

H264-E-BPS

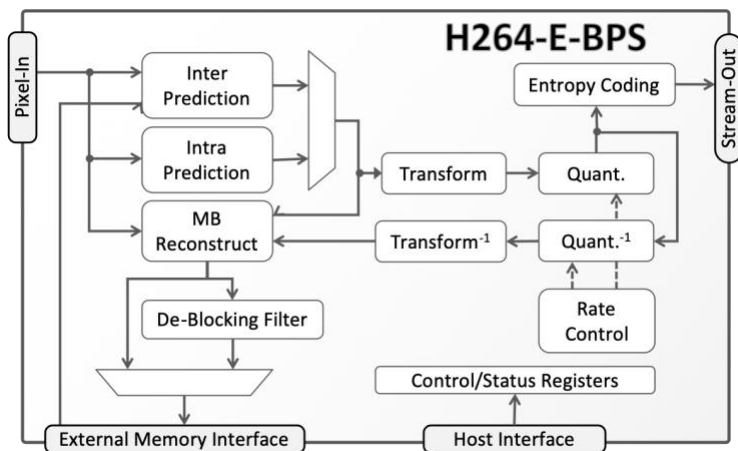
Low-Power AVC/H.264 Baseline Profile Encoder

The H264-E-BPS IP core is a video encoder supporting the Constrained Baseline Profile of the ISO/IEC 14496-10/ITU-T H.264 standard. It implements an energy-efficient hardware architecture that is optimized for ultra-low-latency video streaming at low bit rates.

The H264-E-BPS encoder requires less than half the silicon area of most competing hardware encoders—approximately 125K gates—allowing for very cost-effective ASIC or FPGA implementations. Its small silicon footprint, low external memory bandwidth requirements, and zero software overhead enable H.264 coding at an extremely low energy cost. The encoder is able to process UHD/4K video when mapped on modern ASIC technologies, and Full-HD when mapped on FPGAs.

Despite being small, the H264-E-BPS produces high quality video, especially at low bit-rates, and is suitable for systems with low-latency requirements. It uses constant quantization to output video streams of Variable Bit-Rate (VBR), or automatically regulates quantization multiple times within a frame to output Constant Bit-Rate (CBR) streams. In CBR mode it responds rapidly to temporal or spatial changes in the video content. This can be combined with an artifacts-free Intra-Refresh coding implementation to effectively eliminate bit-rate peaks, while preserving the periodic intra-coded references. As a result, the stream buffers can be smaller than those typically required, and the end-to-end latency can be brought down to frame or sub-frame levels. Video quality at low bit rates is preserved, as the encoder intelligently uses block-skipping and quantization coefficient thresholding to reduce bit rate at minimal quality loss, and uses the in-loop deblocking filter to eliminate the blocking artifact.

Block Diagram



The core was designed for ease of use and integration. Once initially programmed, it operates without any assistance from the host processor. The encoder's memory interface is extremely flexible: it operates on a separate clock domain, is independent from the external memory type and memory controller, and is tolerant to large latencies. The core is optionally delivered with a raster-to-block converter, and wrappers for AMBA® AHB, AXI, or AXI-Streaming buses are available.

Customers can further decrease their time to market by using CAST's integration services to receive complete video encoding subsystems. These integrate the encoder core with video and networking interface controllers, networking stacks, or other CAST or third-party IP cores.

The H264-E-BPS IP core is designed using with industry best practices and has been multiple times production proven. Its deliverables include a complete verification environment and a bit-accurate software model.

FEATURES

Low-power AVC/H.264 encoder, with small silicon footprint and optimized for low-latency, low-bit-rate video streaming; multiple times production proven

Standard Support

- ISO/IEC 14496-10/ITU-T H.264 Constrained Baseline Profile specification
- Interlaced Video using Main Profile syntax
- Output Annex B NAL byte stream decodable by Baseline, Main and High Profile decoders

Input Video Formats

- Progressive or Interlaced, 4:2:0 YCbCr input with 8 bits per color sample
- Up to UHD/4K in ASICs; up to Full-HD in FPGAs
- Optional multichannel encoding

Small and Low Power

- 125k gates & 133k bits of RAM
- Uses less power than competitive hardware H.264 encoders thanks to having under half their silicon footprint and small external memory bandwidth.
- Consumes much less power than any equivalent software, or software-hardware encoder

Low Latency and Low Bit Rates with Fewer Artifacts

- Constant Bit-Rate (CBR) output for smaller stream buffers and end-to-end latency
- Advanced rate control regulates Qp multiple times within a frame, and rapidly responds to temporal or spatial video variations
- Enables artifacts-free Intra-Refresh to eliminate bit-rate peak of I frames
- Block skipping, Quantized coefficients thresholding, and in-loop deblocking filter improve quality at low bit rates

Ease of Integration

- Zero CPU overhead, stand-alone operation
- Flexible external memory interface uses separate clock, is independent of memory type and tolerant to latencies

AMBA® Interface Options: DMA-capable AMBA® AHB, AXI or AXI-Streaming

Coding Tools

- Variable Bit-Rate with Constant Qp (VBR-CQP) and Constant Bit-Rate (CBR) output with CAVLC Encoding
- Efficient Inter- and Intra- Prediction
 - Motion vector up to $-16.00/+15.75$ pixels down to $\frac{1}{4}$ pel accuracy
 - All intra16x16 and most intra 4x4 modes
- Options for improved error resilience
 - Multiple slices per frame
 - Intra-only coding
- Options for better quality at low bit-rates
 - Block skipping
 - Deblocking filter
 - Separate quantization values for luma and chrome
 - Thresholding of quantized transform coefficient

Smaller Intra-Only Version

The encoder core can be limited to operate in Intra-Only mode (H264-BIS version). Under this configuration, no external memory is required, and the core's size is further reduced.

The compression efficiency of H.264 Intra-only coding is superior to that of JPEG and comparable to JPEG2000. With Intra-only coding each frame is compressed independently simplifying video editing, and enhancing error resilience.

H.264 Cores Family

The H264-E-HIS is one member of the family of H.264 cores that CAST offers. The following tables summarize the family's encoders and decoders and highlight the cores' basic features.

H.264 ENCODER CORES	H264-E-BIS Intra-Only Baseline Profile	H264-E-BPS Low-Power Baseline Profile	H264-E-MPS Low-Power Main Profile	H264-E-CFS Ultra-Low-Power Baseline Profile	H264-E-HIS Intra-Only High Profile	H264-E-BPF Ultra-Fast Baseline Profile
Cycles/Pixel	4	4	4	4	2.5	2 or 1
Silicon Resources *	Very Small	Small	Small	Small	Moderate	Moderate-High
Profile	Constrained Baseline	Constrained Baseline	Main	Constrained Baseline	High 10 Intra	Constrained Baseline
Slices Types	IDR	IDR, P	IDR, P	IDR, P	IDR	IDR, P
Chroma Formats	4:2:0	4:2:0	4:2:0	4:2:0	4:2:0	4:2:0
Bits per sample	8	8	8	8	8, 10	8
Progressive/Interlaced	✓ / ✓	✓ / ✓	✓ / ✗	✓ / ✗	✓ / ✗	✓ / ✓
Multiple video channels	Optional	Optional	Optional	Optional	✗	Optional
CAVLC / CABAC	✓ / ✗	✓ / ✗	✗ / ✓	✓ / ✗	✓ / ✗	✓ / ✗
CBR and VBR	✓	✓	✓	✓	✗	✓
Intra-Refresh	N/A	✓	✓	✓	N/A	✓
Multiple Slices	✓	✓	✓	✓	✗	✓
Compressed Frame Store	✗	✗	✗	✓	N/A	N/A

* Very Small <100k Gates, Small < 200k Gates, Moderate < 500K Gates, and High > 500KGates

Silicon Resources Utilization

The H264-E-BPS synthesizes to approximately 125K gates and requires 133 kbits of internal memory. The intra-only H264-E-BIS version synthesizes to approximately 70K gates and 60 kbits of memory. Both versions can process UHD/4K at 30fps on modern ASIC technologies.

Deliverables

The core is available in source-code HDL (Verilog or VHDL) or as a targeted netlist, and its deliverables include everything required for successful implementation:

- Sophisticated self-checking Testbench
- Synthesis scripts.
- Simulation script, vectors and expected results.
- Software (Bit-Accurate Model and test vector generator)
- Comprehensive user documentation.

Evaluation

Potential customers can readily evaluate the video encoder's compression efficiency by using:

- Available sample compressed video streams
- The available Bit-Accurate Model with your choice of input videos
- The Video over IP reference design with video captured over an HDMI interface

Please contact CAST to arrange for your evaluation.