H264 Encoder 2.0 on HDVICP2 and Media Controller Based Platform Data Sheet

FEATURES

- Supports H.264 baseline, high and main profile up to level 5.1
- Supports arbitrary resolution from 96x80 to 4352 x 4096. Encoder should be created with appropriate level – for example, Level 5.1 for 4096x2048.
- Supports stereoscopic SEI for 3D video coding
- Supports B frame encoding
- Supports progressive and interlaced coding with different controls such as ARF (Adaptive Reference Field), MRF (Most recent Reference Field), and SPF (Same parity Reference Field)
- Supports multiple Scaling Matrix Preset and User Defined Scaling Matrices
- Supports Region of Interest (ROI) encoding along with privacy masking capability. Maximum number of regions supported is 36
- Supports SVC Temporal scalability and Hierarchical-P coding with maximum of 4 temporal layers
- Supports Hierarchical-P field based interlaced coding with different controls such as MRF (Most Recent Reference Field) and SPF (Same parity reference field) with maximum of 4 temporal layers
- Supports Multi frame processing capability in single process call
- Supports watermarking of encoded data for tamper detection.
- Supports different error resilient features like Gradual Decoder refresh, Long term Reference picture Encoding, Cyclic intra refresh mechanism, constrained intra prediction.
- Supports H264 Lite configuration(High Speed preset) for Higher performance
- Supports long term reference frame and allows user to force referencing to long term reference frame at frame level to improve error resilience capability
- Supports insertion of IDR frame at random point with forceFrame control
- Supports user controlled partition size till 8x8 block for inter prediction
- Supports all user controlled POC types: 0, 1 and 2
- Supports low latency features – sub frame level synchronization for input and output. Output data synchronization is based upon slices and fixed length of bit-stream and input data synchronization is based on MB rows.
- Supports change of resolution, frame rate, bit rate and a lot of other parameters dynamically
- Supports TI propriety rate control for storage and low delay devices with finer control of quantization parameter range, initial Quantization Parameter, HRD Buffer Size, max and min Pic Size, Partial Frame Skip, MB level perceptual Rate control and expensive coefficients threshold
- Supports masks to insert user controlled NALU at different access points in the sequence
- Supports Encoding SEI messages containing GMV and RefIdx information to enable closed loop decoder
- Supports forcing a frame or field pair with all macroblocks as skipped
- Supports multiple slices per picture based upon number of macroblocks in each slice or sliceStartOffset

PRODUCT PREVIEW

- **Supports multiple slices per picture based upon number of bytes per slice for H.241 based MTU packetization**
- **Supports H.241 defined RCDO profile and staticMbCount exposure**
- **Supports user controlled in-loop filtering**
- **Supports exposure of Analytic Info – SAD and motion vector**
- **Supports image width and height that are multiple or non-multiple of 16**
- **Supports user controlled quarter-pel interpolation and integer pel for motion estimation**
- **Supports unrestricted motion vector search that allows motion vectors to be outside the frame boundary**
- **Supports user controlled all intra modes (4x4, 16x16, and 8x8)**
- **Supports user controlled constraint set flags**
- **Supports 8x8 and 4x4 transform size**
- **Supports user controlled IDR frequency control**
- **Supports buffering period, timing_info, stereo video info SEI and user defined SEI**
- **Supports control to have Bottom field first for interlaced coding**
- **Supports control to have Bottom field Inter or Intra for interlaced coding**
- **Supports user configurable Group of Pictures (GOP) length and different GOP structures: Non-Uniform (IBBP) and Uniform (BBIBBP)**
- **Supports control to enable/disable skip MB**
- **Supports capability to generating only headers**
- **The other explicit features that TI's H.264 Encoder supports are**
  - **eXpressDSP Digital Media (XDM IVIDENC2) interface compliant**
  - **Supports multi-channel functionality**
  - **Supports booting of HDVICP2**
  - **Implements different power optimization schemes**
  - **Supports YUV 420 semi-planar color subsampling format**
  - **Independent of any operating system**
  - **Ability to get plugged in any multimedia frameworks (eg. Codec Engine, OpenMax, GStreamer, etc)**

Description

H.264 is the latest video compression standard from the ITU-T Video Coding Experts Group and the ISO/IEC Moving Picture Experts Group. This H.264 Encoder is validated on HDVICP2 and Media Controller based platform with code generation tools version 4.5.1.

Performance and Memory Summary

This section describes the performance and memory usage of H.264 Encoder.

Table 1 Configuration Table

CONFIGURATION	ID
H.264 high/main profile level 4.1. With High Speed Encoding Preset which have features 1 MV, IPPP seq, intra modes(6 I4x4(for main profile), 6 I8x8(for high profile), 4 I16x16, All Chroma modes with Cr Component only)	H264_ENC_000
H.264 high profile levels 1, 1.b, 1.1, 1.2, 1.3, 2, 2.1, 2.2, 3, 4, and 4.1. With features 1 MV, intra modes(8 I8x8, 4 I16x16, All Chroma modes with Cr Component only)	H264_ENC_001
H.264 high profile levels 1, 1.b, 1.1, 1.2, 1.3, 2, 2.1, 2.2, 3, 4, and 4.1. With features 4 MV, intra modes(8 I8x8, 4 I16x16, All Chroma modes with Cr Component only)	H264_ENC_002

Table 2 Cycles Information - Profiled on DM816x REV-A2 EVM with Code Generation Tools Version 4.5.1

CONFIGURATION ID	HDVICP2 PERFORMANCE STATISTICS (MEGA CYCLES PER SECOND)(1)		
	TEST DESCRIPTION(2)	AVERAGE(3)	PEAK(4)
H264_ENC_000	AIRSHOW_P176X144_680_HIGH_PROFILE_512KBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	7.30	9.14(5)
	AIRSHOW_P176X144_680_MAIN_PROFILE_512KBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER	7.33	8.88(5)
	AIRSHOW_P352X288_680_ HIGH_PROFILE _1MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	13.40	17.71(5)
	AIRSHOW_P352X288_680_ MAIN_PROFILE _1MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	13.58	17.54(5)
	AIRSHOW_P720X480_680_ HIGH_PROFILE _4MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	33.54	43.93(5)
	AIRSHOW_P720X480_680_ MAIN_PROFILE _4MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	34.91	44.33(5)
	AIRSHOW_P1280X720_680_ HIGH_PROFILE _11MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	82.95	94.37(5)
	AIRSHOW_P1280X720_680_ MAIN_PROFILE _11MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	85.18	98.00(5)
	AIRSHOW_P1920X1080_680_ HIGH_PROFILE _25MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	180.37	197.04(5)
	AIRSHOW_P1920X1080_680_ MAIN_PROFILE _25MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	186.82	203.18(5)
	AIRSHOW_P1920X1080_680_ HIGH_PROFILE _ROI_25MBPS_30FPS.YUV, YUV420, CABAC CODING, 5 ROI REGIONS@ 30 FRAMES PER SECOND	177.62	197.96(5)
	AIRSHOW_P1920X1080_680_ROI_ MAIN_PROFILE _25MBPS_30FPS.YUV, YUV420, CABAC CODING, 5 ROI REGIONS@ 30 FRAMES PER SECOND	187.00	199.05(5)
	AIRSHOW_P1920X1080_680_ HIGH_PROFILE _QP0_30MBPS_30FPS.YUV, YUV420, CAVLC CODING WITH QP = 0 @ 30 FRAMES PER SECOND	175.19	196.15(5)
	FRUITS_I1920X1080_680_ HIGH_PROFILE _25MBPS.YUV, YUV420, CABAC CODING @ 60 FIELDS PER SECOND	184.23	199.21(5)
	AIRSHOW_P4096X2048_680_ HIGH_PROFILE _50MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	788.67	808.14(5)
	AIRSHOW_P4320X2048_680_ HIGH_PROFILE _60MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	832.95	853.69(5)
	AIRSHOW_P4096X2048_680_ HIGH_PROFILE _HIGH_SPEED_MODE_50MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	713.15	773.03(5)
	AIRSHOW_P4320X2048_680_ HIGH_PROFILE _HIGH_SPEED_MODE_60MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	754.23	815.10(5)
H264_ENC_001	AIRSHOW_P176X144_1MV_512KBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	9.12	10.10
	AIRSHOW_P352X288_1MV_1MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	16.41	17.36
	AIRSHOW_P720X480_1MV_4MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	39.70	40.98
	AIRSHOW_P1280X720_1MV_11MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	96.63	98.64
	AIRSHOW_P1920X1080_1MV_25MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	209.25	211.68
	AIRSHOW_P1920X1080_1MV_ROI_25MBPS_30FPS.YUV, YUV420, CABAC CODING, WITH 5 ROI REGIONS@ 30 FRAMES PER SECOND	211.55	216.33
	AIRSHOW_P1920X1080_1MV_QP0_30MBPS_30FPS.YUV, YUV420, CAVLC CODING WITH QP = 0 @ 30 FRAMES PER SECOND	216.78	222.09
	FRUITS_I1920X1080_1MV_25MBPS.YUV, YUV420, CABAC CODING @ 60 FIELDS PER SECOND	214.92	218.82
	AIRSHOW_P4096X2048_1MV_50MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	857.31	867.61
	AIRSHOW_P4320X2048_1MV_60MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	908.66	919.63
H264_ENC_002	AIRSHOW_P176X144_4MV_512KBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	9.69	10.81
	AIRSHOW_P352X288_4MV_1MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	18.35	19.88
	AIRSHOW_P720X480_4MV_4MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	45.42	49.69
	AIRSHOW_P1280X720_4MV_11MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	109.13	120.35
	AIRSHOW_P1920X1080_4MV_25MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	235.00	265.76
	AIRSHOW_P1920X1080_4MV_ROI_25MBPS_30FPS.YUV, YUV420, CABAC CODING WITH 5ROI REGIONS @ 30 FRAMES PER SECOND	242.60	275.77
	FRUITS_I1920X1080_4MV_25MBPS.YUV, YUV420, CABAC CODING @ 60 FIELDS PER SECOND	238.23	257.76
	AIRSHOW_P4096X2048_4MV_50MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	935.12	964.00
	AIRSHOW_P4320X2048_4MV_60MBPS_30FPS.YUV, YUV420, CABAC CODING @ 30 FRAMES PER SECOND	989.57	1017.33

(1) Measured on DM816x REV-A2 EVM having Cortex-A8 @ 1GHz, HDVICP2 @ 533MHz, Media Controller @ 250 MHz, L3 interconnect @ 500 MHz and DDR2 @ 400 MHz and there could be a variation of around 1-2% in the numbers.
   a) Media Controller code is placed in cacheable memory region in DDR.
   b) No latency from system at process call and processing unit as frame (no sub-frame level communication) is assumed.
   c) All Luma 2D Video buffers of codec being in TILED_8 Bit Memory and all Chroma 2D Video buffers of codec being in TILED_16 Bit Memory
(2) The intra period for the test vectors is 30, inter frame interval is 3 (2 B frames), and 4 slices per picture, assuming no Latency from system at process call, and processing unit as frame (no sub-frame level communications).
(3) It is computed based on worst case cycles having 2 extra input frame buffer.
(4) It is based on worst case cycles having no extra input frame buffer.
(5) The peak values for the configuration ID H264_ENC_000 are very high as compared to average value because in this configuration Intra picture (I/IDR) consumes more cycles compared to Inter picture (P) and the peak values here corresponds to Intra picture.

Table 3 Memory Statistics of Media Controller - Generated with Code Generation Tools Version 4.5.1

CONFIGURATION ID	RESOLUTION	MEMORY STATISTICS(1)							
		PROGRAM MEMORY	DATA MEMORY						TOTAL
			INTERNAL	EXTERNAL(2)					
				PERSISTENT(3)			CONST	STACK	
				TILED8 (numBufs x Width x Height)	TILED16 (numBufs x Width x Height)	TILED PAGE / RAW	RAW		
H264_ENC_000 H264_ENC_001 H264_ENC_002	352x288 (Progressive)	30	2	2x512x352	2x512x176	39	688	2	1289
	720x480 (Progressive)	30	2	2x896x544	2x896x272	46	688	2	2196
	1920x1088 (Progressive)	30	2	2x2048x1152	2x2048x576	99	688	2	7733
	1920x1080 (Interlaced)	30	2	2x2048x1216	2x2048x608	99	688	2	8117
	4096x2048 (Progressive)	30	2	2x4224x2112	2x4224x1056	296	688	2	27154
	4096x4096 (Progressive)	30	2	2x4224x4160	2x4224x2080	552	688	2	52754

(1) All memory requirements are expressed in kilobytes (1 K-byte = 1024 bytes) and there might be rounding to next integer K-byte. Stack can be kept in internal/external memory, negligible performance impact can be observed in Media Controller cycles if it is placed in external memory.
(2) Codec's request of memory container can be over-ridden by application, adhering to the below rules
   a. TILED PAGE can be overridden by RAW
   b. TILED8, TILED16 can be overridden by TILED PAGE, RAW
   c. TILED16 can be overridden by TILED8, RAW, TILED PAGE
   However, in case of overriding of 2B and 2C, there can be some performance impact.
(3) Persistent memory is instance specific and does not include I/O buffers.

Table 4 Split-up of Media Controller Internal Data Memory Statistics

CONFIGURATION ID	DATA MEMORY - INTERNAL(1)		
	SHARED		INSTANCE
	CONSTANTS	SCRATCH	
H264_ENC_000, H264_ENC_001, H264_ENC_002	0	2	2

(1) Internal memory refers to on chip memory. If the system doesn't have enough internal memory, then external memory can also be used. Memory requirements are expressed in kilobytes.

Notes

- I/O buffers:
  - Input buffer size = 3037.5 KB (1080p, one YUV420 SP)
  - Output buffer size = 3037.5 KB (for encoding one 1080p frame)
- None of the buffers at input and output level is accessed by Media Controller processor hence the data should be valid in DDR (not in cache)
- Total data memory for N non pre-emptive instances = Constants + Runtime Tables + Scratch + N * (Instance + I/O buffers + Stack)
- Total data memory for N pre-emptive instances = Constants + Runtime Tables + N * (Instance + I/O buffers + Stack + Scratch)
- MAIL BOX FIFO #0 and #1 are used and user numbering for Media Controller as 2 and for HDVICP2 as 3 is assumed
- It is assumed that RTS library from ARM is available in system because few symbols like memcpy are used in codec
- All constants and Input/Output Buffers to encoder are assumed to be in VDMA addressable space in DDR

References

- ISO/IEC 14496-10:2005 Information technology -- Coding of audio-visual objects -- Part 10: Advanced Video Coding
- eXpressDSP Algorithm Interoperability Standard (TMS320 Algorithm Interface Standard)
- H.264 High Profile Encoder on HDVICP2 and Media Controller Based Platform User's Guide (Literature Number: SPRUHG3)

Glossary

Term	Description
Constants	Elements that go into .const memory section
Scratch	Memory space that can be reused across different instances of the algorithm
Shared	Sum of Constants and Scratch
Instance	Persistent-memory that contains persistent information - allocated for each instance of the algorithm

Acronyms

Acronym	Description
AIR	Adaptive Intra Fresh
CIF	Common Intermediate Format
EVM	Evaluation Module
GOP	Group of Pictures
IDR	Instantaneous Decoding Refresh
LPF	Loop Filter
MV	Motion Vector
NAL	Network Abstraction Layer
PPS	Picture Parameter Set
QCIF	Quarter Common Intermediate Format
QPI	Quarter Pel Interpolation
QVGA	Quarter Video Graphics Array
SPS	Sequence Parameter Set
SQCIF	Sub Quarter Common Intermediate Format
UMV	Unrestricted Motion Vectors
VGA	Video Graphics Array
XDM	eXpressDSP Digital Media

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