Fast, Compact, High Strength Magnetic Pulse Generator

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Introduction

Problem Statement

The goal of the project was to design and fabricate a device in a small package capable of producing high strength, fast magnetic field pulses. The device should be capable of producing magnetic field pulses greater than or equal to 500 gauss within 100 nanoseconds, must be powered by a source voltage of less than or equal to 15 Volts DC, and should be less than 3.5" by 2" in physical size.

Solution

Given the design requirements and resources from the previous iterations of this project, we planned to create an improved design including a reduced rise time, functional programmable control of the magnetic field generation, reduced overall noise, and increased stability.

Design Requirements

Functional Requirements

- Generates magnetic fields ≥ 500 Gauss
- Pulses with a rise time ≤ 100 ns
- Programmable Control of magnetic field generation

Non-Functional Requirements

- Physical board with dimensions ≤ 3.5" x 2"

Engineering Constraints

- Uses a source voltage ≤ 15 V (DC)
- Cost budget of $500

Operating Environment

- Low EM interference environment

Relevant Standards

- IEEE 370-2020: Electrical characterization for PCBs
- IEEE C95.1-2019: Safety for human exposure to EMFs

Testing

Testing Environment

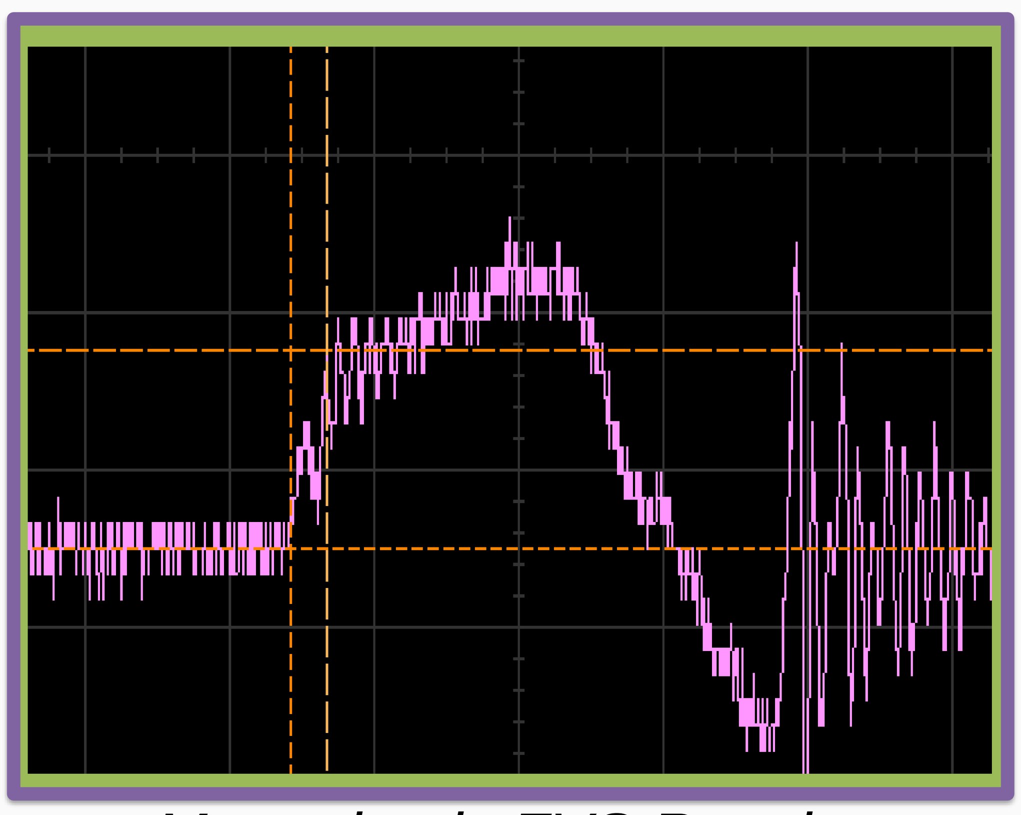
- Low electromagnetic interference
- Cool temperature

Testing Strategy

- System Level Testing Progression
  1. Multisim: feasibility testing
  2. Advance Design System: non-ideal testing
  3. Breadboarding: physical circuit testing
  4. PCB: final design testing

Testing Results

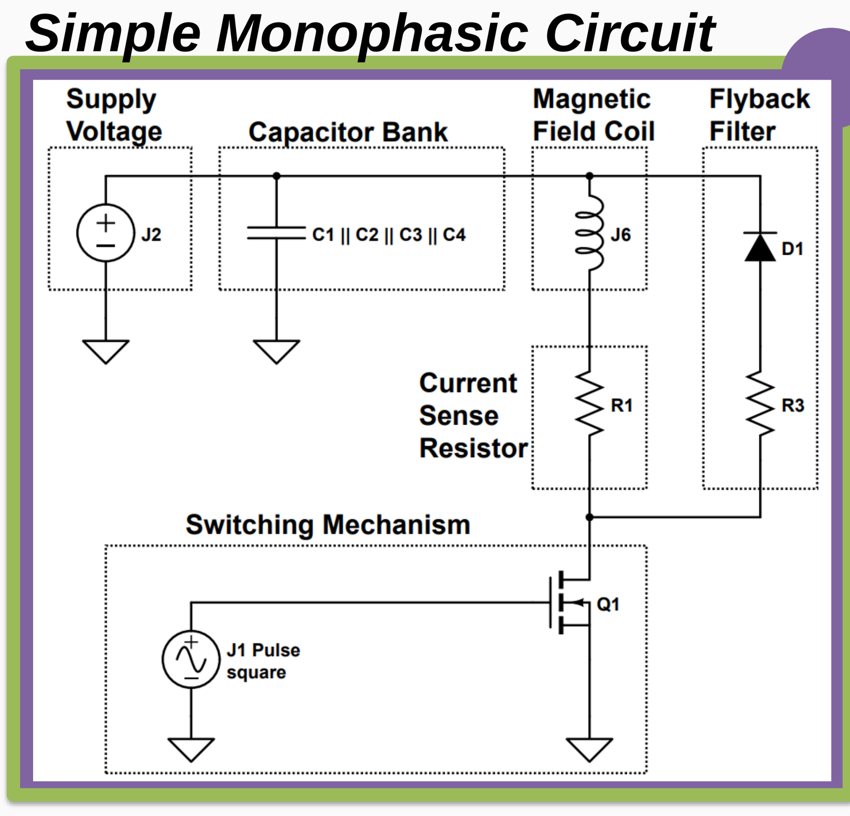
- Rise Time = 50 ns
- Amplitude = 626 mV
- Current:
  - $I = \frac{Voltage\ Amplitude}{Rsense} = 12.52$ A
- Field Strength:
  - $B = \frac{\mu N I}{\sqrt{l^2 + 4r^2}} = 0.0508$ Tesla $= 508$ Gauss



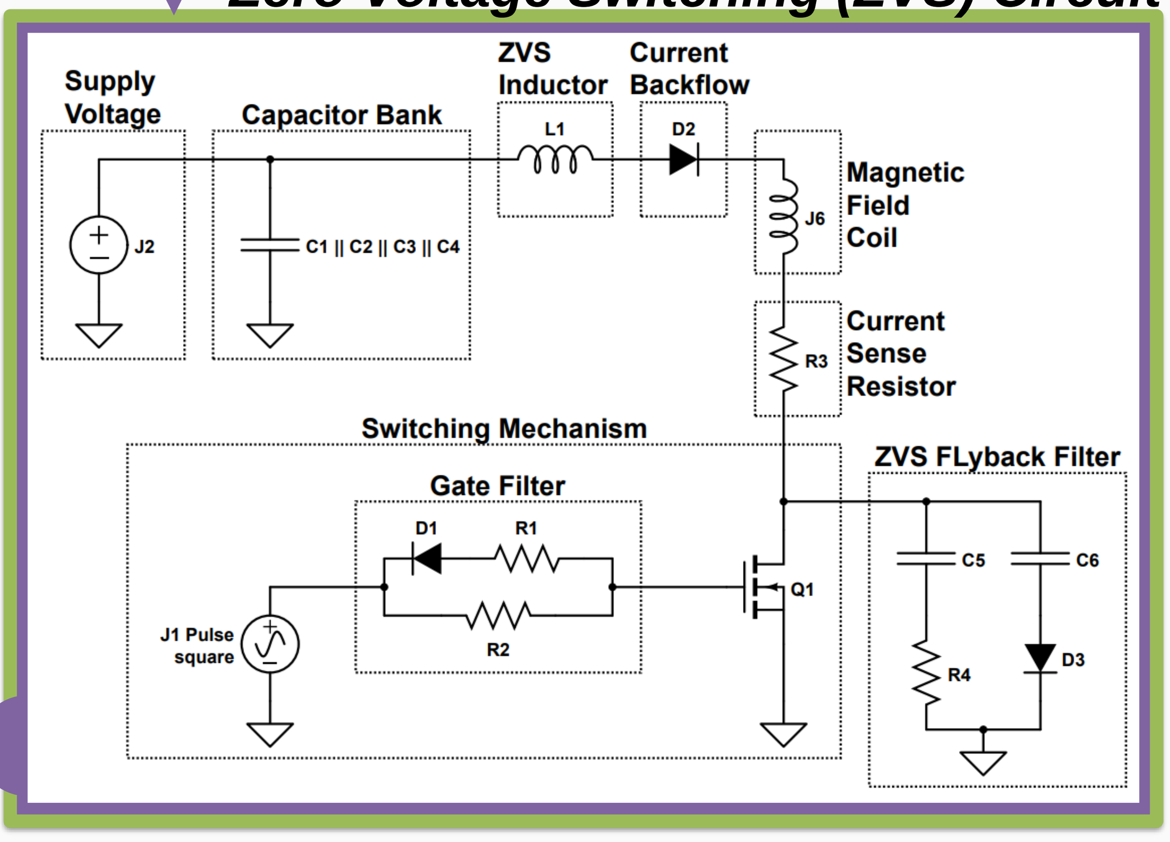
Monophasic ZVS Results

Technical Details & Design Evolution

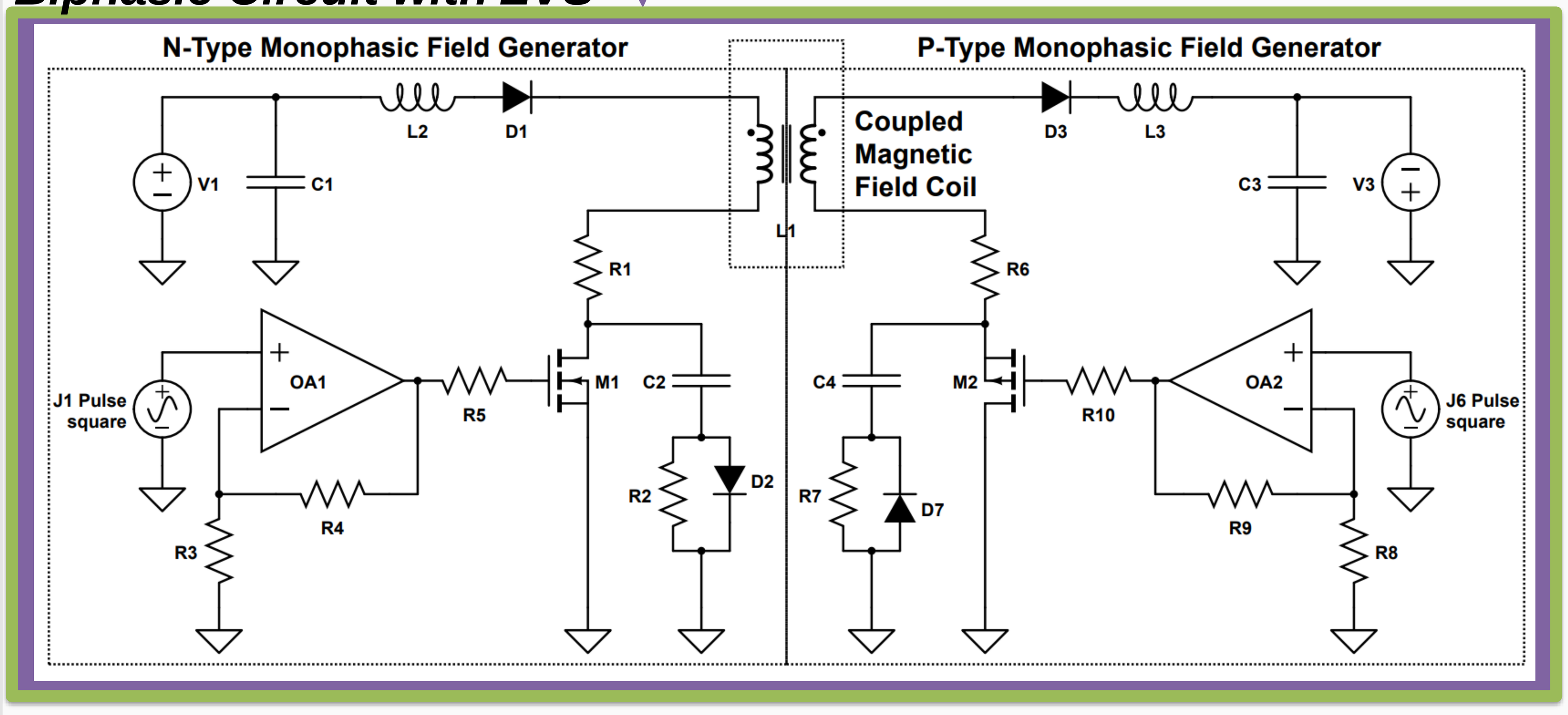
Simple Monophasic Circuit



Zero Voltage Switching (ZVS) Circuit



Biphasic Circuit with ZVS



Coil Characteristics

	Monophasic	Biphasic
Turns N	10	5
Length L	3.0 mm	3.0 mm
Radius r	37.5 mm	37.5 mm
Inductance L	18.9 nH	4.72 nH
Current Needed I	12.32 A	24.65 A

Zero Voltage Switching PCB (Most Successful Design)

Intended Users & Applications

Users

- Companies producing or using medical/routing equipment
- Companies producing or using of the listed devices/processes below

Applications

- Small fiber optic switches/routers
- Pulsed resonance
- Power converters
- Medical therapy
- Megawatt Q-switched laser systems
- Biomagnetism R&D
- Small solenoid systems

Design Approach

1. Define Problem
2. Research & Previous Group Circuit Testing
3. Identify Areas for Improvement
4. Design & Optimize New Circuit
5. Simulation Testing
6. Breadboard Prototype testing
7. PCB Design
8. Create BOM / Order Components
9. PCB Testing
10. Deliver Final Product