Prototyping, Designing with FPGA Boards Made Affordable and Absorbing

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Field programmable gate array (FPGA) development boards, like any device following Moore's law, are more powerful and inexpensive than ever before. The amount of logic you can fit on these devices is staggering, informs Mark A. Bowers, co-founder, MicroNova Electronics. He says, "These have evolved from containing simple glue logic to emulating entire processors and churning through complex digital signal processing (DSP)."

Today, developers are interested in choosing FPGAs for designing their prototypes of pre-silicon deliverables due to their moderate portability in nature, informs Sudharsan Palanikumar, senior analyst, Femto Logic Design Pvt Ltd. He says, "We also see that FPGAs are chosen for this prototyping objective for their ease-of-integration method in software development processes for demonstration."

FPGA platform availability has improved very much in India today. There are many affordable options available, informs Anoop Jose, manager - research and development, Numato Systems Pvt Ltd. He says, "In 2008, one had no option but to import low-cost FPGA boards. And importing even the cheapest board would have costed ₹ 10,000 or more, once shipping charges and import duties were considered."

Industries use off-the-shelf FPGA development boards as proof-of-concept/prototype hardware platform to validate logic, architecture, data flow or performance requirements and eventually custom-build their own product based on FPGA/application-specific integrated circuit (ASIC). Dhiraj Kumar, director, Systems Engineering, Argus Technologies, says, "This specific

Point of view: Tips for beginners looking to buy FPGA development boards

FPGA size not that important. If you are just beginning, you will not likely be creating huge designs. Even the smallest FPGA you can find on a development board will suffice for quite some time.

SoC FPGAs not recommended. While system on chip (SoC) FPGAs are really cool, these are also fairly complicated to work with and definitely not a recommended starting point for beginners. Beginners can experiment with Mojo board, where you get to program Arduino (ATmega32U4) and the FPGA (XC6SLX9) as it aims to simplify getting started with FPGA and digital designing.

Availability of tools and support. The most important factor when looking for a development board is the tools and support offered. If either is lacking, it will make learning how to use the board so much harder. Almost all FPGA development boards are targeted at FPGA developers, not people wanting to be FPGA developers. This is incredibly important and what I feel is the biggest factor setting Mojo board apart.

Tool cost is another major factor. You do not want to drop a thousand dollars on some super-powerful board only to find out that you have to spend another chunk of money to get access to the tools to even work with it. Many larger FPGAs require a licence to work with. I highly recommend avoiding these for as long as possible. Also, some boards may require a JTAG programmer. Xilinx's programmer costs a staggering US$ 225. Mojo has no hidden costs. All tools are free and the only thing you need besides the board is a micro universal serial bus (USB) cable.

Avoid feature overload. Many development boards are designed to show-off some features of the FPGA rather than be super useful. Too many boards are packed with useless features that take up general I/O pins and drive up the cost. The first (and only) FPGA development board I bought was Spartan-3AN evaluation board. It cost US$ 230 and had all the features you could think of. However, it only had a handfull of I/O pins that were easy to hook up to something I made. I ended up never using this board beyond playing with a few of its demonstrations.

Mojo was designed to be minimal. You have access to basically all I/O pins. If you want some extra feature, you can add it on as a shield. There is no need to jam everything on a single board. Mojo was designed to be used in bigger projects and not just to demonstrate features on the board.

FPGAs are not that complicated. FPGAs are amazing. I fell in love with these when I first learnt what these were. The idea that I could easily create my own digital circuits was captivating. However, I had a ton of help learning about these, and before I had that, I failed to do it on my own. I want to change this so that anyone who wants to learn about these can, without needing a personal mentor or going to school for electrical engineering. I think that FPGAs are seen as more complicated than these actually are, but it is just about getting the right combination of tools and tutorials to really open the doors for many people.

— Contributed by Justin Rajewski, CEO, Embedded Micro

Point of view: Suggestions for professionals looking to buy mid- or high-end boards

FPGA density (or how large of a design can fit in to the FPGA). This is more important for advanced-level boards.

Price and on-board peripherals. The less the number of peripherals already available on board, the more additional extension boards users may have to purchase, thereby resulting in higher total cost. For advanced-level boards, sometimes it may be desirable to not have a lot of on-board peripherals because the user can pick and choose the exact functionality by selecting or buying specific expansion boards. There is a cost versus flexibility case here.

Must-have features. Double data rate synchronous dynamic random access memory (DDR SDRAM) and a serial interface is a must if soft processor based (like, Microblaze) embedded system building is planned.

Ethernet. Especially important if planning to run Linux.

Configuration options. Built-in configuration system preferred since USB JTAG cables can be very expensive.

— Contributed by Anoop Jose, manager - research and development, Numato Systems Pvt Ltd

user group should consider mid- or high-end FPGA platforms with a broad category of features. It enables them to quickly prototype their subsystems or system concept without being limited by the performance of FPGA platforms."

On the other hand, student communities use FPGA development platforms as a learning platform as well as a target platform for their projects and research activity. Kumar says, "This user group should consider easy-to-use, low-cost platform having additional features support through piggyback or daughter cards." He adds, "With this approach, a user can set up basic development with low cost and add additional interfaces as required, instead of investing into feature-rich, expensive hardware."

Later in the article we will take an in-depth look at parameters to be considered and some FPGA development boards available in the market that will help you make an informed decision before buying one. Before that, let us take a brief look at how today's FPGA boards are accelerating prototyping and designing.

Today's boards provide faster performance and time-to-market

Increasing FPGA densities, board interfaces, supported connectors for add-on modules from third-party vendors and built-in joint test action group (JTAG) interfaces are making boards more powerful and capable. These are driving down the overall cost and providing improved timelines for product development. Natarajan M.M., vice president for South Asia of Arrow Asia-Pacific components business, says, "New-generation FPGA boards are equipped with high-speed mezzanine card (HSMC)/ FPGA mezzanine card (FMC) connectors, allowing add-on kits from third-party boards to be plugged on base boards designed on Altera's FPGAs."

Kumar says, "Adding support for various configurations of external analogue-to-digital converter (ADC)/ digital-to-analogue converter (DAC) cards, network processing modules and industrial control modules has enabled users to use a common platform with applications having varied signal acquisition, interfacing and performance targets." He adds, "With re-usability being a requirement today, supporting the use of a common FPGA based prototyping environment for different designs has significant cost and time-to-market advantages."

Integration of hard floating-point DSP blocks, 64-bit application class processors, up to 1GHz core fabric speed, high system interconnect bandwidth, C based modelling and hardware design with Altera software development kit (SDK) for Open Computing Language (OpenCL) allows for high-performance and power-efficient heterogeneous computing that meets customers growing design challenges.

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Bowers informs that their goal was to make Mercury development board as friendly as possible for engineers who want to include FPGAs in their projects, be it students making one-time projects or professionals working to prototype their designs. He says, "Users do not have to worry about soldering tiny FPGA packages, providing multiple voltage rails and numerous bypass capacitors, adding an ADC, soldering on a fast external memory or worrying about interfacing with 5V logic. Mercury takes care of all this, leaving the user to worry about the goals of the actual design."

Selecting the right board

Every user will have different needs based on the design, feels Bailey Hsu, director - marketing division, Terasic. Factors such as memory speed, capacity and compatibility with other hardware are pretty fundamental. He says, "The most important thing to look for is the kind of input/output (I/O) expansion on the FPGA development board. A good board must have advanced fundamental features that are accommodating for everyone and at the same time leave enough expansion space for users to connect and expand for their needs."

Let us take a look at the four most important factors to consider before buying a development board.

Features. The first and foremost factor that affects an engineer's development board selection is the feature set on offer. Bryan Fletcher, global technical marketing director, Avnet Electronics, says, "A board manufacturer helps engineers make this easier by offering multiple product offerings in a full portfolio of development boards and adoptable

Some FPGA Developments Boards Available in the Market Today

Company	Product name	Features	Price
Altera	MAX 10 FPGA development kit 	• Built around 50k logic elements (LEs) MAX 10 FPGA and includes on-die ADC converter, dual-configuration flash and DDR3 memory interface support • Features onboard USB-BlasterTM II, high-speed mezannine card (HSMC) and PMOD expansion, high-definition multimedia interface (HDMI) output and dual Ethernet	US$ 200*
Arrow	BEMI-CROMAX10 	• Features Altera MAX 10 FPGA with 8000 logic elements, ADC block, temperature sense diode, on-chip RAM, user flash memory and non-volatile self-configuration • Extensible via two digital PMOD interface headers • Allows for further expansion from two 40-pin prototyping headers	US$ 30*
Avnet	Xilinx Artix-7 50T FPGA evaluation kit 	• Board includes Artix-7 50T FPGA with 52,160 logic cells, 2.7Mbits of block RAM and 120 DSP48 slices • Has six Digilent-compatible Pmod connectors, two 10/100 Ethernet connector ports and a USB port	US$ 239*
Embedded Micro	Mojo V3 	• Uses the logic-optimised Spartan 6 Lx9 and ATmega32U4 • Includes Spartan 6 XC6SLX9 FPGA, 84 digital I/O pins, eight analogue inputs, eight general-purpose LEDs and onboard flash memory to store the FPGA configuration file	US$ 74.99*
MicroNova Electronics	Mercury 200K FPGA w/ 4Mbit SRAM 	• With a 64-pin DIP package, the core of Mercury is Spartan-3A FPGA • Includes an 8-channel 200kSPS ADC, set of bi-directional level shifters to keep the FPGA safe when interfacing with 5V logic and 4Mbit 10ns SRAM • USB programming interface and 8Mbit SPI flash memory	US$ 70*
Microsemi	SmartFusion2 Security evaluation kit 	• Comes with SmartFusion2 M2S090TS-FGG484 device that also includes 5G SERDES transceivers • Includes a one-year free Libero SoC tool (Development tool used to develop application using Microsemi's SoC/FPGAs) Platinum licence • 64Mb SPI flash memory, 512MB LPDDR, PCI Express Gen2 x1 interface, four SMA connector for testing of full-duplex	US$ 399*
Microsemi	SmartFusion2 Advanced development kit 	• Includes SmartFusion2 SoC FPGA in FCG1152 package, DDR3 synchronous dynamic random access memory (SDRAM), SPI flash memory, one pair of SMA connectors, two FMC connectors with HPC/LPC pinout for expansion, headers for I2C, SPI, GPIOs, JTAG/SPI programming interface	US$ 999*
Numato Lab	Elbert V2 - Spartan 3A FPGA development board 	• Features Xilinx XC3S50A 144-pin FPGA with maximum 108 user I/Os and USB2 interface • Includes flash memory: 16Mb SPI flash memory (M25P16), eight LEDs, six push buttons and 8-way DIP switch for a user-defined application	US$ 29.95* or ₹ 1862*
Numato Lab	Mimas V2 Spartan 6 FPGA development board 	• Features Xilinx Spartan-6 FPGA with onboard 512Mb DDR SDRAM • Includes 16Mb SPI flash memory (M25P16), USB 2.0 interface for onboard flash programming, FPGA configuration via JTAG and USB	US$ 49.95* or ₹ 3105*
Numato Lab	Galatea PCI Express Spartan 6 FPGA development board 	• Features Xilinx Spartan-6 FPGA with x1 PCIe interface and two 1Gb DDR3 SDRAM devices • Shipped with a dual-port 100BASE-T Ethernet module and an I/O expansion module pre-installed	US$ 299.95* or ₹ 18,641*
Terasic	Altera DE0 board 	• Equipped with Altera Cyclone III 3C16 FPGA device, which offers 15,408Les • Board includes 346 user I/O pins, one 8Mbyte single data rate synchronous dynamic RAM memory chip, two 40-pin expansion headers, built-in USB blaster circuit	US$ 119* Academic: US$ 81*
Terasic	DE1-SoC board 	• Built around Altera SoC FPGA, which combines the dual-core ARM Cortex-A9 (HPS), providing 85k programmable logic elements • Includes 64MB (32Mx16) SDRAM on FPGA, 1GB (2x256Mx16) DDR3 SDRAM on HPS, serial configuration device EPCS128 on FPGA, onboard USB Blaster II	US$ 249* Academic: US$ 175*

**Prices excluding shipping and other charges*

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system on modules (SoMs). For example, our Xilinx Zynq offering includes six different Zynq devices."

"A development board's native features can be augmented by expansion boards. It should include some kind of expansion, be it FMC, Digilent-compatible peripheral module (Pmod), or both," he adds.

Prasad Reddy, FAE manager, South Asia Pacific, Altera, too feels development boards should have features that accelerate the development time by directly using the board for the final application with a whole slew of application-specific daughter cards. He says, "In addition, manufacturers having a large partner network that also provides application-specific daughter cards is an added advantage."

Resources. The second factor that should be considered is availability of tutorials, reference designs and printed circuit board (PCB) sources. Fletcher informs, "Our development boards come with several tutorials and reference designs based on the latest Xilinx software. PDF copies of all PCB design sources are freely available and the full source may be available through the local Avnet field application engineers (FAEs)."

After-sales support. The third factor is support, such as online documentation, training and forums. Fletcher says, "These capabilities mean engineers can get the help they need as they are learning new technology and developing their products." Reddy, too, believes, for users adopting new technology, training would be another important factor to consider before buying a board. He says, "Altera offers in-depth training courses that are instructor-lead or online or virtual-classroom based trainings that would offer in-depth insight into the given technology."

Cost. Last, the cost of acquisition also matters. Depending on your budget, you must select the right board that meets your requirements.

Buyers should also consider the quality of documentation and support. Documentation plays a major role in improving user experience, feels Sachin Gupta, product marketing engineer, SoC product line marketing, Microsemi. Hence, he says, "A step towards improvement in hardware kits is to improve documentation quality as well."

There are plenty of offerings out there for FPGA development boards, but surprisingly not all are open and accessible to engineers who want to learn, informs Bowers. He says, "As a student, I was shocked to discover that some major FPGA development board vendors do not include complete schematics of their boards, citing portions of these as proprietary. One vendor did not include any schematics." He adds, "When we built our Mercury FPGA development board, we were happy to provide the complete, unabridged schematics, a reference manual and several reference designs to our users. We have also released the entire source code for our USB programmer application so users can modify and use it for their own purposes." He firmly believes that FPGA development boards should be as open and friendly as possible.

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Make the right choice

Hardware platforms for FPGAs are primarily influenced by system-level requirements of today's applications' necessities. Vendors are looking to provide low-cost FGPA development boards especially for academic end users. There is continuous effort to bring down the cost of the boards to increase adaptability, informs Gupta. He says, "Ease of use is being ensured by vendors by improving documentation quality and providing an extensive set of demonstration guides and application notes with the kit, which also help in quick learning."

There are many FPGA boards available from individual vendors and third-party companies. Users have a choice of buying a kit that meets their requirements for their proof-of-concept before starting development activity on custom boards. ●