# Sequential JPEG Decoder (v1.12.000) on DM355

*eXpressDSP™DM Compliant*

**DSP** TEXAS INSTRUMENTS

## FEATURES

- **eXpressDSP™ algorithm interface standard (xDAIS) compliant**
- **eXpressDSP™ digital media (xDM) Interface compliant**
- **IDMA3 Compliant**
- **Implements IIMGDEC1 interface of xDM**
- **Supports baseline sequential process with the following limitations:**
    - **Cannot support non-interleaved scans**
    - **Only supports 1 and 3 components**
    - **Huffman tables and quantization tables for U and V components must be the same**
- **Supports a maximum of four (two tables each) for AC and DC DCT coefficients**
- **Supports YUV 422 interleaved output format only (planar output is not supported)**
- **Supports YUV420, YUV422, YUV444, and gray level( with 8x8 pixels MCU) input format**
- **Supports 8-bit quantization tables**
- **Supports frame level decoding of images**
- **Images with resolutions up to 700 Mpixels can be decoded. This is the theoretical maximum; however, only images up to 64 Mpixels have been tested).**
- **Skips JPEG file interchange format (JFIF) header**
- **Supports frame level re-entrancy**
- **Supports resizing by various factors from 1/8 to 7/8**
- **Supports frame pitch greater than picture width, as specified as display width parameter**
- **Supports rotation and decode area individually, but does not support both together**

- **Supports ring buffer configuration of bitstream buffer for reducing buffer size requirement. Ring buffer size should be multiple of 4096 Bytes**
- **Supports rotation of 90, 180, and 270 degree**
- **Supports multi-instance of JPEG Decoder, and single/multi instance of JPEG Decoder with other DM355 codecs**
- **Validated on DM355 EVM (MontaVista® Linux® 4.0.1)**
- **Unsupported features: The limitations will not be removed in future releases. These limitations are not defects, but intentional or known deficiencies.**
    - **Extended DCT-based process**
    - **Lossless process**
    - **Hierarchical process**
    - **Progressive scan**
    - **Planar output**
    - **Input format of YUV411, gray level with 16x16 pixels MCU**
    - **Source images of 12-bits per sample**
    - **Does not support image width less than 64 pixels for YUV420/422 and 32 pixels for YUV444**
    - **IDMA3 interface support is limited. Current implementation of the JPEG decoder uses the following TCCs for its DMA resource requirements along with its associated PaRAM Sets. Channel numbers 33-47 and 52-55 have the following associated PaRamSet Numbers: 33 – 47, 52 - 55 (PaRamSet number = channel number). Only eight additional PaRamSets are passed to the codec through the IDMA3 interface.**

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## DESCRIPTION

This sequential JPEG decoder accepts YUV4:2:0, YUV4:2:2, YUV4:4:4 planar, YUV4:2:2 interleaved, and Gray (with 8x8 pixels MCU) images. Output format is YUV4:2:2 interleaved. It is validated on the DM355 EVM with MontaVista Linux 4.0.1.

### Product Support

When contacting TI for support on this codec, please quote the product name (JPEG Decoder on DM355) and version number. The version number of the codec is included in the Title of the Release Notes that accompanies this codec.

### Validation

The decoder has been validated by running it on the DM355 EVM (MontaVista Linux 4.0.1) platform and measuring the resource usage during this process.

### Performance Summary

This section describes the performance of the Sequential JPEG Decoder (v1.12.000) on DM355.

**Table 1. Configuration Table**

| CONFIGURATION | ID |
|---|---|
| Sequential JPEG Decoder, I/D Cache Enabled Input Format: YUV420P Output Format: YUV422ILE Rotation 0. | JPEG_DEC_001 (420P: Resolution Grouping) |
| Sequential JPEG Decoder, I/D Cache Enabled Input Format: YUV422P Output Format: YUV422ILE Rotation 0. | JPEG DEC_002 (422P: Resolution Grouping) |
| Sequential JPEG Decoder, I/D Cache Enabled Input Format: YUV422P Output Format: YUV422ILE Rotation Enabled. | JPEG _DEC_003 (Rotation Grouping) |

### Performance Measurement Procedure

1. Standalone codec test application, which makes codec process call at xDM layer (without codec engine), is used to measure the performance numbers in this data sheet.
2. The process time is measured across algActivate/process/algDeactivate function call using gettimeofday() utility of linux.
3. NAND File system is used as an environment in performance measurement. A variation of upto 0.35 ms is seen in performance numbers between multiple runs of same test.
4. To avoid the impact of file I/O operation in performance measurement, file write operation is disabled and checksum calculation is included after fread() function to make sure file read has really completed before process call.
5. After rebooting the board, codec binary must be executed at least once before start of performance measurement.

**NOTE:**

Codec process time is divided in ARM load and MJCP load. ARM is idle during MJCP processing, and can be utilized to execute any other program in different thread during this time.

**Table 2. Cycles Information for JPEG_DEC_001 – Profiled on DM355 EVM (ARM = 216 MHz, DDR = 171 MHz, MontaVista Linux 4.0.1))**

| Input name | Resolution | Compres-sion Ratio | Total Process Time[1] | Time Across MJCP (ms) | ARM Load (ms) | Total Process Load[2] | MJCP Load (Mcycles) | ARM Load (Mcycles) | Process Time[3] |
|---|---|---|---|---|---|---|---|---|---|
| Fruitbasket.jpg | CIF (352 x 288) | 3 | 6.13 | 2.85 | 2.92 | 1.32 | 0.62 | 0.63 | 5.77 |
| | | 7 | 5.44 | 2.15 | 2.93 | 1.18 | 0.46 | 0.63 | 5.08 |
| | | 11 | 5.21 | 1.9 | 2.95 | 1.13 | 0.41 | 0.64 | 4.85 |
| test_2.jpg | VGA (640 x 480) | 3 | 11.10 | 7.87 | 2.88 | 2.40 | 1.70 | 0.62 | 10.75 |
| | | 7 | 9.74 | 6.42 | 2.98 | 2.10 | 1.39 | 0.64 | 9.40 |
| | | 14 | 8.74 | 5.51 | 2.87 | 1.89 | 1.19 | 0.62 | 8.38 |
| Chrsweep.jpg | D1 (720 x 480) | 11 | 9.54 | 6.27 | 2.90 | 2.06 | 1.35 | 0.63 | 9.17 |
| | | 18 | 9.22 | 5.86 | 2.99 | 1.99 | 1.27 | 0.65 | 8.85 |
| | | 22 | 8.90 | 5.70 | 2.86 | 1.92 | 1.23 | 0.62 | 8.56 |
| mobcal_ter.jpg | 720 p (1280 x 720) | 2 | 30.15 | 26.86 | 2.93 | 6.51 | 5.80 | 0.63 | 29.79 |
| | | 5 | 23.70 | 20.34 | 3.01 | 5.12 | 4.39 | 0.65 | 23.35 |
| | | 10 | 20.96 | 17.55 | 3.05 | 4.53 | 3.79 | 0.66 | 20.60 |

(1)   Total Process Time (Process + activate + deactivate) (ms/frame).
(2)   Total Process Load in Mcycles (Process + activate + deactivate).
(3)   Process Time (without activate/deactivate) (ms).

**Table 3. Cycles Information for JPEG_DEC_002 – Profiled on DM355 EVM (ARM=216 MHz, DDR=171 MHz, MontaVista Linux 4.0.1))**

| Input name | Resolution | Compres-sion Ratio | Total Process Time[1] | Time Across MJCP (ms) | ARM Load (ms) | Total Process Load[2] | MJCP Load (Mcycles) | ARM Load (Mcycles) | Process Time[3] |
|---|---|---|---|---|---|---|---|---|---|
| Fruitbasket.jpg | CIF (352 x 288) | 2 | 7.44 | 4.05 | 3.03 | 1.61 | 0.87 | 0.65 | 7.08 |
| | | 6 | 6.55 | 3.19 | 3.00 | 1.41 | 0.69 | 0.65 | 6.19 |
| | | 10 | 6.25 | 2.97 | 2.92 | 1.35 | 0.64 | 0.63 | 5.89 |
| test_2.jpg | VGA (640 x 480) | 3 | 14.61 | 11.22 | 3.03 | 3.16 | 2.42 | 0.65 | 14.25 |
| | | 5 | 13.06 | 9.82 | 2.88 | 2.82 | 2.12 | 0.62 | 12.70 |
| | | 10 | 12.19 | 8.7 | 3.13 | 2.63 | 1.88 | 0.68 | 11.83 |
| shrek.jpg | D1 (720 x 480) | 12 | 12.99 | 9.74 | 2.88 | 2.81 | 2.10 | 0.62 | 12.62 |
| | | 14 | 12.71 | 9.40 | 2.94 | 2.74 | 2.03 | 0.63 | 12.34 |
| | | 16 | 12.60 | 9.27 | 2.96 | 2.72 | 2.00 | 0.64 | 12.23 |
| mobcal_ter.jpg | 720p[4] (1280 x 720) | 3 | 29.50 | 26.87 | 2.34 | 6.38 | 5.81 | 0.50 | 29.22 |
| | | 6 | 25.74 | 23.13 | 2.33 | 5.56 | 4.99 | 0.50 | 25.46 |
| | | 9 | 23.93 | 21.30 | 2.34 | 5.17 | 4.60 | 0.50 | 23.63 |
| mire_YUV422_Q90.jpg | SXVGA[4] (1280 x 960) | 10 | 29.80 | 27.31 | 2.21 | 6.44 | 5.90 | 0.48 | 29.52 |

(1)   Total Process Time (Process + activate + deactivate) (ms/frame).
(2)   Total Process Load in Mcycles (Process + activate + deactivate).
(3)   Process Time (without activate/deactivate) (ms).
(4)   Performance numbers for 720P and SXVGA are interpolated for the DM355UH part; i.e., ARM @270 MHz, DDR @216 MHz.

**Table 4. Cycles Information for JPEG_DEC_003 – Profiled on DM355 EVM (ARM=216 MHz, DDR=171 MHz, MontaVista Linux 4.0.1))**

| Input name | Resolution | Rotation | Total Process Time[1] | Time Across MJCP (ms) | ARM Load (ms) | Total Process Load[2] | MJCP Load (Mcycles) | ARM Load (Mcycles) | Process Time[3] |
|---|---|---|---|---|---|---|---|---|---|
| Fruitbasket.jpg | CIF (352 x 288) | 0 | 6.55 | 3.19 | 3.00 | 1.41 | 0.69 | 0.65 | 6.19 |
| | | 90 | 8.59 | 4.41 | 3.82 | 1.86 | 0.95 | 0.83 | 8.23 |
| | | 180 | 8.14 | 4.26 | 3.52 | 1.76 | 0.92 | 0.76 | 7.78 |
| | | 270 | 8.62 | 4.44 | 3.82 | 1.86 | 0.96 | 0.83 | 8.26 |

(1)   Total Process Time (Process + activate + deactivate) (ms/frame).
(2)   Total Process Load in Mcycles (Process + activate + deactivate).
(3)   Process Time (without activate/deactivate) (ms).

**PRODUCT PREVIEW**

**PRODUCT PREVIEW**

### Table 4. Cycles Information for JPEG_DEC_003 – Profiled on DM355 EVM (ARM=216 MHz, DDR=171 MHz, MontaVista Linux 4.0.1))  (continued)

| Input name | Resolution | Rotation | Total Process Time[1] | Time Across MJCP (ms) | ARM Load (ms) | Total Process Load[2] | MJCP Load (Mcycles) | ARM Load (Mcycles) | Process Time[3] |
|---|---|---|---|---|---|---|---|---|---|
| shrek.jpg | D1 (720 x 480) | 0 | 12.99 | 9.74 | 2.88 | 2.81 | 2.10 | 0.62 | 12.62 |
| | | 90 | 18.35 | 14.37 | 3.62 | 3.96 | 3.10 | 0.78 | 17.99 |
| | | 180 | 17.60 | 13.79 | 3.45 | 3.80 | 2.98 | 0.75 | 17.24 |
| | | 270 | 18.44 | 14.46 | 3.63 | 3.98 | 3.12 | 0.78 | 18.09 |

### Table 5. DDR Bandwidth Usage for Worst Case

| Resolution | Number of MBs per Frame | DDR Bandwidth for One Frame (in KB) |
|---|---|---|
| CIF (352 x 288) | 396 | 198 |
| VGA (640 x 480) | 1200 | 600 |
| D1 (720 x 480) | 1350 | 675 |
| 720p (1280 x 720) | 3600 | 1800 |
| SXVGA (1280 x 960) | 4800 | 2400 |

### Table 6. Codec Memory Statistics Generated with Code Generation Tools v 6.0.3

| Resolution | MEMORY STATISTICS[1] | | | | TOTAL |
|---|---|---|---|---|---|
| | PROGRAM MEMORY | DATA MEMORY | | | |
| | | INTERNAL | EXTERNAL | STACK | |
| SXVGA (1280 x 960) | 48.33 | 0 | 10.15 | 2 | 60.48 |
| 720P (1280 x 720) | 48.33 | 0 | 10.15 | 2 | 60.48 |
| D1 (720 x 480) | 48.33 | 0 | 10.15 | 2 | 60.48 |
| VGA (640 x 480) | 48.33 | 0 | 10.15 | 2 | 60.48 |
| CIF (352 x 288) | 48.33 | 0 | 10.15 | 2 | 60.48 |

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

### Table 7. Codec Usage of External Memory via CMEM

| Buffer | | |
|---|---|---|
| Input Buffer[1] | | (FrameSize)*3[2] |
| Output Buffer | | (FrameSize)*2 |
| External Memory | memTab[1] | 8200 |
| | memTab[2] | 512 |

(1)    Input buffer size is theoretical value based on 1:1 compression ratio. Actual size will be lower than this.
(2)    FrameSize = (maxWidth * maxHeight).

### References

- ISO/IEC 10918-1: *Digital compression and coding of continuous-tone still images (JPEG)*

### 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 |
| Compression ratio | A compression ratio of N:1 indicates that compressed data occupies N times less space than original data |

### Acronyms

| Acronym | Description |
|---------|-------------|
| CIF | Common Intermediate Format |
| DCT | Discrete Cosine Transform |
| DMA | Direct Memory Access |
| DMAN3 | DMA Resource Manager |
| EVM | Evaluation Module |
| IDMA3 | DMA Resource specification and negotiation protocol |
| JPEG | Joint Photographic Experts Group |
| MCU | Minimum Coded Unit |
| XDAIS | eXpressDSP Algorithm Interface Standard |
| XDM | eXpressDSP Digital Media |
| YUV | Raw Image format<br>Y: Luminance component<br>U,V : Chrominance components |
| Exif | Exchangeable image file format |
| JFIF | JPEG File Interchange Format |
| MJCP | MPEG4-JPEG co-processor |

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