JPEG-LS-E

Lossless & Near-Lossless JPEG-LS Encoder

Microsemi

The JPEG-LS-E core implements a highly efficient, low-power, lossless and near-lossless image compression engine that is compliant to the JPEG-LS, ISO/IEC 14495-1 standard.

Based on LOCO-I (LOw COmplexity LOssless COmpression for Images), the JPEG-LS algorithm leads in numerically lossless compression efficiency, attaining compression ratios similar or superior to those obtained with more advanced algorithms such as JPEG 2000. JPEG-LS also enables hardware implementations with a much smaller silicon footprint and lower memory requirements, thanks to its lower computational complexity and line-based processing. Further, the Near-Lossless mode of the JPEG-LS standard makes higher compression ratios and visually lossless compressed images feasible, allowing the user to set the maximum acceptable difference between a reconstructed and an original image sample.

The JPEG-LS-E core delivers the full compression efficiency of the standard in a compact and easy-to-use hardware block. The core interfaces to the system via standardized AMBA® interfaces: it accepts images and outputs compressed data via AXI4-Stream interfaces and provides access to its control and status registers via a 32-bit APB interface. After its registers are programmed, the core can encode an arbitrary number of images without requiring any further assistance or action from the system. Users can optionally insert timestamps or other metadata in the compressed stream using a dedicated AXI Streaming interface.

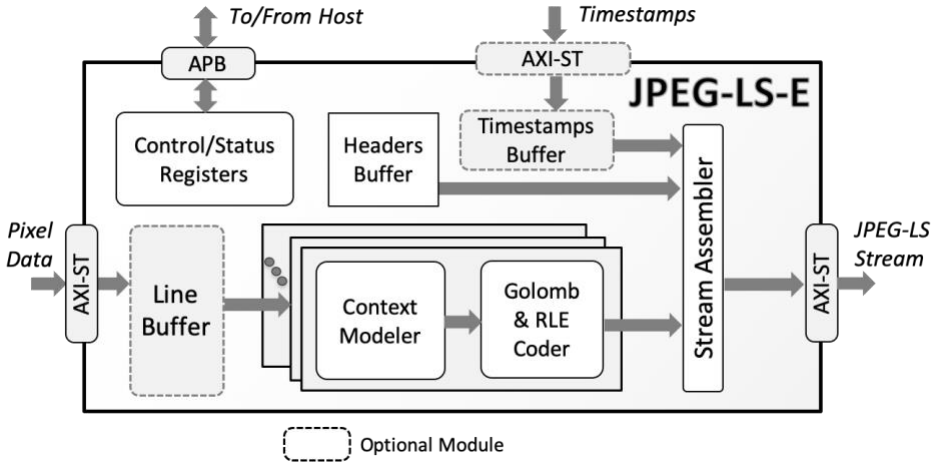
The core is designed with industry best practices, and its reliability has been proven through both rigorous verification and silicon validation. The deliverables include a complete verification environment and a bit-accurate software model.

Versions

The core is available in two versions: size-optimized JPEG-LS-ES and scalable throughput JPEG-LS-EF. The **JPEG-LS-ES** version uses just 40K gates, provides a throughput of one sample per cycle, and requires only one image line of buffering. A single JPEG-LS-ES core can compress several hundreds of Msamples per second when mapped on an ASIC technology.

The scalable-throughput **JPEG-LS-EF** version can process multiple samples per cycle by internally aggregating a user-defined number of JPEG-LS-ES cores. It is suitable for compressing images or video with ultra-high resolutions and/or frame rates.

Block Diagram



FEATURES

JPEG-LS Encoder

- Highly Efficient Numerically Lossless Compression
  - Better compression ratio than most lossless compression algorithms (JPEG2000, PNG, etc.)
- Near-Lossless Compression
  - Enables greater compression with visually lossless quality by constraining the maximum difference between reconstructed and original image samples
- Maximum image resolution of 64Kx64K, or higher via support for oversize image dimension parameters
- Up to 16 bits per color sample; up to four color components

Easy to Use and Integrate

- Run-time programmable input and encoding parameters
  - Image resolution, number of color components, color depth
  - Maximum reconstruction error, Point-Transform, Local Gradient, Reset Frequency
- Automatic program-once encode-many operation
- AXI4-Stream interfaces for image and compressed data, and 32-bit wide APB for register access
- Dedicated, easy-to-use timestamps interface

Versions and Throughput

- Area-optimized JPEG-LS-E-S: one sample per cycle
  - From 9,000 4LUTs
- Throughput optimized JPEG-LS-EF: synthesis-configurable number of samples per cycle

Deliverables

- Source code RTL (Verilog) or Targeted FPGA Netlist
- Bit Accurate Model
- Sample simulation and synthesis scripts
- Verification testbenches
- Comprehensive documentation

Supported Microsemi FPGA Families

- All Microsemi FPGA families, provided sufficient resources are available

Silicon Resources Utilization

The JPEG-LS-E can be mapped to any Microsemi device, provided sufficient silicon resources are available. The following tables provide sample performance and resource utilization data for different Microsemi device families for the JPEG-LS-ES and the JPEG-LS-EF versions of the core. The sample results do not represent the higher speed or smaller area for the core.

Family/ Device	Logic Resources	Memory Resources	Freq. (MHz)	Throughput (Msamples/sec)
Igloo2 M2GL150-STD	9,402 4LUT	29 RAM64x18 4 RAM1K18	80	80
PolarFire MPF500T-STD	8,892 4LUT	31 uSRAM 6 LSRAM	120	120
RTG4 RT4G150 -STD	9,289 4LUT	29 RAM64x18 4 RAM1K18	60	60
SmartFusion2 M2S150-STD	9,402 4LUT	29 RAM64x18 4 RAM1K18	80	80

Table 1: Sample results for the JPEG-LS-ES version of the core configured to support a max image width of 2048 pixels, 8 bits per sample, and 1 color component.

Family/ Device	Logic Resources	Memory Resources	Freq. (MHz)	Throughput (Msamples/sec)
Igloo2 M2GL150-STD	15,889 4LUT	40 RAM64x18 12 RAM1K18	80	160
PolarFire MPF500T-STD	15,463 4LUT	40 uSRAM 12 LSRAM	120	240
RTG4 RT4G150 -STD	15,571 4LUT	42 RAM64x18 14 RAM1K18	50	100
SmartFusion2 M2S150-STD	15,889 4LUT	40 RAM64x18 12 RAM1K18	80	160

Table 2: Sample results for the JPEG-LS-EF version of the core configured to support a max image width of 2048 pixels, 8 bits per sample, 1 color component, and 2 samples/cycle throughput.

Support

The core as delivered is warranted against defects for ninety days from purchase. Thirty days of phone and email technical support are included, starting with the first interaction. Additional maintenance and support options are available.

Deliverables

The core is available in source code RTL (Verilog) or as an FPGA netlist, and its deliverables include everything required for successful implementation:

- Sophisticated self-checking Testbench
- Software (C++) Bit-Accurate Model
- Sample simulation and synthesis scripts
- Comprehensive user documentation

Applications

The JPEG-LS-E is suitable for systems requiring numerically or visually lossless compression of images or video of potentially high color or greyscale accuracy. Application areas include medical Imaging (DICOM), aerospace imaging or surveillance, and advanced driver assistance systems.

JPEG-LS Compression Efficiency

Despite its lower computational complexity JPEG-LS offers exceptionally high lossless compression efficiency. JPEG-LS is expected to outperform PNG, and to provide similar compression ratios as lossless JPEG 2000 for both color and greyscale images.

The following shows the lossless compression advantage of JPEG-LS over other, more complex algorithms using several indicative example images.