JPEG Marker Definitions

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Definition of SOF_n Markers

Name	Code	Length	Category
Nondifferential Huffman-coding frames:			
SOF_0	X'FFC0'	V	Baseline DCT
SOF_1	X'FFC1'	V	Extended sequential DCT
SOF_2	X'FFC2'	V	Progressive DCT
SOF_3	X'FFC3'	V	Lossless (sequential)
Differential Huffman-coding frames:			
SOF_5	X'FFC5'	V	Differential sequential DCT
SOF_6	X'FFC6'	V	Differential progressive DCT
SOF_7	X'FFC7'	V	Differential lossless
Nondifferential arithmetic-coding frames:			
SOF_9	X'FFC9'	V	Extended sequential DCT
SOF_{10}	X'FFCA'	V	Progressive DCT
SOF_{11}	X'FFCB'	V	Lossless (sequential)
Differential arithmetic-coding frames:			
SOF_{13}	X'FFCD'	V	Differential sequential DCT
SOF_{14}	X'FFCE'	V	Differential progressive DCT
SOF_{15}	X'FFCF'	V	Differential lossless

V – Variable length with known structure.

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Definition of non-SOF$_n$ Markers

Table 7-5. Definition of non-SOF$_n$ markers

Name	Code	Length	Category
APP$_n$	X'FFE0'		
	– X'FFEF'	V	Reserved for application use
COM	X'FFFE'	V	Comment
DAC	X'FFCC'	V	Define arithmetic conditioning table(s)
DHP	X'FFDE'	V	Define hierarchical progression
DHT	X'FFC4'	V	Define Huffman table(s)
DNL	X'FFDC'	4	Define number of lines
DQT	X'FFDB'	V	Define quantization table(s)
DRI	X'FFDD'	4	Define restart interval
EOI	X'FFD9'	N	End of image
EXP	X'FFDF'	3	Expand reference image(s)
JPG	X'FFC8'	U	Reserved for JPEG extensions
JPG$_n$	X'FFF0'		
	– X'FFFD'	U	Reserved for JPEG extensions
RES	X'FF02'		
	– X'FFBF'	U	Reserved
RST$_m$	X'FFD0'		
	– X'FFD7'	N	Restart with modulo 8 counter m
SOI	X'FFD8'	N	Start of image
SOS	X'FFDA'	V	Start of scan
TEM	X'FF01'	N	For temporary use in arithmetic coding

N – No length or parameter sequence follows.
U – Undefined at this time.
V – Variable length with known structure.

SOI (FFD8)

- **Start of Image**
- *Length :* **No length or parameter sequence follows**
- *Function :* **begins the compressed data stream**

DQT (FFDB)

- **Define Quantization Table(s)**
- *Length :* **Variable length with known structure**
- *Function :* **defines one or more quantization tables**

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SOF$_0$ (FFC0)

- **Start of Frame (Baseline DCT)**
- *Length :* **Variable length with known structure**
- *Function :* **begins a frame header**
- **n in SOF$_n$ identifies the mode of compression and the entropy coder used within the frame**

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DHT (FFC4)

- **D**efine **H**uffman **T**able(s)
- *Length :* **Variable length with known structure**
- *Function :* **defines one or more Huffman tables**

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SOS (FFDA)

- **S**tart **o**f **S**can
- *Length :* **Variable length with known structure**
- *Function :* **begins a scan header**
- **The scan header is always followed immediately by entropy-coded data for the scan.**

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EOI (FFD9)

- **End of Image**
- *Length :* **No length or parameter sequence follows**
- *Function :* **terminates the JPEG compressed data stream**

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Frame Header Structure (SOF$_n$)

Parameter	Symbol	Size (bits)
Marker (X'FFC0–3, 5–7, 9–B, D–F')	SOF$_n$	16
Frame header length	Lf	16
Sample precision	P	8
Number of lines	Y	16
Number of samples/line	X	16
Number of components in frame	Nf	8
Frame component specification ($i = 1, ..., Nf$)		
Component identifier	C_i	8
Horizontal sampling factor	H_i	4
Vertical sampling factor	V_i	4
Quantization table destination selector	Tq_i	8

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DQT Marker Segment Structure

Parameter	Symbol	Size (bits)
Marker (X'FFDB')	DQT	16
Quantization table definition length	Lq	16
For each quantization table:		
Quantization table element precision	Pq	4
Quantization table identifier	Tq	4
Quantization table element ($k = 0, ..., 63$)	Q_k	8 or 16

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DHT Marker Segment Structure

Parameter	Symbol	Size (bits)
Marker (X'FFC4')	DHT	16
Huffman table definition length	Lh	16
For each Huffman table:		
Table class	Tc	4
Huffman table identifier	Th	4
Number of Huffman codes of length i for $i = 1, ..., 16$	L_i	8
Value associated with each Huffman code for $i = 1, ..., 16; j = 1, ..., L_i$	V_{ij}	8

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Scan Header Structure (SOS)

Parameter	Symbol	Size (bits)
Marker (X'FFDA')	SOS	16
Scan header length	Ls	16
Number of components in scan	Ns	8
Scan component specification ($k = 1,...,Ns$)		
Scan component selector	Cs_k	8
DC entropy coding table selector	Td_k	4
AC entropy coding table selector	Ta_k	4
Start of spectral selection or predictor selection	Ss	8
End of spectral selection	Se	8
Successive approximation bit position high	Ah	4
Successive approximation bit position low or point transform	Al	4

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Example of Nonhierarchical Compressed Data Structure

SOI
    DQT, length, quantization table definition(s).
    DRI, length, restart interval
        SOF_n, length, frame parameters
            DHT, length, Huffman table definition(s)
            SOS, length, scan parameters
                compressed data for restart interval, RST_0
                ... etc. ...
                compressed data for restart interval, RST_m
                ... etc. ...
                compressed data for final restart interval
            DHT, length, Huffman table definition(s)
            SOS, length, scan parameters
                ... etc. ...
EOI

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Example of Baseline compressed data structure

- SOI (FFD8)
  - DQT (FFDB), length, Q Table def.
  - SOF (FFC0), length, frame parameters
  - DHT (FFC4), length, Huffman Table def.
  - SOS (FFDA), length, Scan parameters
    - compressed data
- EOI (FFD9)

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Baseline Compressed Data Stream for Y

SOI →	FF D8
DQT →	FF DB 00 43 00 10 0B 0C 0E 0C 0A 10 0E 0D 0E 12 11 10
	13 18 28 1A 18 16 16 18 31 23 25 1D 28 3A 33 3D
	3C 39 33 38 37 40 48 5C 4E 40 44 57 45 37 38 50
	6D 51 57 5F 62 67 68 67 3E 4D 71 79 70 64 78 5C
	65 67 63
SOF →	FF C0 00 0B 02 40 02 DB 80 01 01 11 00
DHT →	FF C4 00 D2 00 00 01 05 01 01 01 01 01 01 00 00 00 00
	00 00 00 00 01 02 03 04 05 06 07 08 09 0A 0B 10
	00 02 01 03 03 02 04 03 05 05 04 04 00 00 01 7D
	01 02 03 00 04 11 05 12 21 31 41 06 13 51 61 07
	22 71 14 32 81 91 A1 08 23 42 B1 C1 15 52 D1 F0
	24 33 62 72 82 09 0A 16 17 18 19 1A 25 26 27 28
	29 2A 34 35 36 37 38 39 3A 43 44 45 46 47 48 49
	4A 53 54 55 56 57 58 59 5A 63 64 65 66 67 68 69
	6A 73 74 75 76 77 78 79 7A 83 84 85 86 87 88 89
	8A 92 93 94 95 96 97 98 99 9A A2 A3 A4 A5 A6 A7
	A8 A9 AA B2 B3 B4 B5 B6 B7 B8 B9 BA C2 C3 C4 C5
	C6 C7 C8 C9 CA D2 D3 D4 D5 D6 D7 D8 D9 DA E1 E2
	E3 E4 E5 E6 E7 E8 E9 EA F1 F2 F3 F4 F5 F6 F7 F8
	F9 FA
SOS →	FF DA 00 08 01 01 00 00 3F 00 ...
EOI →	FF D9

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Baseline Compressed Data
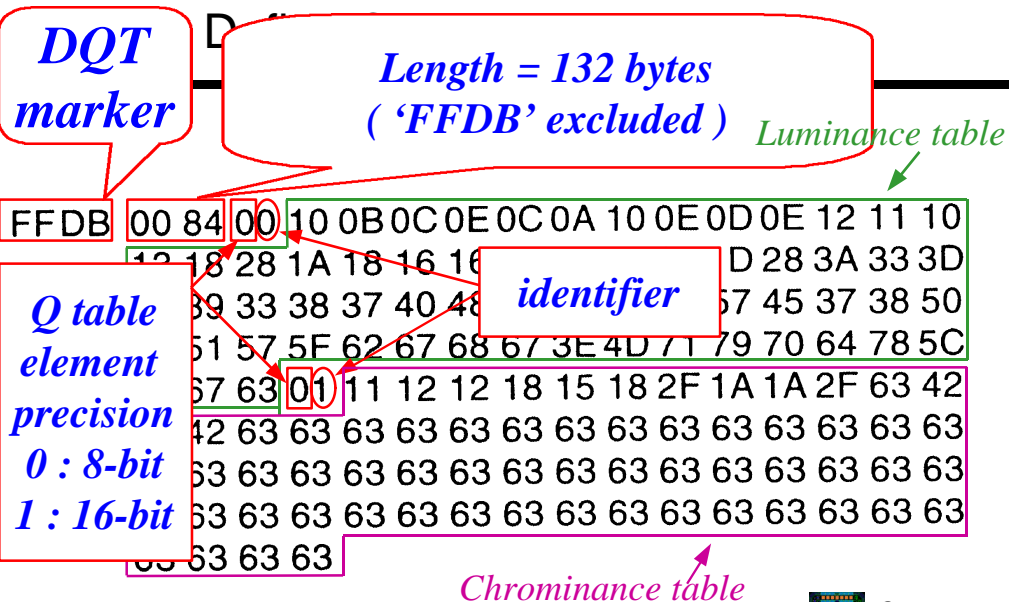## for Interleaved YYCbCr

```
FFD8
FFDB  00 84 00 10 0B 0C 0E 0C 0A 10 0E 0D 0E 12 11 10
      13 18 28 1A 18 16 16 18 31 23 25 1D 28 3A 33 3D
      3C 39 33 38 37 40 48 5C 4E 40 44 57 45 37 38 50
      6D 51 57 5F 62 67 68 67 3E 4D 71 79 70 64 78 5C
      65 67 63 01 11 12 12 18 15 18 2F 1A 1A 2F 63 42
      38 42 63 63 63 63 63 63 63 63 63 63 63 63 63 63
      63 63 63 63 63 63 63 63 63 63 63 63 63 63 63 63
      63 63 63 63 63 63 63 63 63 63 63 63 63 63 63 63
      63 63 63 63
FFC0  00 11 08 02 40 02 D0 03 01 21 00 02 11 01 03 11
      01
FFC4  01 A2 00 00 01 05 01 01 01 01 01 01 00 00 00 00
      00 00 00 00 01 02 03 04 05 06 07 08 09 0A 0B 10
      00 02 01 03 03 02 04 03 05 05 04 04 00 00 01 7D
      01 02 03 00 04 11 05 12 21 31 41 06 13 51 61 07
      22 71 14 32 81 91 A1 08 23 42 B1 C1 15 52 D1 F0
      24 33 62 72 82 09 0A 16 17 18 19 1A 25 26 27 28
      29 2A 34 35 36 37 38 39 3A 43 44 45 46 47 48 49
```

```
      4A 53 54 55 56 57 58 59 5A 63 64 65 66 67 68 69
      6A 73 74 75 76 77 78 79 7A 83 84 85 86 87 88 89
      8A 92 93 94 95 96 97 98 99 9A A2 A3 A4 A5 A6 A7
      A8 A9 AA B2 B3 B4 B5 B6 B7 B8 B9 BA C2 C3 C4 C5
      C6 C7 C8 C9 CA D2 D3 D4 D5 D6 D7 D8 D9 DA E1 E2
      E3 E4 E5 E6 E7 E8 E9 EA F1 F2 F3 F4 F5 F6 F7 F8
      F9 FA 01 00 03 01 01 01 01 01 01 01 01 01 00 00
      00 00 00 00 01 02 03 04 05 06 07 08 09 0A 0B 11
      00 02 01 02 04 04 03 04 07 05 04 04 00 01 02 77
      00 01 02 03 11 04 05 21 31 06 12 41 51 07 61 71
      13 22 32 81 08 14 42 91 A1 B1 C1 09 23 33 52 F0
      15 62 72 D1 0A 16 24 34 E1 25 F1 17 18 19 1A 26
      27 28 29 2A 35 36 37 38 39 3A 43 44 45 46 47 48
      49 4A 53 54 55 56 57 58 59 5A 63 64 65 66 67 68
      69 6A 73 74 75 76 77 78 79 7A 82 83 84 85 86 87
      88 89 8A 92 93 94 95 96 97 98 99 9A A2 A3 A4 A5
      A6 A7 A8 A9 AA B2 B3 B4 B5 B6 B7 B8 B9 BA C2 C3
      C4 C5 C6 C7 C8 C9 CA D2 D3 D4 D5 D6 D7 D8 D9 DA
      E2 E3 E4 E5 E6 E7 E8 E9 EA F2 F3 F4 F5 F6 F7 F8
      F9 FA
FFDA  00 0C 03 01 00 02 11 03 11 00 3F 00 ...
FFD9
```

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DQT marker

Length = 132 bytes ('FFDB' excluded)

Luminance table

identifier

Q table element precision 0 : 8-bit 1 : 16-bit

```
FFDB  00 84 00 10 0B 0C 0E 0C 0A 10 0E 0D 0E 12 11 10
      13 18 28 1A 18 16 16 ...    D 28 3A 33 3D
      39 33 38 37 40 48 ...  57 45 37 38 50
      51 57 5F 62 67 68 67 3E 4D 71 79 70 64 78 5C
      67 63 01 11 12 12 18 15 18 2F 1A 1A 2F 63 42
      42 63 63 63 63 63 63 63 63 63 63 63 63 63 63 63
      63 63 63 63 63 63 63 63 63 63 63 63 63 63 63 63
      63 63 63 63 63 63 63 63 63 63 63 63 63 63 63 63
      63 63 63 63
```

Chrominance table

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