Investigating Motor Control

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JUNIOR

PHYSICS

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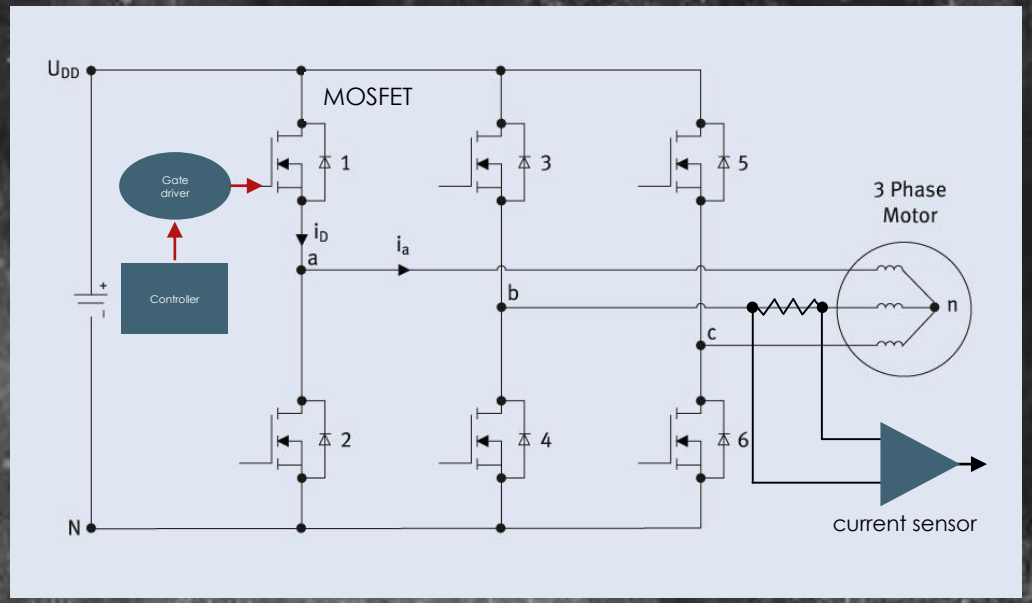
Why motor control?

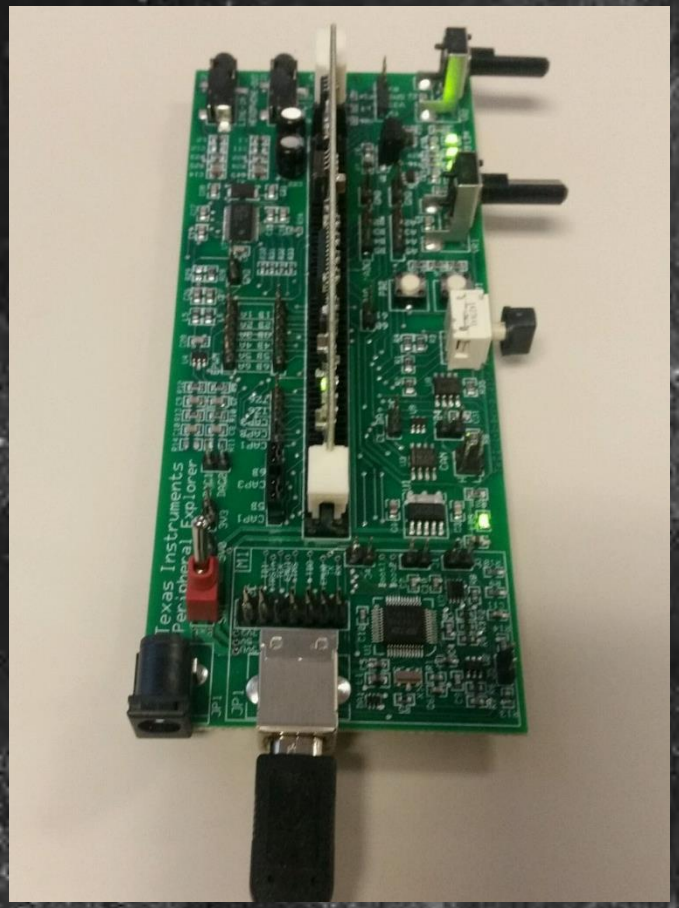
- Industrial and commercial applications
  - Machinery and infrastructure
- Electric vehicles
- Heist – Hybrid electric integrated system test-bed
  - Need for custom motor controller

Overview of motor control system

- H-bridge
- 3 phase inductor motor
- Microcontroller
- Gate driver
- MOSFETs / Transistors
- Sine wave output
- Current sensing for feedback and PID

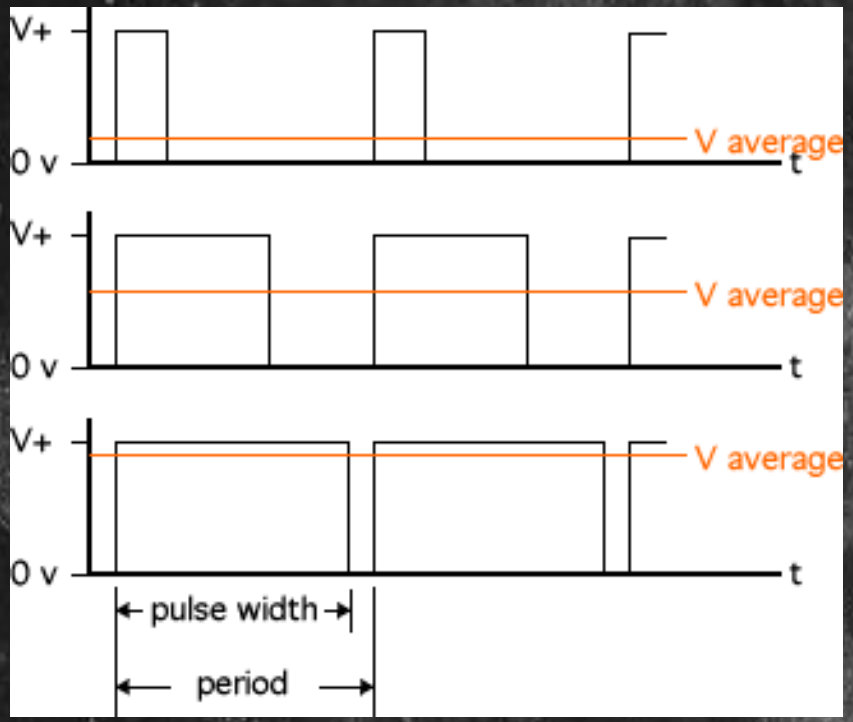


Microcontroller (F28335)



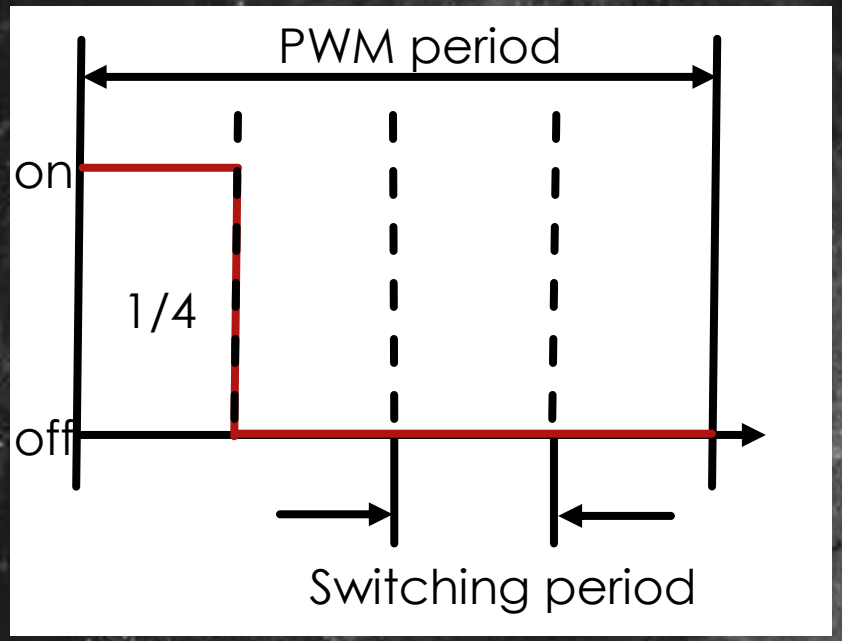
- F28335
  - CPU
  - Math units
  - Memory
  - Analogue to digital converter (ADC) and DAC
  - Timer and counters
  - Digital input and output
  - Pulse width modulation (PWM) -IMPORTANT-
- Texas Instruments explorer board

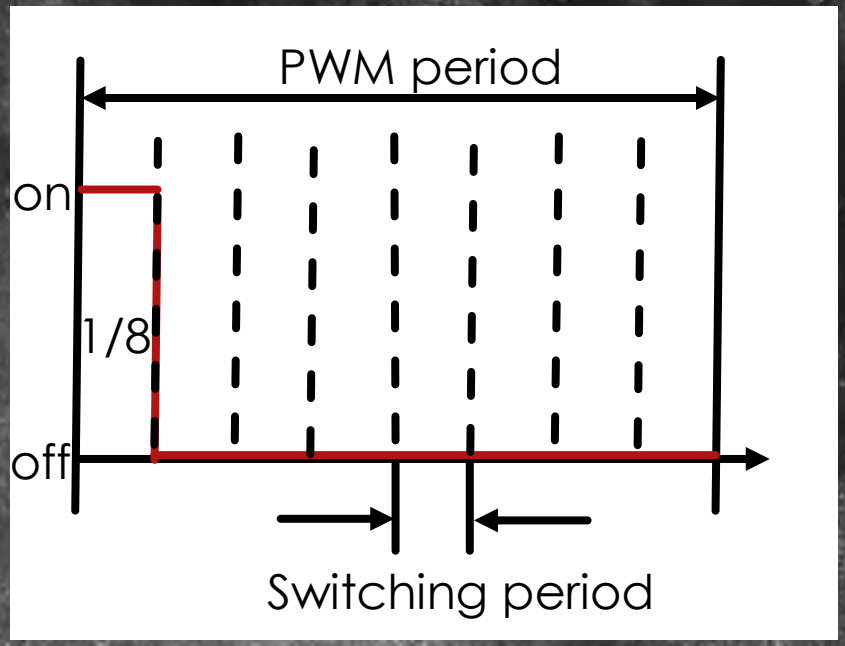
What is PWM?



- Method of approximating an analogue signal on a digital output
- Features
  - Period
  - Duty cycle / pulse width
  - Switching frequency

PWM resolution comparison

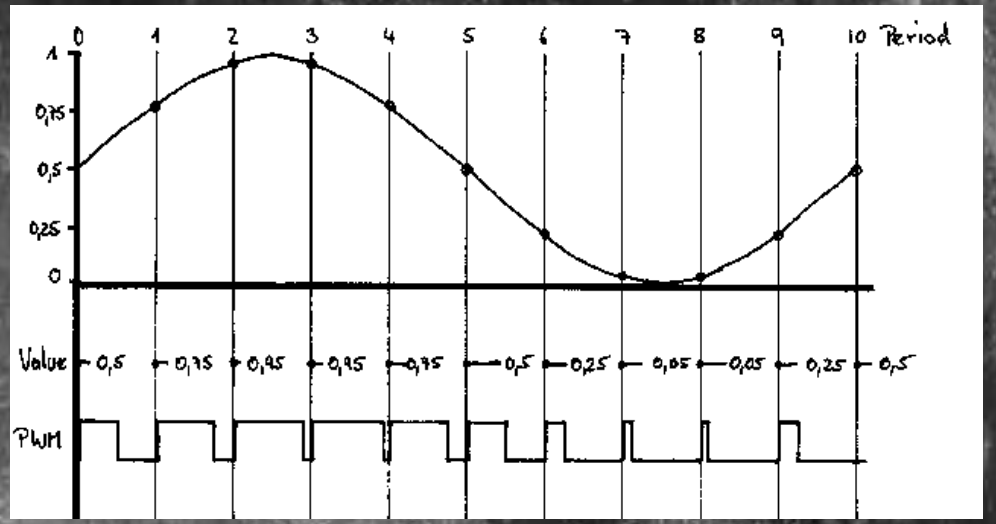




- Faster switching frequency = more steps in the PWM period
- More steps in the PWM period = smaller voltage step size

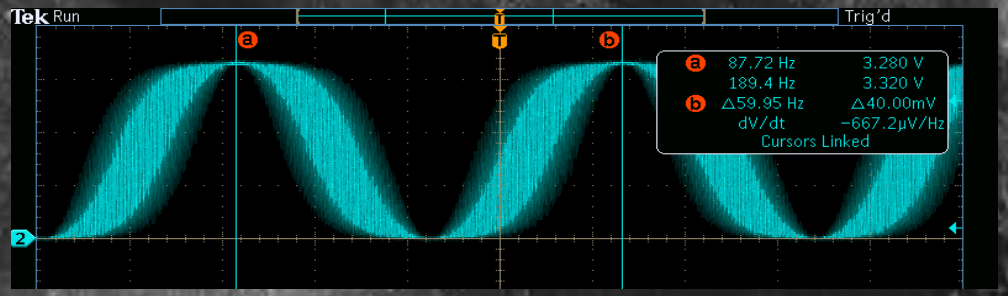
PWM sine wave

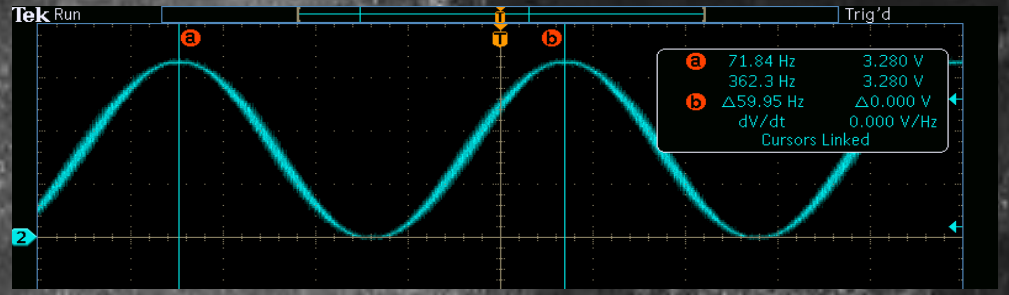
- Method for controlling motors
- On-the-fly changes to duty cycle
- F28335 has sine wave lookup table

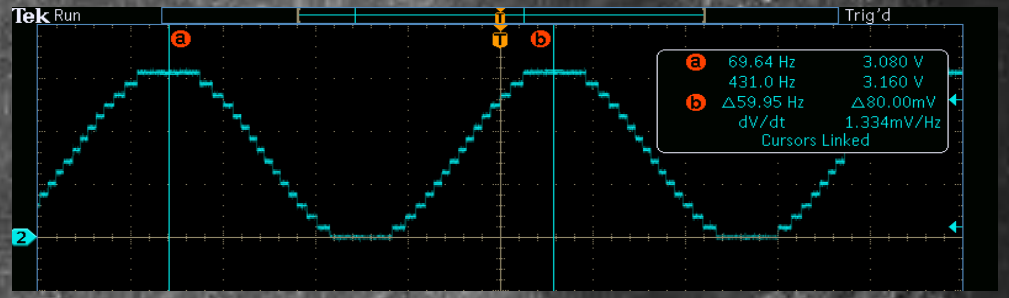


Success – Sine wave output

- Ready to try controlling MOSFETs
- Found correct resolution







Gate driver

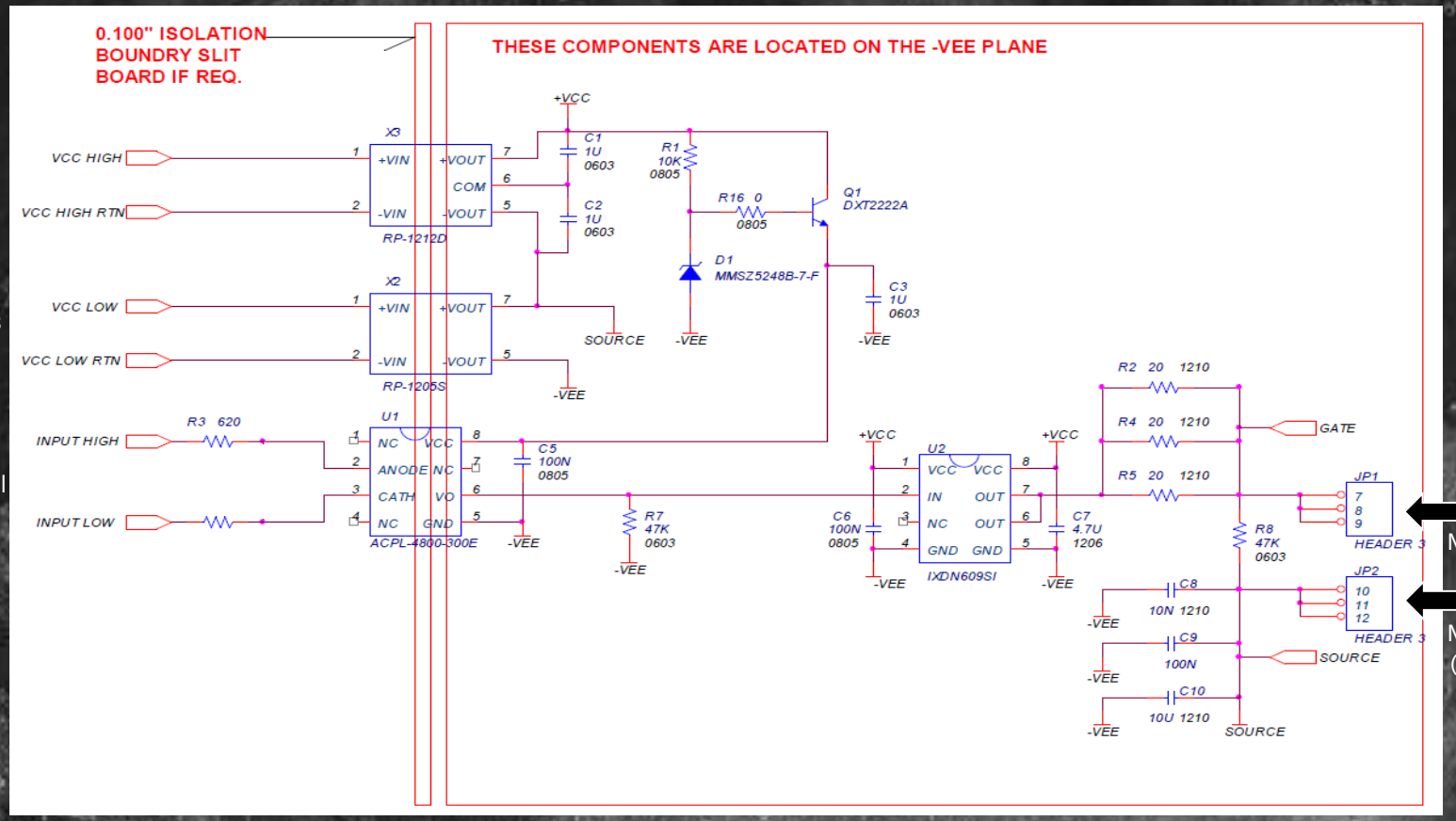
- Gate driver is like an amplifier
- Needed to control MOSFET
- Controlling CREE silicon-carbide MOSFETs
  - Faster switching
  - Better thermal conductor
  - High voltages

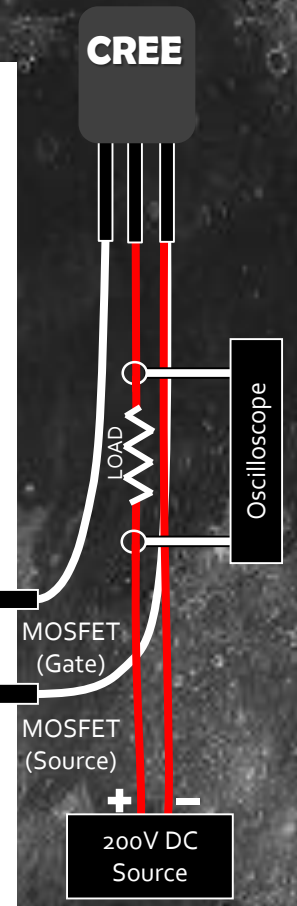
Experimental setup

Gate driver's ON voltage

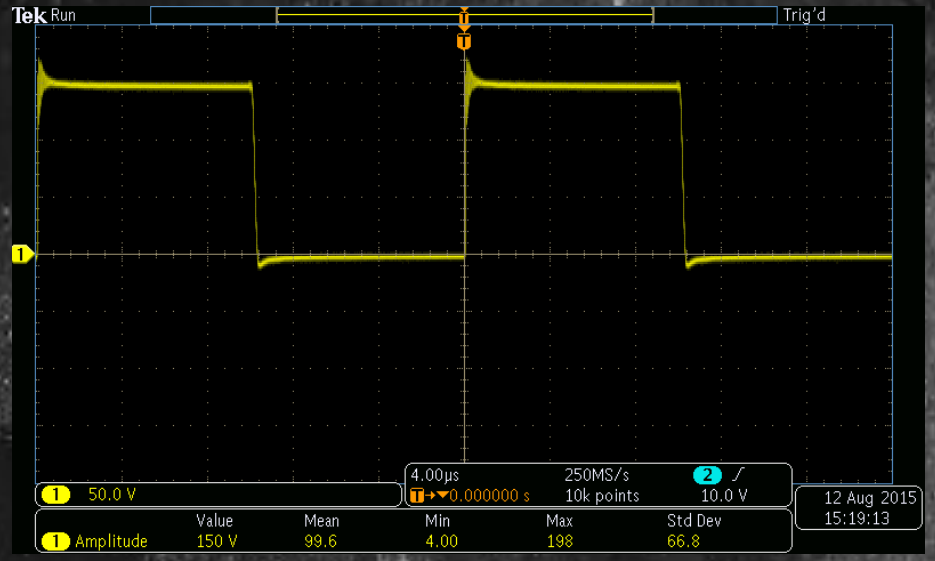
Gate driver's OFF voltage

Control signal



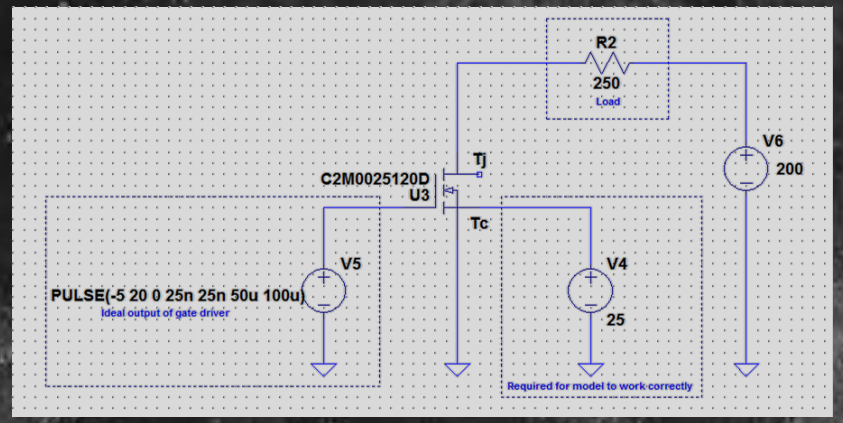


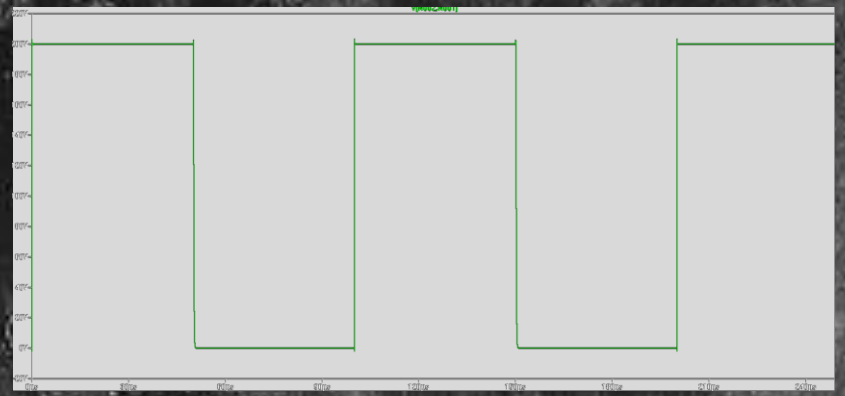
Experimental Results

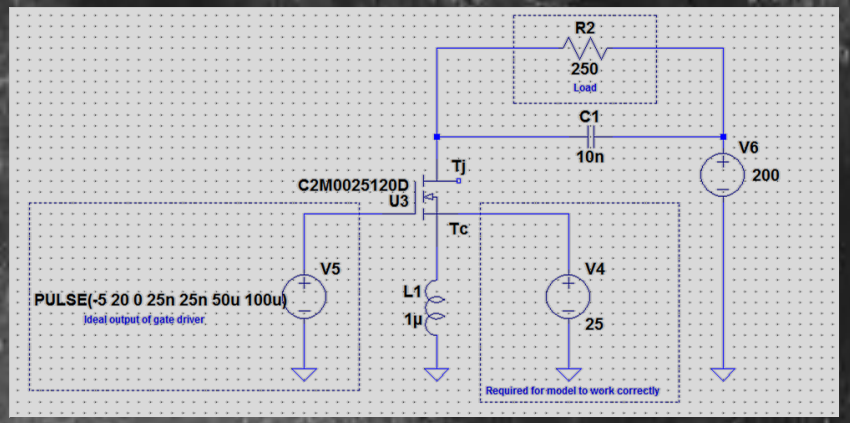


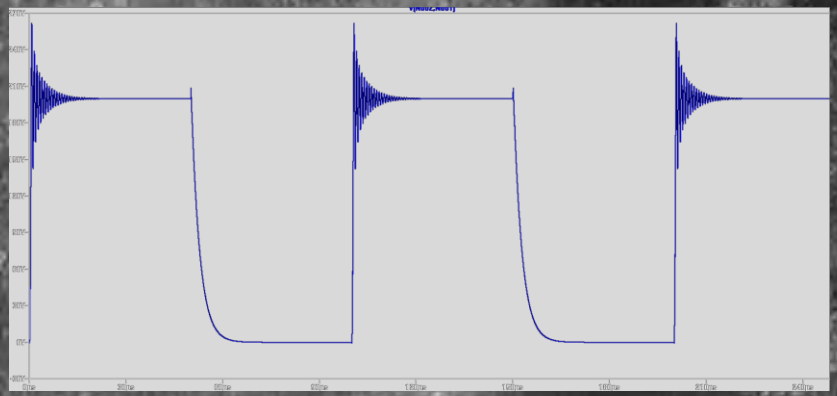
- Successfully controlled MOSFET
- Switched 150V DC using 5V signal
- Not perfect output
  - Ringing

SPICE simulation results





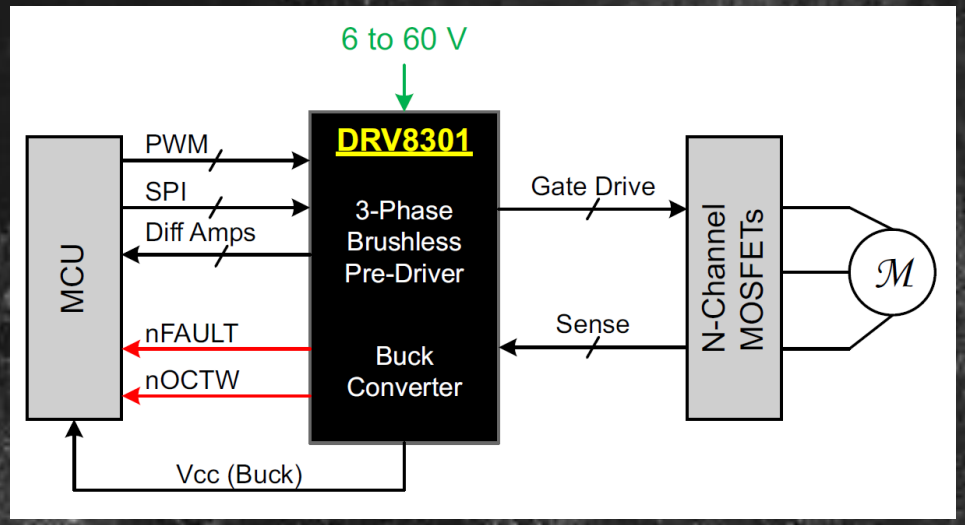




Summery of gate driver experiment

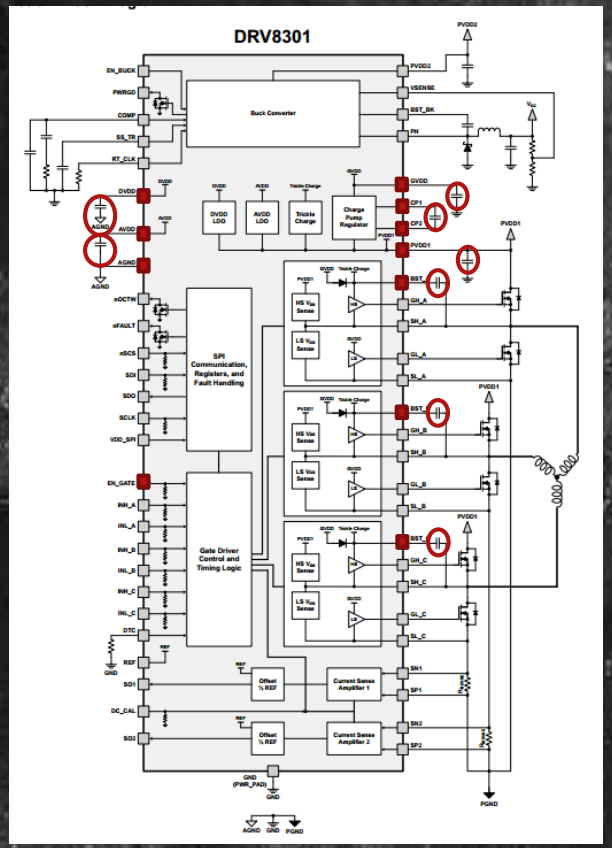
- SPICE output close, but not close enough
  - Need to make more accurate model representation
  - Use model to reduce parasitic components in gate driver output

Future work - DRV8301

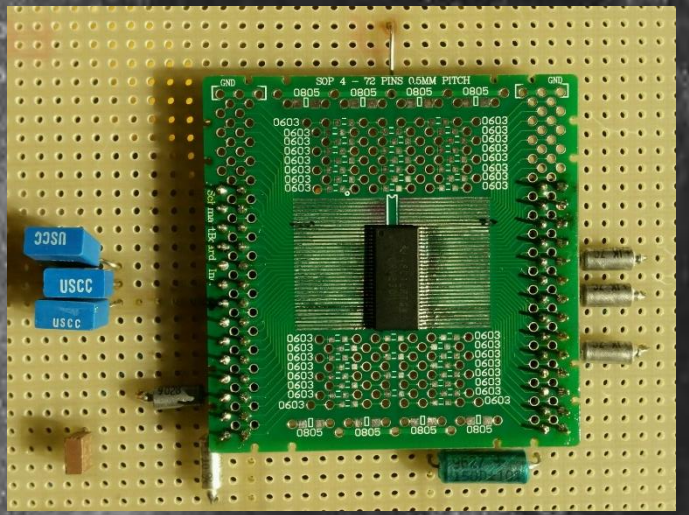


- Three-phase gate driver IC
- Hand-shaking to prevent current shoot-through
- Current shunt amplifiers for low-side current measurement
- Already have code that works with the chip

Already on my way!



- Started by connecting bare minimum
  - Power
  - Filter capacitors
  - Charge pump capacitors
  - Boot strap capacitors
- Testing was inconclusive
- Continue work



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Questions?