Power Electronics Overview & Course Sequence Description

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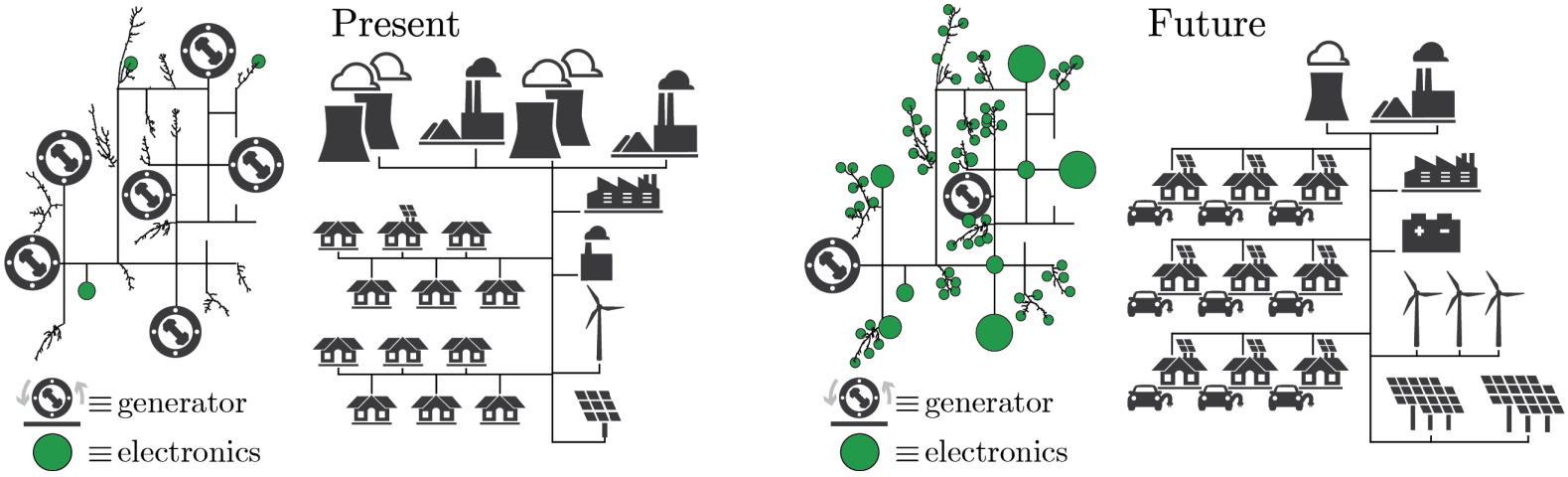
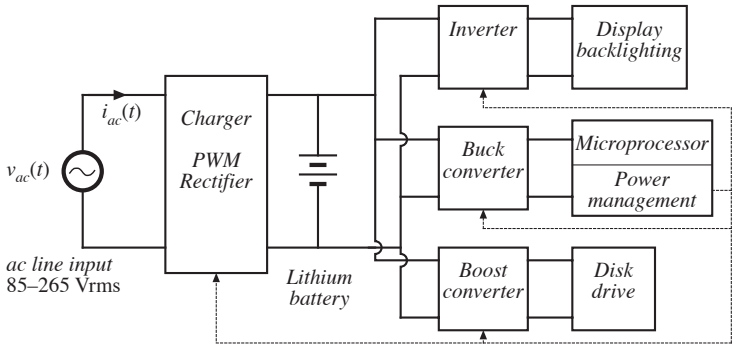
ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

Power Electronics are Everywhere



Used from grid infrastructure (MegaWatts) down to handheld devices (Watts).

Computer power supplies



Laptop power system

iPhone power system and charger

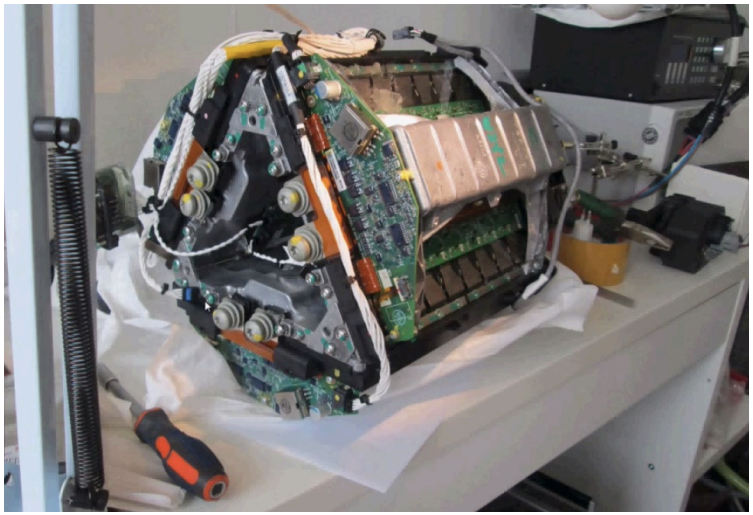
- MOSFETs mostly used here

Computer servers
Server farms

Electric Vehicles

EV Power Electronics Module:

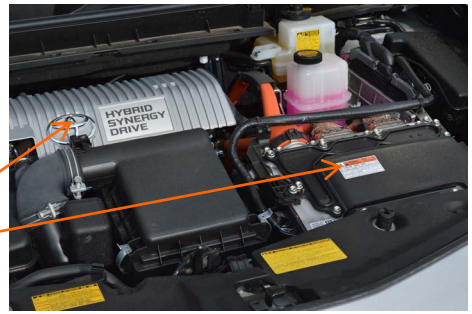
- Convert DC battery voltage to variable AC required to drive AC motor
- Includes dc-dc boost converter and dc-3ϕac inverter



Tesla Model S inverter/drive:

3 phase represented by the triangle, each phase has two "switches" comprised of 14 IGBTs in parallel

Under the hood:
Gas engine
Power electronics module



Electronics for Hybrid Prius

PV Converters

Module-level
Microinverters
- Typical power rating ~ 300W
- Single-phase (split-phase 240V)
- Typically use MOSFETs

String Inverters
- Typical power rating ~ 1kW – 10kW
- Single-phase (split-phase 240V)
- MOSFETs and IGBTs

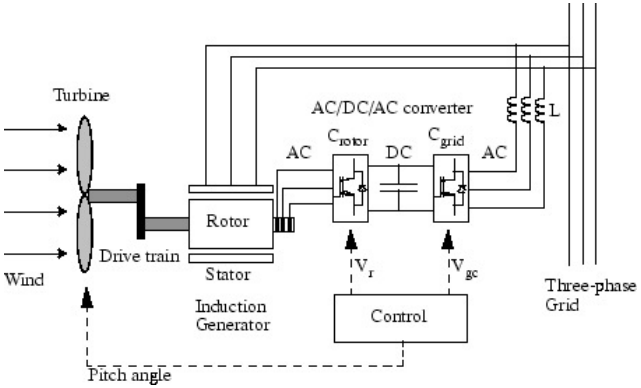
Centralized Inverters
- 100's of kW – few MW
- Three phase, 208V – 480V line-line
- Many units in parallel at plant
- IGBTs

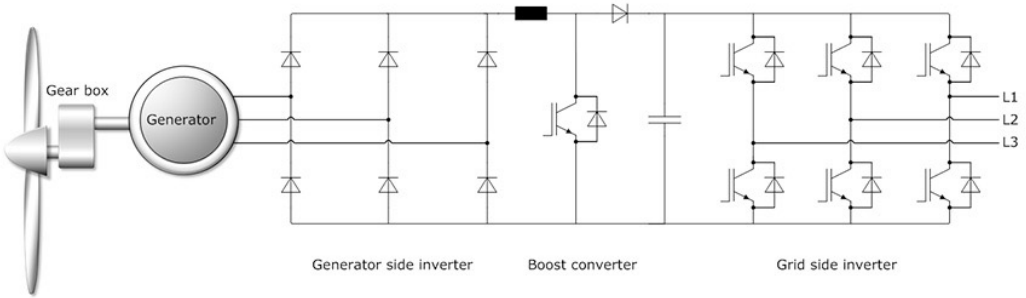
Grid-scale Battery Storage Inverters

Utility-scale Systems

- Installations typically a few MW
- Three phase, 208V – 480V line-line
- Many units in parallel at plant

Wind Systems

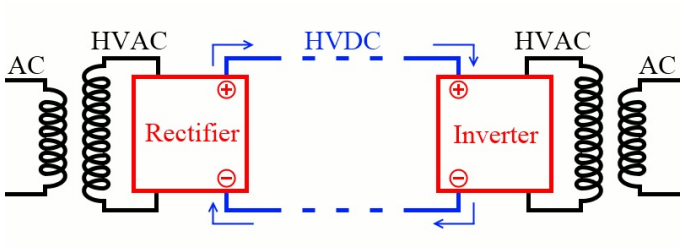


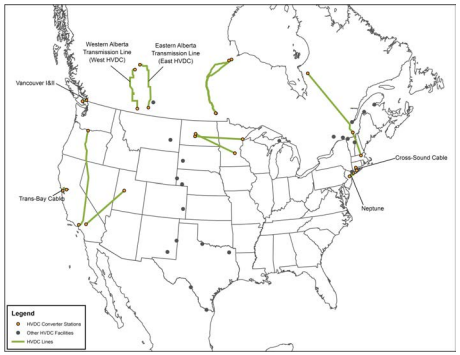


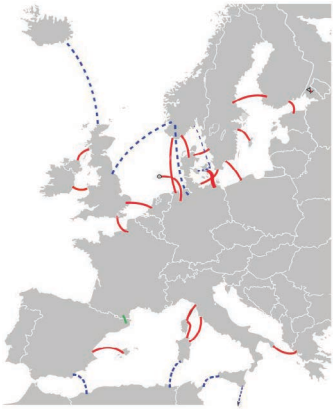
Converter rating typically a few MW

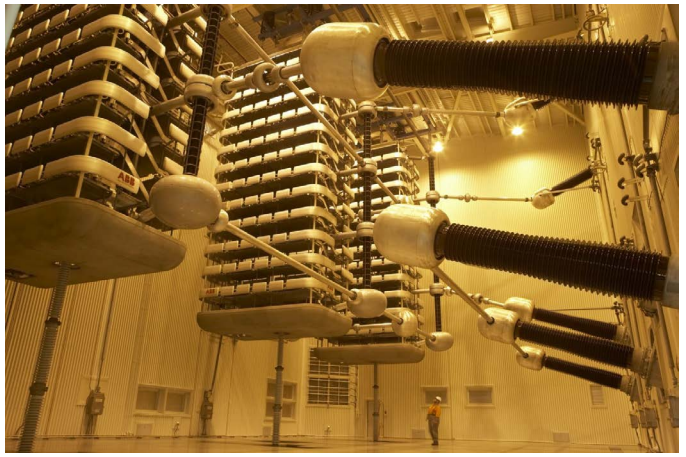
- IGBTs and Diodes

High voltage dc (HVDC)





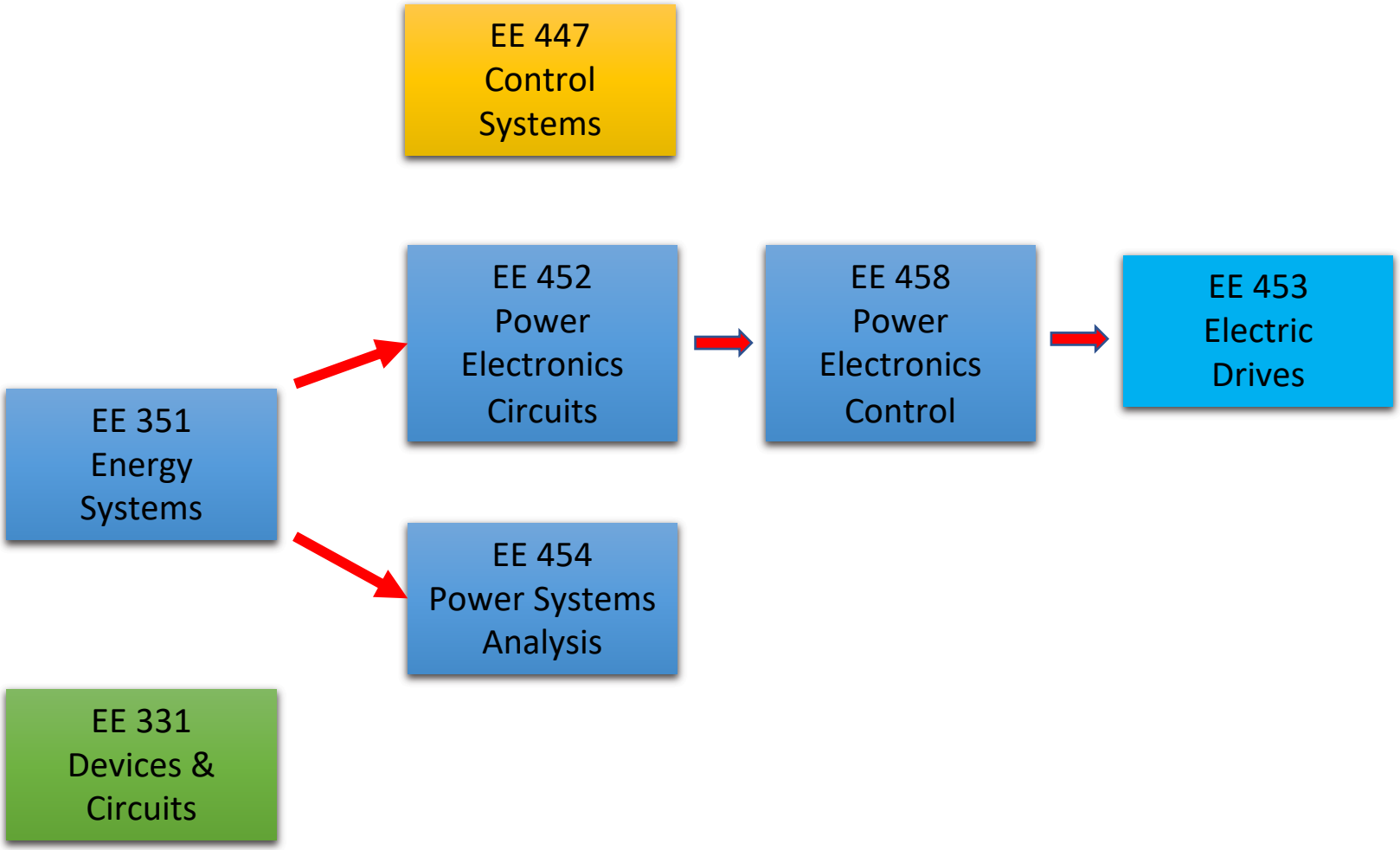




350 kV, 1.2 GW

Thyristors

Power Electronics and Drives Curriculum

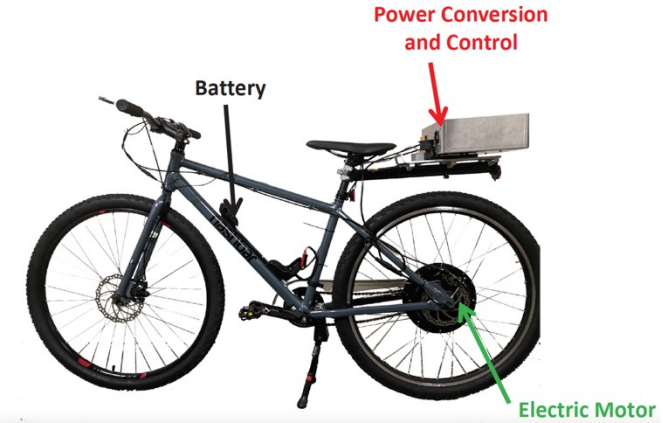


Power Electronics and Drives Curriculum

Fall	Winter	Spring
EE 452 **Power Electronics Design**	**EE 458** **Power Electronics Controls**	**EE 453, *capstone*** **Power Electronics & Drives**

A unified year-long 400 sequence covers:

- Converter fundamentals – Fall
- Converter controls – Winter
- Closed-loop prototyping – Spring

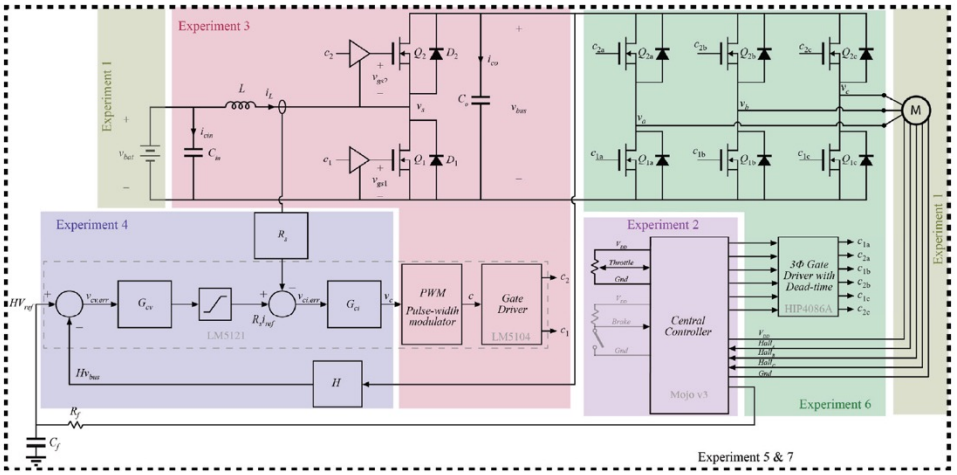


E-bike application for each 400-level lab

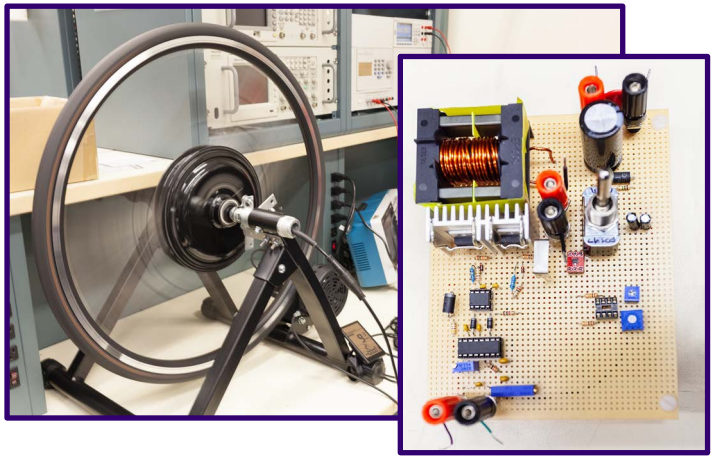
Power Electronics and Drives Curriculum

Fall	Winter	Spring
EE 452 **Power Electronics Design**	**EE 458** **Power Electronics Controls**	**EE 453, *capstone*** **Power Electronics & Drives**

Focus: Power converter **physics/theory** + open-loop power stage **experiment**



* Boost + three-phase inverter drive system

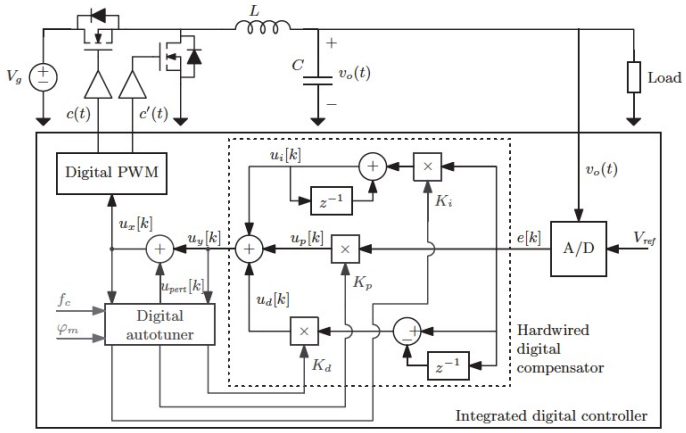


protoboard build

Power Electronics and Drives Curriculum

Fall	Winter	Spring
EE 452 **Power Electronics Design**	**EE 458** **Power Electronics Controls**	**EE 453, *capstone*** **Power Electronics & Drives**

Focus: Control **theory** for converters + DSP coding with HIL **experiments**



Applied controls and digital systems

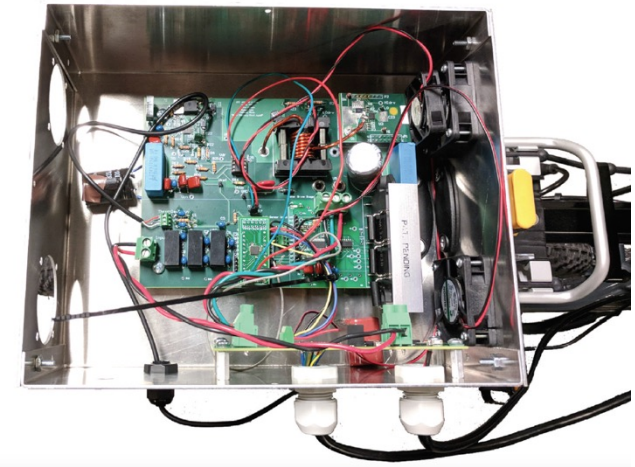
DSP controller with HIL emulated E-bike drive

plecs

Power Electronics and Drives Curriculum

Fall	Winter	Spring
EE 452 **Power Electronics Design**	**EE 458** **Power Electronics Controls**	**EE 453, *capstone*** **Power Electronics & Drives**

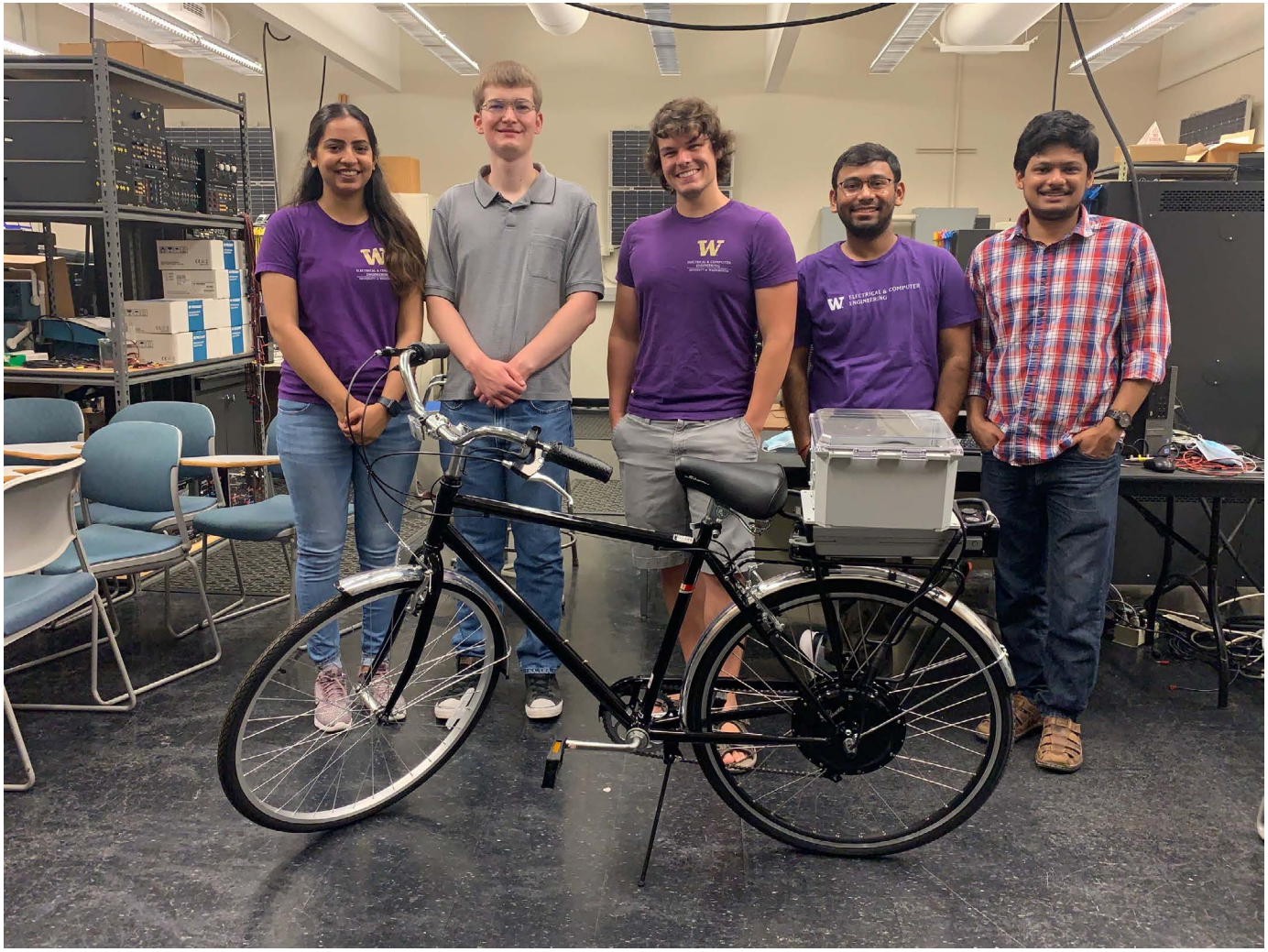
Focus: Refine E-bike converters/controls, integrate, and race!



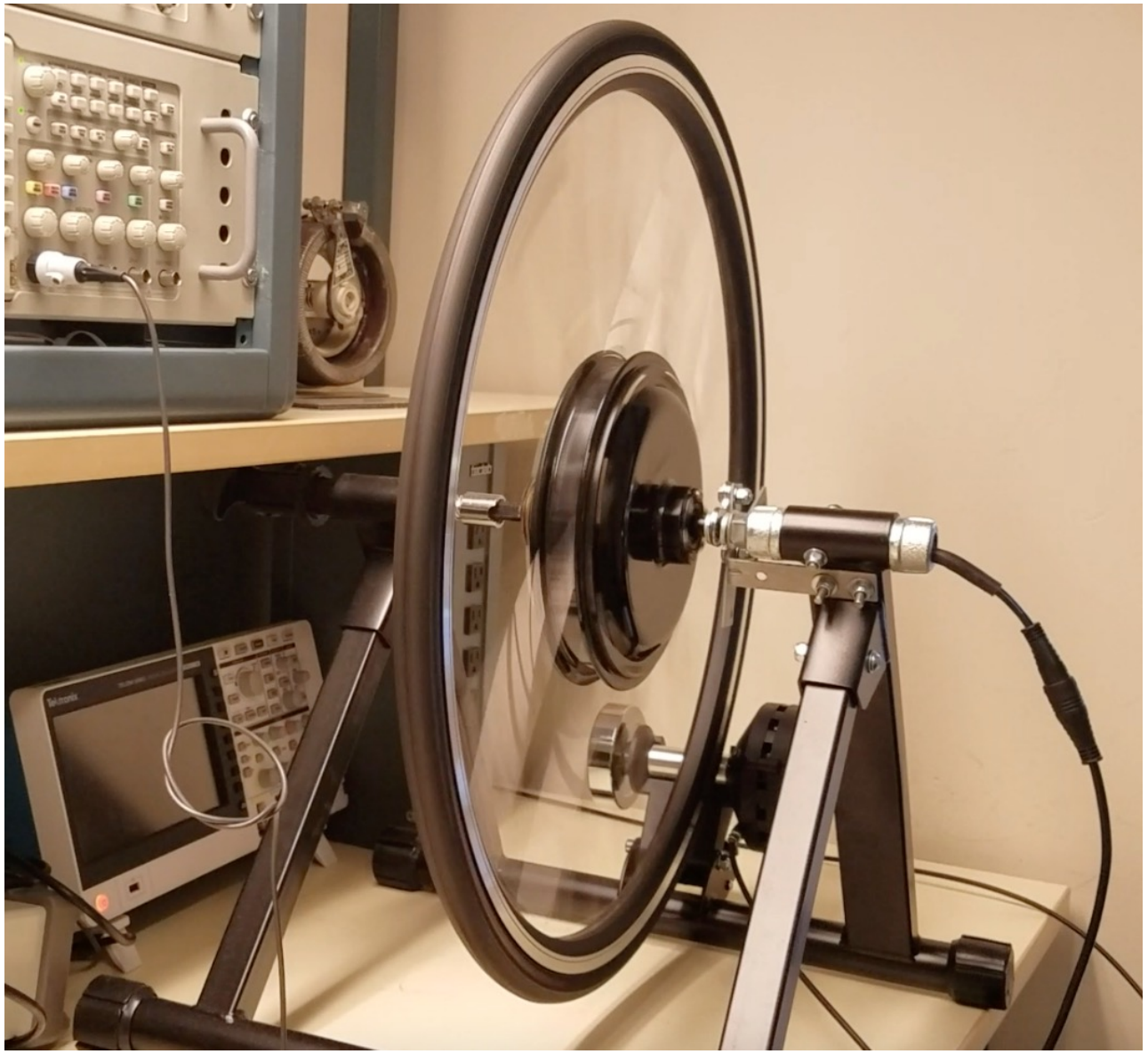
Convert protoboard design to PCB

A complete development process

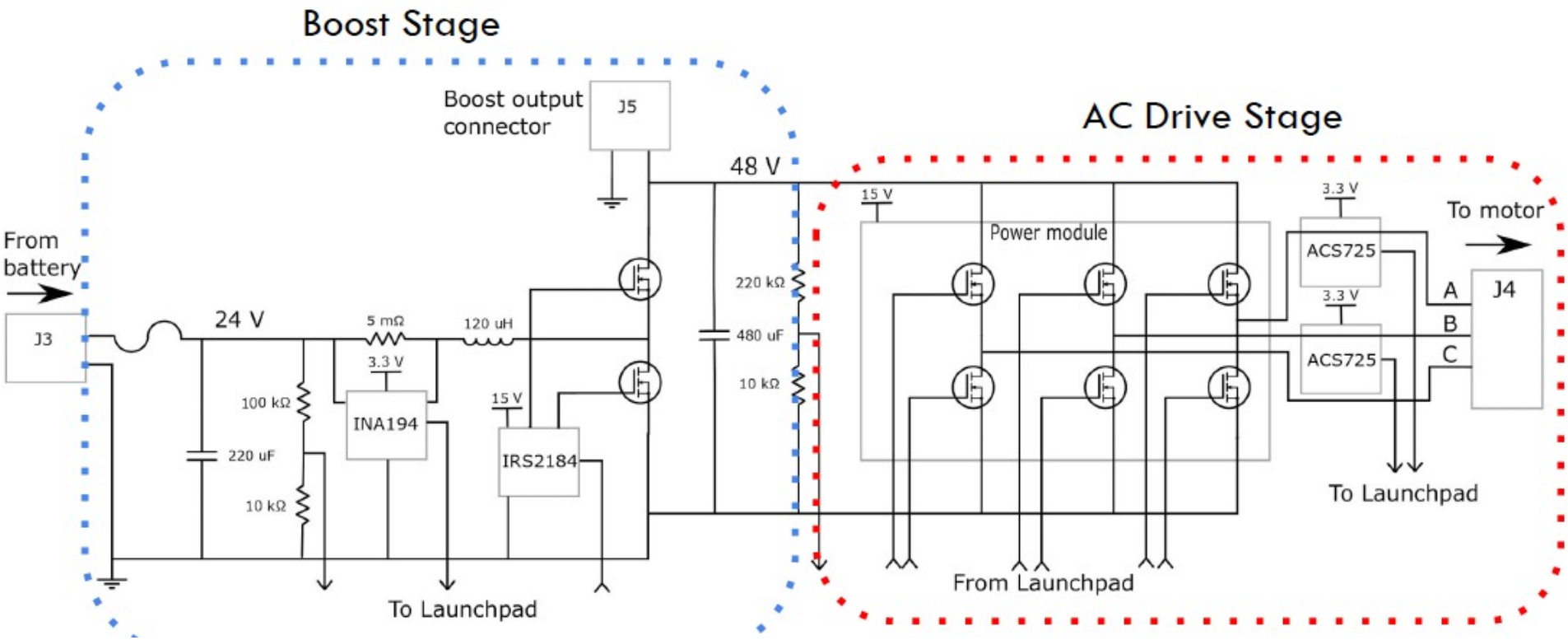
The Final Bike Build in EE 453 for Spring



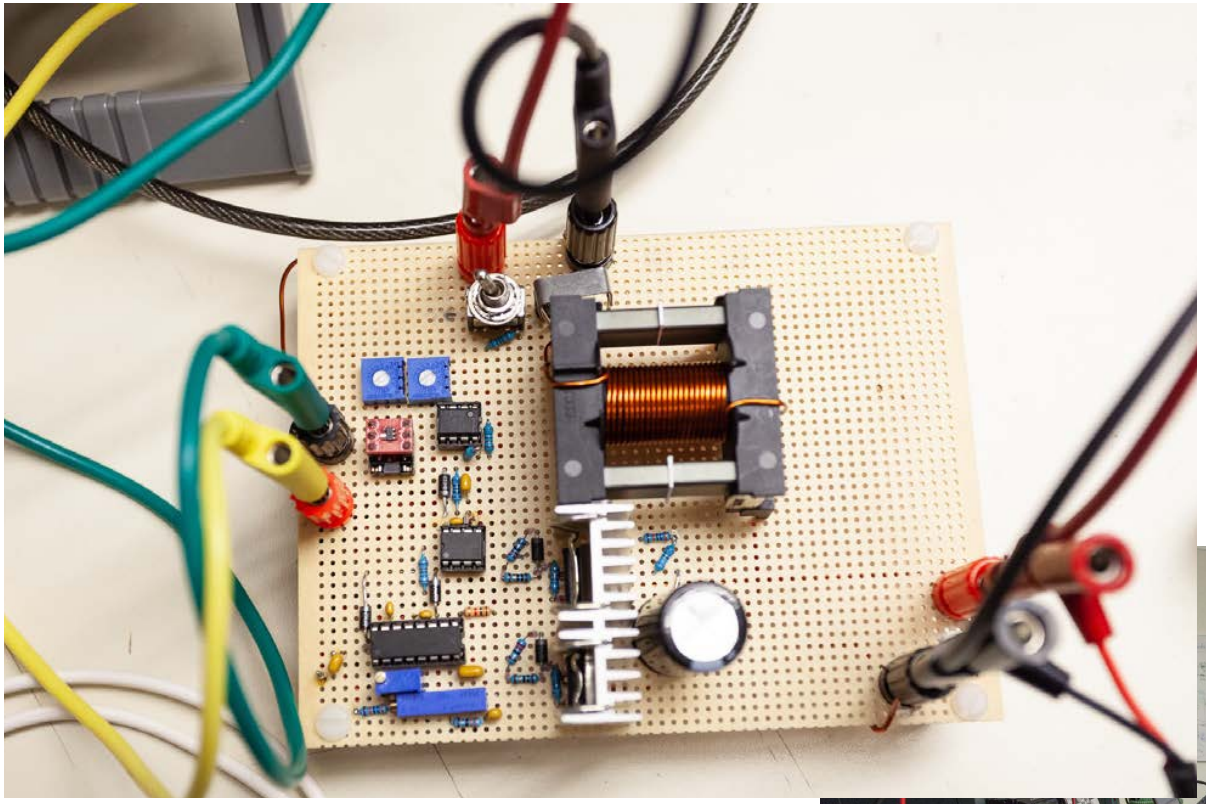
Benchtop Bike Trainer for EE 452 in this Class

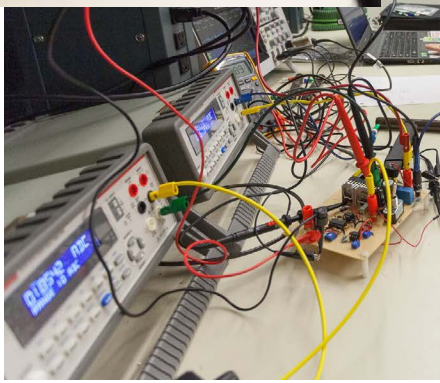


Circuit Diagram of dc-dc + Drive Electronics

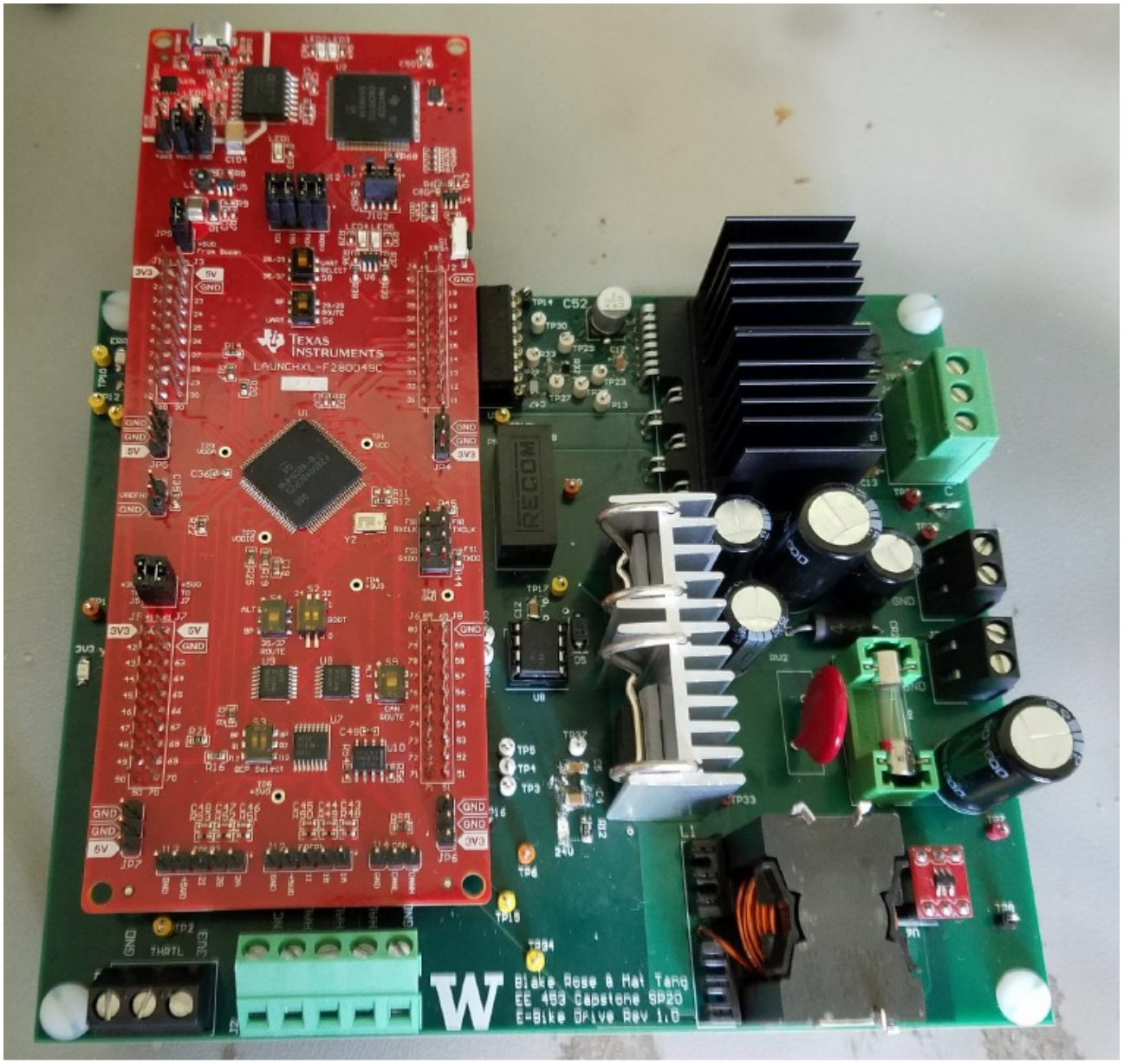


Example Protoboard dc-dc for EE 452 in this Class





Example of Final Build Project in EE 453 for Spring

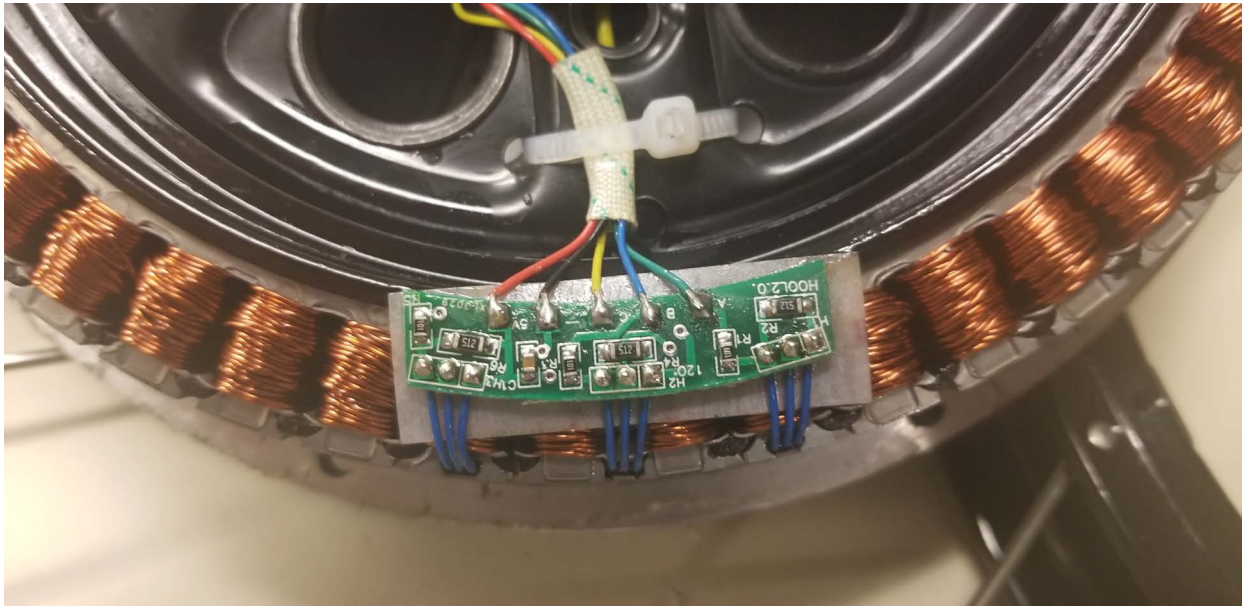


Three-phase Permanent Magnet Motor for Lab

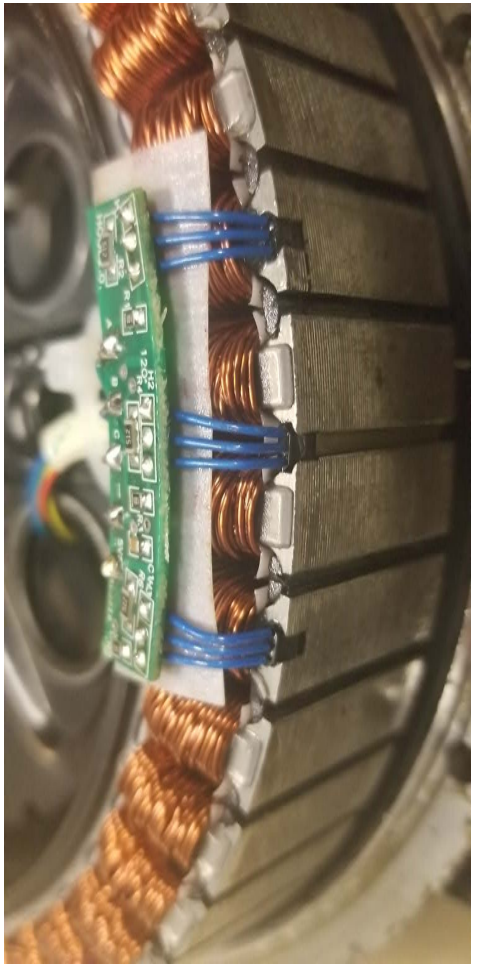
Wheel with cover popped off. Magnets rotate on outer perimeter as wheel turns.

Up-close look of motor and stationary coils.

Three-phase Permanent Magnet Motor for Lab



Position sensor circuitry.



Hall-effect sensors are nestled within motor tooth and sense magnetic field of moving outer wheel magnets.

Thanks!