MATHSTAR™

April 2007

1 GHz Field Programmable Object Array™ Overview

FPOA Overview

The Arrix Family of Field Programmable Objects Arrays is the second generation of FPOA products from MathStar. A 1 GHz FPOA delivers up to four times the performance of today's top FPGAs and combines high performance and re-programmability to meet a wide variety of application needs. FPOAs are comprised of hundreds of objects that pass data and signals to each other through a patented 1 GHz interconnect fabric. The Arrix Family of FPOAs support 256 Arithmetic Logic Unit (ALU), 80 Register File, and 64 MAC (multiply accumulator) objects. The objects and the interconnect fabric run on a common clock and operates deterministically at frequencies up to 1 GHz. This deterministic performance eliminates the tedious timing closure steps associated with FPGAs, reducing design iterations and development time. Below is one example from MathStar's Arrix FPOA product line:

FPOA Advantages:

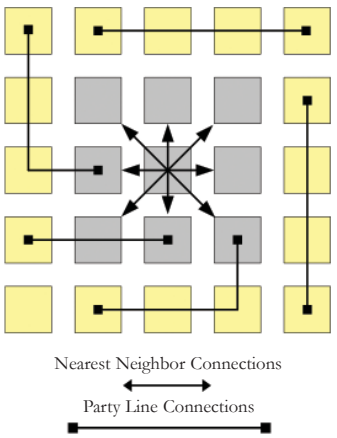
- 1 GHz Operation
- 1 GHz Interconnect Fabric
- No Timing Closure Required
- Faster Time-to-Market

Discover our FPOA product family at **www.mathstar.com**

A	Arithmetic Logic Units
R	Register Files
M	Multiply/Accumulators
IRAM	Internal SRAM Banks
XRAM	External Memory Interfaces
GPIO	General Purpose I/O Banks
TX	High Speed Transmit Ports
RX	High Speed Receive Ports

1 GHz FPOA Architecture

The FPOA architecture provides a massively parallel, high-performance computation fabric consisting of hundreds of 16 bit processing elements called Silicon Objects. Each Silicon Object is programmed individually and acts autonomously. Each ALU Silicon Object can be programmed from a choice of 32 instructions. Each MAC performs multiplication and accumulation of two 16 bit words of data with a 40 bit result. Each RF of 64 words can operate as a dualport RAM or FIFO. These objects are surrounded by additional Internal RAM (IRAM) blocks, memory controllers and a rich mix of high-performance I/O. Communication between adjacent Silicon Objects is accomplished via the *Nearest Neighbor* interconnects. Communication across multiple objects is via patent-pending *Party Line* technology. All communication planes operate at 1 GHz, are independently configurable and provide deterministic timing.



Silicon Object and I/O Characteristics

Resource	Architecture	Operating Speed
ALU	16 bit data, 5 bits control, 32 operations, control logic	Up to 1 GHz
RF	128 Byte, dualport RAM or FIFO	Up to 1 GHz
MAC	16x16 bit multiply, 40 bit accumulate	Up to 1 GHz
Internal RAM	2K x 76 bits each	Up to 500 MHz
External RAM	36 bit RLDRAM II	Up to 300 MHz DDR
General Purpose I/O	48 pins per bank, programmable clocking	Up to 100 MHz
High Speed I/O Transmit	16 + 1 bit LVDS	Up to 500 MHz DDR
High Speed I/O Receive	16 + 1 bit LVDS	Up to 500 MHz DDR

Algorithm Support

FPOA devices have the performance to support large, computationally-intensive applications. The programmability and 1 GHz clock of the FPOA make these devices ideally suited for the following algorithms:

- JPEG 2000 Encoder/Decoder
- MPEG-4/H.264 Encoder/Decoder
- MPEG-2 Encoder/Decoder
- Flat Field Error Correction
- Scalable Ultrasound Beamforming
- Sobel Edge Detector
- Multi-point FFT implementation
- Scalable 2D Convolution Filter
- Multi-tap FIR filter

See **www.mathstar.com** for a complete list

FFT Performance

Points	Sample Frequency	ALU	RF	MAC	Memory	Throughput
64	2000 MHz	76	24	24	1 IRAM	2 samples/cycle
256	2000 MHz	122	32	32	2 IRAM	2 samples/cycle
1K	2000 MHz	192	40	40	8 IRAM	2 samples/cycle
4K	1000 MHz	184	24	24	12 IRAM	1 sample/cycle
16k	500 MHz	216	48	28	12 IRAM	0.5 sample/cycle

FIR Performance

Tap	Sample Frequency	ALU	RF	MAC	Memory	Throughput
8	1000 MHz	10	4	8	0	1 sample/cycle
32	1000 MHz	40	16	32	0	1 sample/cycle
64	1000 MHz	80	32	64	0	1 sample/cycle
128	500 MHz	83	33	64	0	0.5 sample/cycle
256	250 MHz	87	36	64	0	0.25 sample/cycle
512	125 MHz	98	40	64	0	0.125 sample/cycle

Video Codec Performance

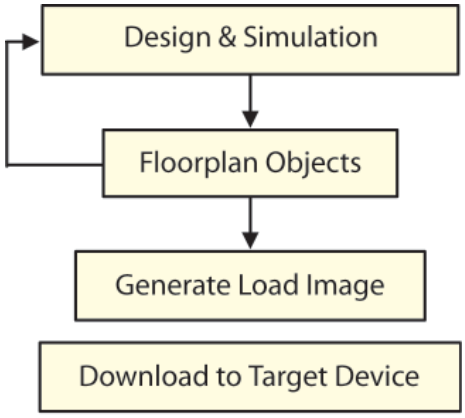
Codec	Profile	Level	HD Resolution	MSPS	Core Clock
MPEG-2	422P	High	1080i/720p	67 Color	800 MHz
MPEG-4/H.264	High422	4	1080i/720p	67 Color	800 MHz
JPEG 2000	N/A	N/A	2K/2K	200 Mono	1 GHz

Development System

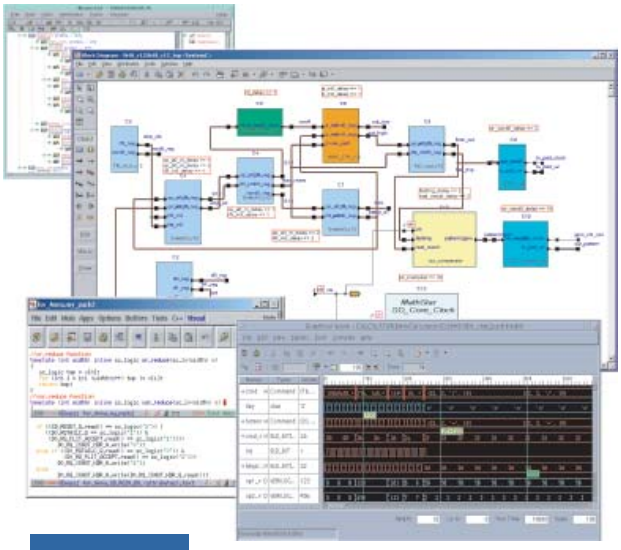
MathStar offers the high-performance Arrix FPOA product as part of a development system that is designed to speed algorithm and system development. Applications or algorithms can be designed in the FPOA tool suite well in advance of designing specific hardware platforms. This speeds time-to-market and decreases risk.

Design Flow

MathStar's Field Programmable Object Array design software enables designers to create, verify, program and debug their algorithms on FPOA devices at a higher level of abstraction than used in FPGAs. Designs are entered and simulated behaviorally using Visual Elite™ from Mentor Graphics. Then they are compiled and mapped into the hardware resources of the FPOA device using MathStar COAST design software. An object code stream is generated and is loaded onto the array via a PROM or through a JTAG interface. FPOA designs have a deterministic timing structure. As such, they are timed only on cycle boundaries of the internal clock with no need for gate-level timing closure. This greatly simplifies the design process, improving productivity and development predictability. MathStar also provides a debug tool to enable designers to analyze their designs, once they have been loaded on the FPOA.



MathStar FPOA Design Flow



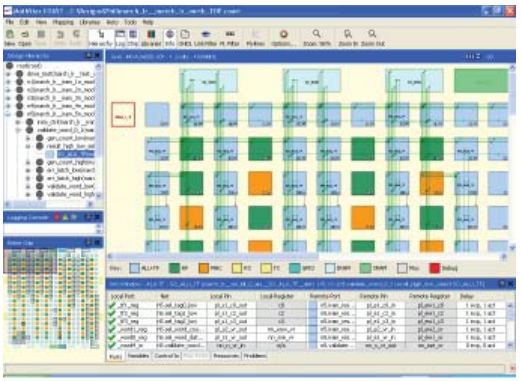
Create designs for FPOA using Visual Elite™ by Mentor Graphics™

Design Flow Features

- Graphical design using Visual Elite™ from Mentor Graphics
- No RTL synthesis or gate-level timing closure is required
- Cycle-accurate models support fast and accurate hardware simulation
- Includes tools for floorplanning, compilation, and debugging tools

COAST

A design is floorplanned and optimized using MathStar's COAST (COnnection and ASsignment Tool) software. COAST is a graphical floorplanning editor that allows the designer to assign functional modules to the physical resources of the FPOA. In addition to floorplanning, COAST includes powerful analysis and guidance logic to assist the user. COAST presents the user with graphical representations of the design hierarchy and the array resources. COAST enables designers to alter, upgrade, or optimize existing designs as requirements change during the design process. A variety of predefined library elements are also available to assist the designer.



Place FPOA objects using MathStar's Connection and Assignment Tool (COAST)

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Target Applications

Professional Video

The MathStar FPOA is ideal for high-performance video applications. The FPOA Architecture - with its combination of programmability, high performance, high-speed I/O and flexible object array mix - makes it well-suited for 4:2:2 high definition encoding and decoding such as: MPEG-2, MPEG-4/H.264 and JPEG 2000. Other real time applications include: color space conversion, flat field error correction, 2D filtering and 2D/3D image processing.

Machine Vision

The MathStar FPOA is well suited for demanding applications within the Machine Vision industry. The FPOA Architecture - with its combination of programmability, high performance, high-speed I/O and flexible object array mix - makes it ideal for image processing, edge detection, object recognition, pattern matching, high resolution cameras, high speed filtering and real-time displays.

Medical Imaging

The most computationally intensive aspect of medical imaging is the application of image processing algorithms to the analysis of medical and biological data. The FPOA architecture is well suited to high-performance image processing and these advantages can be leveraged in state-of-the art medical imaging equipment. FPOA application examples include 2D and 3D rendering, CT filtered back projection, ultrasound beamforming and high speed filtering.

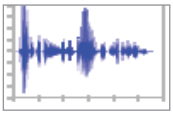
Test & Measurement

The MathStar FPOA is a great match for the demanding applications within the Test & Measurement industry. The FPOA Architecture is capable of very high sample rates and can be completely reconfigured hundreds of times per second. This makes it ideally suited for multi-channel data processing, signal processing, programmable triggering and real-time displays.

Military/Aerospace

The MathStar FPOA is well suited for high-performance applications within the Military & Aerospace industry. Whether the application is sonar, radar, image processing, or software defined radio, the FPOA will provide a flexible and high performance processing solution. The FPOA can be utilized where extreme performance FFTs, IIRs and/or PolyPhase Filters are required.

Signal Processing



High-performance Digital Signal Processing (DSP) is used in most imaging and communications applications today. The MathStar FPOA Architecture is designed for demanding DSP applications which utilize FFT, IIR and FIR filters. MathStar FPOAs are also well suited for applications in adaptive beamforming, 3G cellular basestations, JPEG 2000, MPEG-2 and MPEG-4/H.264. The FPOA's 1 GHz speed and object array flexibility take these applications to a new level of performance.

Ordering Information

Product	Product Code	Max Operating Frequency
Arrix FPOA Component	MOA2400D-10R*	1 GHz
Arrix FPOA Component	MOA2400D-09R*	900 MHz
Arrix FPOA Component	MOA2400D-06R*	800 MHz
Arrix FPOA Component	MOA2400D-06R*	600 MHz
Arrix FPOA Development System	MS2400D-10	1 GHz
Arrix FPOA Design Software	MDS-VCD02-T12FW	N/A

* Available in RoHS and Eutectic packages.

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