



January 2008

Preliminary Product Brief

## Features

- Input sampling rate up to 200 megasamples/sec (mono) or 66 megasamples/sec (4:4:4 RGB color)
- User programmable image size, multiples of 64, up to a maximum of 2048 x 2048 samples
- Supports 8, 10, or 12 bit sample precision for mono or color
- Reversible Color Transform (RCT)
- DWT filter type – 5/3 supports numerically lossless compression
- Designed to meet ISO/IEC 15444-1 JPEG 2000 Image Coding System requirements

## Applications

- High-performance digital imaging
- Professional video
- Military / aerospace
- Medical imaging
- Machine vision

## Arrix FPOA Overview

The MathStar Arrix Field-Programmable Object Array™ (FPOA) architecture comprises an array of silicon objects, each performing a specific function at clock rates up to 1-GHz. The architecture supports three kinds of 16-bit core objects: an Arithmetic Logic Unit (ALU), a Multiply-Accumulator (MAC) and a Register File (RF). The objects are interconnected by a two-tier interconnect structure. The interconnect structure allows for 1-GHz connectivity between Nearest Neighbor connections as well as 1-GHz connectivity between non-adjacent objects through patented Party Line interconnects. These objects

are coupled with distributed internal RAM (IRAM), dedicated external memory controllers (XRAM) and a wide range of high-speed and general-purpose I/O

to form the complete FPOA architecture. Because of its high performance, an FPOA can run many applications up to two to four times faster than top FPGA architectures.

## Functional Overview

The JPEG 2000 Encoder for Arrix FPOA is an implementation of the JPEG 2000 compression algorithm based on the ISO/IEC 15444-1 standard. The encoder can accept a high rate of incoming sample data. Some examples of image resolution and frame rate that are supported are shown below.

| Image size  | Frame rate (mono) | Frame rate (color) |
|-------------|-------------------|--------------------|
| 1024 x 768  | 250 frames/sec    | 84 frames/sec      |
| 1920 x 1080 | 96 frames/sec     | 32 frames/sec      |
| 2048 x 1080 | 90 frames/sec     | 30 frames/sec      |

The JPEG 2000 Encoder is comprised of five modules (Figure 1). These include the DC level shifter, Color Conversion, Discrete Wavelet Transform (DWT), and Coefficient Bit Modeling (CBM) / MQ-Coder. The FPOA processes all modules except the CBM/MQ-Coder, which is implemented on a small FPGA. The JPEG 2000 Encoder can effectively process monochrome or RGB color samples.

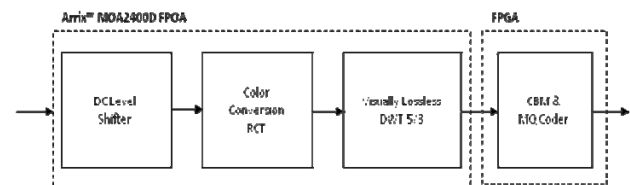


Figure 1 - JPEG 2000 block diagram

### DC Level Shifter

The DC level shifter module subtracts half the dynamic range of the pixel data from the incoming stream to center the data about zero.

## Color Conversion

The Color Conversion Module converts 4:4:4 RGB input into 4:4:4 YUV format. The JPEG 2000 supports Reversible Color Transform (RCT) for 5/3 numerically lossless conversion.

## Discrete Wavelet Transform (DWT)

Images are wavelet transformed by four separate stages of DWT, resulting in a collection of thirteen sub-bands that represent several approximation scales. To obtain a transformation with four levels of resolution, the DWT is applied sequentially on the sub-band that contains the lowest horizontal and vertical frequency information.

## Coefficient Bit Modeling / MQ-Coder

The quantized sub-bands are split into code-blocks. The CBM encodes the bits of all quantized coefficients of a code-block, starting with the most significant bits and progressing to least-significant bits in a series of coding passes. The bits selected by these coding passes are encoded by a context-driven, binary MQ-coder that produces a code stream. The resulting, code stream can be packaged into one of the JPEG 2000 file formats if necessary. The CBM/MQ-Coder is implemented in VHDL and ported to a small FPGA.

## Support

The JPEG 2000 Encoder for the FPOA is warranted against defects for one year from purchase. Twelve months of technical support are included as standard. Licensing terms are available from MathStar.

## IP Summary

The table below lists the estimated resources required for the JPEG 2000 Encoder for Arrix FPOA.

| Variable/parameter | Value         |
|--------------------|---------------|
| Pixel depth        | Up to 12 bits |

|                           |  |
|---------------------------|--|
| Throughput                | 200 megasamples/sec (monochrome)<br>66 megasamples/sec (4:4:4 RGB color) |
| Frequency (max)           | Scalable to 1000 MHz   |
| FPOA target device        | Arrix MOA2400D FPOA  |
| FPOA Resource utilization | Approx. 85%  |
| Companion FPGA resources  | 42K LUTs, 100 RAM36  |

*Note: The information provided above is preliminary and should be considered as an estimate.*

## Verification Environment

Mentor Graphics Visual Elite™ (available from MathStar) and ModelSim SE (available from Mentor Graphics).

## Deliverables

The JPEG 2000 Encoder for FPOA includes the following components.

- Cycle-accurate, bit-true simulation model for Mentor Graphics™ Visual Elite™ simulator
- Synthesizable VHDL code for the CBM/MQ-Coder module
- OHDL files for FPOA
- Mapping files for MathStar's COAST tool
- Testbench for entire design
- Design guide documentation

## Ordering Information

The JPEG 2000 Encoder for FPOA will be available from MathStar as part number **MIP-J2E02-P12**. For further information, contact MathStar, Inc. at [info@mathstar.com](mailto:info@mathstar.com)

### JPEG-2000 Encoder for FPOA. Revision 2.6

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