# Introduction to Power Electronics

Dr. Martin Ordonez
Canada Research Chair
Holder of the Fred Kaiser Professorship
University of British Columbia

Fall 2021

THE UNIVERSITY OF BRITISH COLUMBIA

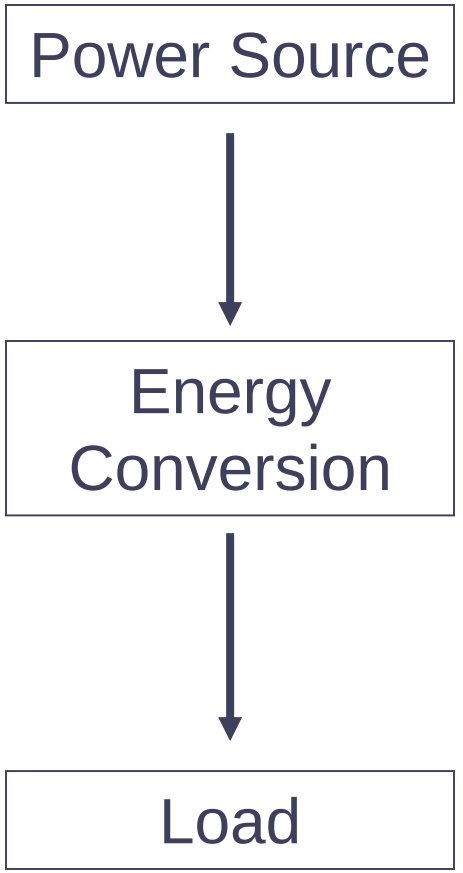
MARTIN ORDONEZ
Ph.D. - Renewable & Alternative Power Conversion

# Lecture Overview

- Electrical energy conversion today
- Key concepts in electrical energy conversion
- Design example and prototyping
- Summary

# Energy Conversion Today: Applications

Portable
Automotive and transportation
Aerospace
Renewable energy harvesting
Lighting
UPS / Backup power
Power generation and transmission
Telecommunications
Programmable power
Military
Consumer electronics



# Energy Conversion Today: Basic Scheme

Utility (single and three-phase) batteries, fuel cells, photovoltaic, generator, flywheel, etc

Power Source

PFC, rectifier, isolation, step-up, step-down, charger, ballast, inverter, etc

Energy Conversion

Heater, electric motor, lamp, electronics equipment, battery, transmission line, grid, appliances, vehicle, portable equipment, electrolyzer, etc

Load

# Basic Power Converter: Heating System

DEVICES

MODULATION

CONTROL

LOSSES / EFFIC.

MAGNETICS

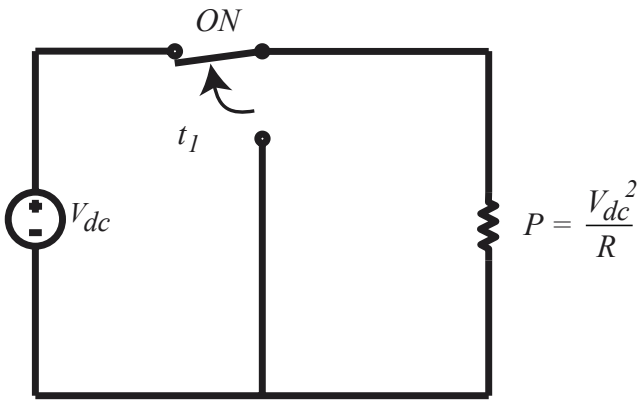
POWER QUALITY

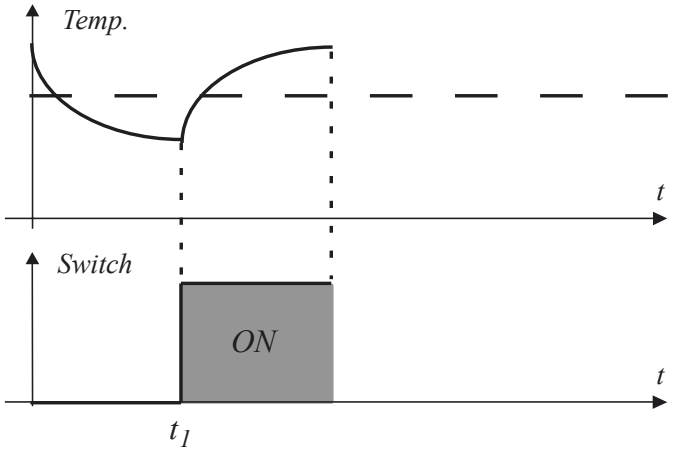
SOURCE CHARACT.

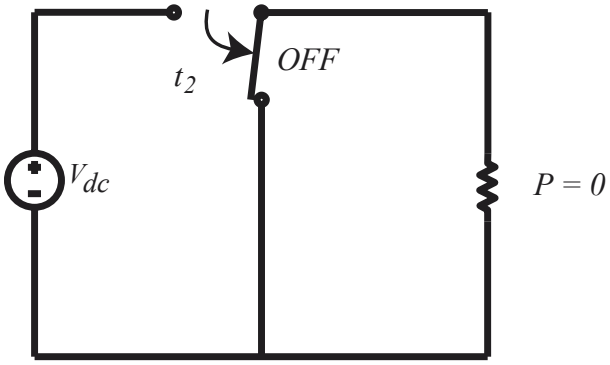
LOAD CHARACT.

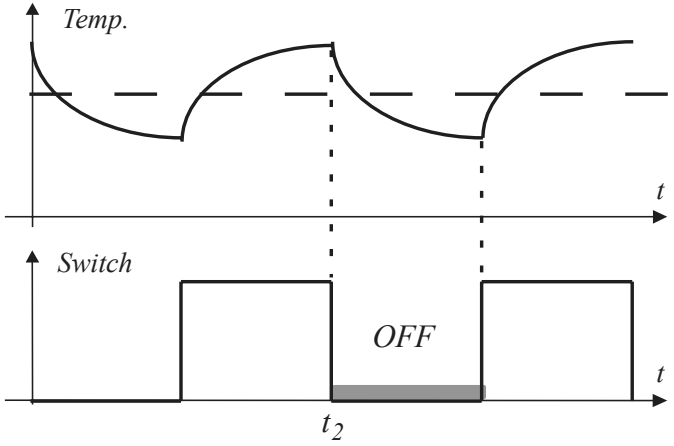
THERMAL MANAG.

# Basic Power Converter: Heating System

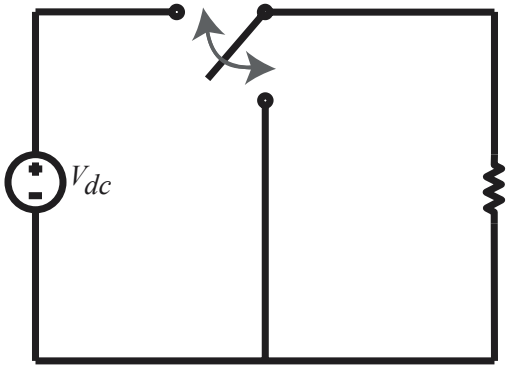


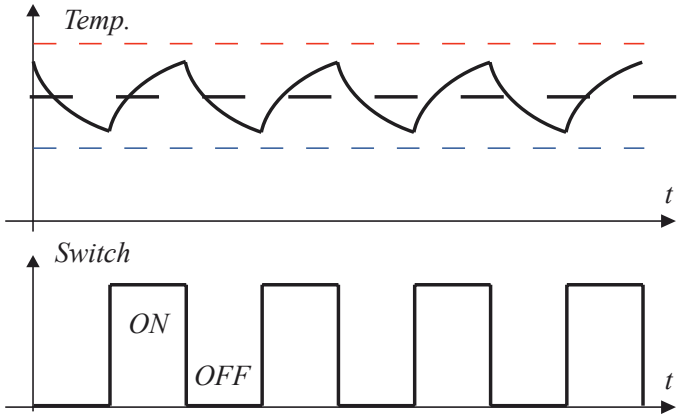



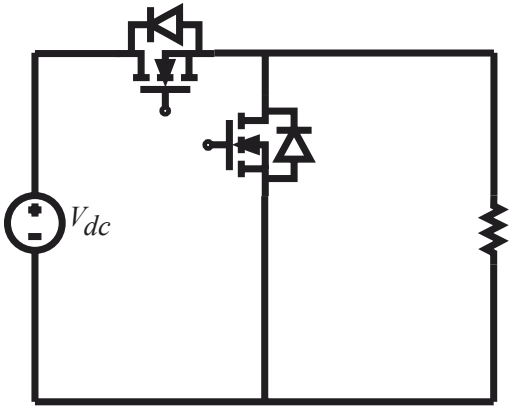



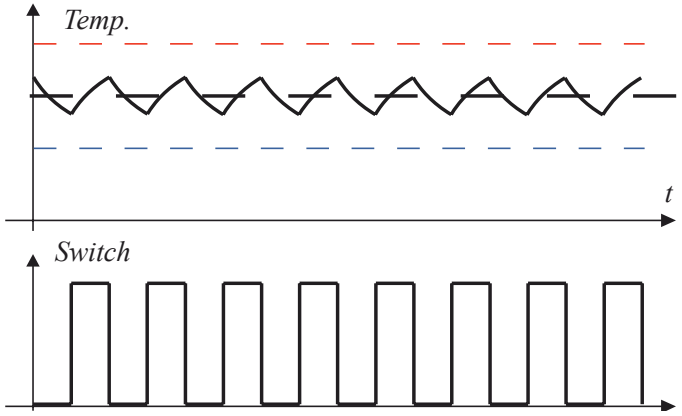



# Basic Power Converter: Devices

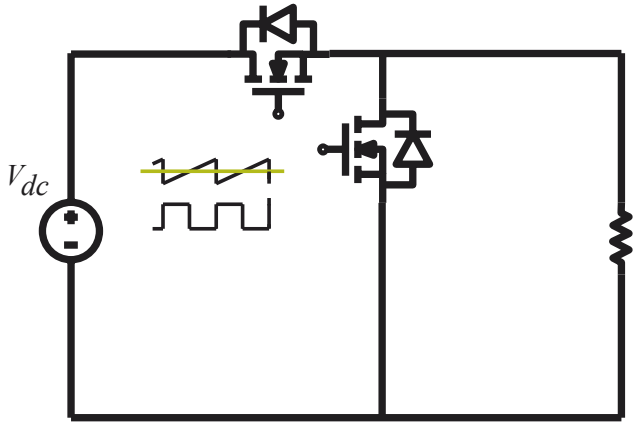


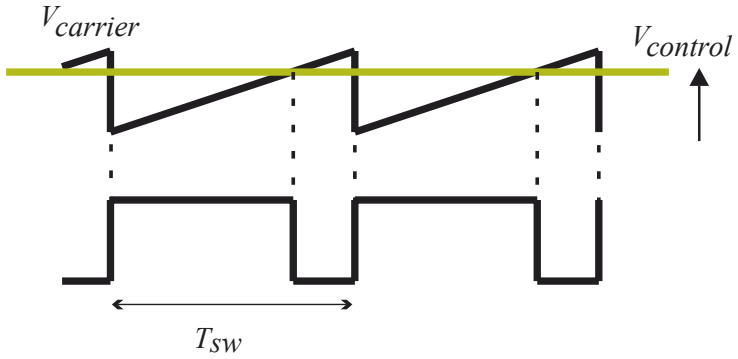



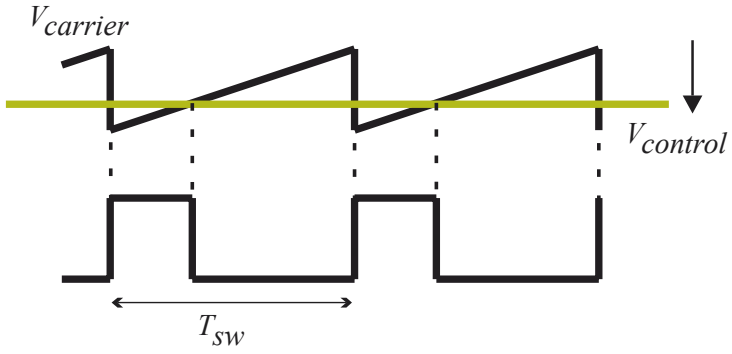



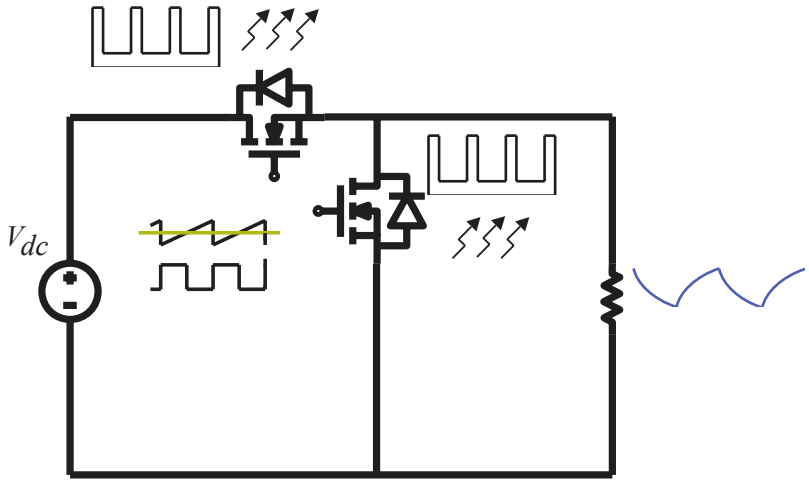
# Basic Power Converter: Modulation and Control

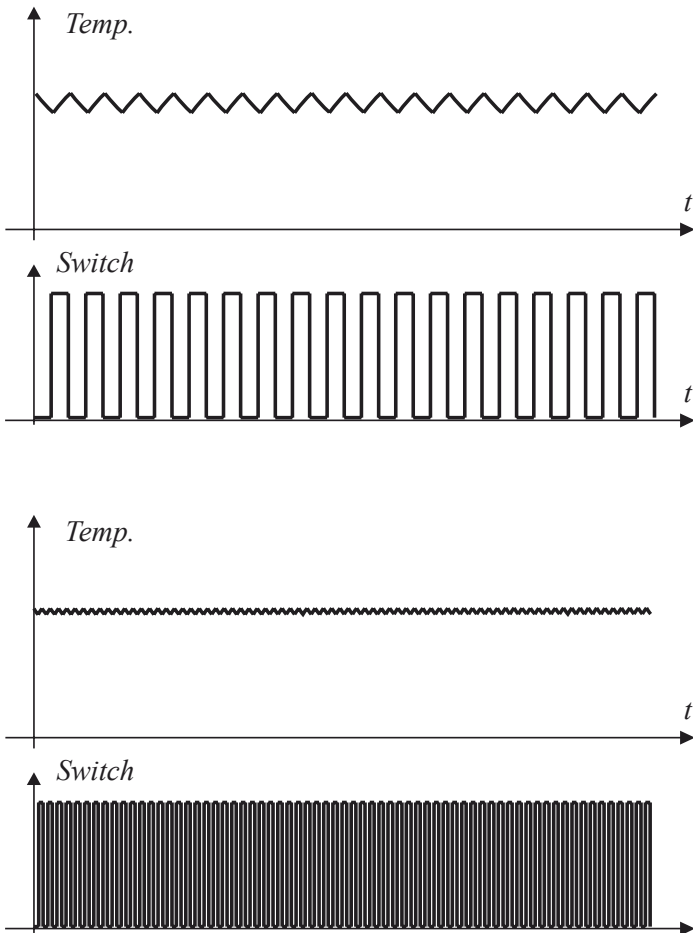


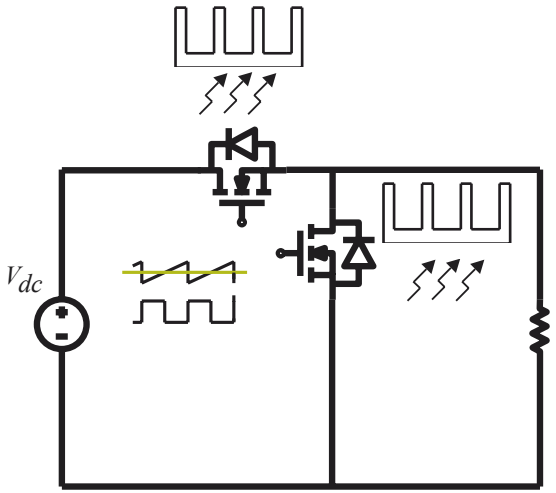



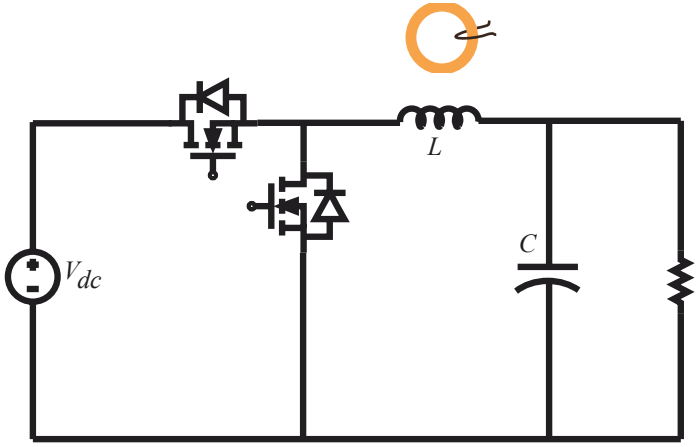
# Power Quality, Losses, and Thermal Management



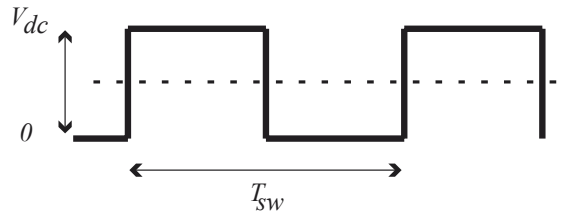



# Output Filter: Magnetics

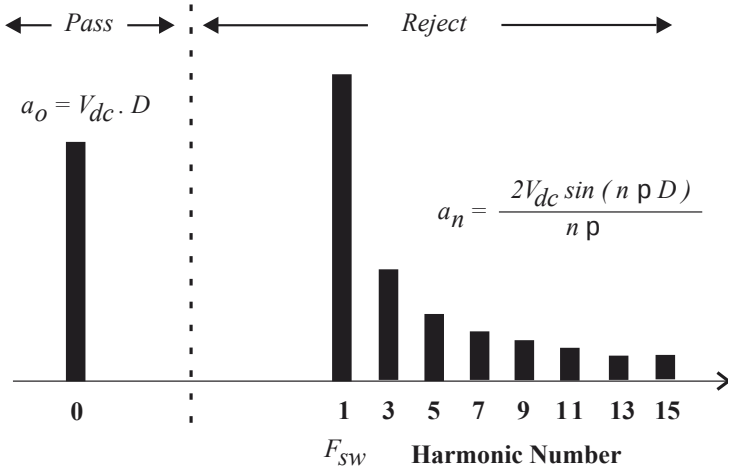


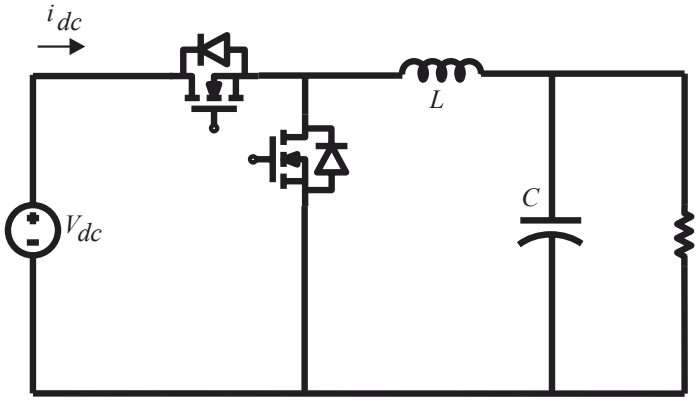

**TIME DOMAIN**

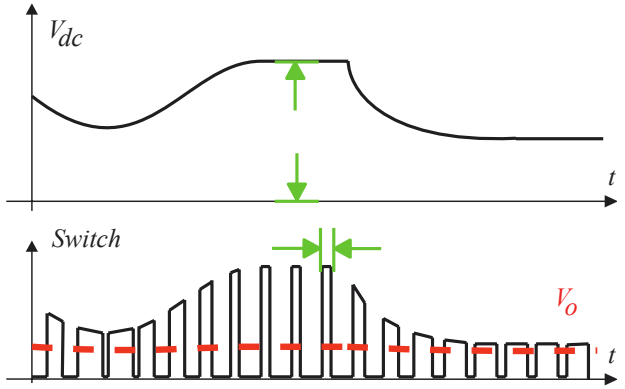


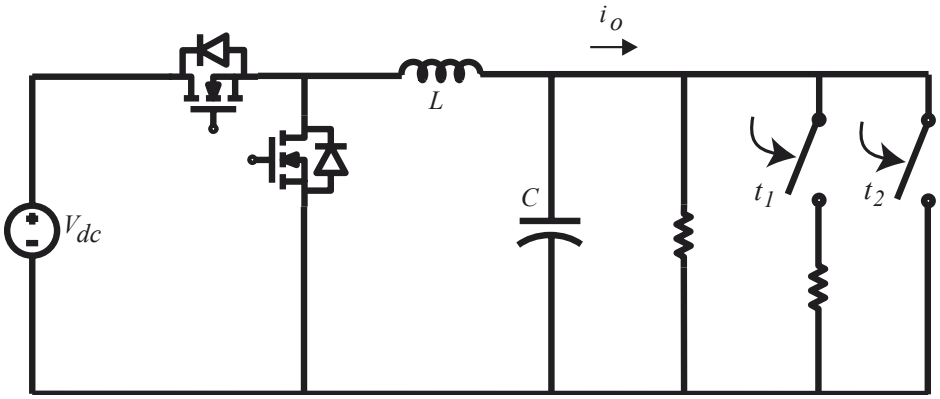

**FREQUENCY DOMAIN**

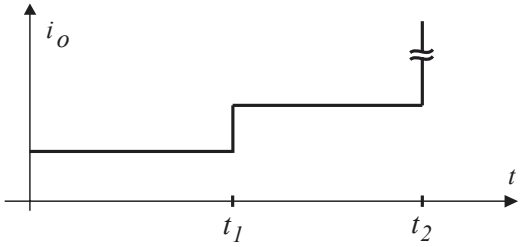


# Source and Load




DEVICES

MODULATION

CONTROL

POWER QUALITY

LOSSES / EFFIC.

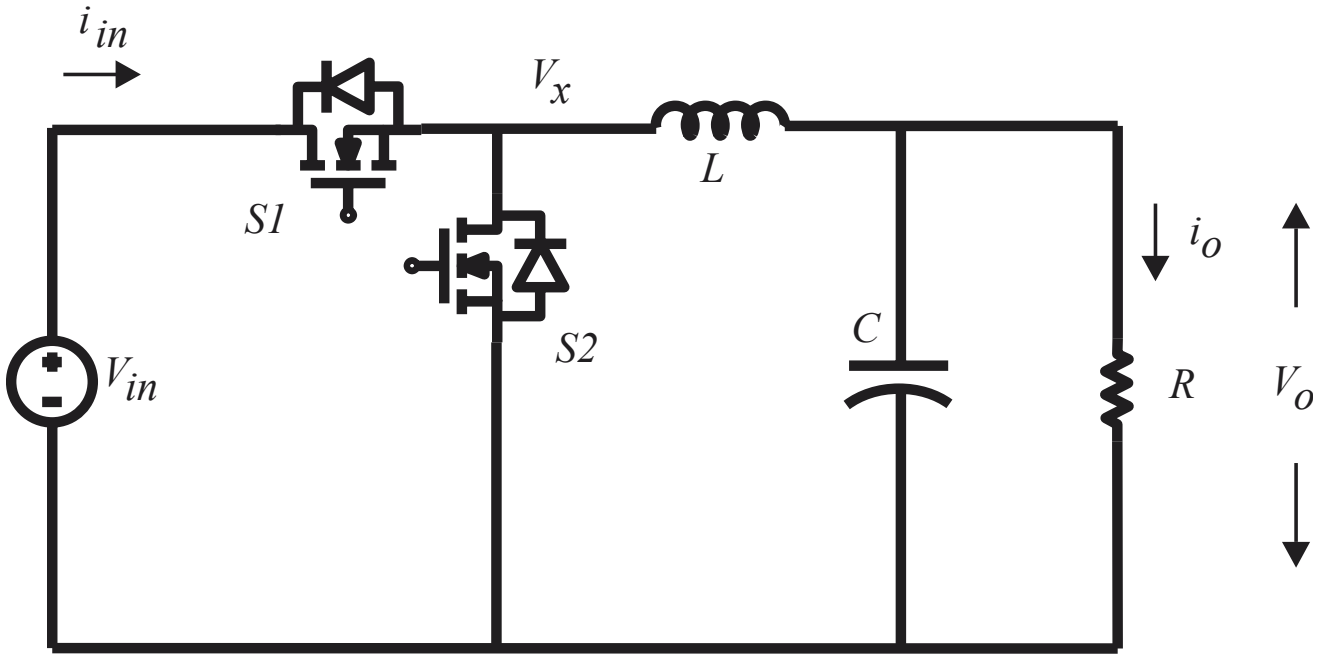
THERMAL MANAG.

MAGNETICS

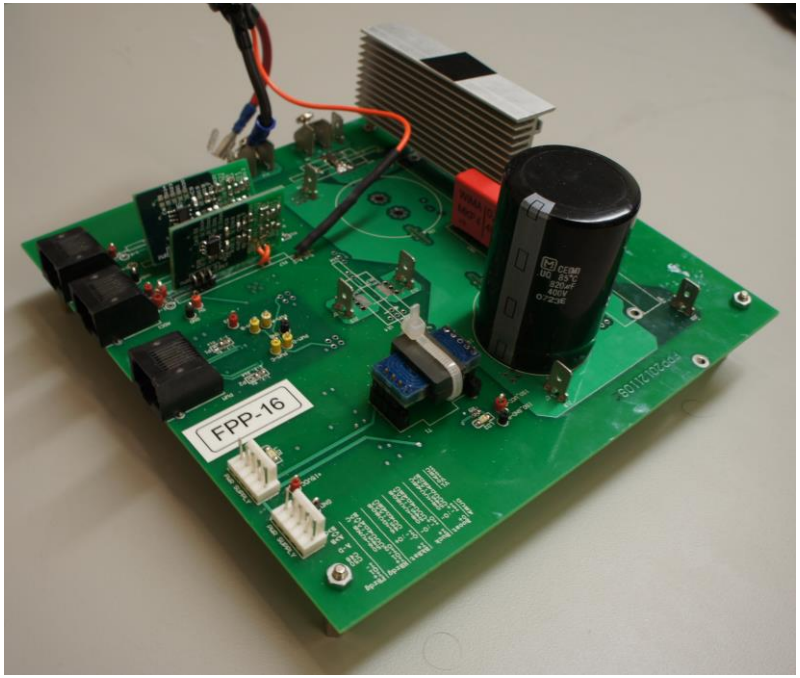
SOURCE CHARACT.

LOAD CHARACT.

# Example: Selection of Parameters



# Prototype




**System Integration**: Packaging, Thermal Management EMI and EMC.

**Modeling, Simulation, and Control**: Parasitics, Circuit and System, CAD/CAE Tools, Sensor and Sensorless Control, Digital Control.

**AC Power:** Single- and Multi-Phase Inverters, PWM Techniques, sensor integration, fault tolerant operation.

**Devices and Components**: Semiconductor Devices, Magnetic Components, Capacitors, Batteries, Sensors, Interconnects, Device Integration.

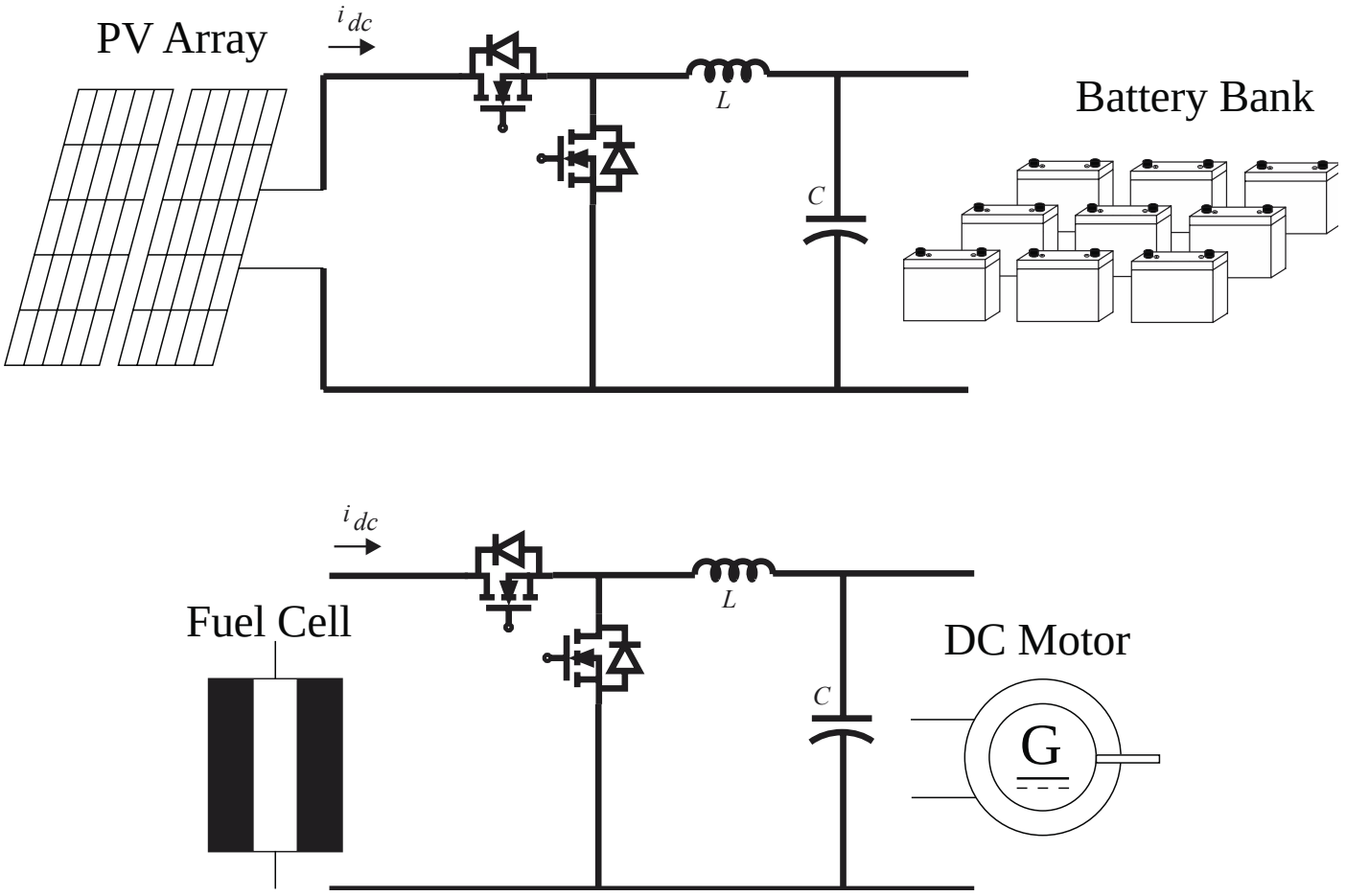
**Grid rectifiers and DC-DC Converters**: Single- and Multi-Phase, Single- Multi Level, Hard- and Soft-Switched, Resonant.

**Utility Interface**: Power Factor Correction, Power Quality, Electronics and Controls for Distributed Energy Systems.

**Motor Drives**: AC and DC

DEVICES
MODULATION
CONTROL
POWER QUALITY
LOSSES / EFFIC.
THERMAL MANAG.
MAGNETICS
SOURCE CHARACT.
LOAD CHARACT.

# Fuel Cell, Batteries, PV, Motor…



# Introduction to Power Electronics

POWER QUALITY

Presented by:
Dr. Martin Ordonez

SOURCE CHARACT.

THERMAL MANAG.

LOSSES / EFFIC.

Questions?

MAGNETICS

CONTROL



MODULATION

LOAD CHARACT.

DEVICES