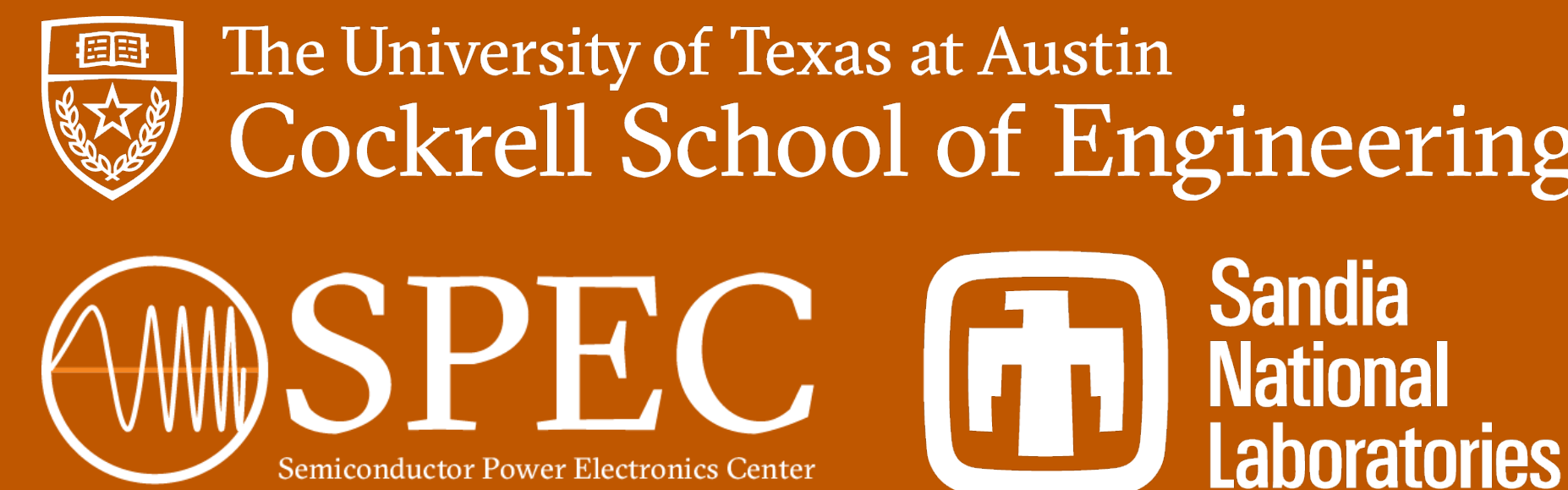


PCBSchemaGen: LLM-Driven Automated Printed Circuit Board (PCB) Schematic Design

Huanghaohe Zou, Peng Han, Emad Nazerian, ECE, UT Austin
Dr. Alex Q. Huang, Professor, ECE, UT Austin

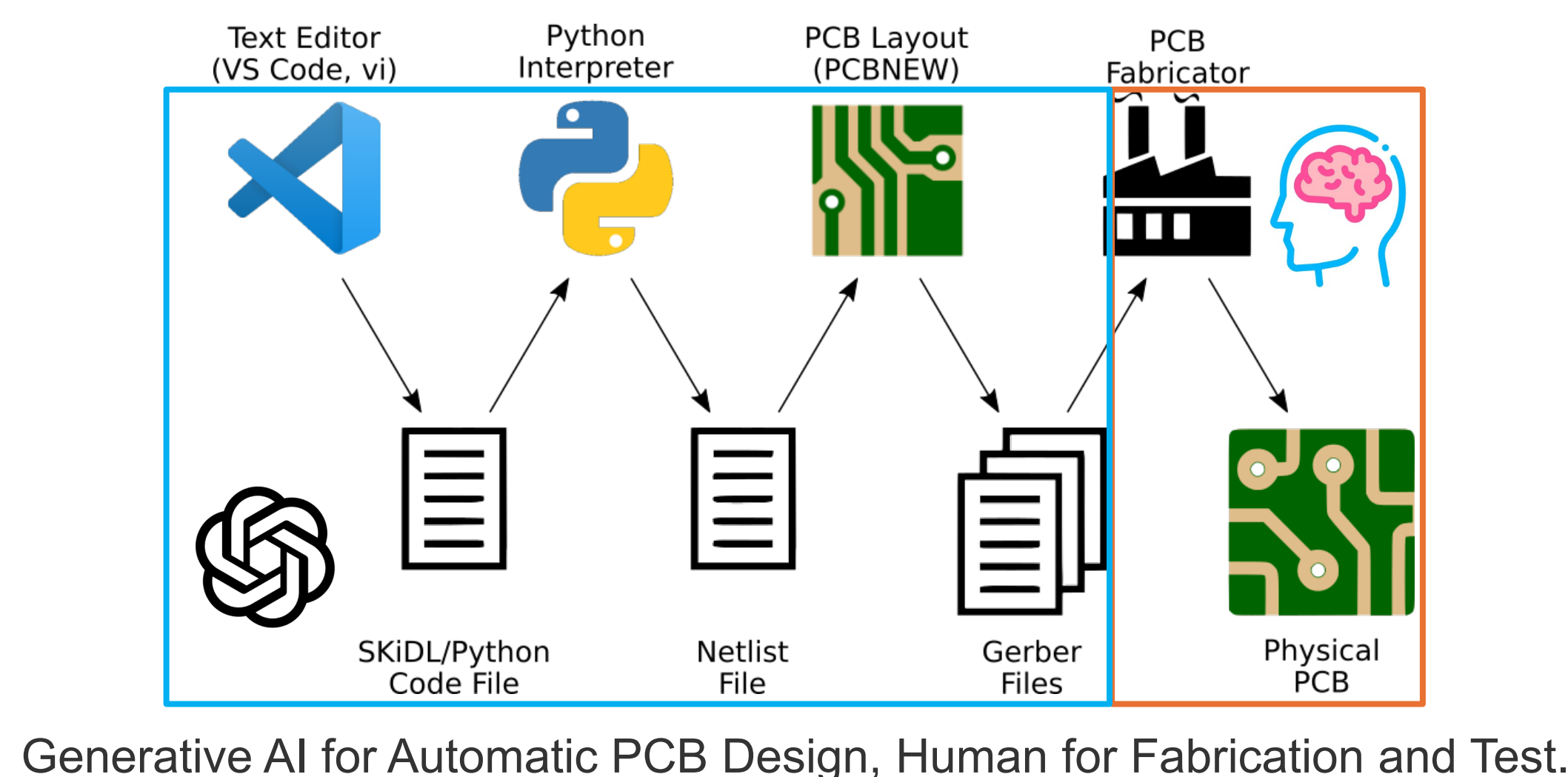


Project Profile

Topic: Power Electronics
Vertical: Materials and Systems Innovation
Strategic Pathway: advancing new technologies
Project Start & Finish: FY25-FY26

Motivation

- PCB market: \$74B (2025) → \$113.5B (2032). Traditional schematic R&D takes months of manual expert work
- Mix of digital, analog circuits, and power stage, harder than IC-level design
- Rare open-source data, no standardized language

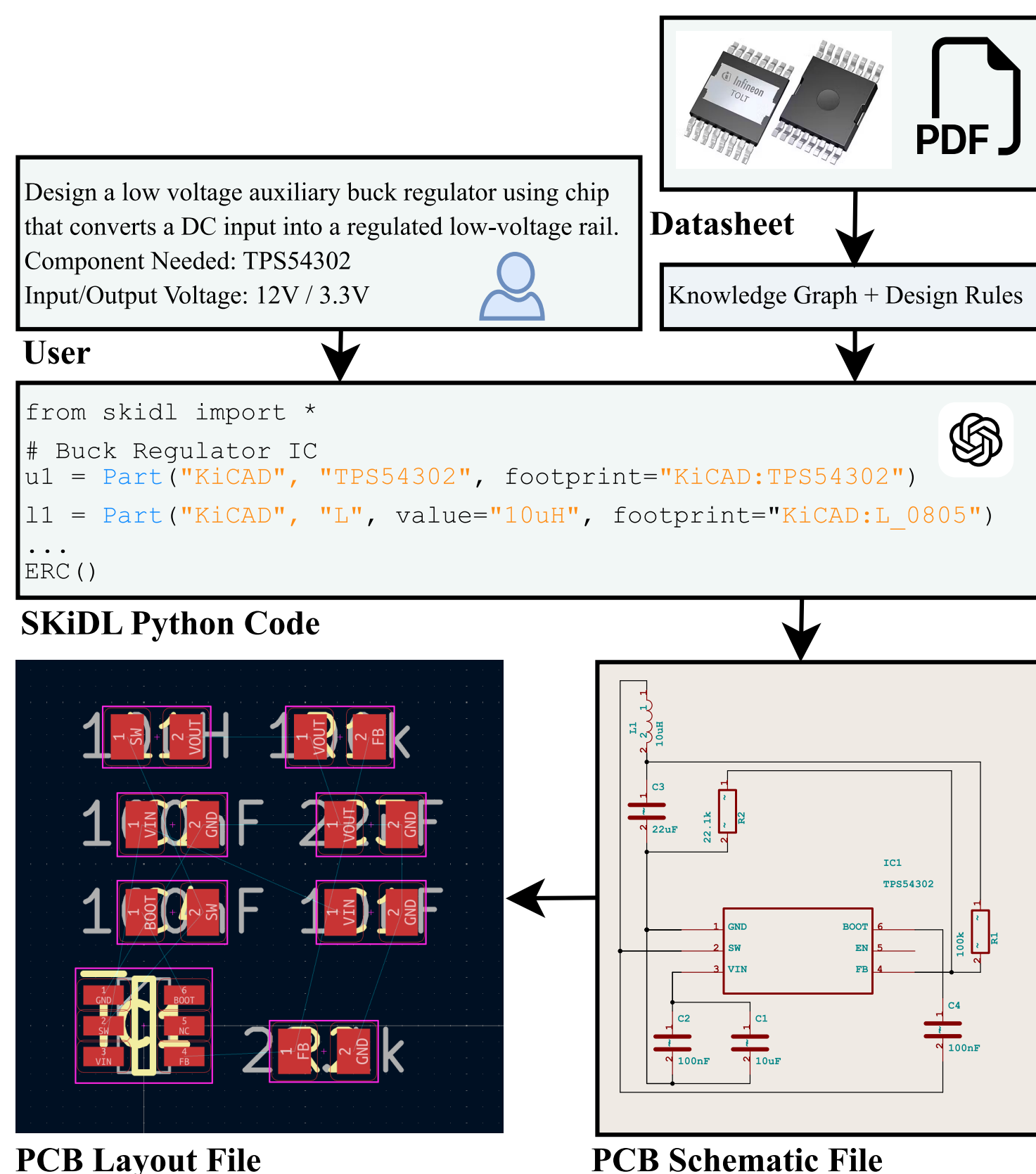


Generative AI for Automatic PCB Design, Human for Fabrication and Test.

Framework Overview

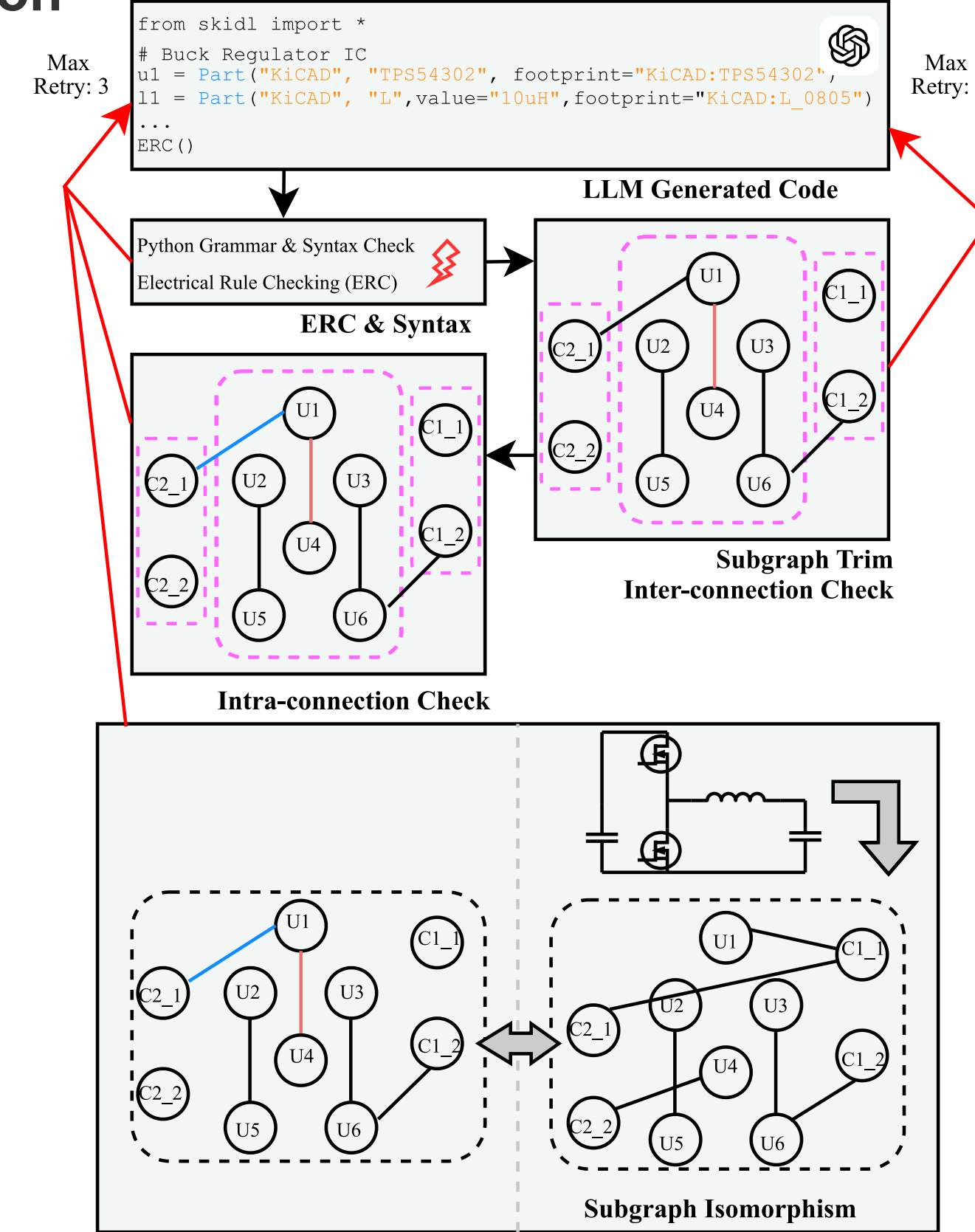
Generative Framework Pipeline:

Natural Language Input → Design Rules Agent → SKIDL Code → KiCAD Schematic → KiCAD PCB Layout

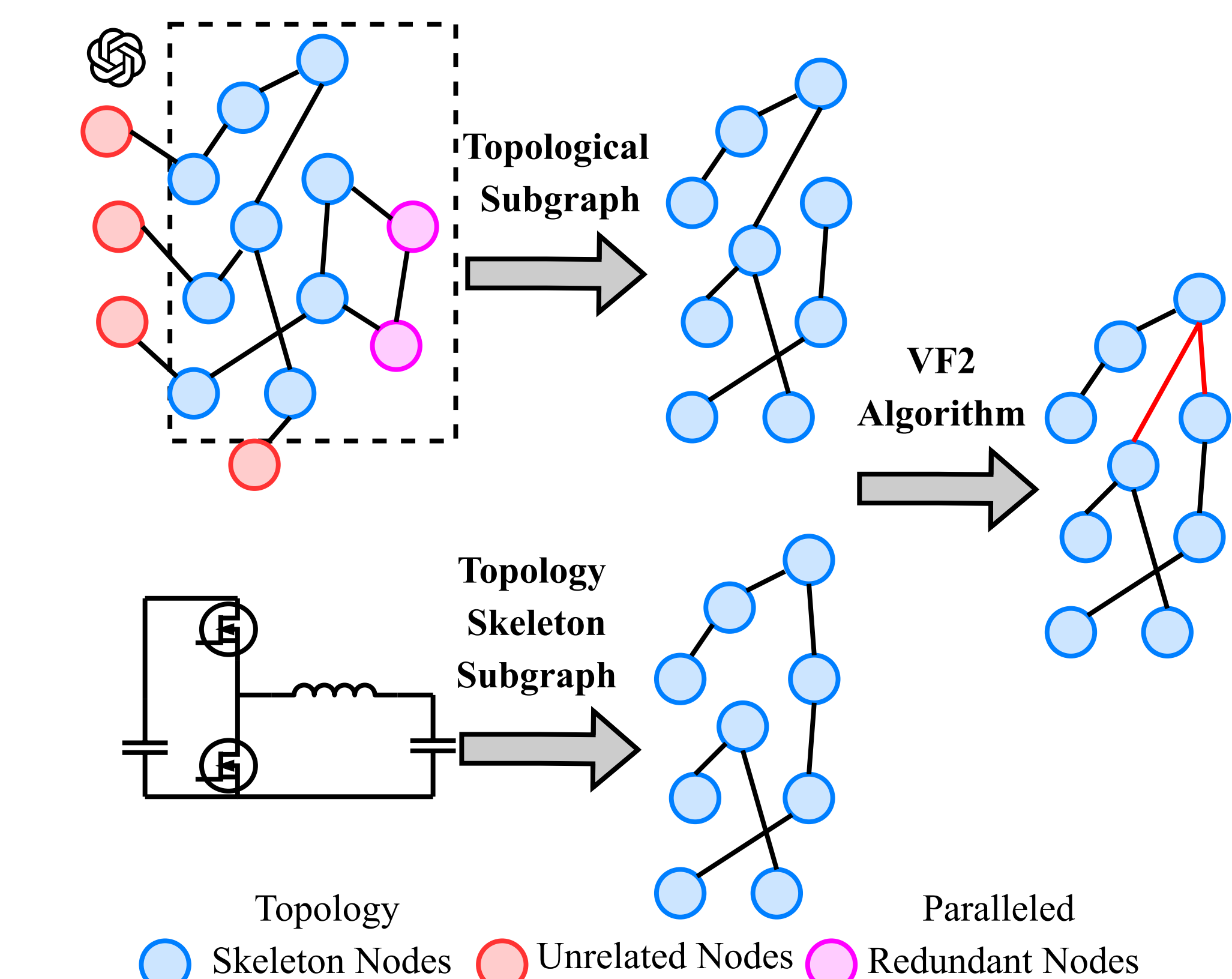


Self-Aware Iteration Pipeline:

LLM Code Generation → Electrical Rules Check → Graph Verification → Error Localization → LLM Self Iteration



Sub-Isomorphism Verification



• Multi-stage: Syntax → ERC → Bipartite Graph → KG Rule Check → VF2 Isomorphism

• Knowledge Graph(KG) compresses IC information from ~16000 to ~300 tokens (50× reduction)

• Encoding semantic pin-role types for cross-IC-family pattern matching

Benchmark

Category	Domains	# Tasks	Pin Range
Analog	Sensing, EMI/Analog Filter	11	3–20
Power Supply	Aux Power, Power Mgmt	6	4–12
Power Stage	Power Stage, Gate Driver	9	4–16
Power Converter	DC-DC, DC-AC	7	20–100+
Digital / MCU	MCU, Comm, Isolation, Storage, Memory	13	3–106+
Data Acquisition	Data Conversion, Ethernet, High-Speed	7	3–48
BMS / Motor	Battery Mgmt, Motor Control	4	24–100+
System Integration	Digital Power, Motor Drive, Sys Integration	8	3–150+
Total	22 domains	65	3–150+

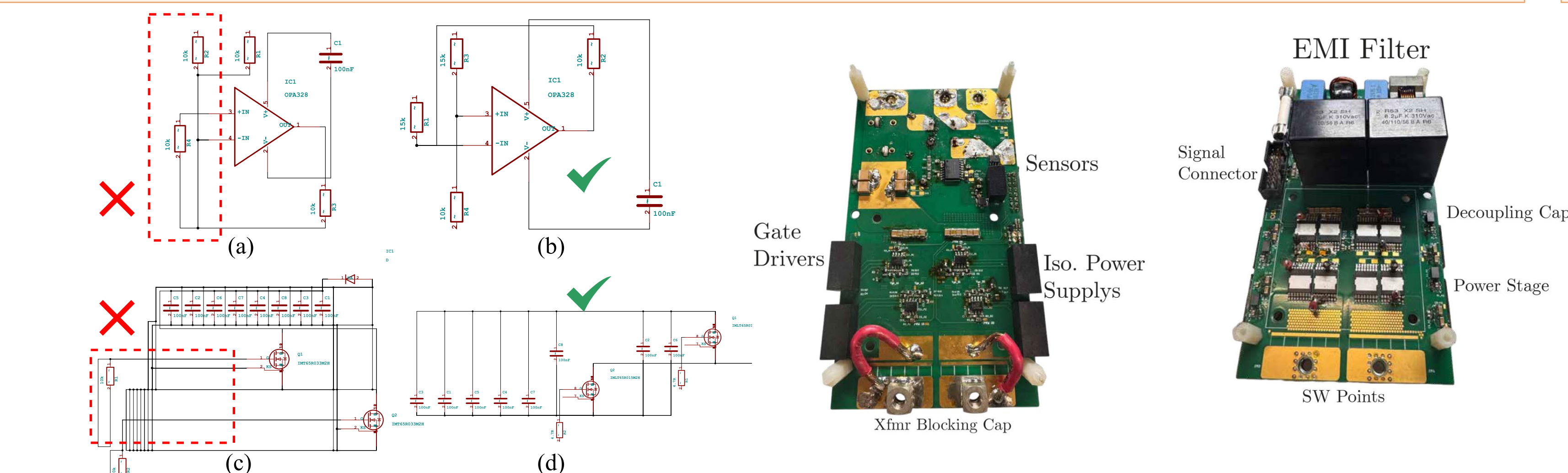
- 65 tasks across 22 PCB function domains
- 44 unique ICs from 11 vendors
- Proved broad coverage of real-world hardware functionalities

Main Results & Robustness

Category	Gemini-3-Flash	DeepSeek-V3.2
Analog Sensing	80.0%	61.8%
Power Supply	81.1%	71.1%
Power Stage	91.8%	74.1%
Power Converter	73.3%	57.2%
Digital & MCU	90.3%	68.7%
Data Acquisition	80.0%	73.3%
BMS & Motor	46.7%	40.0%
System Integration	51.7%	49.2%
Overall	77.5%	63.6%

- Close source LLMs outperform open source LLMs
- Circuit library ensures retrieval correctness
- Complex circuit system remains challenging

Case Study: AI Generated Schematics & Real PCB



Step 1: LLM generates correct PCB Schematic

Step 3: Verified AC/DC 5kW Power Supply for Battery Energy Storage System (BESS)

