Design Automation of Power Electronics: Hardware and Control
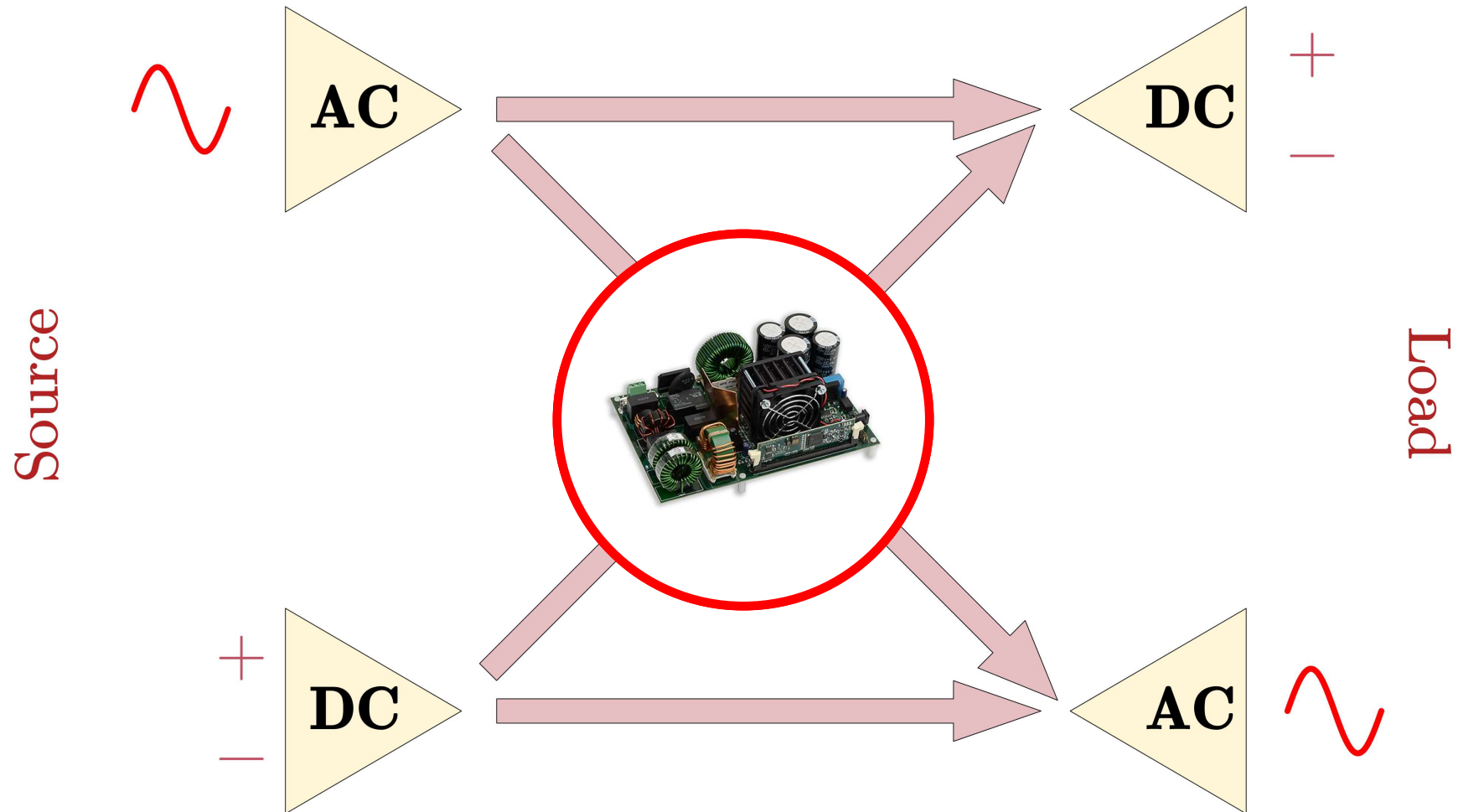
Presentation to Data-centric Engineering Group

Presented by
Dr. Sinan Li, Lecturer, ARC DECRA Fellow
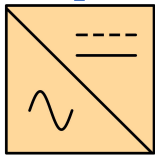School of Electrical and Information Engineering
University of Sydney (USyd)

THE UNIVERSITY OF
SYDNEY

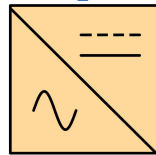# What is Power Electronics

Source

Load

AC

DC

DC

AC

Ubiquity of Power Electronics
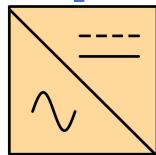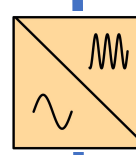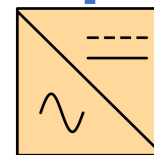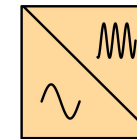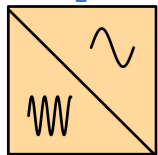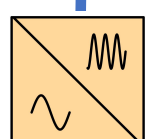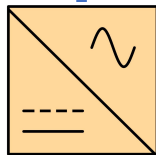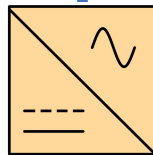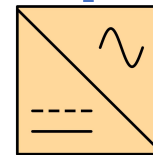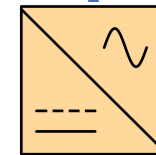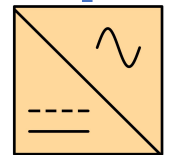
A Future with More Power Electronics [1]

100%
All Primary
Energy

40%

Electricity is 40% of total
primary energy consumption,
expected to grow

32%

30% of all electrical energy passes
through power electronics today,
can reach 80% next decade

$20 billion industry growth from 2018 to 2023

Electrical Energy
Applications

Generation

Transmission

Utilization

Storage

Significant energy savings with
small efficiency improvements

[1] Samantha B. Reese, Timothy Remo, Johney Green, Andriy Zakutayev, "How Much Will Gallium Oxide Power Electronics Cost?", Joule, Volume 3, Issue 4, 2019, Pages 903-907.

Opportunities in Design Automation
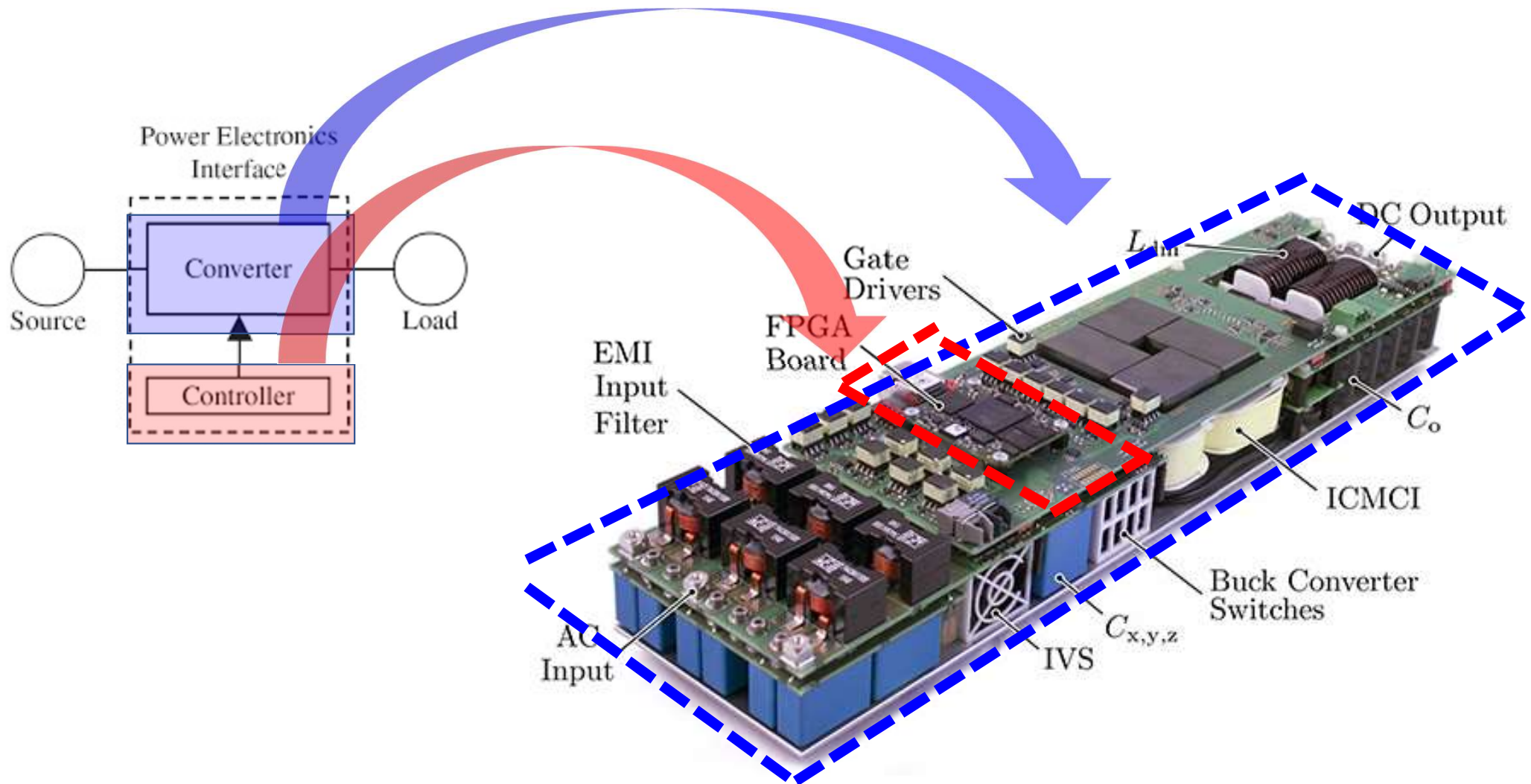

Design cycle
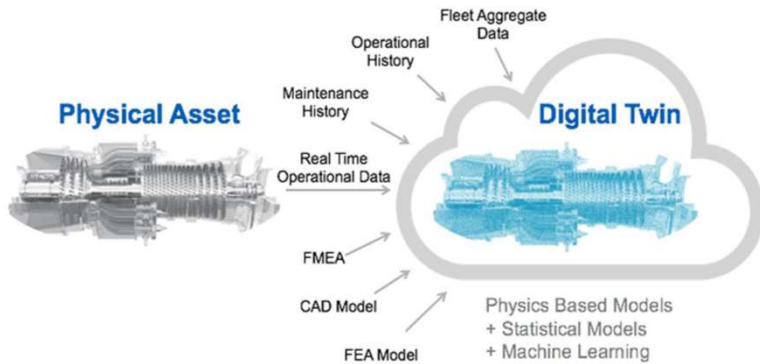**12–18 months**

Controller testing costs up to
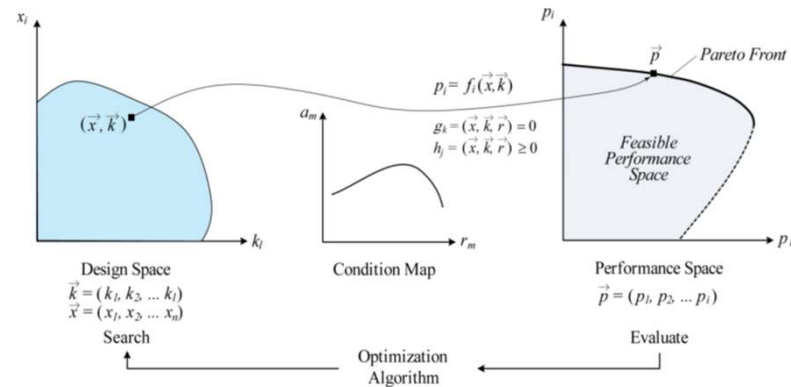**$60,000/day**

--- ABB's automotive traction system design [2]

[2] R. Ionutiu, E. Scheiben, X. Ke, et al., "Real-time simulation for power electronics in railway applications and beyond," in IEEE Design Automation for PE Workshop, 2019, pp. 34–39.

Overview of My Research Scope

Power Electronics Interface

Source

Converter

Load

Controller

EMI Input Filter

FPGA Board

Gate Drivers

L_m

DC Output

AC Input

IVS

$C_{x,y,z}$

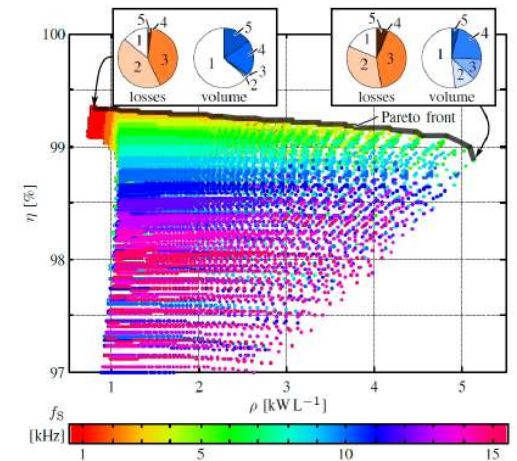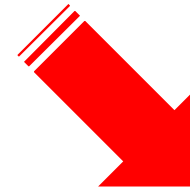Buck Converter Switches

ICMCI

C_o

Topic 1: Design Automation of PE "Hardware"

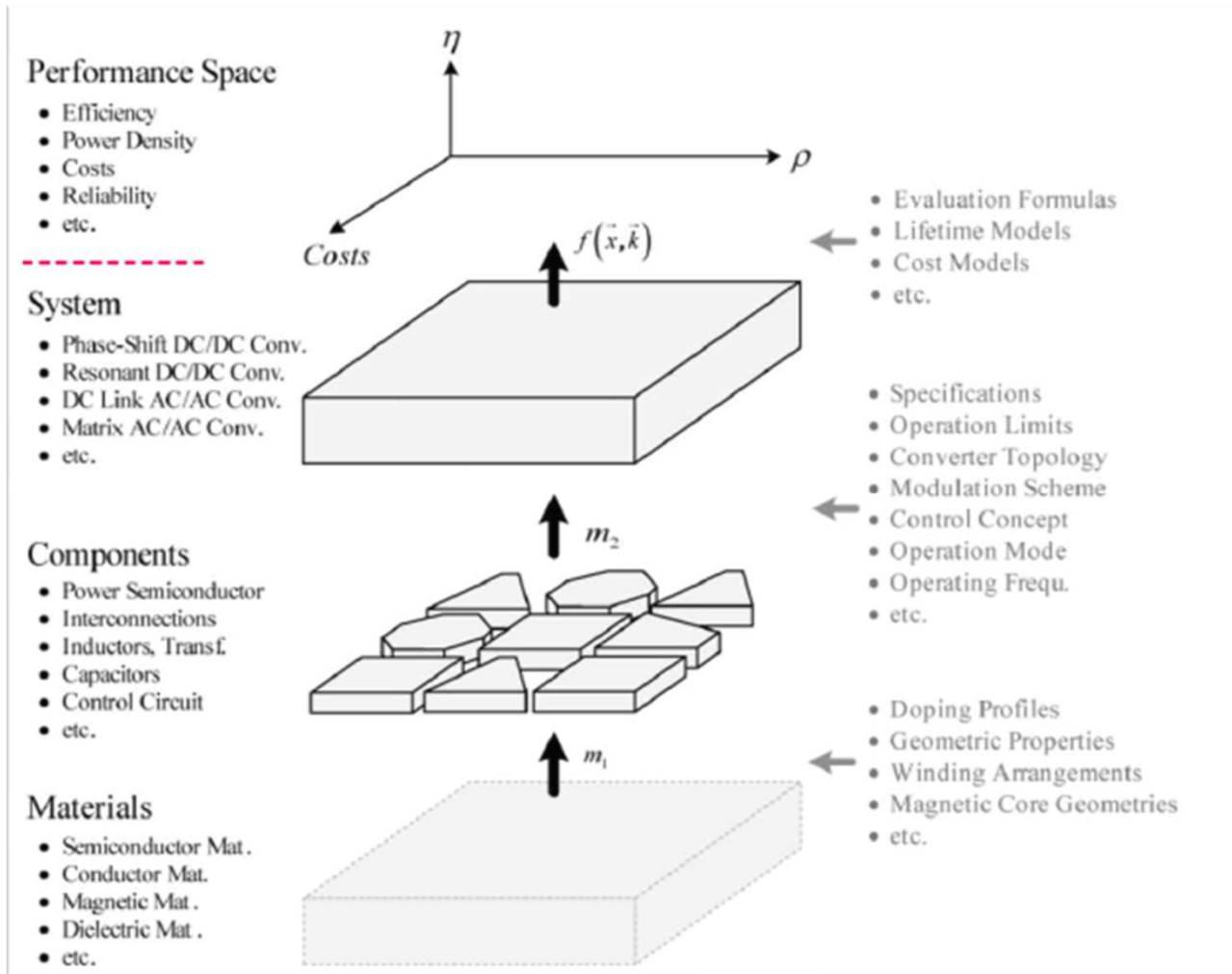**Digital Twin Simulation**

Performance mapping

Optimization
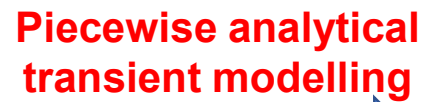
Problem: Existing Simulation Techniques are Slow
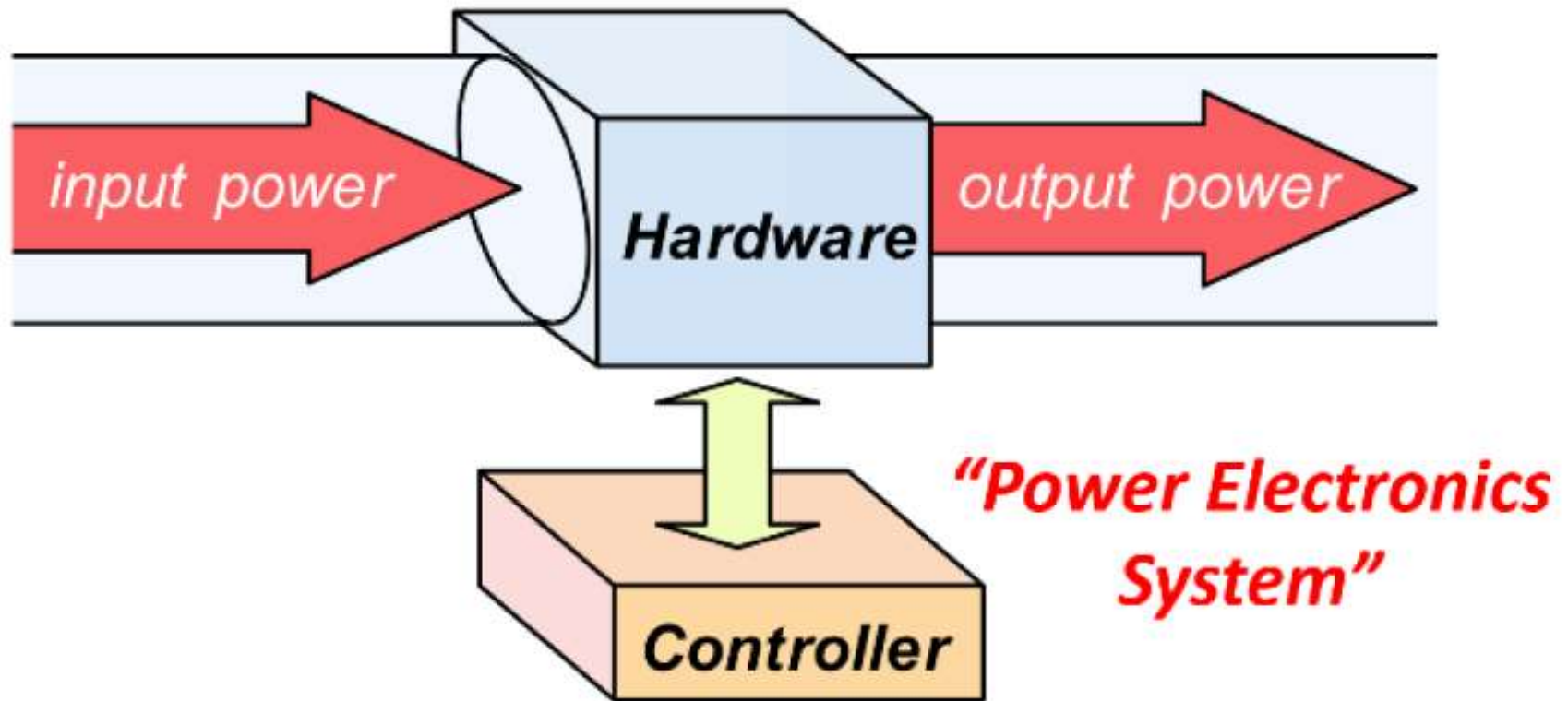

If each simulation takes

1 second

a design space with 10^8 design candidates
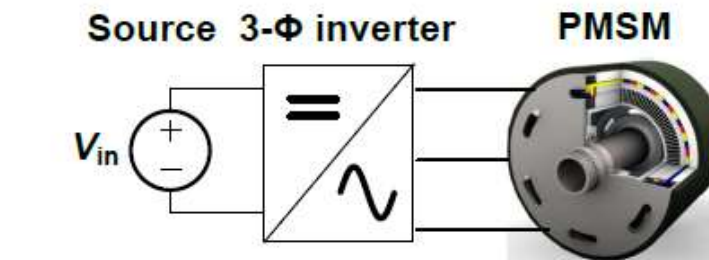
needs **> 3 years** to complete.

Project-X1: Eagle Eye (> 1000x faster)

Discrete Event Driven Simulation

ms time scale

Piecewise analytical transient modelling

ns time scale

Topic 2: Design Automation of PE "Controller"

input power

Hardware

output power

"Power Electronics System"

Controller

Project X2 – Model-Free Control

(a)

(b)

PE system (1): 3-Φ PMSM Driving System
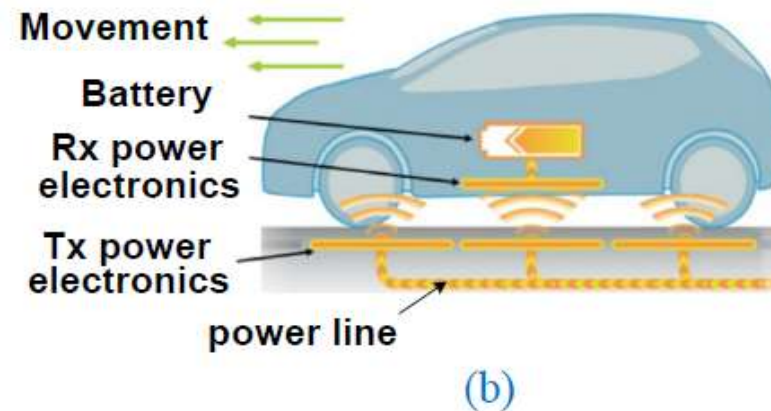
PE system (2): Dynamic WPT System

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Thanks + Q&A

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Sinan Li
The University of Sydney