

## H.264 High Profile Decoder (v01.00.00) on DM365

### FEATURES

- eXpressDSP™ Digital Media (XDM 1.0 IVIDDEC2) interface compliant
- Validated on DM365 EVM with and without Linux®
- H.264 High Profile up to level 3.1 compliant
- Byte stream NAL unit format for input bit-stream
- Progressive frame type picture decoding supported
- Multiple slices and multiple reference frames supported
- CAVLC and CABAC decoding supported
- Main Profile features like B-Slice decoding and CABAC supported
- Weighted prediction for motion compensation in both P and B-slices supported
- Transform 8x8 mode, interspersed with transform 4x4 MBs supported
- Parsing and decoding with scaling lists present both in SPS and PPS NAL units supported
- Second chroma qp index offset value present in PPS supported
- All intra-prediction and inter-prediction modes supported
- Up to 16 MV per MB supported
- Adaptive and sliding window DPB management supported
- Output order conformance using frame bumping process supported
- Frame based decoding with frame size being multiples of 2 supported
- Outputs are available in YUV420 interleaved

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- Supplemental Enhancement Information (SEI) and Video Usability Information (VUI) supported
- Uses configurable frame display delay for out of order display
- Performs basic error concealment on erroneous frames and reports the type of error occurred
- Resolution upto 720p supported
- This version of the decoder does not support the following features:
  - Error concealment features such as ASO/FMO and redundant slices
  - Dynamic change in resolution
  - Raw NAL unit format for input bit-stream

### 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



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## Performance Summary

This section describes the performance of Standalone H.264 High Profile Decoder validated on DM365 EVM resulting in performance equivalent to 30fps.

**Table 1. Configuration Table**

CONFIGURATION	ID
H.264 High Profile levels up to 3.1	H264_DEC_01

### 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\_DEC\_01**

INPUT NAME	PERFORMANCE STATISTICS (MEGA CYCLES) <sup>(1)</sup>						
	RESOLUTION	AVERAGE			PEAK		
		ARM926 PER FRAME	DECODE PER FRAME (ARM926 and ARM968)	FPS	ARM926 PER FRAME	DECODE PER FRAME (ARM926 and ARM968)	FPS
CIF_L1.2_384Kbps_15fps_news.264	CIF (352x288)	0.49	1.38	215.3	0.87	2.72	109.1
foreman_p640x480_30fps_420pl_300fr_1ref.264	VGA (640x480)	0.50	3.07	96.6	0.57	3.33	89.3
D1_football_720x480_384_30fBP.264	D1(720x480)	0.51	3.23	91.9	0.65	3.35	88.6
16MV_lpb_city_p1280x720_30fps_420pl_600fr.264	720p (1280 x 720)	0.48	8.78	33.8	0.53	9.94	29.9

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

**Table 3. Cycles Information for H264\_DEC\_01 for Closed Loop Configuration<sup>(1)</sup>**

INPUT NAME	PERFORMANCE STATISTICS (MEGA CYCLES) <sup>(2)</sup>						
	RESOLUTION	AVERAGE			PEAK		
		ARM926 PER FRAME	DECODE PER FRAME (ARM926 and ARM968)	FPS	ARM926 PER FRAME	DECODE PER FRAME (ARM926 and ARM968)	FPS
akiyo_p352x288_30fps_420pl_300fr.264	CIF(352x288)	0.50	1.36	218.0	0.57	1.47	202.1
foreman_i640x480_30fps_420pl_300fr.264	VGA(640x480)	0.50	3.16	93.9	0.65	4.85	61.3
shields_p720x480_25fps_420pl_252fr.264	D1(720x480)	0.50	3.41	87.1	0.62	4.76	62.4
parkrun_p1280x720_30fps_420pl_300fr.264	720p (1280 x 720)	0.50	7.65	38.8	0.61	9.23	32.2

(1) Closed loop configuration refers to the streams encoded by DM365 H.264 encoder.

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

**Note:**

- Decode frame depicts the cumulative load on ARM926 and ARM968.
- The values in [Table 2](#) and [Table 3](#) are as measured on the ARM926 side. These are the actual cycles as seen from the host on the DM365 EVM board and will be close to cycles seen on the final system (for average case).
- ARM926 represents mega cycles per frame spend on ARM926.
- Decode 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. Decoder frame time has no connection with HDVICP running at 243 MHz.
- All the values are collected (both average and peak) at frame-level processing.
- For streams with more than 50 frames, profiling is done for first 50 frames only.
- They are measured with 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 stream.

**Table 4. Memory Statistics (Host ARM926 External Memory)**

CONFIGURATION ID	MEMORY STATISTICS (IN BYTES) <sup>(1)</sup>							
	PROGRAM MEMORY	DATA MEMORY				STACK	DPB FOR LEVEL 3.1 <sup>(3)</sup>	TOTAL
		CONSTANT <sup>(2)</sup>	HEAP					
			PERSISTENT <sup>(4)</sup>	SCRATCH				
H264_DEC_01	314262	564	7247000	0	12288	9289728	16863842	

- (1) All these memory requirements are for ARM926 decoder library only. They do not include any memory requirements from test application side. Stack, heap and code requirements for test-application are additional.
- (2) Constant memory size requirements include code memory of ARM968 since it forms a constant table on ARM926 before transfer.
- (3) DPB for level 3.1 indicates tentative buffer requirements on the test application side to manage the DPB requirements of level 3.1 compliant H.264 decoder library implementing XDM1.0 API. DPB memory requirements given here include padding requirements of 24 pixels on either sides of all dimensions (luma and packed chroma) assuming 4:2:0 format. It also includes memory required for holding the current frame. To enable optimal DMA transfers in the application, the picture width has been aligned to the next 32-byte boundary. For example, padded and aligned 720p picture will have a width of 1280 + 48 (padding) + 16(alignment) = 1344. Due to this padding and alignment constraints, the DPB requirement for a normal picture is different from its rotated version. The DPB requirement for some of the supported resolutions on the higher-end is provided in [Table 5](#).
- (4) Persistent memory includes space required for 256 PPS and 32 SPS.

**Table 5. DPB Requirement (for level 3.1)**

RESOLUTION	DPB REQUIREMENT
720p (1280x720)	9289728

**Table 6. Internal Data Memory Split-Up**

CONFIGURATION ID	DATA MEMORY - VICP AND HDVICP (IN BYTES)			
	HDVICP			VICP <sup>(1)</sup>
	ARM 968 ITCM	ARM 968 DTCM	HDVICP BUFFERS	
H264_DEC_01	48K	32K	ALL	30176

- (1) Three buffers are used in VICP, one buffer for storing ECD MB info and two buffers for storing intra prediction data. The number in the table is calculated for a 720p stream.  
 Formula for calculating ECD-MB information buffer size:  $Size = (\maxWidthMbs + 2) * 304$ ;  
 Formula for calculating intra prediction buffer size:  $Size = (((\maxWidthMbs + 2) \ll 4) \ll 1)$ ;

**Table 7. H264 Decoder DM365 Codec Usage of Memory Through CMEM**

BUFFER	YUV420P
Input Buffer <sup>(1)</sup>	0x20000
Output Buffer	1548288

- (1) The size of the input buffer should be equal to or greater than one frame data..

**Table 7. H264 Decoder DM365 Codec Usage of Memory Through CMEM (continued)**

BUFFER	YUV420P
MEMTAB NUMBER	SIZE IN BYTES <sup>(2)</sup>
Memtab 0	896
Memtab 1	8704
Memtab 2	8704
Memtab 3	2688
Memtab 4	5632
Memtab 5	6650880
Memtab 6	282624
Memtab 7	47752
Memtab 8	158368
Memtab 9	26224
Memtab 10	384
Memtab 11	10240
Memtab 12	13184
Memtab 13	30720

(2) The table has numbers for 720p resolution.

The following CMEM allocations are dependent on the maxWidth and maxHeight and it provides the formula for calculating the size based on the input resolution:

- Output Buffer = frameSize\_padded  

$$\text{frameSize\_padded} = ((\text{maxWidth} + 48 + \text{alignment}) * (\text{maxHeight} + 48))$$
- Memtab 4 =  $2 * (((\text{maxWidth} + 4 * 16) * 2) + 8 + 127) \& 0\text{FFFFFF}80$   
 This is for storing the top rows for intra prediction. One for even row and one for odd row.
- Memtab 5 =  $((((\text{maxWidth} \gg 4) + 1) * (\text{maxHeight} \gg 4)) + 1) * (\text{dpb\_limit at level 3.1} + 1)$   
 This is for storing ecd mb information.

## 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 8. DMA Configuration**

TC Q's	TC 0	TC 1	TC 2	TC 3	TOTAL
<b>Usage</b>	Reserved for system	Used by codec	Used by codec	Used by codec	-
<b>Priority</b>	0	1	1	2	-
<b>EDMA Channels</b>	NA	16	9	1	26
<b>PaRAM Entries</b>	NA	14	52	1	67
<b>QDMA Channels</b>	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 Decoder on DM365 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.

## 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 Decoder on DM365 User's Guide* (literature number: SPRUEV0)

## 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
720p	1280x720 resolution
DMA	Direct Memory Access
DPB	Decoded Picture Buffer
DTCM	Data Tightly Coupled Memory
EVM	Evaluation Module
FIQ	Fast Interrupt Request
FMO	Flexible Macro-block Ordering
HDVICP	High Definition Video and Imaging Co-Processor sub-system
IRQ	Interrupt Request
PPS	Picture Parameter Set
QCIF	Quarter Common Intermediate Format
QVGA	Quarter Video Graphics Array
RS	Redundant Slice

<b>ACRONYM</b>	<b>DESCRIPTION</b>
SEI	Supplemental Enhancement Information
SPS	Sequence Parameter Set
SQCIF	Sub Quarter Common Intermediate Format
UMV	Unrestricted Motion Vectors
VICP	Video and Imaging Co-Processor sub-system
VUI	Video Usability Information
WFI	Wait For Interrupt
XDM	eXpressDSP Digital Media

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