

The Design Process of Commercial Circuit Design

Alex Xie, Victor Miao, Surabi Seshasayee, Mattan Firouztala, Laila McPhatter
USC Viterbi School of Engineering, University of Southern California

Abstract— Commercial circuit design turns an idea into a product that can be manufactured reliably at scale, not just a working prototype. This paper walks through the main phases of that process, the biggest challenges commercial teams face, and where the field is heading.

Keywords— circuit design, PCB layout, EDA, verification, DFM, commercial electronics.

I. REQUIREMENTS AND ARCHITECTURE

Every project starts with a requirements document built together with marketing, manufacturing, and customers. It typically covers functional needs (voltage levels, data rates, interfaces), constraints like power budget and size, reliability targets, and cost/volume goals. Teams often run a Failure Mode and Effects Analysis (FMEA) early to flag high-risk subsystems before serious engineering work begins. From there, the team defines the system architecture: how the design splits into subsystems, which processor or components to use, and how power and signal paths are organized.

II. SCHEMATIC CAPTURE AND SIMULATION

The schematic phase turns the architecture into a detailed circuit using parts pulled from an approved vendor list, ideally with a backup source for high-risk components. Standard practices like placing decoupling capacitors near ICs and correctly sizing pull-up/pull-down resistors help avoid downstream problems. Tools such as Altium, Cadence Allegro, and KiCad check the schematic for electrical errors in real time [1]. Before anything is built, the design is simulated: SPICE-based tools check analog behavior, and signal/power-integrity tools confirm the layout will behave correctly at speed. For chip and complex digital designs, the industry standard is the Universal Verification Methodology (UVM), a framework for building reusable, coverage-driven test environments [4]. Coverage tracking is how a team knows it has

tested enough of the design's behavior, not just run a lot of tests [5].

III. PHYSICAL LAYOUT AND PROTOTYPING

Physical layout turns the schematic into a real board or chip: choosing the layer stackup, placing components, routing traces, and generating manufacturing files. Manufacturability (DFM) and testability reviews happen throughout this stage rather than at the end, since problems are far cheaper to fix while the layout is still flexible [2]. Once layout is done, a small batch of prototypes is built and tested against the original requirements, including early EMC testing to catch compliance issues before formal certification. Multiple prototype rounds are common before a design is ready for volume production.

IV. DESIGN FOR MANUFACTURABILITY

DFM is the practice of designing so a product can be built repeatedly and consistently at scale, not just once by hand [6]. In practice this means looping in the contract manufacturer early, sticking to components available from multiple suppliers, minimizing part count, and following standard footprint and spacing guidelines so automated assembly and inspection equipment can do their job. Teams that build DFM in from the start tend to see fewer defects and fewer costly late-stage redesigns.

V. KEY CHALLENGES

Commercial teams deal with pressures beyond getting the circuit to work. Component sourcing has been a major one: the 2020 semiconductor shortage pushed some lead times past a year, and while things have eased, shortages and tight allocation still show up for specific parts, especially as AI and data-center demand competes for capacity [7]. Regulatory compliance (EMC/EMI, safety, wireless

certification) has to be planned for early, since failing certification late in the program is expensive to fix. Cost targets and time-to-market pressure often pull in opposite directions, and rising product complexity, more wireless, sensing, and processing packed into less space, keeps raising the bar on all of it.

VI. AI-ASSISTED DESIGN

AI is increasingly built into EDA tools rather than being a separate add-on. It shows up in synthesis, layout, and verification, helping automate tasks that used to take a lot of manual iteration [3]. In verification specifically, AI is being used to generate more useful test cases and spot coverage gaps faster. There is also growing interest in using large language models to help write hardware description code and testbenches, an area sometimes called agentic EDA [8]. These tools speed things up, but they are not a replacement for engineering judgment; a human still needs to review and sign off, especially on safety-critical or cost-sensitive designs.

VII. CONCLUSION

Commercial circuit design succeeds when requirements, manufacturability, and verification are treated as ongoing, interacting constraints rather than a strict one-way sequence. On top of the technical work, teams have to manage supply chain risk, compliance, and cost pressure the whole way through. AI tools are likely to keep taking over more of the repetitive work across the flow, but the underlying discipline, planning early and catching problems before they get expensive, remains what actually makes a commercial design successful.

VIII. REFERENCES

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