Guest Editors' Introduction

Open-Source Silicon—Unleashing Innovation and Collaboration

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In this landmark special issue of *IEEE Design & Test*, we are thrilled to present the burgeoning realm of Open-Source Silicon, a sector that is not just evolving but also revolutionizing the way we approach IC design and semiconductor technology. Since the inception of the OpenMPW program by Google, SkyWater, and Efabless in 2020, the landscape of open-source IC design has expanded exponentially, signaling a new era of innovation, collaboration, and accessibility in semiconductor design.

The statistics are a testament to this rapid growth: over 6,500 users are actively engaged in the open-silicon Slack community, and over 1,000 design projects have been initiated on the Efabless' project portal. These figures underscore the vibrant and collaborative nature of this community, which has been further enriched by the inclusion of open process design kits (PDKs) by Globalfoundries (180 nm) and IHP (130-nm BiCMOS), alongside Skywater's 90- and 130-nm offerings. This expansion in technology options has catalyzed hundreds of tape-outs across 12 shuttle runs, yielding tangible, measured silicon results that are beginning to shape the future of IC design.

The driving forces behind this movement are manifold. A significant motivator is the need to address the challenges posed by the traditional IC design ecosystem, which is often hampered by nondisclosure agreements and a lack of transparency. By pivoting to an open-source approach, the new ecosystem is breaking down these barriers, promoting reproducibility, and encouraging the reuse of designs. This shift is not merely a technological one; it represents a cultural change toward openness and collaboration, enabling designers to share knowledge and work collectively toward enhanced reliability and productivity.

Furthermore, the open-source silicon initiative is democratizing IC design, extending its reach beyond the realm of electrical engineering. This accessibility is a boon for educational institutions and research organizations and fosters innovative cross-disciplinary projects. The implications of this are profound, enabling a diverse range of thinkers and creators to contribute to the field of semiconductor design.

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Another exciting aspect of this movement is its potential to reshape design methodologies through the utilization of open data. These data are invaluable for training artificial intelligence (AI)-based generators, which are expected to lead to significant advancements in design techniques and efficiency.

In this special issue, our primary focus is to showcase the most exciting and impactful results of open-source silicon to date. We specifically invited contributions that center on circuit design and measured results, building on the foundation laid by our previous issue, which focused on design tools. We also invited contributions on novel AI-driven designs that leverage open-source designs and explore methodologies never before used. A crucial criterion for all submissions is that the circuits must be designed exclusively using open-source tools and PDKs.

To this end, we have accepted three interesting articles ranging from using generative AI to open-source mixed-signal and analog design. The first article by Salcedo et al. [A1] presents a novel approach to using generative AI, specifically GPT-4, to accelerate the design and verification of a vector processor SoC, demonstrating the potential of AI to streamline chip development processes and reduce time-to-market. The second article by Marin et al. [A2] discusses the design, implementation, and validation of a power IC, specifically a three-level flying capacitor buck converter, using open-source tools and PDKs, showcasing the feasibility of achieving efficient, low-cost designs for energy-constrained applications in technologies such as the Skywater 130-nm CMOS. The final article by Yang and Xia [A3] discusses the design and implementation of a 12-bit 10-kS/s incremental analog-to-digital converter (ADC) using open-source tools and the Skywater 130-nm CMOS process, with an emphasis on system-level design, circuit implementation, and performance results from silicon measurements.

We are at a pivotal moment in the history of semiconductor technology, and this issue aims to capture the essence of this transformation. It is a celebration of the achievements thus far and an invitation to the global community to continue pushing the boundaries of what is possible in open-source chip design. Join us in exploring these developments, as we uncover the innovations that are defining the future of open-source silicon. ■

Appendix: Related Articles

[A1] W. Salcedo, S. Achour, and C. McBeth, "Leveraging generative AI for rapid design and verification of a vector processor SoC," *IEEE Design Test*, vol. 41, no. 6, pp. 8–18, Nov./Dec. 2024, doi: 10.1109/MDAT.2024.3404117.

[A2] J. Marin et al., "Open-source multilevel converter power IC design and test," *IEEE Design Test*, vol. 41, no. 6, pp. 19–27, Nov./Dec. 2024, doi: 10.1109/MDAT.2024.3405892.

[A3] R. H. Yang and Y. Xia, "An open-source 12-bit 10-kS/s incremental ADC in 130-nm CMOS," *IEEE Design Test*, vol. 41, no. 6, pp. 28–35, Nov./Dec. 2024, doi: 10.1109/MDAT.2024.3444728.

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