http://may1530.ece.iastate.edu/>.

Current-Sense Resistor

Main idea

For observing and testing needs, we have to add some device to make it be able to observe and test the current change of inductor. Last group used a 0.05ohms resistor to work as the current-sense device. And we build our new board with two 0.05Ω resistors on the two side of the MOSFET.

	Original circuit current sensor	New current sensor
Rise time	292.5ns	97.0ns
Amplitude	21.2V	24.1V
Tuning	Yes	Not obvious
Graph		

MOSFET TESTING

MOSFET	Input Capacitance	ON Resistance	Amplitude	Rise/Fall Time	Connection Type	Result
CSD 17507Q5A	0.41nF	20mΩ	1.57V	9.5ns	Soldered	Figure 1
CSD 18542KCS	3.9nF	10mΩ	0.96V	756ns	Wired	Figure 2
CSD 18563Q5A	1.15nF	>25mΩ	1.65V	80ns	Soldered	Figure 3

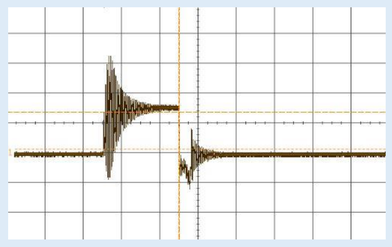


Figure 1

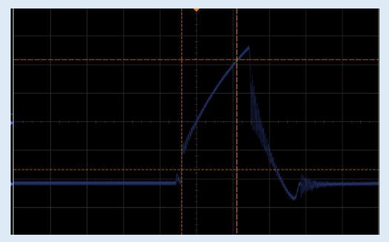
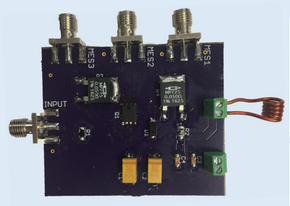
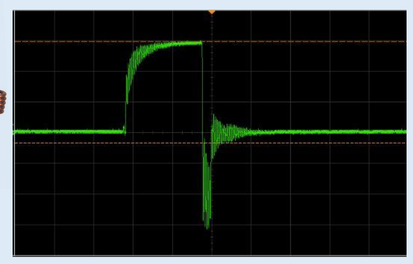


Figure 2





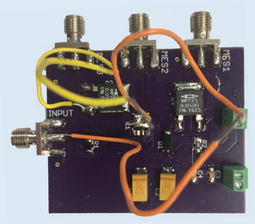


Figure 3

Future Work

1. Perform further testing on new MOSFET options
   - Filter out high frequency ringing
   - Test more options
2. Perform further testing on new current sense resistor
   - Higher power rating
   - Higher resistance
3. Further optimize coil design

Last Edited on: 4.17.2017