H.264 High Profile Encoder (v01.00.00) on DM365

FEATURES

- eXpressDSP™ Digital Media (XDM 1.0 IVIDENC1) interface compliant
- Validated on DM365 EVM
- H.264 High Profile up to level 3.1 compliant
- Resolutions up to 720p(1280 x 720) supported
- YUV420 semi-planar input format for the frames supported
- Progressive and interlaced encoding supported
- Generates bit-stream compliant with H.264 standard
- CAVLC and CABAC encoding supported
- 16x16, 8x16, 16x8, and 8x8 MB partition supported
- Sequence scaling matrix is supported
- Transform 8x8 and transform 4x4 is supported
- Frame based encoding with frame size being multiples of 2 supported
- Rate Control (CBR and VBR) supported
- Insertion of Buffering Period and Picture Timing Supplemental Enhancement Information (SEI) and Video Usability Information (VUI) supported
- Unrestricted Motion Vectors (UMV) supported
- Half pel and quarter pel interpolation for motion estimation supported
- Supported features in high quality mode:
  - TI's proprietary motion estimation supported (2 types of search algorithms supported
  - All 16x16, 8x8, and 4x4 Intra-Prediction Modes supported
  - Multiple slice encoding supported upto 720p resolution (for CAVLC only)
  - 4-motion vector per macroblock till 720p resolution supported
  - Adaptive Intra Refresh (AIR) supported
- Supported features in standard quality mode:
  - TI's proprietary motion estimation supported (low power ME supported)
  - All 16x16, 8x8, and 4x4 intra-prediction Modes supported in I-Frame and INTRA16x16 DC is supported in P-frames
  - Only single slice per frame is supported
  - Only single motion vector per macroblock supported
- This encoder does not support the following features:
  - Error resilience features such as ASO/FMO and redundant slices
  - Adaptive reference picture marking
  - Reference picture list reordering

DESCRIPTION

H.264 (from ITU-T, also called as H.264/AVC) is a popular video coding algorithm enabling high quality multimedia services on a limited bandwidth network. H.264 standard defines several profiles and levels which specify restrictions on the bit stream and hence limits the capabilities needed to decode the bit streams. This project is developed using Code Composer Studio version 3.3.81.6 and using the code generation tools version 4.1.3.

PRODUCT PREVIEW

Performance Summary

This section describes performance of Standalone H.264 Encoder validated on DM365 EVM.

Table 1. Configuration Table

CONFIGURATION	ID
H.264 High profile levels up to 3.1, UMV – OFF, PRC – ON, T8x8Inter – OFF and T8x8Intra – ON, SM – ON, CABAC – ON, Quality – Standard Quality, IntraPeriod-30	H264_ENC_01
H.264 High profile levels up to 3.1, UMV – OFF, PRC – ON, T8x8Inter – ON and T8x8Intra – ON, SM – ON, Quality – High Quality, MeAlgo = 1, IntraPeriod-30	H264_ENC_02

Performance Measurement Procedure

- Measured with program memory and I/O buffers in external memory, I/D cache enabled, ARM @297 MHz, HDVICP @243 MHz, DDR @243 MHz, Monta Vista® Linux® 5.0
- Linux is used to measure the performance numbers in this Datasheet.
- The process time is measured across algActivate/process/algDeactivate function call using gettimeofday() utility of Linux.
- NFS File system is used as an environment in performance measurement.

Table 2. Cycles Information for H264_ENC_01

INPUT NAME	PERFORMANCE STATISTICS FOR STANDARD QUALITY SETTINGS (MEGA CYCLES)(1)						
	RESOLUTION	AVERAGE			PEAK		
		ARM926 PER FRAME	ENCODE PER FRAME (ARM926 and ARM968)	FPS	ARM926 PER FRAME	ENCODE PER FRAME (ARM926 and ARM968)	FPS
parkrun_p1280x720_30fps_420pl_300fr.yuv	720p@30fps, 4mbps	0.31	9.02	33.27	0.29	11.79	25.44
shields_p720x480_25fps_420pl_252fr.yuv	D1@30fps, 2mbps	0.27	3.67	81.73	0.29	4.72	63.55
foreman_i640x480_30fps_420pl_300fr .yuv	VGA @30fps, 3mbps	0.27	3.27	91.71	0.27	4.18	71.74
akiyo_p352x288_30fps_420pl_300fr.yuv	CIF@30fps, 512kbps	0.25	1.59	188.90	0.27	1.91	157.38

(1) Average and peak values may vary by +/-5%.

Table 3. Cycles Information for H264_ENC_02

INPUT NAME	PERFORMANCE STATISTICS FOR HIGH QUALITY SETTINGS (MEGA CYCLES)(1)						
	RESOLUTION	AVERAGE			PEAK		
		ARM926 PER FRAME	ENCODE PER FRAME (ARM926 and ARM968)	FPS	ARM926 PER FRAME	ENCODE PER FRAME (ARM926 and ARM968)	FPS
shields_p720x480_25fps_420pl_252fr.yuv	D1@30fps, 2mbps	0.26	7.34	40.86	0.26	7.63	39.35
foreman_i640x480_30fps_420pl_300fr .yuv	VGA @30fps, 3mbps	0.28	6.53	45.88	0.22	6.88	43.59
akiyo_p352x288_30fps_420pl_300fr.yuv	CIF@30fps, 512kbps	0.25	2.49	120.24	0.71	3.16	94.82

(1) Average and peak values may vary by +/-5%.

Note:

- Encode frame MHz depicts the cumulative load on ARM926 and ARM968.
- ARM926 represents mega cycles per frame spend on ARM926.
- Encode frame time is the time seen from ARM926 only. Since most of the processing happens at HDVICP, the active load on ARM926 is the value mentioned in ARM926 column. Encoder frame time has no connection with HDVICP running at 243 MHz.
- All numbers are collected (both average and peak) at frame-level processing for first 300 frames.
- They are measured in presence of Linux without any system traffic.
- The version of the code used to collect these numbers have the following features included:
  - Interrupt mode of operation – one interrupt signal processing overhead per frame.
  - Resetting of HDVICP and loading of code into ARM968 DTCM – once per Process call.

Table 4. Memory Statistics

CONFIGURATION ID	MEMORY STATISTICS (IN BYTES)(1)(2)					
	PROGRAM MEMORY	DATA MEMORY				TOTAL
		CONSTANT	HEAP		STACK	
			PERSISTENT	SCRATCH		
H264_ENC_01 H264_ENC_02	256264	796	3247996	25960	12288	3543292

(1) All these memory requirements are for ARM926 encoder library(including DMA library). They do not include any memory requirements from test application side. Stack, heap and code requirements for test-application are extra. Constant memory size requirements include code memory of ARM968 since it forms a constant table on ARM926 before transfer.
(2) The constant size is the sum of .cinit, .bss, and .const sections used by H.264 encoder library.

Table 5. Internal Data Memory Split-Up - HDVICP

CONFIGURATION ID	DATA MEMORY - HDVICP (IN BYTES)		
	ARM968 ITCM	ARM968 DTCM	HDVICP BUFFERS
H264_ENC_01 H264_ENC_02	49152	32768	ALL

Table 6. Internal Data Memory Split-Up - VICP and ARM TCM (with useARM926Tcm = 0)

CONFIGURATION ID	DATA MEMORY – VICP AND ARM TCM			
	VICP(1)		ARM TCM(2)	
	REQUESTS	SIZE (BYTES)	REQUESTS	SIZE (BYTES)
H264_ENC_01 H264_ENC_02	1	24928(720p)	-	-
	2	5408(720p)	-	-
	3	2624(720p)	-	-
	4	2624(720p)	-	-
	TOTAL	35584(720p)	-	-

(1) Formula for VICP memory usage:
REQUEST 1: ((no.of.rowmbpairs+1) * 608)
REQUEST 2: maxSupportedWidth + 4096 + 32
REQUEST 3: ((no.of.rowmbs + 2) * 32)
REQUEST 4: ((no.of.rowmbs + 2) * 32)
(2) Formula for ARM TCM memory usage: NA

Table 7. Internal Data Memory Split-Up – VICP and ARM TCM (with useARM926Tcm = 1)

CONFIGURATION ID	DATA MEMORY – VICP AND ARM TCM			
	VICP[1]		ARM TCM[2]	
	REQUESTS	SIZE (BYTES)	REQUESTS	SIZE (BYTES)
H264_ENC_01 H264_ENC_02	1	5408(720p)	1	24928(720p)
	2	2624(720p)	-	-
	3	2624(720p)	-	-
	TOTAL	10656(720p)	TOTAL	24928(720p)

(1) Formula for VICP memory usage:
REQUEST 1: maxSupportedWidth + 4096 + 32
REQUEST 2: ((no.of.rowmbs + 2) * 32)
REQUEST 3: ((no.of.rowmbs + 2) * 32)
(2) Formula for ARM TCM memory usage:
REQUEST 1: ((no.of.rowmbpairs+1) * 608)

Table 8. DM365 H264 Encoder usage of Memory through CMEM

BUFFER	YUV 420P
Input Buffer	1382400 (for 720p) (InputWidth * InputHeight * 1.5)[1]
Output Buffer	691200 (for 720p) (worst case: InputBuffer/2)
MEMTAB	**SIZE (IN BYTES)**
Memtab 0	1344
Memtab 1	4680
Memtab 2	4680
Memtab 3	20480
Memtab 4	2048
Memtab 5[2]	3112704
Memtab 6	800
Memtab 7	48548
Memtab 8	60288
Memtab 9	3600
Memtab 10	14400
Memtab 11	384

(1) 'Height' and 'Width' used in equations are the parameters specified at the creation time. The memory requirement calculation is theoretical worst case for a particular resolution.
(2) Memtab 5 is calculated based on the resolution. The formula is:
If(interlaced)
uHeight = maxHeight + (PAD_VERT << 2)
else
uHeight = maxHeight + (PAD_VERT << 1)
uWidth = maxWidth + (PAD_HORIZ << 1)
uSize = (uHeight * uWidth * 3) >> 1
Example: If maxHeight = 144, maxWidth = 176, PAD_VERT = 26 and PAD_HORIZ = 32
uSize = (240*196*3) >> 1 = 70560 (for progressive)

Notes

- HDVICP and VICP
  - The entire HDVICP is a video resource and is used by the codec
  - The codec uses VICP memory as scratch buffers and hence there is restriction on the usage of VICP concurrently
- DMA configuration

Table 9. DMA Configuration

TC Qs	TC 0	TC 1	TC 2	TC 3	TOTAL
Usage	Reserved for system	Used by codec	Used by codec	Used by codec	-
Priority	0	1	1	2	-
EDMA Channels	NA	22	7	7	36
PaRAM Entries	NA	45	10	7	62
QDMA Channels	0	0	0	0	0/8

- The HDVICP/VICP/EDMA resources are acquired using a generic resource manager known as Framework Component. See *H.264 High Profile Encoder User's Guide* for details.
- Code Placement - All the algorithm code are placed in external memory. The performance quoted is not sensitive to algorithm code placement.
- Memory requests mentioned in the table are as requested by codec. The actual memory allocation may be slightly different (on the higher side), based on the alignment implementation of the memory allocator.

References

- ISO/IEC 14496-10:2005 (E) Rec. - Information technology – Coding of audio-visual objects – H.264 (E) ITU-T Recommendation
- *H.264 High Profile Encoder User's Guide* (literature number: SPRUEU9)

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
ASO	Arbitrary Slice Order
CIF	Common Intermediate Format
D1	Video Resolution for PAL(720x576) and NTSC(720x480)
DMA	Direct Memory Access
DPB	Decoded Picture Buffer
EVM	Evaluation Module
FMO	Flexible Macro-block Ordering
HDVICP	High Definition Video and Imaging Co-Processor sub-system
MONA	Media Oriented Negotiation Acceleration
NTSC	National Television System Committee
PAL	Phase Alternating Line
PSNR	Peak Signal to Noise Ratio
QCIF	Quarter Common Intermediate Format
QVGA	Quarter Video Graphics Array

ACRONYM	DESCRIPTION
RS	Redundant Slice
SEI	Supplemental Enhancement Information
SPS	Sequence Parameter Set
SQCIF	Sub Quarter Common Intermediate Format
UMV	Unrestricted Motion Vectors
VGA	Video Graphics Array
VICP	Video and Imaging Co-Processor sub-system
VUI	Video Usability Information
WVGA	Wide Video Graphics Array (864x480)
XDM	eXpressDSP Digital Media

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