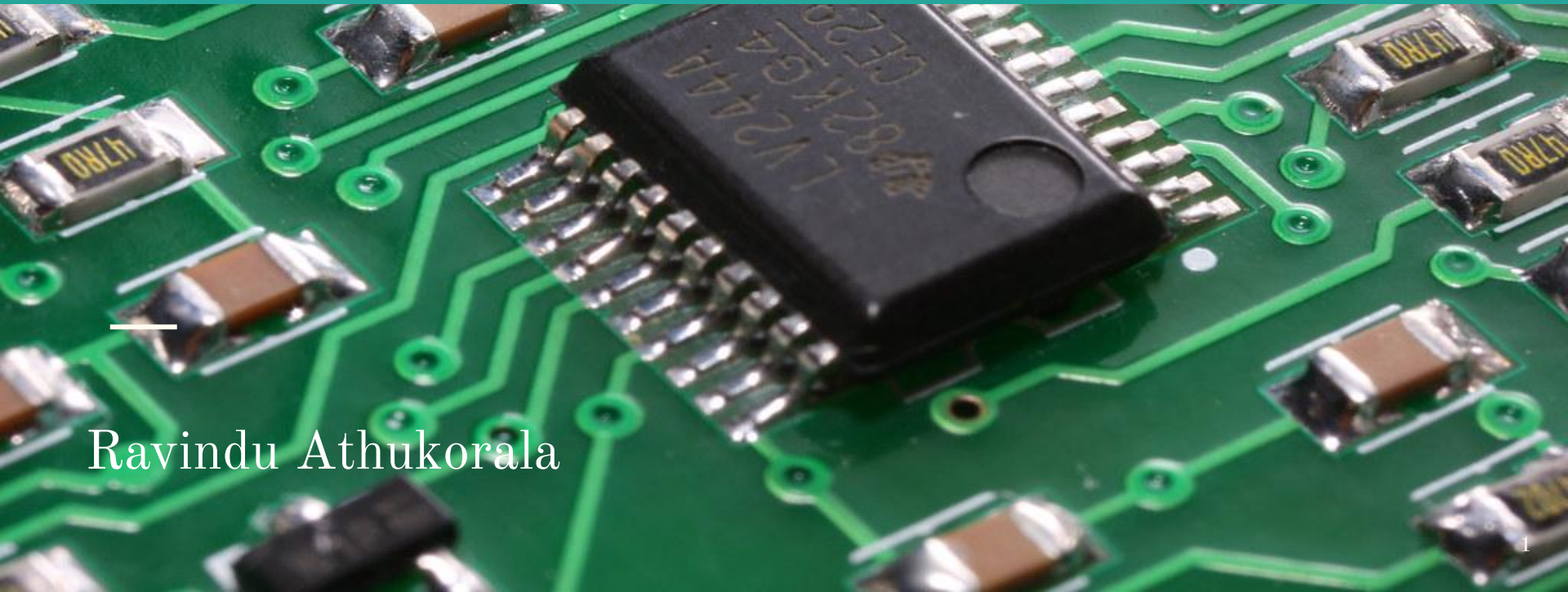
FPGA DEVICES SURVEY AND ANALYSIS



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OVERVIEW OF ALL MANUFACTURERS

- AMD Xilinx
- Intel Altera
- Lattice Semiconductor
- Microsemi

AMD XILINX

Global presence and headquarters

- Xilinx, founded in Silicon Valley in 1984, has a global presence with primary headquarters in San Jose, USA.
- The company maintains offices in various locations worldwide, including the USA, Ireland, Singapore, India, China, Australia, Japan, and Armenia.

Name Origin and Programmable Logic

- According to former CTO Bill Carter, the name Xilinx symbolizes the chemical symbol of silicon and the links that connect programmable logic blocks.
- The focus on programmable logic has been a key aspect of Xilinx's identity and technology development.

Advancements in Defense-Grade Products

- In 2018, Xilinx upgraded its XQ UltraScale+ defense-grade products using TSMC's advanced 16nm FinFET manufacturing process.
- These products, including XQ Zynq UltraScale+ MPSoCs, RFSoCs, Kintex, and Virtex FPGAs, were the industry's first defense-grade heterogeneous multi-processor SoC devices.

AMD-Xilinx Merger and Market Leadership

- The AMD-Xilinx merger, finalized in February 2022, valued Xilinx at 35 billion USD.
- Post-acquisition, all Xilinx products are co-branded as AMD Xilinx, marking a consolidation under AMD's branding since June 2023.
- AMD Xilinx has emerged as the leader in the FPGA market, controlling over 50 percent of the world's FPGA market share.
- Future strategies involve targeting the high-performance computing market with Xilinx FPGAs.

INTEL ALTERA

Long-Standing Collaboration and Acquisition

- Intel's involvement in programmable logic dates back to its collaboration with Altera before the acquisition in 2015.
- The two companies had a history of collaboration, with Intel licensing Altera's technology for use in its programmable products until Altera acquired Intel's PLD division in 1994.

Altera's Innovative Approach and FDSOI Technology

- From December 2012, Altera adopted the fully depleted silicon-on-insulator (FDSOI) chip manufacturing technique to create system-on-a-chip FPGA devices.
- These devices integrated FPGAs and ARM-based hard processor systems into a single unit, showcasing a forward-looking approach.

Evolution of Intel FPGA and SoC Offerings

- Intel's FPGAs and SoCs have evolved significantly from their early EP300 days
- Today, developers can choose from a range of options suitable for diverse applications, including low-power consumer devices, industrial and automotive solutions, and high-performance data centers

Market Leadership and Product Range

- Intel Altera is currently the second leader in the global FPGA market, holding approximately thirty-three percent of the worldwide FPGA market share.
- The product range covers the low-end, mid-end, and high-end markets with complex programmable logic devices and high-end field programmable gate arrays.
- Highlight specific FPGA series, including Arria, Stratix, Max, Cyclone, and Agilex, which cater to different market segments.

LATTICE SEMICONDUCTOR

Founding and Resilience

- Founded in 1983 by Norm Winningstad in Hillsboro, United States, Lattice Semiconductor faced early struggles and declared bankruptcy in July 1987.
- Remarkably, the company emerged from bankruptcy after sixty-two days, restructured, and relocated its headquarters to an unincorporated area.

Focus on Low-Power FPGAs

- Lattice Semiconductor is recognized as the world's low-power FPGA leader.
- The company specializes in small, low-power FPGAs and offers programmable mixed-signal and interconnect products, along with associated software and intellectual property (IP).

Product Lines and Applications

- Lattice Semiconductor's key product lines include general-purpose FPGAs in the ECP and Certus-NX series, video bridging and processing-focused CrossLink FPGAs, low-power ICE FPGAs, and control and security-focused MachXO FPGAs.
- These products find applications in various scenarios, including cloud computing and edge computing.

Global Presence and Employee Count

- With over 700 employees worldwide, Lattice Semiconductor is headquartered in Hillsboro, United States, situated in the Silicon Forest high-tech area.
- Despite a reduction in the workforce, the company managed to post record revenue after restructuring.

Independence After AMD's Acquisition

- Following AMD's acquisition of Xilinx in 2022, Lattice Semiconductor became the only fully independent large-scale FPGA manufacturer in the world.
- As of today, the company controls around 10 percent of the world's FPGA market share.

MICROSEMI

Founding and Company Overview

- Founded in 1959 in the United States by Arthur Feldon and Steve Manning, Microsemi was an American semiconductor company.
- It played a significant role in providing a diverse range of semiconductors and system solutions for the aerospace, defense, communication, and industrial markets.

Focus on High-Performance Technologies

- Microsemi primarily focused on producing high-performance and radiation-hardened analog mixed-signal integrated circuits (ICs), FPGAs, SoCs (system-on-chips), ASICs (application-specific integrated circuits), and power management products.

Markets and Product Range

- Microsemi serve three main markets: Aerospace and Defense, Communications, and Industrial.
- Their product range included high-performance and radiation-hardened analog mixed-signal ICs, FPGAs, SoCs, ASICs, and power management products.

Aerospace and Defense Solutions:

- In the Aerospace and Defense market, Microsemi's products played a crucial role in avionics systems, providing precision timing, data conversion, and signal processing.
- The company's radar solutions, including RF front-ends, ADCs, and DSPs, were utilized in applications like air traffic control, weather radar, and military radar.
- Microsemi's security solutions, featuring FPGAs, SoCs, and ASICs, met the stringent security requirements of aerospace and defense applications, being applied in secure communications, encryption, and authentication.

Communication Solutions

- Microsemi's communication solutions found applications in various areas, including Wireless Communication (WiFi, LTE, 5G), Industrial Communication (industrial networking protocols, remote I/Os), and Data Center.

FPGA ARCHITECTURE

1. Configurable Logic Blocks (CLBs)

Core elements of FPGA architecture.

Consist of look-up tables, multiplexers, flip-flops, and other elements.

Look-up tables provide the ability to implement combinational logic, allowing users to define specific functions.

2. Programmable Interconnect (PIN)

Utilizes a grid of programmable interconnects for routing signals between CLBs.

Interconnects are dynamically configurable, enhancing flexibility in signal routing.

3. Input/Output Blocks

Facilitate interfacing with the external world by connecting FPGA to input and output devices.

Configurable to adapt to specific interface requirements.

4. Clock Management

Includes resources for clock management, such as phase-locked loops (PLLs) and delay-locked loops (DLLs).

Enables control over clock signals, crucial for synchronization and timing.

5. Embedded Memory

Many FPGAs incorporate embedded memory blocks, including Block RAM and Distributed RAM.

Used for data storage, memory-intensive tasks, and buffering, contributing to overall FPGA performance enhancement.

FPGA DESIGN METHODOLOGY AND TOOLS

1. **Design Specifications**

   Begin with defining the desired functionality and performance requirements of the digital circuit.

2. **High-Level Hardware Description Languages (HDLs)**

   Use high-level hardware description languages such as Verilog or VHDL to create a register transfer level (RTL) representation of the design.

3. **Synthesis**

   Utilize synthesis tools to map the HDL representation into a netlist, a description of the logical connections between the elements in the design.

4. **Place and Route**

   Employ place and route tools to determine the optimal physical placement of different parts of the design on the FPGA chip and establish the connections between them.

5. Timing Verification

Check the timing of the design to ensure that it meets the required specifications for speed and performance.

6. Bitstream Generation

Generate a bitstream file, which contains instructions for configuring the FPGA. This file will be uploaded to the FPGA to define its functionality.

TOOLS

- **Synthesis tools -** Xilinx Vivado: For Xilinx FPGAs./Intel Quartus Prime/Synopsys Design Compiler, Cadence Genus
- **Simulation tools** - ModelSim/VCS (Verilog Compiler Simulator): A simulator from Synopsys./Questasim
- **Place and Route Tools** - Vivado Implementation/Synopsys IC Compiler II
- **Timing Analysis Tools** - TimeQuest Timing Analyzer (Quartus Prime)/Vivado Timing Analyzer
- **Programming Tools** - Xilinx Impact, Vivado Hardware Manager/Quartus Prime Programmer
- **Debugging Tools** - Integrated Logic Analyzer (ILA)/SignalTap (Quartus Prime)

APPLICATIONS OF FPGA

Artificial Intelligence (AI)

High-end AI devices, particularly those relying on deep neural networks, benefit from powerful and energy-efficient tools provided by FPGAs.

Energy-efficient accelerators like P-Neuro showcase the efficiency of FPGAs, outperforming regular chips (GPUs) in terms of both speed and energy consumption.

Space Technology

In Satellite Systems, FPGAs enhance communication system performance by enabling onboard processing activities such as data compression, encryption, and signal processing.

Reconfigurable nature allows FPGAs to be updated and modified in-flight, adapting to changing mission needs.

Defence Systems

FPGAs are utilized in defense systems for their fast data processing capabilities, providing safety, high performance, and integration.

Anti-tamper technology reduces the risk, and FPGAs play a crucial role in electronic warfare systems, where ECCM (Electronic Counter-Countermeasures) is essential.

Renewable Energy Systems

In solar charging systems, FPGAs play a vital role in adjusting and rotating solar panels to face sunlight perpendicularly, ensuring optimal energy absorption.

Used in systems utilizing electromagnetic waves to break down limescale deposits in pipes, preventing oxidation.

Sensor-based FPGA systems detect toxic gases, showcasing versatility in various applications in renewable energy systems.

CHALLENGERS AND OPPORTUNITIES

Challengers

- Complexity of design
- Resource constraints
- High development cost

Opportunities

- Hardware Acceleration
- Reconfigurability
- Parallel processing

Conclusion