H.264 HD Baseline Profile Encoder (v2.00.01) on DM6446

FEATURES

- **eXpressDSP™ Digital Media (XDM 1.0 IVIDENC1) interface compliant**
- **Validated on the DM6446 EVM**
- **H.264 Baseline Profile upto level 4.1 supported**
- **Quarter-pel interpolation for motion estimation supported**
- **In-loop filtering, which can be switched off for whole picture and for slice boundaries supported**
- **User controllable multiple slices per picture supported**
- **Error-robustness features like intra slice insertion in inter frames, adaptive intra refresh, constrained intra prediction, and forcefully encoding of any frame, such as I frame supported**
- **User controllable quantization parameter range supported**
- **Unrestricted motion vector search, which allows motion vectors to be outside the frame boundary supported**
- **Image width and height that are non-multiple of 16 supported (multiples of 4, 8 supported, non-multiples of 4 not supported)**
- **TI proprietary rate control algorithms supported**
- **Arbitrary resolutions up to HD resolutions of 3840x2176 including standard image sizes such as PAL D1 (720x576), SQCIF, QCIF, CIF, QVGA, and VGA supported**
- **User configurable Group of Pictures (GOP) length supported**
- **User configurable parameters like pic_order_cnt_type, log2_max_frame_num_minus4, and chroma_qp_index_offset supported**
- **YUV422 interleaved and YUV420 planar color sub-sampling formats supported**
- **Controls the balance between encoder speed and quality by using the user defined motion estimation settings and encoding Preset option**
- **Constraint to keep macro block bits within 3200 bits as per the standard not supported**

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 the DM6446 EVM with Code Composer Studio version 3.2.37.12 and code generation tools version 6.1.2.

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Performance Summary

This section describes the performance of the H.264 HD Baseline Profile Encoder on DM6446 EVM.

Table 1. Configuration Table

CONFIGURATION	ID
H.264 base profile levels up to level 4.1	H264_ENC_001

Table 2. Cycles Information - Profiled on DM6446 EVM with IMCOP and Code Generation Tools Version 6.1.2

CONFIGURATION ID	PERFORMANCE STATISTICS (MEGA CYCLES PER SECOND)(1)		
	TEST DESCRIPTION	AVERAGE(2)	PEAK (3)(4)
H264_ENC_001	720p5994_parkrun_ter_1280x720_422i_205fr.yuv, targetFrameRate=13fps, targetBitRate=2Mbps, IntraPeriod=0.5sec, encodingFrameRate=15fps, rcAlgo=PLR4_RC,NFAVG=102	510	537
	smaninrest_p1920x1080_30fps_420pl_60fr, targetFrameRate=5 fps, targetBitRate=9 Mbps, IntraPeriod=1sec (encoding Frame rate=5 fps), rcAlgo=PLR4_RC, NFAVG=10	571	622
	mobile_p352x288_30fps_420pl_300fr, targetFrameRate=30 fps, targetBitRate=0.768 Mbps, IntraPeriod=1sec (encoding Frame rate=30 fps), rcAlgo=PLR4_RC, NFAVG=100	139	145
	sheilds_720x480_422i_252frames.yuv, targetFrameRate=30 fps, targetBitRate=1.572 Mbps, IntraPeriod=0.5sec (encoding Frame rate=30 fps), rcAlgo= PLR4_RC, NFAVG=252	418	448
	Amazing_caves_1280x720_yuv422i_250frames targetFrameRate=13 fps, targetBitRate=3 Mbps, IntraPeriod=0.5sec (encoding Frame rate=15 fps), rcAlgo=PLR4, NFAVG=125	557	608
	720p50_shields_ter_1280x720_422i_300fr.yuv, target frame rate = 13 fps, targetBitRate=2mbps,rcAlgo=PLR4_RC, NFAVG=150,IntraPeriod=0.5 sec (encoding Frame rate=15 fps)	505	532
	tennis_p704x480_30fps_420pl_150fr, targetFrameRate=30 fps, targetBitRate=1.572 Mbps, IntraPeriod=1sec (encoding Frame rate=30 fps) rcAlgo=PLR4_RC, NFAVG=100	344(5)	380(5)
	720p5994_parkrun_ter_1280x720_422i_205fr.yuv, targetFrameRate=13 fps, targetBitRate=3 Mbps, IntraPeriod=1sec (encoding Frame rate=15fps), rcAlgo=PLR4_RC, NFAVG=102	442(5)	472(5)

(1) Measured with program memory, stack, and I/O buffers in external memory with cache configuration : 32 K-bytes L1P Program Cache, 64 K-bytes L1D Data Memory, and 16 K-bytes L1D Data Cache, 64 K-bytes L2 Cache, 32 bit DDR @ 162 MHz, CPU @ 594 MHz and only used by encoder.
(2) Average MCPS is calculated by multiplying average Mega Cycles Per Frame numbers by target frame rates. Average MCPS is calculated over NFAVG frames.
(3) Peak MCPS is calculated on moving average of 4 frames over NFAVG frames.
(4) For higher bit-rates of encoding, actual cycles performance will be worse than the above mentioned numbers.
(5) For these, encodingPreset = High speed, option is used. All other performance numbers use (encodingPreset = User_defined, which uses High quality option).

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Note: Average and peak MCPS measurements can vary by +/-5%.

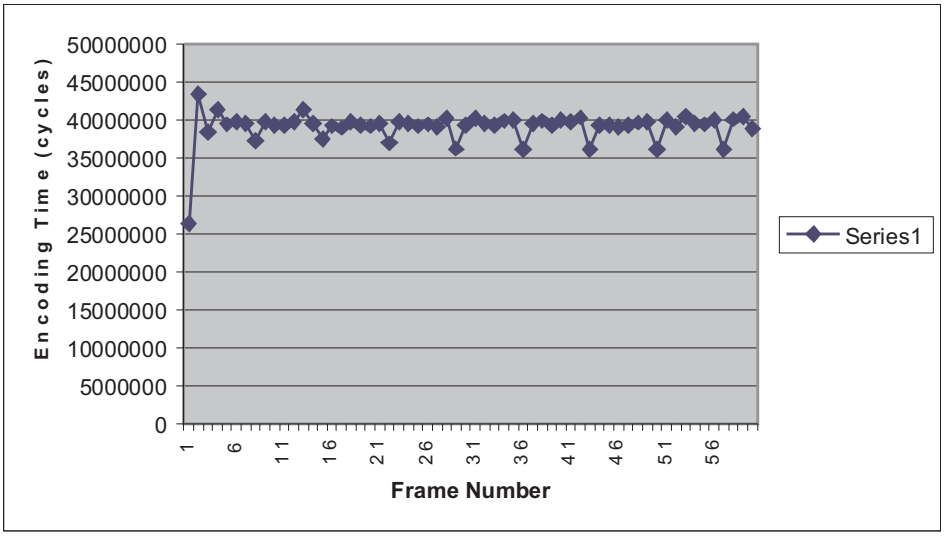

Figure 1. Encoding Time for Individual Frames (720p50_shields_ter_1280x720_422i_300fr.yuv @ 2Mbps @ 15 fps, with 1 MV, QPI, LPF, UMV, Target Frame rate = 13fps, rc algo PLR4_RC, NFAVG = 150 Intra Period = 0.5sec and User_defined Preset)

Table 3. Memory Statistics - Generated with Code Generation Tools Version 6.1.2

CONFIGURATION ID	LEVEL AND RESOLUTION	MEMORY STATISTICS(1)						TOTAL
		PROGRAM MEMORY	DATA MEMORY					
			INTERNAL	EXTERNAL			STACK	
				PERSISTENT	CONSTANTS	SCRATCH		
H264_ENC_001	Level 3.0 D1 (720x576)	162.53	63.25	1532	9.3	469	8	2242.55
	Level 4.0 HD (1280x720)	162.53	63.25	3207	9.3	964	8	4412.55
	Level 4.0 HD (1920x1080)	162.53	63.25	6949	9.3	2089	8	9279.55
	Level 4.1 HD (3840x2176)	162.53	63.25	26576	9.3	8276	8	35093.55

(1) All memory requirements are expressed in kilobytes (1 K-byte = 1024 bytes) and there could be a variation of around 1-2% in numbers.

Table 4. Internal Data Memory Split-Up

CONFIGURATION ID	DATA MEMORY - INTERNAL (1)		
	SHARED		INSTANCE(2)
	CONSTANTS	SCRATCH	
H264_ENC_001	0	63.25	0

(1) Internal memory refers to L1DRAM. All memory requirements are expressed in kilobytes and there could be a variation of around 1-2% in numbers.
(2) I/O buffers not included. Some of the instance memory buffers could be scratch.

Table 5. Co-Processor(s) Memory Statistics

CONFIGURATION ID	SEQ DATA MEMORY(1)	SEQ PROG MEMORY(1)	IMX WORKING MEM(1)	IMX IMG BUF(1)	IMX CMD MEM(1)
H264_ENC_001	1	4	27	9	4

(1) All memory requirements are expressed in kilobytes and all are scratch buffers.

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Table 6. PSNR and Bit-Rate Details

TEST SEQUENCE	BITRATE / AVERAGE LUMA PSNR (in dB)				
	1572000 (bps)	2000000 (bps)	4000000 (bps)	6000000 (bps)	8000000 (bps)
parkrun_p1280x720_30fps_420pl_302fr, target frame rate = 7.5 fps, rcAlgo=PLR3_RC, NFAVG=63, IntraPeriod=1 sec	-	25.98	29.05	-	-
shields_p1280x720_30fps_420pl_302fr, target frame rate = 7.5 fps rcAlgo=PLR3_RC, NFAVG=75 IntraPeriod=1 sec	-	35.15	-	38.96	-
stockholm_p1280x720_30fps_420pl_302fr, target frame rate = 7.5 fps rcAlgo=PLR3_RC, NFAVG=75 IntraPeriod=1 sec	-	34.70	36.48	-	-
tennis_p704x480_30fps_420pl_150fr.yuv, target frame rate = 30 fps rcAlgo=DCES_TM5, NFAVG=100 IntraPeriod=0.5 sec	29.98	-	-	-	-
stockholm_p1280x720_30fps_420pl_302fr, target frame rate = 7.5 fps rcAlgo= DCES_TM5, NFAVG=150 IntraPeriod=0.5 sec	-	32.63	-	-	-

Note:

1. Scene change detection is OFF
2. Loop Filter enabled

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Notes

- I/O buffers:
  - Input buffer size = 4 M-bytes (1080P, one YUV422 interleaved frame)
  - Output buffer size = 2025 K-bytes (for encoding one 1080P frame)
- Memory Configuration
  - L1P: 32 K-bytes Program Cache
  - L1D: 64 K-bytes Data Memory and 16K-bytes Data Cache
  - L2: 64 K-bytes Cache
- The performances obtained in Table 2 are sensitive to algorithm code placement. Refer the sample linker file provided in the test application setup for algorithm code placement. This is used for profiling in Table 2.
- The algorithm uses 6 QDMA channels and parameter space equal to 35 parameter entries. The algorithm uses DMAN3 interface for logical allocation of these channels.
- 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)

References

- ISO/IEC 14496-10:2005 Information technology -- Coding of audio-visual objects -- Part 10: Advanced Video Coding
- *H264 HD Baseline Profile Encoder on DM6446 User's Guide* (literature number: SPRUFQ6)

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
CIF	Common Intermediate Format
DMA	Direct Memory Access
DMAN3	DMA Manager
EVM	Evaluation Module
GOP	Group of Pictures
IDR	Instantaneous Decoding Refresh
LPF	Loop Filter
MV	Motion Vector
QCIF	Quarter Common Intermediate Format
QDMA	Quick Direct Memory Access
QPI	Quarter Pel Interpolation
QVGA	Quarter Video Graphics Array
SQCIF	Sub Quarter Common Intermediate Format
UMV	Unrestricted Motion Vectors
VGA	Video Graphics Array (640x480 resolution)
XDM	eXpressDSP Digital Media

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