Developing High-Performance PCIe* Acceleration Boards with Intel Agilex® 7 FPGAs

Hitek Systems develops the latest PCIe-based high-performance accelerators using Intel Agilex 7 FPGAs and Open FPGA Stack (OFS) for networking, computational, and high-capacity storage applications.

At a Glance

- Hitek Systems addresses industry demand for FPGA-based acceleration boards that utilize the Intel Agilex® 7 FPGA series, popular for delivering industry-leading fabric and I/O speeds

- Open FPGA Stack (OFS) is an open-source hardware and software infrastructure that Hitek leverages to scale and standardize their line of high-performance accelerators named HiPrAcc*

- Hitek Systems has two OFS-enabled HiPrAcc boards shipping today, with more in development and available in Q4 2023

Executive Summary

Following the launch of the Intel Agilex® FPGA family in 2019, now widely acknowledged as the industry's highest performing 7 nm FPGAs, Hitek Systems incorporated Intel Agilex FPGAs in its line of high-performance accelerators named HiPrAcc*. After evaluating our current board design and development flows, we concluded that standardizing our development flows to maximize reuse and expedite time to market would better capture the increasing demand for FPGA-based accelerators.

We integrated the open-source Open FPGA Stack (OFS) hardware and software infrastructure to do so. Using base OFS hardware and software components, paired with open-source technical documentation, helped ease the development flow and increase reuse and portability across our family of PCIe* accelerators.

Using the OFS infrastructure, Hitek Systems has two Intel Agilex 7 FPGA-based accelerator platforms available today, with more coming in 2023 and 2024.

Authors

Haris Tauqeer
Senior Principal Engineer
Hitek Systems

Tamara Lin
Product Marketing Specialist
Intel Programmable Solutions Group

Background and Challenges

Hitek Systems is a company specializing in high-end, state-of-the-art FPGA-powered boards and development platforms, networking and forward error correction (FEC) intellectual property (IP) cores, FPGA firmware, FPGA design services, device drivers, and application programming interfaces (APIs) based in Germantown, Maryland. Hitek Systems develops everything in-house, allowing them a flexible business model that can be leveraged for an expedited time to market for custom board development.

Intel introduced the Intel Agilex FPGA family in 2019. Since then, the Intel Agilex FPGA family has expanded to include low to high power and logic densities over various applications. The Intel Agilex 7 FPGA series incorporates the industry's highest performing FPGAs, delivering approximately 2X better fabric performance per watt compared to competing 7 nm FPGAs. The Intel Agilex 7 FPGAs and SoC FPGAs are currently available in F, I, and M-Series, targeting a broad range of bandwidth-intensive, compute-intensive, and memory-intensive applications respectively.

In 2023, Intel Agilex FPGA families are still delivering the industry's highest performance and have become a staple in the FPGA industry for leading performance and power efficiency. Consequently, end-user demand for Intel Agilex FPGA-based acceleration cards, particularly those that enabled high-level development flows with oneAPI, has only grown recently.

However, developing custom FPGA-based boards from scratch is complicated and intensely time-consuming, particularly with high-performance FPGAs pushing the bounds of PCIe card performance. Additionally, porting existing FPGA designs to different vendor FPGAs or different model FPGAs is also a notoriously difficult task, thanks to the different vendor IPs, tools, libraries, and built-in hardware, such as double data rate (DDR), digital signal processing (DSP), and I/Os, that varies between manufacturers and FPGA families.

Without a reusable and standardized infrastructure, multiple custom boards require multiple board support packages (BSPs) to be built, developed, and maintained separately. Custom APIs and software tools are also needed for each FPGA card, making it difficult to manage and maintain across FPGA families and tool versions. This array of cards, using different APIs, tools, and versioning, also demands a high level of customer support.

To leverage the latest and best performing FPGA technology, meet the demand of this market, and bring our solutions to market sooner, Hitek Systems found a need to adopt a standardized and unified approach to their board portfolio.
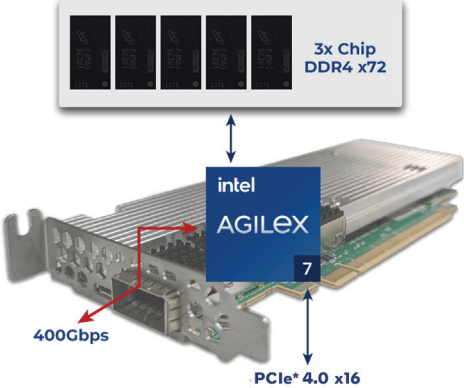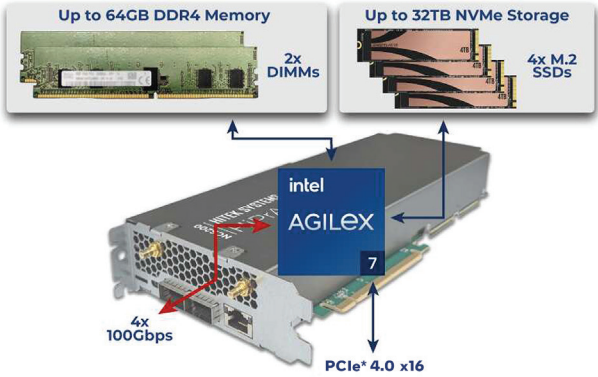
Solution

To help FPGA board and workload vendors scale and bring their solutions to market sooner, Intel has developed and open-sourced the OFS infrastructure, a key foundational tool for Intel Agilex FPGA-based development. OFS provides all the hardware and software source code, documentation, reference examples, and tools needed to jump-start FPGA-based development in an open-source GitHub repository. This reference infrastructure incorporates all the necessary components that board developers can modify or leverage.

The OFS infrastructure provides a unified approach for building and maintaining BSPs across the family of Hitek Systems HiPrAcc boards. This infrastructure consists of an FPGA Interface Manager (FIM), commonly called a 'shell,' and an Accelerator Functional Unit (AFU) region, a designated region for workload development. Using OFS, board – or FIM developers – can leverage the open-source infrastructure – or base FIM – to quickly develop a tailored, customized FIM for their board based on the target application or industry. Similarly, OFS includes an open-source software framework where developers can leverage up-streamed and open-sourced kernel drivers to accelerate integration into common frameworks. OFS offers other capabilities, namely partial reconfiguration, high-level development flows such as oneAPI, and standard Arm AMBA* and AXI interfaces. OFS enables board developers to carry forward a uniform AFU interface, thus enabling their customers, who are AFU developers, to leverage their IP investment across different FPGA boards.

By adopting the OFS infrastructure and development flow and utilizing the provided base FIMs, Hitek Systems found more standardization and portability across FPGA families and tool flows, enabling us to develop our BSPs quickly with more reuse across platforms and providing our customers with a uniform and predictable AFU design experience.

Results

Hitek Systems is shipping and developing a family of high-performance accelerators, HiPrAcc, based on Intel Agilex 7 FPGAs, which target networking, computational, and on-card storage applications. These cards are available in a variety of PCIe-based form factors, including low profile (HHHL-SS), full height (FHHL-SS), and GPU profile (FH¾L-DS). GPU profile cards are designed to be dropped into any server that supports NVIDIA GPUs.

HiPrAcc NC100 Board	HiPrAcc NC100 Board
• FPGA: Intel Agilex 7 FPGA F-Series P-Tile and E-Tile • Applications: Networking and computational • Networking: 200 Gbps • Memory: 3x DDR4 (up to 24 GB) • Form factor: HHHL, single slot • PCIe: PCIe 4.0 x16 • oneAPI enabled: Yes • First board with fully ported and hardware verified OFS and oneAPI toolkits supported	• FPGA: Intel Agilex 7 FPGA F-Series, two P-Tiles and E-Tiles • Applications: Networking, computational, and storage • Networking: 2x QSFP-DD, up to 4x100G • Memory: Supports up to 4 Gen4 M.2 NVMe SSDs (Up to 32 TB of storage) • Form factor: FH¾L, dual slot • PCIe: PCIe 4.0 x16 • oneAPI enabled: Yes • Supports 1588 and Precision Time Protocol (PTP) network synchronization

Hitek Systems is also developing two more HiPrAcc PCIe cards utilizing the Intel Agilex 7 FPGA F-Series and I-Series with R and F tiles. These additional boards will hit production by the end of 2023.

> "Partnering with Intel and utilizing the recently open-sourced OFS, we've simplified the FPGA support package development process, particularly for our HiPrAcc PCIe-based accelerator cards. OFS paired with our Intel Agilex FPGA PCIe cards has abstracted the time-consuming, low-level intricacies of FPGA application development for our customers," said Tariq Muhammad, President of Hitek Systems.

How to Get Started with FPGA Acceleration Using OFS and Hitek Systems Solutions

FPGA developers can choose from Hitek Systems' HiPrAcc NC100 or HiPrAcc NCS200 OFS-enabled boards and use the open-source documentation and source code to get started building their custom workload.

The following table outlines how a developer can get started with FPGA-based workload development using a Hitek Systems acceleration board.

Steps	Leverage FPGA acceleration for your workload
Step 1: Choose a board	Browse Hitek Systems' OFS-enabled boards, the HiPrAcc NC100 or HiPrAcc NCS200.
Step 2: Evaluate OFS open-source resources	Hitek Systems will provide the corresponding version of OFS technical documentation.
Step 3: Access open-source hardware and software code	Hitek Systems will provide the corresponding OFS software and hardware code. This is their specific distribution of the OFS base code (provided by Intel).
Step 4: Develop workload using RTL or C/C++ (using oneAPI)	Follow the OFS RTL flow OR OFS enables the compilation of oneAPI kernels. Utilize the oneAPI development flow and build FPGA workloads in C/C++.

Further Information

To learn how SigmaX is delivering huge performance gains in their JSON to Apache Arrow data management workload using the Hitek Systems HiPrAcc NC100 Board, read the solution brief or watch the video.

Learn More

- Intel Agilex FPGA Low Profile PCIe Card (HiPrAcc NC100)
- Intel Agilex FPGA Network Computational Storage Card (HiPrAcc NCS200)
- OFS open-source code and documentation
- OFS board catalog for third-party OFS-enabled boards
- Learn more about OFS

intel.

ss-1165-1.0