INTERNATIONAL STANDARD

ISO 12234-2

First edition
2001-10-15

Electronic still-picture imaging — Removable memory —

Part 2: TIFF/EP image data format

Imagerie de prises de vue électroniques — Mémoire mobile —

Partie 2: Format de données image TIFF/EP

Reference number
ISO 12234-2:2001(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 12234 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 12234-2 was prepared by Technical Committee ISO/TC 42, *Photography*.

ISO 12234 consists of the following parts, under the general title *Electronic still-picture imaging — Removable memory*:

— *Part 1: Basic removable-memory module*

— *Part 2: TIFF/EP image data format*

— *Part 3: Design rule for camera file system (DCF)*

Annex A of this part of ISO 12234 is for information only.

Introduction

The term TIFF/EP refers to Tag Image File Format/Electronic Photography, defined in this part of ISO 12234. The term “TIFF 6.0” refers to the TIFF Revision 6.0 specification. TIFF/EP is defined to be as compatible as possible with existing desktop software packages, to enable them to operate with images from electronic still-picture cameras. TIFF Revision 6.0 is used as the basis for achieving this interoperability with the large installed base of imaging software. Wherever possible, TIFF/EP uses tags already defined in TIFF 6.0 and provides guidelines for the use of these tags as well as the allowed field values. New tags are defined to encode image data features that are not included in TIFF 6.0. These new tags conform to the practices specified in TIFF 6.0. This document also describes how related images, such as both “parent” high resolution and “thumbnail” low resolution images of the same subject, or temporal sequence “bursts” of the same scene, can be stored in a single TIFF/EP file.

With the permission of Adobe Systems Incorporated, sections of this TIFF/EP specification have been copied verbatim from the TIFF 6.0 specification dated June 3, 1992 specification © 1986-1988, 1992 Adobe Systems Incorporated. All Rights Reserved.

In this part of ISO 12234, references to tags and tag values defined in TIFF 6.0 are shown in bold typeface. Tags and tag values that are not defined in TIFF 6.0 are identified in italic type face. These new tags have been chosen to be as compatible as possible with the Exif tags defined in “Digital Still Camera Image File Format Standard (Exchangeable image file format for Digital Still Cameras: Exif)”, Version 2.1, June 1998 by the Japan Electronic Industry Development Association (JEIDA). The new TIFF/EP tag fields containing enumerated values follow the TIFF 6.0 convention, where the lower half of the values (0 to 127 for byte values, 0 to 32,767 for short values, and 0 to 2,147,483,647 for long values) are reserved by TIFF/EP and the upper half of the values (128 to 255 for byte values, 32,768 to 65,535 for short values, and 2,147,483,648 to 4,294,967,296 for long values) are private values that may be registered by I3A.

I3A may be contacted at the Photographic and Imaging Manufacturers Association, 550 Mamaroneck Avenue, Suite 307, Harrison, NY 10528-1612 USA, or by e-mail at pima@pima.net.

TIFF/EP complies with the TIFF 6.0 specification and uses the same header specified in TIFF 6.0. The reason for this is to maintain the highest degree of compatibility with existing TIFF readers and to make the adoption of TIFF/EP, including the new TIFF/EP tags, as easy as possible. In the future, if TIFF is revised, a revised version of TIFF/EP may be developed using the revised TIFF specification. TIFF/EP editors of a given TIFF/EP version number shall not update TIFF/EP files having a higher version number without warning the user that, in doing so, unknown tags will be deleted. This is explained in the section describing the ***TIFF/EPStandardID*** tag.

TIFF/EP tag definitions do not allow default values. All values shall be explicitly stated in order to improve interoperability with future versions of TIFF/EP. Images may be stored in uncompressed form or using JPEG baseline (DCT based) compression. In the latter case, an uncompressed baseline-TIFF-readable reduced resolution “thumbnail” image should also be stored in the 0th IFD to allow the images to be identified using a baseline TIFF 6.0 reader.

TIFF/EP uses the TIFF/JPEG specification given in “DRAFT TIFF Technical Note No. 2”. This method differs from the JPEG method described in the TIFF 6.0 specification. In the method used within TIFF/EP, each image segment (tile or strip) contains a complete JPEG data stream that is valid according to the ISO JPEG standard (ISO/IEC 10918-1). TIFF/EP requires that readers only support the DCT based lossy JPEG process.

TIFF/EP currently does not define how to embed audio information within a TIFF/EP image file. Audio can be stored in a separate file on the same removable media, if desired, or stored within a TIFF/EP file using a private TIFF tag obtained from Adobe Corp. This does not preclude a future release of TIFF/EP from implementing embedded audio as part of the TIFF/EP file.

TIFF/EP image files should be stored in a READ-ONLY fashion using the appropriate file system mechanism. This will prevent accidental loss of important TIFF/EP tag-value information if the image is edited by a non-TIFF/EP compliant application. TIFF editors generally remove unknown tags when saving or updating an image file to

maintain the integrity of the TIFF file, since the unknown tags might not apply to the edited image. By creating TIFF/EP image files READ-ONLY, accidental loss of important information is prevented. TIFF/EP editors, on the other hand, shall warn the user, whenever editing a newer version TIFF/EP file with an older version TIFF/EP editor, that proceeding may result in the loss of information. The mandatory ***TIFF/EPStandardID*** tag-field specifies the TIFF/EP version used in creating a TIFF/EP image file.

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this International Standard may involve the use of patents from the following companies:

— Canon Incorporated

— Eastman Kodak Company

— Fuji Photo Film Company Ltd.

— Nikon Corporation

— Olympus Optical Company Ltd.

The holders of these patent rights have assured ISO that they are willing to negotiate licenses under reasonable and non-discriminatory terms and conditions throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Information may be obtained from the companies listed. Other companies have also determined that, upon approval of this International Standard, they too will grant patent licenses in accordance with ISO Directives, Part 2. Information regarding these companies may also be obtained from the ISO Central Secretariat

ISO takes no position concerning the evidence, validity and scope of any of the patent rights listed.

Electronic still-picture imaging — Removable memory —

Part 2:
TIFF/EP image data format

1 Scope

This part of ISO 12234 specifies the TIFF/EP data format described in ISO 12234-1.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 12234. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 12234 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 12232:1998, *Photography — Electronic still-picture cameras — Determination of ISO speed*

ISO 12233:2000, *Photography — Electronic still-picture cameras — Resolution measurements*

ISO 12234-1:2001, *Electronic still-picture imaging — Removable memory — Part 1: Basic removable-memory module*

ISO 14524:1999, *Photography — Electronic still-picture cameras — Methods for measuring opto-electronic conversion functions (OECFs)*

ISO/IEC 10918-1:1994, *Information technology — Digital compression and coding of continuous-tone still images: Requirements and guidelines*

ITU-R BT.709-4 (03/00), *Parameter values for the HDTV standards for production and international programme exchange*

3 Terms and definitions

For the purposes of this part of ISO 12234, the following terms and definitions apply.

3.1
file system
software structure which specifies how the data is logically organized on a given storage medium

3.2
image data format
structure and content which specifies how the data is logically organized on a given storage medium

4 Image data features

This clause describes all the features of the TIFF/EP standard and lists the tags used to implement each feature.

4.1 TIFF/EP file encoding structure

A TIFF/EP file is a valid TIFF file that contains the TIFF/EP format identifier and conforms to the restrictions described in this part of ISO 12234. The TIFF/EP header is exactly the same as the TIFF header. The use of the TIFF/EP format and revision number is identified in the ***TIFF/EPStandardID*** tag-field.

TIFF is an image file format. In this part of ISO 12234, a *file* is a sequence of 8-bit bytes, where the bytes are numbered from 0 to N. The largest possible TIFF file is 2**32 bytes in length. A TIFF file begins with an 8-byte *image file header* that points to an *image file directory (IFD).* An image file directory contains information about the image, as well as pointers to the actual image data.

A TIFF file structure is shown in Figure 1.

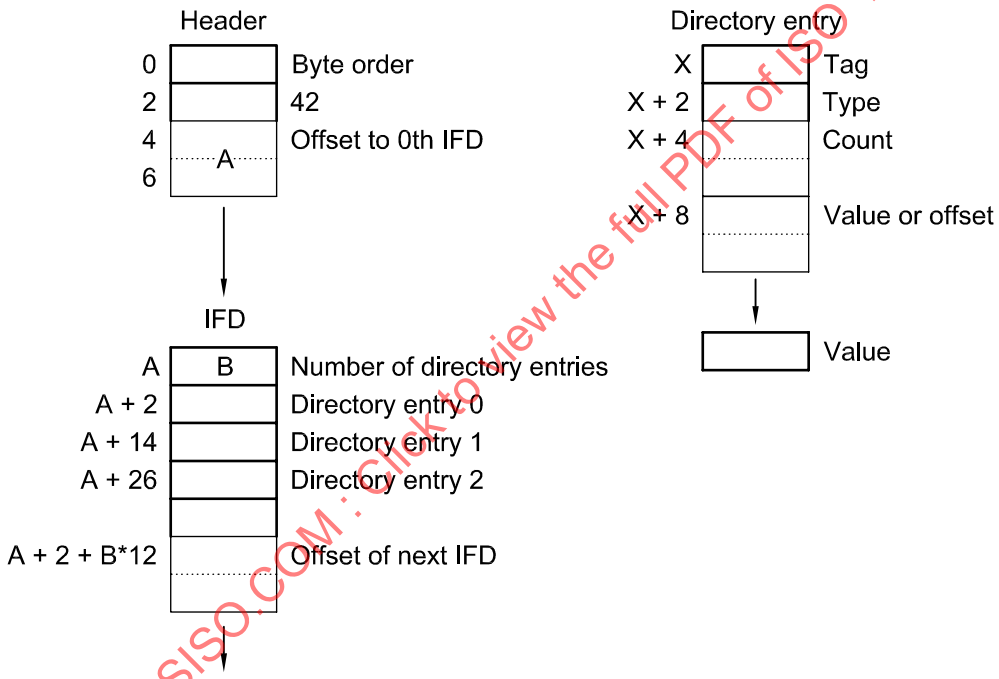

Figure 1 — TIFF file structure

4.1.1 Image file header

A TIFF file begins with an 8-byte image file header, containing the following information:

Bytes 0-1: The byte order used within the file. Legal values are:

II (4949.H)

MM (4D4D.H)

In the II format, byte order is always from the least significant byte to the most significant byte, for both 16-bit and 32-bit integers. This is called *little-endian* byte order. In the MM format, byte order is always from the most significant byte to the least significant byte, for both 16-bit and 32-bit integers. This is called *big-endian* byte order.

Bytes 2-3: An arbitrary but carefully chosen number (42) that further identifies the file as a TIFF file.

The byte order depends on the value of Bytes 0-1.

Note that, in order to allow backward compatibility with future versions of TIFF/EP based on future versions of TIFF, all TIFF/EP readers should test the TIFF header version value to determine if VERSION >= 42, not to test if VERSION == 42. This will allow higher version numbers to be used in the future and to be detected as TIFF/EP files.

Bytes 4-7: The offset (in bytes) of the first IFD. The directory may be at any location in the file after the header but shall begin on a word boundary. In particular, an image file directory may follow the image data it describes. Readers shall follow the pointers wherever they may lead.

The term *byte offset* is always used in this part of ISO 12234 to refer to a location with respect to the beginning of the TIFF file. The first byte of the file has an offset of 0.

4.1.2 Image file directory (IFD)

An IFD consists of a 2-byte count of the number of directory entries (i.e. the number of fields), followed by a sequence of 12-byte field entries, followed by a 4-byte offset of the next IFD (or 0 if none). Do not forget to write 4 bytes of 0 after the last IFD.

There shall be at least 1 IFD in a TIFF file and each IFD shall have at least one entry.

4.1.2.1 IFD entry

Each 12-byte IFD entry has the following format:

Bytes 0-1: The tag that identifies the field.

Bytes 2-3: The field type.

Bytes 4-7: The number of values, *Count* of the indicated type.

Bytes 8-11: The value offset, i.e. the file offset (in bytes) to the value(s) for the field. This value offset is expected to begin on a word boundary; the corresponding value offset will thus be an even number. This file offset may point anywhere in the file, even after the image data. (See below for more information.)

4.1.2.2 IFD terminology

A *TIFF field* is a logical entity consisting of a TIFF tag and its value. This logical concept is implemented as an *IFD entry*, plus the actual value if it doesn't fit into the value/offset part, the last 4 bytes of the *IFD entry*. The terms *TIFF field* and *IFD entry* are interchangeable in most contexts.

4.1.2.3 Sort order

The entries in an IFD shall be sorted in ascending order by tag. The values to which directory entries point need not be in any particular order in the file.

4.1.2.4 Value/Offset

To save time and space, the value offset contains the value instead of pointing to the value only if the value fits into 4 bytes. If the value is shorter than 4 bytes, it is left-justified within the 4-byte value offset, i.e. stored in the lower-numbered bytes. Whether the value fits within 4 bytes is determined by the type and count of the field.

Note that the 4 byte value offset should not be thought of as a LONG data type since, if the value is shorter than 4 bytes, it is always left-justified regardless of whether the II or MM byte order is used. For example, to store the SHORT hex value "AB CD" in MM byte order, the 4 bytes are "AB CD xx xx" (where x indicates "don't care"). The same hex value in II byte order is given by "CD AB xx xx".

4.1.2.5 Count

Count, called *Length* in previous versions of the TIFF specification, is the number of values. Note that count is not the total number of bytes. For example, a single 16-bit word (SHORT) has a count of 1 not 2.

4.1.2.6 Types

The field types and their sizes are:

1=BYTE	8-bit unsigned integer.
2=ASCII	8-bit byte that contains a 7-bit ASCII code; the last byte shall be NUL (binary zero).
3=SHORT	16-bit (2-byte) unsigned integer.
4=LONG	32-bit (4-byte) unsigned integer.
5=RATIONAL	Two LONGs: the first represents the numerator of a fraction, the second represents the denominator.
6=SBYTE	An 8-bit signed (twos-complement) integer.
7=UNDEFINED	An 8-bit byte that may contain anything, depending on the definition of the field.
8=SSHORT	A 16-bit (2-byte) signed (twos-complement) integer.
9=SLONG	A 32-bit (4-byte) signed (twos-complement) integer.
10=SRATIONAL	Two SLONGs: the first represents the numerator of the fraction, the second represents the denominator.
11=FLOAT	Single precision (4-byte) IEEE format.
12=DOUBLE	Double precision (8-byte) IEEE format.

WARNING — It is possible that other TIFF field types will be added in the future. Readers should ignore fields containing an unexpected field type.

The value of the count part of an ASCII field entry includes the NUL. If padding is necessary, the count does not include the pad byte. Note that there is no initial count byte as in Pascal-style strings. Any ASCII field can contain multiple strings, each terminated with a NUL. A single string is preferred whenever possible. The count for multistring fields is the number of bytes in all strings in that field plus their terminating NUL bytes. Only one NUL is allowed between strings, so that the strings following the first string will often begin on an odd byte.

The reader shall check the type to verify that it contains an expected value. TIFF currently allows more than 1 valid type for some fields. For example, ImageWidth and ImageLength are usually specified as having type SHORT. But images with more than 64K rows or columns shall use the LONG field type. TIFF readers should accept BYTE, SHORT or LONG values for any unsigned integer field. This allows a single procedure to retrieve any integer value, makes reading more robust and saves disk space in some situations.

Each TIFF field has an associated count. This means that all fields are actually one-dimensional arrays, even though most fields contain only a single value. For example, to store a complicated data structure in a single private field, use the UNDEFINED field type and set the count to the number of bytes required to hold the data structure.

4.1.3 Vendor unique information

Each camera manufacturer may choose to store additional information in the form of private tags or private tag-values. This can be done by obtaining private tags and/or tag-values for TIFF 6.0 tags from the Adobe Developers Desk and vendor unique tag-values from PIMA/IT10 for the new TIFF/EP defined tags. When storing additional vendor unique information within TIFF/EP files, care shall be taken not to violate the TIFF/EP guidelines described in this part of ISO 12234.

4.2 Image data

The image width, i.e. horizontal or X dimension, is recorded as a binary value in the **ImageWidth** tag-field. The image width may be the shorter or longer dimension of the image, depending upon the orientation of the camera during image capture. The image orientation is defined by the **Orientation** tag-field. The image length, i.e. vertical or Y dimension, is recorded as a binary value in the **ImageLength** tag-field. The camera's desired image output rendering resolution in the X-dimension, i.e. the horizontal dimension when the camera is normally oriented, is recorded using the **XResolution** tag-field, while the output resolution in the Y-dimension is recorded in the **YResolution** tag-field. The **ResolutionUnits** tag-value gives the units for the **XResolution** and **YResolution** values. These mandatory TIFF 6.0 tag-fields are typically used to determine the default size of the image on the screen. They do not indicate the sample spacing of the image sensor in an electronic still-picture camera. The latter is given in the **FocalPlaneXResolution**, **FocalPlaneYResolution** and **FocalPlaneResolutionUnits** tag-values. The pixel aspect ratio (ratio of the pixel width to pixel height) is determined by the ratio of the **XResolution** and **YResolution** values. The recommended TIFF/EP pixel aspect ratio is 1:1 (square), so that **XResolution** equals **YResolution**.

The number of colour components or samples per pixel in the image is recorded using the **SamplesPerPixel** tag-field as a binary value. For example, an image captured using a monochrome sensor has only one colour component or sample per pixel, while a 3-sensor colour RGB camera has three colour components or samples per pixel. The number of bits needed to store each of the colour components (samples) is recorded using the **BitsPerSample** tag-field as a set of binary values. In the case of a monochrome image, the **BitsPerSample** tag-field contains only one value, equal to the actual number of bits per pixel. In the case of an RGB image having three colour samples per pixel, the **BitsPerSample** tag-field contains three values equal to the actual number of bits of storage used to store each component or sample. In the latter case, the number of bits for each colour-component could be different and hence is explicitly stated.

The type of image data components are provided by the **PhotometricInterpretation** tag-value. All TIFF/EP readers shall handle greyscale, RGB and YCbCr data. If YCbCr data values are stored, the number of Cb and Cr values may either be equal to the number of Y values or smaller owing to subsampling. The chrominance subsampling factors of a YCbCr image are encoded in the **YCbCrSubSampling** tag-field. This tag-field contains both the horizontal and vertical subsampling factors, which are labelled YCbCrSubSamplingHoriz and YCbCrSubSamplingVert respectively. The subsampling factors are given relative to the appropriate dimension of the corresponding luminance image. The positions of the subsampled chrominance components relative to the luminance samples are encoded in the **YCbCrPositioning** tag-field. The headroom/footroom image data values (codes) for each each pixel component associated with a YCbCr image is specified within the **ReferenceBlackWhite** tag-field. The pair of headroom/footroom values (codes) associated with the luminance component (Y) refer to this component's ReferenceWhite and ReferenceBlack. The pair of headroom/footroom values (codes) associated with the chrominance components, Cb and Cr, refer to these components' ReferenceBlack and ReferenceWhite, where here the ReferenceWhite value is used to code reference blue and reference red respectively.

The image data may optionally be stored using a single image component having a colour filter array (CFA) area pattern of the image data derived from a single-chip colour CCD image sensor. TIFF/EP readers are not required to handle this type of image data. The colour filter array area pattern is the repetitive spatial colour sampling pattern of photosites on the CCD image sensor. There are many different CFA-type CCDs which capture only one colour component per photosite on the CCD. The tags used to describe a CCD's CFA pattern are: **SamplesPerPixel**, **PlanarConfiguration**, ***CFARepeatPatternDim***, ***CFAPattern*** and ***SensingMethod***.

The image data is stored using either strips or tiles, which are collectively termed segments. If strips are used, the following tag-fields define the number of strips and the number of rows of image data stored in each strip: **StripOffsets**, **RowsPerStrip** and **StripByteCounts**. The image shall be divided into an integral number of strips, from one strip to the maximum number of strips, which equals the image's length. If necessary, the final strip can be "padded" with zeros. TIFF/EP recommends that the image data, prior to compression, does not exceed 64 Kbytes per strip. This value is chosen to maximize compatibility with various operating systems. The **StripOffsets** tag-field stores the offsets from the start of the image file to the start of each image data strip. In this way, the reader can easily access various parts of the image. The number of rows per strip is stored in the **RowsPerStrip** tag-field. The number of image data bytes stored within each strip is recorded in the **StripByteCounts** tag-field. The "strip" mechanism is very useful in accessing images, because it uses less buffer memory than would otherwise be needed to read in the entire image all at one time. The order of the image strips is from the top to the bottom of the image.

EXAMPLE ImageWidth = 768

ImageLength = 512

PhotometricInterpretation = 2 (RGB)

SamplesPerPixel = 3

BitsPerSample = 8,8,8

PlanarConfiguration = 1 (Chunky), i.e. RGBRGBRGB...

The size in bytes of each row in this image is 768 PixelsPerRow * (3 SamplesPerPixel * 8 BitsPerSample)/8 BitsPerByte ==> 2304 BytesPerRow. Assuming 8 rows of image data in each strip, the number of bytes per strip is 8 RowsPerStrip * 2304 BytesPerRow ==> 18,432 BytesPerStrip. The number of strips equals 512 Rows/8 RowsPerStrip ==> 64 strips.

If tiles are used, the following tag-fields define the number of tiles and the size of each tile: **TileWidth**, **TileLength**, **TileOffsets** and **TileByteCounts**. The image shall be divided into an integral number of tiles. The purpose of tiles is to provide the reader with the ability to perform image "panning", i.e. to view portions of the image on a display which is smaller than the overall image size. The **TileWidth** tag-field stores the width of the tile in pixels. The **TileLength** tag-field stores the length of the tile in rows. The **TileOffsets** tag-field stores the offsets from the start of the image file to the start of each image data tile. The number of image data bytes in each tile is recorded in the **TileByteCounts** tag-field. TIFF/EP recommends that the image data, prior to compression, does not exceed 64 Kbytes per tile.

Using the above example, the image could be broken up into 64 tiles each having a width of 96 pixels and a length of 64 pixels. Each tile would have a size in bytes of 96 PixelsPerTileWidth * 64 RowsPerTileLength * (3 SamplesPerPixel * 8 BitsPerSample)/8 BitsPerByte ==> 18,432 BytesPerTile, i.e. 18K BytesPerTile.

NOTE If the image data is compressed using JPEG, i.e. **Compression** tag-field contains the value of 7, each segment (strip or tile) shall contain a valid JPEG datastream according to the ISO JPEG standard's rules for interchange-format or abbreviated-image-format data.

4.3 Thumbnail images

There may be more than one IFD in a TIFF 6.0 file. Each IFD defines a *subfile*. One potential use of subfiles in TIFF 6.0 is to describe related images, such as the pages of a facsimile transmission. A baseline TIFF 6.0 reader is not required to read any IFDs beyond the first one.

In TIFF/EP files, the 0th IFD should be an image that can be read by a baseline TIFF 6.0 reader. Note that JPEG compression is not required for baseline TIFF 6.0 readers. Therefore, if the full-resolution image is stored using compression, the TIFF/EP file should include a thumbnail (reduced-resolution) image stored in the 0th IFD that is readable by a baseline TIFF 6.0 reader. This thumbnail should not be compressed, and should be stored in strips, rather than in tiles, in order to be fully compatible with TIFF 6.0. A ***SubIFDs*** tag in the 0th IFD is used to point to the compressed full-resolution image. If the full-resolution image is stored uncompressed as a baseline-readable TIFF image, the full-resolution image could be stored in the 0th IFD. However, TIFF/EP recommends that a thumbnail image be stored in the 0th IFD, regardless of whether the full-resolution image is baseline TIFF readable or not. This provides a version of the image that is small (relative to the full-resolution image) and that may be quickly accessed by reader software. The use of the ***SubIFDs*** tag is the TIFF recommended method of performing this "treeing" mechanism. The idea of IFD treeing via the use of the ***SubIFDs*** tag is described below. TIFF/EP uses the IFD "chaining" mechanism to store a "burst" motion sequence of temporally related images in the same TIFF/EP file. Figure 2 shows graphically an example of IFD treeing to store both the thumbnail image and the full resolution "main" image. This is done using the ***SubIFDs*** tag. The ***SubIFDs*** tag is used within a given IFD to initiate a "tree" or "branch" to another IFD describing another rendition of the same image within a TIFF/EP file. This tag is described in detail in the tag-definition section of this document. The ***SubIFDs*** tag is not described in the TIFF 6.0 specification, but is described in "TIFF Technical Note 1: TIFF Trees" available from Adobe Corporation. This technical note describes the mechanism to use if treeing is needed. The TIFF/EP ***SubIFDs*** tag value provides the offset from the start of the TIFF/EP file to the beginning of the IFD for the full resolution image. The **NewSubFileType** tag identifies the image as a full resolution image. This IFD treeing technique, using the

SubIFDs and **NewSubFileType** tags, is a clear and unambiguous method associating the thumbnail images and main images. IFD treeing is used instead of IFD chaining because TIFF/EP recommends that chaining be used to store a burst of temporally related images in the same file, as described in 4.4.

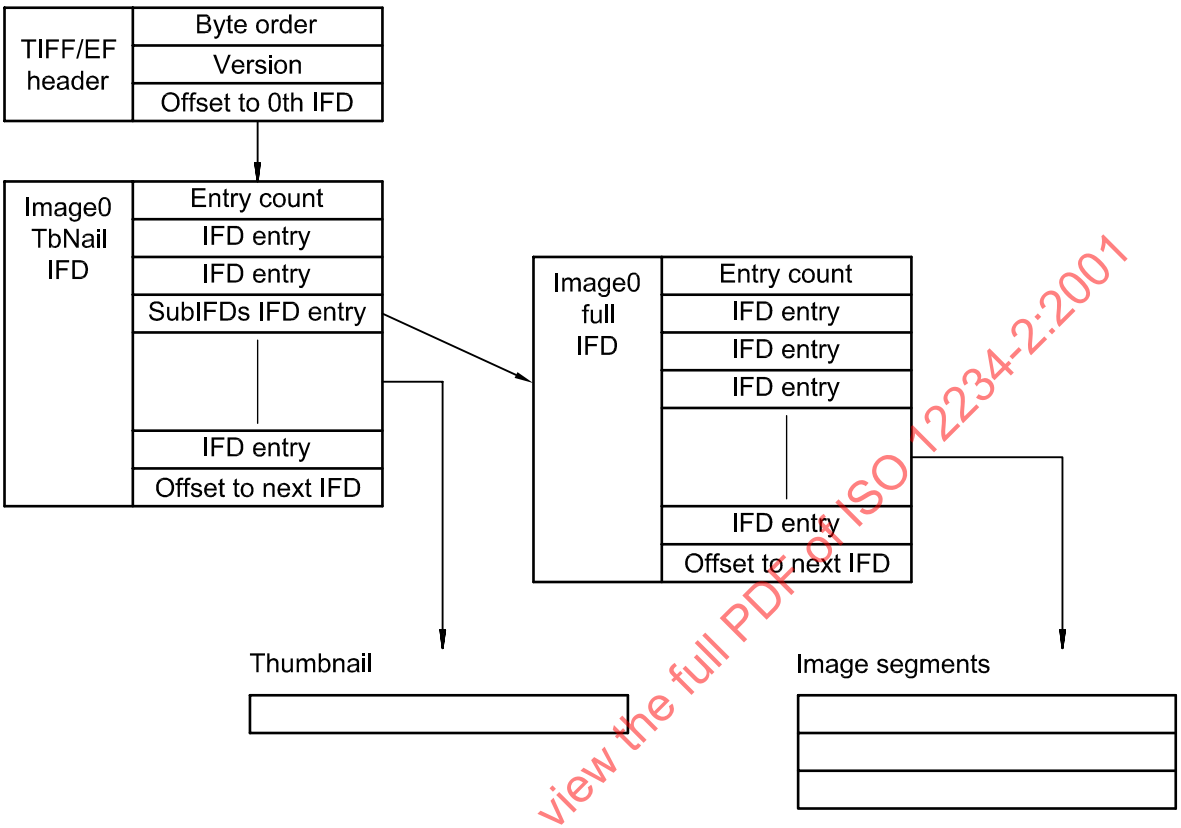

Figure 2 — TIFF/EP encoding structure with treeing

TIFF/EP requires that the thumbnail image be stored in strips, so that the thumbnails may be read by any baseline TIFF 6.0 reader. The dimensions of the thumbnail image are restricted by TIFF/EP to 256 pixels maximum horizontally and 256 pixels maximum vertically. The following tag-fields are necessary to define the number of strips and the number of rows of thumbnail image data stored in each strip: **StripOffsets**, **RowsPerStrip** and **StripByteCounts**.

In the example below, the thumbnail image has one eighth the number of lines and one eighth the number of pixels per line as its parent image. The thumbnail image is a single strip which holds the thumbnail image data. The **StripOffsets** tag-field stores the offset from the start of the image file to the start of the thumbnail image data strip. The number of rows per strip, i.e. 64 rows, is stored in the **RowsPerStrip** tag-field. The number of thumbnail image data bytes stored in the strip is recorded in the **StripByteCounts** tag-field.

EXAMPLE Parent ImageWidth = 768

Parent ImageLength = 512

Parent PhotometricInterpretation = 2 (RGB)

Parent SamplesPerPixel = 3

Parent BitsPerSample = 8,8,8

Parent PlanarConfiguration = 1 (Chunky), i.e. RGBRGBRGB...

Thumbnail ImageWidth = 96

Thumbnail ImageLength = 64

Thumbnail PhotometricInterpretation = 2 (RGB)

Thumbnail SamplesPerPixel = 3

Thumbnail BitsPerSample = 8,8,8

Thumbnail PlanarConfiguration = 1 (Chunky), i.e. RGBRGBRGB...

The size in bytes of the single thumbnail image strip is 96 PixelsPerRow * (3 SamplesPerPixel * 8 BitsPerSample)/8 BitsPerByte ==> 288 BytesPerRow. We are storing 64 rows of thumbnail image data in the strip, hence the number of bytes per strip is 64 RowsPerStrip * 288 BytesPerRow ==>18,432 BytesPerStrip. The number of strips is equal to 64 Rows/64 RowsPerStrip ==> 1 strip.

4.4 Burst sequences using chaining

Figure 3 shows how TIFF/EP allows image chaining to be used to store a burst motion sequence of temporally related images. The Image0 IFD stores the first image in the sequence, the Image1 IFD stores the second image in the sequence and so on. Therefore, the IFD numbers indicate the temporal sequence of the burst of images. By storing the entire sequence in a single TIFF/EP file via chaining, the sequence is encapsulated in a way that allows it to be copied without losing images or altering the image sequence. As noted earlier, the **SubIFDs** tag provides the mechanism to store both thumbnail and main images for each temporal sample of the "chain" all in the same TIFF/EP file.

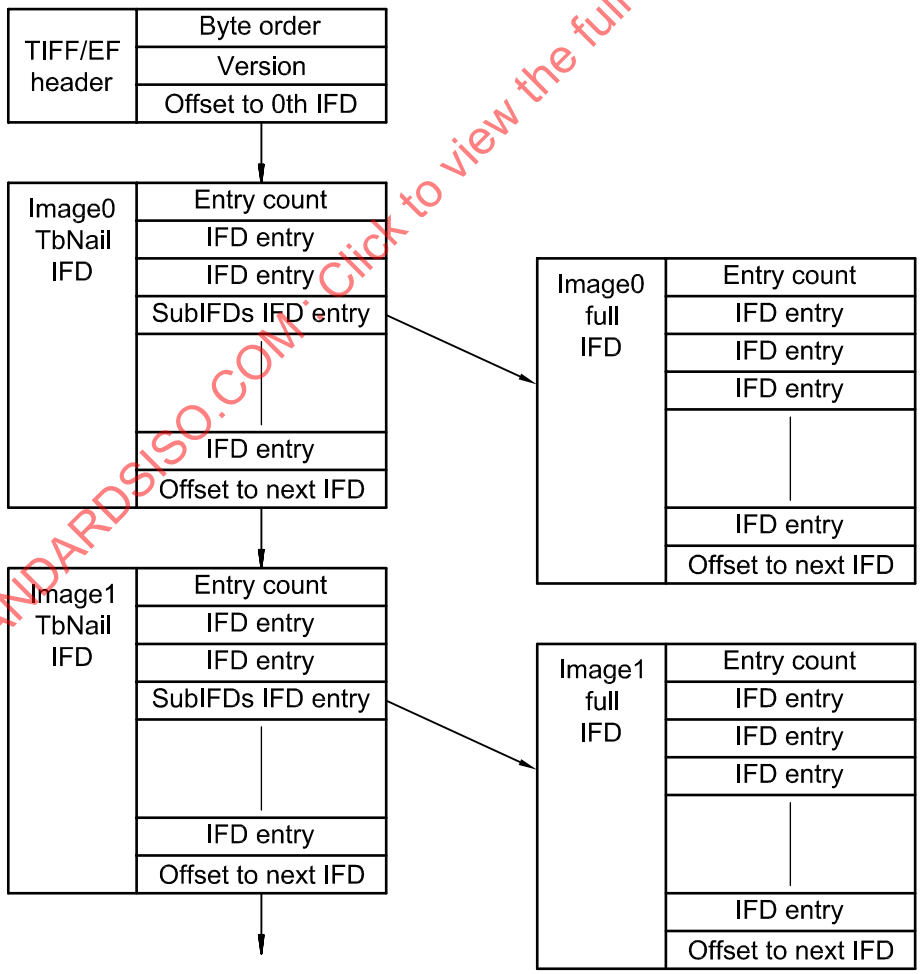

Figure 3 — TIFF/EP encoding structure with image chaining

TIFF/EP recommends that chaining be used to store a motion sequence burst of images. Note that if chaining is used for both thumbnails and motion sequences, readers could be confused by the relationships between IFDs in the file. Neither TIFF/EP nor TIFF 6.0 requires baseline readers to read past the first image in the chain. Note that if image categorization or databasing is required, the filing system should provide this mechanism. Image chaining should not be used for this purpose. The definition of a filing system for image databasing is outside the scope of the TIFF/EP specification.

4.5 Camera colour space information

The ICC (InterColour) profile, contained in the ***InterColourProfile*** tag-field, may be used to provide the information required to interpret the digital code values of a colour image. Note that the ICC profile format may be revised in the future and the most recent version of the ICC specification should be used. To prevent duplication and confusion, the TIFF 6.0 PrimaryChromaticities, WhitePoint and TransferFunction tags are not allowed in TIFF/EP, since this same information is specified within the ***InterColourProfile*** tag value. In some applications, the use of an ICC profile may be inadequate to achieve the desired level of camera colour charactization. In these applications, the camera spectral sensitivities and OECF (opto-electronic conversion function) may be provided, using the ***SpectralSensitivity*** and ***OECF*** tag values, in order to provide the desired camera colour characterization information.

The target colour space describes the number and type of colour components and is recorded in the **PhotometricInterpretation** tag-field. The allowed target colour spaces are greyscale, RGB, YCbCr and CFA (colour filter array).

The chromaticities of the primaries of the image are encoded using the redColourantTag, greenColourantTag and blueColourantTag values within the ***InterColourProfile*** tag value. The chromaticity of the white point of the image is encoded using the mediaWhitePointTag values within the ***InterColourProfile*** tag value.

The transfer function which indicates the meaning of each image data code is encoded using the redTRCTag, greenTRCTag and blueTRCTag values within the ***InterColourProfile*** tag value. The recommended TIFF/EP reference colour primaries and opto-electronic conversion function (gamma correction) are equal to the values given in ITU-R BT.709: 1993, “Basic parameter values for the HDTV standard for the studio and for international programme exchange”.

The coefficients used in the transformation from RGB to YCbCr image data are encoded in the **YCbCrCoefficients** tag-field as 3 RATIONAL numbers, i.e. LumaRed, LumaGreen and LumaBlue. These three coefficients are the proportions of red, green and blue respectively in the luminance (Y) channel. This tag is only necessary if the image data is stored in YCbCr form.

4.6 Image data compression

This data feature indicates the type of image data compression. The compression method is stored in the **Compression** tag-field as a binary value. If no compression is used, a value of 1 is recorded in this tag-field. Other values indicate some form of image compression. For compressed images, the average number of bits per pixel may be recorded using the ***CompressedBitsPerPixel*** tag-field.

4.6.1 Baseline JPEG compression

All TIFF/EP readers shall support the DCT (lossy) baseline version of the TIFF/JPEG compression method defined by the Independent JPEG Group and described in TIFF technical note number 2. This compression method is in accordance with ISO/IEC 10918-1:1994. To indicate JPEG compression, a value of 7 is stored in the **Compression** tag-field as a binary value. JPEG compression works in either strip-based or tile-based TIFF/EP files. The term “segment” refers to either a strip or a tile. When the **Compression** tag-field has the value 7, each image segment contains a complete JPEG datastream which is valid according to the ISO JPEG standard (ISO/IEC 10918-1). TIFF/EP requires that readers only support baseline (lossy DCT) based compression.

Each image segment in a JPEG-compressed TIFF/EP file shall contain a valid JPEG datastream according to the ISO JPEG standard’s rules for interchange-format (including JPEG quantization and Huffman tables) or

abbreviated-image-format (without JPEG quantization and Huffman tables) data. The datastream shall contain a single JPEG frame storing that segment of the image. The required JPEG markers within a segment are:

— SOI (start of image, shall appear at the very beginning of the segment)

— SOFn (start of frame)

— SOS (start of scan, one for each scan)

— EOI (end of image, shall appear at the very end of the segment)

The actual compressed data follows SOS. It may contain RSTn (restart) markers if DRI (define restart interval) is used.

Additional JPEG “tables and miscellaneous” markers may appear between SOI and SOFn, between SOFn and SOS and before each subsequent SOS if there is more than one scan. These markers can include:

— DQT (define quantization tables)

— DHT (define Huffman tables)

— DRI (define restart interval)

— APPn (define application markers, see note below)

— COM (comment, ignored by TIFF/EP readers)

APPn application markers may be included in the JIF bitstream. TIFF/EP readers are not required to read Appn markers. The EXIF image format uses application marker 1 and the SPIFF image format uses application marker 8. In the case of EXIF, the second word of the APP1 data is the TIFF number 42. When both APP1 and the TIFF number 42 are identified, the APP1 data includes EXIF tags. In the case of SPIFF, the three byte IDENT indentifier in the APP8 data contains the value “SPF”. When both APP8 and “SPF” are identified, the APP8 data includes SPIFF tags.

DNL (define number of lines) markers shall not be used in TIFF files. Readers should abort if any other marker type is found, especially the JPEG reserved markers. Such markers are likely to indicate a JPEG extension.

The tables/miscellaneous markers may appear in any order. Readers are cautioned that, although the SOFn marker refers to DQT tables, JPEG does not require those tables to precede the SOFn, only the SOS. Missing-table checks should be made when SOS is reached.

4.6.2 JPEG tables

When JPEG compression is used, no other compression related tag-fields are required, but the optional **JPEGTables** tag may be used. This optional tag encodes the JPEG quantization and Huffman tables for subsequent use by the JPEG decompression process. The **JPEGTables** tag is useful when the image is stored in multiple segments, in order to reduce the file size. When the **JPEGTables** tag is present, it shall contain a valid JPEG “abbreviated table specification” datastream, beginning with SOI and ending with EOI. It contains one or more JPEG tables, including DQT (define quantization tables) and DHT (define Huffman tables). When a TIFF/EP reader decodes a JPEG compressed image having the optional **JPEGTables** tag, it is prudent for the reader to send the **JPEGTables** abbreviated bitstream prior to each JPEG compressed image segment. This eliminates the need for the TIFF/EP reader to manually determine which JPEG compressed image segments require these tables.

If no **JPEGTables** tag-field is used, then each segment shall be a complete JPEG interchange datastream. Each segment shall define all the tables it references. To allow readers to decode segments in any order, no segment may rely on tables being carried over from a previous segment.

4.6.3 JPEG lossless compression

TIFF/EP files may optionally use lossless JPEG compression, but TIFF/EP readers are not required to decompress these images. A TIFF/EP reader is only required to open the uncompressed thumbnail image that may be present in IFD0. The recommended form of JPEG lossless compression is lossless sequential DPCM using Huffman coding.

4.6.4 Other JPEG compression options

TIFF/EP files may optionally use other JPEG versions, but TIFF/EP readers are not required to decompress these images. A TIFF/EP reader is only required to open the uncompressed thumbnail image that may be present in IFD0.

4.6.5 Vendor unique compression

TIFF/EP files may optionally support vendor unique compression. This can be done by obtaining a private compression tag value from Adobe Systems Incorporated. However, a TIFF/EP reader is only required to open the uncompressed thumbnail image that may be present in IFD0. Vendor unique compression is allowed so that new image formats are not necessary to support some special electronic camera applications.

4.7 Camera information

These are mandatory tags. The camera's "make" is recorded via the **Make** tag-field as an ASCII string. The camera's "model" is recorded via the **Model** tag-field as an ASCII string. The version of software and/or firmware used in the camera to capture and store the TIFF/EP image file is encoded in the **Software** tag-field as an ASCII string.

4.8 Picture annotation

Information recorded with an image that describes and documents the image is called "picture information". The date and time that a given image was originally captured, is recorded using the ***DateTimeOriginal*** tag-field. The date that a given image was last modified, i.e. altered in a way that modifies any image data values, is recorded using the **DateTime** tag-field. For each modification, an associated update to the image's history should be logged. The ***TimeZoneOffset*** tag-field may be used to indicate the time zone of the clocks which generated the ***DateTimeOriginal*** and **DateTime** tag-fields. A string that describes the subject or purpose of the image is recorded using the **ImageDescription** tag-field. A sequence number may be assigned to an image using the ***ImageNumber*** tag-field. This provides a simple image ordering capability which can help readers determine the order in which multiple images were captured. The name of the photographer or image creator is recorded using the **Artist** tag-field as an ASCII string. The owner of the image is recorded using the **Copyright** tag-field as an ASCII string. Pertinent editorial information about the image for news photo applications may be recorded using the ***IPTC/NAA*** tag-field.

The ***SecurityClassification*** tag-field may be used to describe the security classification rating, classification authority and future declassification of an image. The definition of this feature is described in the NITF (National Imagery Transmission Format) specification (MIL-STD-2500).

A list documenting changes to the image data may be recorded in the ***ImageHistory*** tag-field as an ASCII string. As changes are made, additional information about the changes can be concatenated to the previous string.

4.9 Camera and lens settings

These tag values provide the camera settings used when the image was captured. All these tags are optional. In many cases, the settings may be given in either conventional units (seconds, etc.) or in APEX (Additive System of Photographic Exposure) units.

The type of scene illuminant (daylight, tungsten, etc.) is encoded in the ***SceneIlluminant*** tag-field as one of several enumerated VALUEs. Alternatively, the colour temperature of the illuminant is reported. The lens f-number (ratio of lens aperture to focal length) can be recorded as a RATIONAL value using the ***FNumber*** tag-field. Alternatively,

the value may be recorded in the ***Aperture*** tag-field using APEX units. The exposure time used to capture the image can be recorded using the ***ExposureTime*** tag-field as a RATIONAL value containing fractional seconds. Alternatively, the value may be recorded in the ***ShutterSpeed*** tag-field using APEX units.

The exposure bias (i.e. the amount of over- or under-exposure relative to a normal exposure as determined by the camera's exposure system) used to capture the image can be encoded in the ***ExposureBias*** tag-field using APEX units.

The metering mode, for example the camera's method of spatially weighting the scene luminance values to determine the sensor exposure, is encoded in the ***MeteringMode*** tag-field as an enumerated VALUE. Metering modes include simple average, centre-weighted-average, etc. The exposure program used by the camera to set the appropriate capture trade-offs (shutter speed, aperture, etc.) in order to properly expose the image being captured, is encoded within the ***ExposureProgram*** tag-field as an enumerated VALUE. The camera self-timer mode of operation may be specified within the ***SelfTimerMode*** tag-field.

The exposure index setting of the camera used to capture the image is encoded in the ***ExposureIndex*** tag-field as a RATIONAL value. For example, an exposure index of 100 is encoded as 100/1. ISO 12233:1998 shall be used in determining the exposure index value. An exposure index is a numerical value that is inversely proportional to the exposure provided to an image sensor to obtain an image. Images obtained from a camera using a range of exposure index values will normally provide a range of image quality levels. The ISO speed ratings of the electronic still-picture camera are values calculated from the exposure provided at the focal plane of the camera and the resulting camera output signal characteristics. The two ratings are the ISO speed, which is encoded as a single short value, and the ISO speed latitude, which is encoded as two short values. Some electronic still-picture cameras may not have an ISO speed latitude.

NOTE Care should be taken to avoid confusing the ISOSpeedRatings and ExposureIndex tags. The values encoded in the ISOSpeedRatings tag are those determined for the ISO speed of an electronic still-picture camera. The value encoded in the ExposureIndex tag corresponds to the focal plane exposure provided by the camera settings in capturing each image. For example, if the ISO speed ratings of a camera are 50 for the primary noise speed, 25 for the saturation speed and 400 for the upper limit noise speed, then the values 50 (25-400) are recorded in the ISOSpeedRatings tag for all images taken with the camera. If the same camera is used to capture an image with f-number and exposure time settings that produce an arithmetic mean focal plane exposure of 1/20 lux second, the value 200/1 is encoded in the ExposureIndex tag. In summary, the ExposureIndex tag tracks the exposure used to capture each image taken by the camera, while the ISOSpeedRatings tag provides information about the measured ISO speed values of the camera.

The camera lens focal length in millimetres, used to capture the image, is encoded in the ***FocalLength*** tag-field. The distance between the front nodal plane of the camera lens and the subject on which the camera is focused, can be recorded in the ***SubjectDistance*** tag-field. The location of the centre of the main subject in the image may be recorded using the ***SubjectLocation*** tag-field. The scene brightness measured in BVs (Brightness Value) present when the image was captured, is encoded in the ***BrightnessValue*** tag-field using APEX units. The camera lens maximum aperture value, i.e. maximum f/number, is recorded using the ***MaxApertureValue*** tag-field.

Whether or not flash was used when the image was captured can be encoded in the ***Flash*** tag-field. The amount of flash energy, i.e. flash guide number used, can be encoded in the ***FlashEnergy*** tag-field. The battery level may be indicated by the ***BatteryLevel*** tag-field.

4.10 Camera characterization

These are optional tags that describe the performance of the camera used to capture the image file. The camera's focal plane resolution in the X-dimension, i.e. the horizontal dimension when the camera is normally oriented, is recorded using the ***FocalPlaneXResolution*** tag-field. This information, along with the focal plane resolution in the Y-dimension (***FocalPlaneYResolution***) and the resolution units (***FocalPlaneResolutionUnit***) can be used to relate the image data to the camera focal plane dimensions. The camera's "spatial frequency response", which quantifies the camera resolution, may be recorded in the ***SpatialFrequencyResponse*** tag-field. The camera's "noise" level may be recorded in the ***Noise*** tag-field.

5 TIFF/EP tag definitions

This section lists and describes all the allowed tags and tag values for TIFF/EP. Tags defined in the TIFF 6.0 specification are shown in bold type. Tags which are not described in TIFF 6.0 are shown in italic bold type.

5.1 TIFF/EP tag list

Table 1 lists all allowed tags for storing both uncompressed and compressed images and indicates whether the tag is mandatory (M), recommended (R), optional (O), or not allowed (N). All mandatory tags shall be included in the IFD, since default values are not allowed in TIFF/EP, even in cases where default values are given in TIFF 6.0. Table 1 is arranged in ascending tag number order. Both TIFF 6.0 and TIFF/EP require that the tags within the IFD be arranged in ascending order, by tag number. Following Table 1, the purpose and allowed values for each tag are described in detail. Those tags not specifying possible “values” and/or “number of values” are variable and any value may be used, provided any restrictions listed are followed. Either all M1 tags shall be present for strips, or all M2 tags shall be present for tiles, but not both. M3 tags shall be present for YCC images.

Table 1 — TIFF/EP tags, in tag number order

Tag name	Dec.	Hex	Type	No. of values	Compression	
					None	JPEG
NewSubFileType [a]	254	FE	LONG	1	M	M
ImageWidth [b]	256	100	SHORT or LONG	1	M	M
ImageLength [b]	257	101	SHORT or LONG	1	M	M
BitsPerSample [b]	258	102	SHORT	SamplesPerPixel	M	M
Compression [a]	259	103	SHORT	1	M	M
PhotometricInterpretation [a]	262	106	SHORT	1	M	M
ImageDescription [a]	270	10E	ASCII	any	M	M
Make [a]	271	10F	ASCII	any	M	M
Model [a]	272	110	ASCII	any	M	M
StripOffsets [b]	273	111	SHORT or LONG	StripsPerImage	M1	M1
Orientation [a]	274	112	SHORT	1	O	O
SamplesPerPixel [b]	277	115	SHORT	1	M	M
RowsPerStrip [b]	278	116	SHORT or LONG	1	M1	M1
StripByteCounts [b]	279	117	SHORT or LONG	StripsPerImage	M1	M1
XResolution [b]	282	11A	RATIONAL	1	M	M
YResolution [b]	283	11B	RATIONAL	1	M	M
PlanarConfiguration [b]	284	11C	SHORT	1	M	M
ResolutionUnit [b]	296	128	SHORT	1	M	M
Software [a]	305	131	ASCII	any	M	M
DateTime [a]	306	132	ASCII	20	M	M
Artist [b]	315	13B	ASCII	any	O	O
TileWidth [b]	322	142	SHORT or LONG	1	M2	M2
TileLength [b]	323	143	SHORT or LONG	1	M2	M2
TileOffsets [b]	324	144	LONG	TilesPerImage	M2	M2

Table 1 *(continued)*

Tag name	Dec.	Hex	Type	No. of values	Compression	
					None	JPEG
TileByteCounts [b]	325	145	SHORT or LONG	TilesPerImage	M2	M2
SubIFDs [c]	330	14A	LONG	any	R	R
JPEGTables [b]	347	15B	UNDEFINED	any	O	O
YCbCrCoefficients [b]	529	211	RATIONAL	3	M3	M3
YCbCrSubSampling [b]	530	212	SHORT	2	M3	M3
YcbCrPositioning [b]	531	213	SHORT	1	M3	M3
ReferenceBlackWhite [b]	532	214	RATIONAL	6	M3	M3
CFARepeatPatternDim	33421	828D	SHORT	2	O	O
CFAPattern	33422	828E	BYTE	CFARepeatRows * CFARepeatCols	O	O
BatteryLevel [c]	33423	828F	RATIONAL or ASCII	1 or any	O	O
Copyright [a]	33432	8298	ASCII	any	M	M
ExposureTime [d]	33434	829A	RATIONAL	1 or 2	O	O
Fnumber [d]	33437	829D	RATIONAL	1 or 2	O	O
IPTC/NAA [e]	33723	83B B	LONG or ASCII	any	O	O
InterColourProfile [f]	34675	8773	UNDEFINED	any	R	R
ExposureProgram [d]	34850	8822	SHORT	1	O	O
SpectralSensitivity [d]	34852	8824	ASCII	any	O	O
GPSInfo [d]	34853	8825	LONG	1	O	O
ISOSpeedRatings [d]	34855	8827	SHORT	3	O	O
OECF [d]	34856	8828	UNDEFINED	any	O	O
Interlace	34857	8829	SHORT	1	O	O
TimeZoneOffset	34858	882A	SSHORT	1 or 2	O	O
SelfTimerMode	34859	882B	SHORT	1	O	O
DateTimeOriginal [d]	36867	9003	ASCII	20	M	M
CompressedBitsPerPixel [d]	37122	9102	RATIONAL	1	N	O
ShutterSpeedValue [d]	37377	9201	RATIONAL	1	O	O
ApertureValue [d]	37378	9202	RATIONAL	1	O	O
BrightnessValue [d]	37379	9203	SRATIONAL	1 or 2	O	O
ExposureBiasValue [d]	37380	9204	SRATIONAL	1 or 2	O	O
MaxApertureValue [d]	37381	9205	RATIONAL	1	O	O
SubjectDistance [d]	37382	9206	SRATIONAL	1 or 2	O	O
MeteringMode [d]	37383	9207	SHORT	1	O	O
LightSource [d]	37384	9208	SHORT	1	O	O

Table 1 *(continued)*

Tag name	Dec.	Hex	Type	No. of values	Compression	
					None	JPEG
Flash [d]	37385	9209	SHORT	1	O	O
FocalLength [d]	37386	920A	RATIONAL	1 or 2	O	O
FlashEnergy	37387	920B	RATIONAL	1 or 2	O	O
SpatialFrequencyResponse [c]	37388	920C	UNDEFINED	any	O	O
Noise	37389	920D	UNDEFINED	any	O	O
FocalPlaneXResolution [c]	37390	920E	RATIONAL	1	R	R
FocalPlaneYResolution [c]	37391	920F	RATIONAL	1	R	R
FocalPlaneResolutionUnit [c]	37392	9210	SHORT	1	R	R
ImageNumber	37393	9211	LONG	1	O	O
SecurityClassification	37394	9212	ASCII	1 or any	O	O
ImageHistory	37395	9213	ASCII	any	O	O
SubjectLocation [c]	37396	9214	SHORT	2 or 3 or 4	O	O
ExposureIndex [c]	37397	9215	RATIONAL	1 or 2	O	O
TIFF/EPStandardID	37398	9216	BYTE	4	M	M
SensingMethod [c]	37399	9217	SHORT	1	R	R

[a] Tag number and tag values are specified in TIFF Revision 6 specification, Adobe Corporation, 1992. Additional tag values, or additional restrictions on allowed tag values, are specified in this part of ISO 12234.

[b] Tag number and tag values are identical to those defined in TIFF Revision 6 specification, Adobe Corporation, 1992.

[c] SubIFDs tag is defined in TIFF Technical Note 1: TIFF Trees, Adobe Corporation.

[d] The tag name and values for this tag number defined in this part of ISO 12234 are equivalent to those defined in Digital Still Camera File Format Standard (Exchangeable image file format for Digital Still Camera: Exif), Version 2.1, June 1998, Japan Electronic Industry Development Association (JEIDA).

[e] Tag name and values for this tag are defined by IPTC-NAA (International Press Telecommunications Council – Newspaper Association of America) Information Interchange Model and Digital Newsphoto Parameter Record.

[f] InterColourProfile tag is defined in ICC.1:2001, File Format for Colour Profiles.

In each of the tag definitions to follow, there are no default values, in order to enhance interoperability. When a list of possible values is presented, the values listed are the only allowed values. Note that the list of allowed values in some cases is more limited than in the TIFF 6.0 specification.

When the value cannot fit in the 4-byte Value-Offset location in the tag-field, then the Value-Offset is an offset from the beginning of the file to the location where the values for this tag may be found.

5.2 TIFF/EP tag definitions grouped by function

5.2.1 TIFF/EPStandardID

This tag encodes the version of this TIFF/EP file as a four tier revision number, for example 1.0.0.0. This revision number has the form of w.x.y.z where w=0-255, x=0-255, y=0-255, and z=0-255. The purpose of this tag is to allow a TIFF/EP compliant file to identify itself to a TIFF/EP aware reader.

Tag Name = ***TIFF/EPStandardID***

Tag = 37398 (9216.H)

Type = BYTE

N = 4

Value = VALUE (see below)

For the current version of TIFF/EP, ***TIFF/EPStandardID*** tag value shall equal the following four bytes: 1 0 0 0.

Usage: IFD0

5.2.2 ImageWidth

This tag encodes the number of columns in the image, i.e. the number of pixels per line. This tag is mandatory and there is no default value. The image width may be the shorter or longer dimension of the image, depending upon the orientation of the camera during image capture.

Tag Name = **ImageWidth**

Tag = 256 (100.H)

Type = SHORT or LONG

N = 1

Value = VALUE (any value representing the image width)

Usage: Main Image, Thumbnail Image

5.2.3 ImageLength

This tag encodes the number of rows in the image, i.e. the number of lines in the image. This tag is mandatory and there is no default value. The image length may be the shorter or longer dimension of the image, depending upon the orientation of the camera during image capture.

Tag name = **ImageLength**

Tag = 257 (101.H)

Type = SHORT or LONG

N = 1

Value = VALUE (any value representing the image length)

Usage: Main Image, Thumbnail Image

5.2.4 NewSubFileType

This tag indicates whether the given IFD is a thumbnail or main (full-size) image. This tag is mandatory and there is no default value. The value shall be explicitly stated. If the current image is the main image, rather than the "thumbnail" image, a value of 0 shall be encoded in this field.

Tag Name = **NewSubFileType**

Tag = 254 (FE.H)

Type = LONG

N = 1

Value = VALUE (32 bit field as described below)

Bit 0	1 if the image is a "thumbnail", else 0
Bit 1	N/A
Bit 2	N/A

Usage: Main Image, Thumbnail Image

5.2.5 SubIFDs

This tag encodes the offsets from the beginning of the file to the location of IFDs that are treeing from the current IFD. This tag-value is used to point from the thumbnail IFD to the IFD containing the full resolution image. For a full description refer to the section entitled "Thumbnail Images using 'SubIFDs' Trees".

Tag Name = ***SubIFDs***

Tag = 330 (14A.H)

Type = LONG

N = number of child IFDs

Value = VALUE or VALUE_OFFSET

The Value will contain the offset to the "treed" IFD itself if N=1, otherwise the Value will contain an offset to a location containing an array of offsets to each IFD being treed from the current IFD. This array of offsets will contain N entries, i.e. offset pointers to N IFDs. Currently, N=1 and the Value contains the offset to the IFD containing the full resolution image.

Usage: IFD0

5.2.6 XResolution

This tag encodes the number of pixels per **ResolutionUnit** in the **ImageWidth** direction. This tag specifies the desired ouput rendering **XResolution**. This tag is mandatory and there is no default value.

Tag Name = **XResolution**

Tag = 282 (11A.H)

Type = RATIONAL

N = 1

Value = VALUE_OFFSET (any legal rational number may be used)

Usage: Main Image, Thumbnail Image

(See **YResolution, ResolutionUnit)**

5.2.7 YResolution

This tag encodes the number of pixels per **ResolutionUnit** in the **ImageLength** direction. This tag specifies the desired output rendering **YResolution**. This tag is mandatory and there is no default value.

Tag Name = **YResolution**

Tag = 283 (11B.H)

Type = RATIONAL

N = 1

Value = VALUE_OFFSET (any legal rational number may be used)

Usage: Main Image, Thumbnail Image

(See **XResolution, ResolutionUnit)**

5.2.8 ResolutionUnit

This tag encodes the unit of measurement for the **XResolution** and **YResolution**. This tag is mandatory and there is no default value.

Tag Name = **ResolutionUnit**

Tag = 296 (128.H)

Type = SHORT

N = 1

Value = VALUE (possible values listed below)

1	No absolute unit of measurement.
2	Inch
3	Centimetre

Usage: Main Image, Thumbnail Image

(See **XResolution, YResolution)**

5.2.9 FocalPlaneXResolution

This optional tag encodes the number of pixels per ***FocalPlaneResolutionUnit*** in the **ImageWidth** direction for the main image. This tag specifies the actual ***FocalPlaneXResolution*** at the focal plane of the camera.

Tag Name = ***FocalPlaneXResolution***

Tag = 37390 (920E.H)

Type = RATIONAL

N = 1

Value = VALUE_OFFSET (any legal rational number may be used)

Usage: IFD0

(See ***FocalPlaneYResolution, FocalPlaneResolutionUnit)***

5.2.10 FocalPlaneYResolution

This tag encodes the number of pixels per ***FocalPlaneResolutionUnit*** in the **ImageLength** direction for the main image. This tag specifies the actual ***FocalPlaneYResolution*** at the focal plane of the camera.

Tag Name = ***FocalPlaneYResolution***

Tag = 37391 (920F.H)

Type = RATIONAL

N = 1

Value = VALUE_OFFSET (any legal rational number may be used)

Usage: IFD0

(See ***FocalPlaneXResolution, FocalPlaneResolutionUnit)***

5.2.11 FocalPlaneResolutionUnit

This tag encodes the unit of measurement for the ***FocalPlaneXResolution*** and ***FocalPlaneYResolution***.

Tag Name = ***FocalPlaneResolutionUnit***

Tag = 37392 (9210.H)

Type = SHORT

N = 1

Value = VALUE (possible values listed below)

1	Inch
2	Metre
3	Centimetre
4	Millimetre
5	Micrometre

Usage: IFD0

(See ***FocalPlaneXResolution***, ***FocalPlaneYResolution)***

5.2.12 Orientation

This optional tag encodes the orientation of the camera relative to the scene, when the image was captured.

Tag Name = **Orientation**

Tag = 274 (112.H)

Type = SHORT

N = 1

Value = VALUE (possible values are listed below)

1	The 0th row represents the visual top of the image and the 0th column represents the visual left-hand side. The camera orientation is known to be in the normal “landscape” orientation.
3	The 0th row represents the visual bottom of the image and the 0th column represents the visual right-hand side. Normal orientation rotated 180 degrees.
6	The 0th row represents the visual right-hand side of the image and the 0th column represents the visual top. Normal orientation rotated clockwise 90 degrees.
8	The 0th row represents the visual left-hand side of the image and the 0th column represents the visual bottom. Normal orientation rotated counter-clockwise 90 degrees.
9	*Orientation is unknown.*

The orientation indicates the camera’s physical orientation relative to the scene. If the orientation is not known, the value 9 should be used. Note that the TIFF values which correspond to “mirrored” image orientations are not allowed.

Usage: IFD0

5.2.13 PhotometricInterpretation

In TIFF/EP, this tag defines the colour space of the image data components and the order of the components. This tag is mandatory and there is no default value. The value shall be 1, 2 or 6 for the Thumbnail IFD.

Tag Name = **PhotometricInterpretation**

Tag = 262 (106.H)

Type = SHORT

N = 1

Value = VALUE (possible values are listed below)

1	BlackIsZero. Used to describe greyscale images. 0 is black, 2**BitsPerSample - 1 is white
2	RGB. Used for images stored in RGB colour space. Red, green and blue minimum intensity is 0, and maximum intensity is 2**BitsPerSample - 1. The component order shall be R, G, B.
6	YCbCr colour space. Y refers to the luminance component, Cb and Cr refer to the two chrominance components. The component order shall be Y, Cb, Cr.
32803	***CFA***. TIFF/EP readers are not required to handle this tag value. Used to describe "raw" image data from single-chip colour sensors having a colour filter array (CFA) overlay. At a given pixel location either a Red, Green, Blue, Cyan, Magenta, Yellow or White sample value is recorded. For each pixel value, 0 represents minimum intensity, and 2**BitsPerSample - 1 represents maximum intensity. The spatial sampling pattern of the colour filter array is defined using the tags ***CFARepeatPatternDim*** and ***CFAPattern***. The colour of the sample values are defined in the tag ***CFAPattern*** as follows; 0=Red, 1=Green, 2=Blue, 3=Cyan, 4=Magenta, 5=Yellow, and 6=White. **SamplesPerPixel** shall equal 1. The **PlanarConfiguration** shall equal 1 (Chunky). The component values for each pixel are stored contiguously, as specified by the tags ***CFARepeatPatternDim*** and ***CFAPattern***.
Other Values >32767	These values are "Vendor Unique" and are not required to be interpreted by others. These values need to be obtained from Adobe Corporation.

Usage: Main Image, Thumbnail Image

(See **BitsPerSample**, **SamplesPerPixel**, **PlanarConfiguration**, ***CFARepeatPatternDim***, ***CFAPattern)***

5.2.14 PlanarConfiguration

This tag describes how the components (samples) of each pixel are stored. This tag is mandatory and there is no default value.

Tag Name = **PlanarConfiguration**

Tag = 284 (11C.H)

Type = SHORT

N = 1

Value = VALUE (possible values listed below)

1	Chunky format. The component values for each pixel are stored contiguously. The order of the components within the pixel is specified by **PhotometricInterpretation**. For example, chunky data when PhotometricInterpretation equals 2 (RGB) is stored as RGBRGBRGB. The chunky format shall be used when the PhotometricInterpretation value is 1 (greyscale) or 32803 (CFA).
2	Planar format. The components are stored in separate component planes.

Usage: Main Image, Thumbnail Image

(See **BitsPerSample, SamplesPerPixel)**

5.2.15 Interlace

This optional tag indicates the field number of multifield images. The tag allows for both simple vertical interlace of between 2 and 255 interlace fields per frame and for two-dimensional interlace of up to 127 vertical × 127 horizontal spatial offset locations per frame. Another application of this interlace mechanism is to store images for progressive transmission. For 2:1 vertical interlace, as employed in many video systems, the first field (lines 1, 3, 5 from the frame image) is indicated with a tag value = 1, and the second field is indicated with a tag value = 2. For 2-dimensional interlace, the 7 least significant bits of the value indicate the vertical field number, and the next 7 bits indicate the horizontal field number. To store multiple interlace fields in one TIFF/EP file, the different fields shall use the IFD chaining mechanism.

Tag Name = ***Interlace***

Tag = 34857 (8829.H)

Type = SHORT

N = 1

Value = VALUE (from list below)

0	non-interlaced (progressive scan)
1	vertical field 1, horizontal field 1 (video field 1, “odd” lines)
2	vertical field 2, horizontal field 1 (video field 2, “even” lines)
3-127	vertical field 3-127, horizontal field 1
128	vertical field 1, horizontal field 2.
129-255	vertical field 2-127, horizontal field 2
256-16383	vertical field 1-127, horizontal field 3-127

Usage: IFD0

5.2.16 SensingMethod

This mandatory tag encodes the type of image sensor used in the camera or image-capturing device.

Tag Name = ***SensingMethod***

Tag = 37399 (9217.H)

Type = SHORT

N = 1

Value = VALUE (see below)

0	Undefined
1	MonochromeArea sensor
2	OneChipColourArea sensor
3	TwoChipColourArea sensor
4	ThreeChipColourArea sensor
5	ColourSequentialArea sensor
6	MonochromeLinear sensor
7	TriLinear sensor
8	ColourSequentialLinear sensor

Usage: IFD0

5.2.17 CFARepeatPatternDim

This tag encodes the number of pixels horizontally and vertically that are needed to uniquely define the repeat pattern of the colour filter array (CFA) pattern used in the colour image sensor. It is mandatory when **PhotometricInterpretation** = 32803, and there are no defaults allowed. It is optional when **PhotometricInterpretation** = 2 or 6 and **SensingMethod** = 2, where it can be used to indicate the original sensor sampling positions.

Tag Name = ***CFARepeatPatternDim***

Tag = 33421(828D.H)

Type = SHORT

N = 2

Value = VALUE

Short Value 0

CFARepeatRows	The minimum number of rows needed to uniquely define the CFA pattern.

Short Value 1

CFARepeatCols	The minimum number of columns needed to uniquely define the CFA pattern.

Usage: Main Image

(See ***CFAPattern,*** **PhotometricInterpretation)**

5.2.18 CFAPattern

This tag encodes the actual colour filter array geometric pattern of the image sensor used to capture the single-sensor colour image. It is mandatory when **PhotometricInterpretation** = 32803, and there are no defaults allowed. It is optional when **PhotometricInterpretation** = 2 or 6 and **SensingMethod** = 2, where it can be used to indicate the original sensor sampling positions.

Tag Name = ***CFAPattern***

Tag = 33422(828E.H)

Type = BYTE

N = CFARepeatRows * CFARepeatCols

Value = VALUE or VALUE_OFFSET

For example, **PhotometricInterpretation** = CFA (32803), where R=0, G=1, B=2, ***CFARepeatPatternDim*** = 2, 2, and ***CFAPattern*** 4-byte value of 1, 0, 2, 1 corresponds to the CFA pattern shown below. This pattern assumes that the image width and length are both multiples of 2.

Line 0: GRGRGR.....GR

Line 1: BGBGBG.....BG

Line 2: .

Line 3: .

Line n-1: GRGRGR.....GR

Line n: BGBGBG.....BG

Usage: Main Image

(See ***CFARepeatPatternDim,*** **PhotometricInterpretation)**

5.2.19 SamplesPerPixel

This tag encodes the number of components or samples stored for each pixel in the image. This tag is mandatory and there is no default value. The value shall be explicitly stated.

Tag Name = **SamplesPerPixel**

Tag = 277 (115.H)

Type = SHORT

N = 1

Value = VALUE (possible values listed below)

1	When **PhotometricInterpretation** = 1 (greyscale), 32803 (CFA)
3	When **PhotometricInterpretation** = 2 (RGB), 6 (YCbCr)
Other Values > 32767	These values are “Vendor Unique” and are not required to be interpreted by others. These private values need to be obtained from Adobe Corporation.

Usage: Main Image, Thumbnail Image

(See **PhotometricInterpretation)**

5.2.20 BitsPerSample

This tag encodes the number of bits per component for each pixel. This tag is mandatory and there is no default value. This tag provides N values depending upon **SamplesPerPixel** present.

Tag Name = **BitsPerSample**

Tag = 258 (102.H)

Type = SHORT

N = **SamplesPerPixel**

Value = VALUE or VALUE_OFFSET

Usage: Main Image, Thumbnail Image

(See **SamplesPerPixel)**

5.2.21 StripOffsets

This tag encodes the byte offset(s) with respect to the beginning of the file to each strip of the image data**.** When strips are used, this mandatory tag-field is the only way for a reader to find the image data.

TIFF/EP requires that the size of the image data contained in each strip, prior to compression, does not exceed 64 KBytes.

Tag Name = **StripOffsets**

Tag = 273 (111.H)

Type = SHORT or LONG

N = **StripsPerImage** (when **PlanarConfiguration** equals 1)

= **SamplesPerPixel** * **StripsPerImage** (when **PlanarConfiguration** equals 2)

Value = VALUE or VALUE_OFFSET

Refer to the tag **RowsPerStrip** to obtain the derived value for **StripsPerImage**.

Usage: Main Image, Thumbnail Image

(See **PlanarConfiguration, RowsPerStrip)**

5.2.22 RowsPerStrip

This tag encodes the number of rows per strip within the image. This tag is mandatory when the image is stored as strips.

Tag Name = **RowsPerStrip**

Tag = 278 (116.H)

Type = SHORT or LONG

N = 1

Value = VALUE (any value up to and including **ImageLength**)
Note that the number of StripsPerImage equals floor ((ImageLength + RowsPerStrip - 1) / RowsPerStrip)

Usage: Main Image, Thumbnail Image

(See **ImageLength, StripOffsets, StripByteCounts, TileWidth, TileLength, TileOffsets, TileByteCounts)**

5.2.23 StripByteCounts

This tag encodes the number of bytes present in each strip after compression has been applied. This tag is mandatory when the image is stored as strips.

Tag Name = **StripByteCounts**

Tag = 279 (117.H)

Type = SHORT or LONG

N = **StripsPerImage** (when **PlanarConfiguration** equals 1)

= **SamplesPerPixel** * **StripsPerImage** (when **PlanarConfiguration** equals 2)

Value = VALUE or VALUE_OFFSET
Refer to the tag **RowsPerStrip** to obtain the derived value for **StripsPerImage**.

Usage: Main Image, Thumbnail Image

(See **StripOffsets, RowsPerStrip, TileOffsets, TileByteCounts)**

5.2.24 TileWidth

This tag encodes the tile width (in pixels) of the image. This is the number of columns in each tile. This tag is mandatory when the image is stored using tiles. Refer to the TIFF 6.0 specification for a full description of this tag.

Tag Name = **TileWidth**

Tag = 322 (142.H)

Type = SHORT or LONG

N = 1

Value = VALUE (any value up to the size of **ImageWidth**)

The following computed values are useful in implementing TIFF tiles:

TilesAcross = (**ImageWidth** + **TileWidth** - 1) / **TileWidth**

TilesDown = (**ImageLength** + **TileLength** - 1) / **TileLength**
TilesPerImage = **TilesAcross** * **TilesDown**

Usage: Main Image

(See **TileLength, TileOffsets, TileByteCounts)**

5.2.25 TileLength

This tag encodes the tile length (height) in pixels of the image. This is the number of rows in each tile. This tag is mandatory when the image is stored using tiles. Refer to the TIFF 6.0 specification for a full description.

Tag Name = **TileLength**

Tag = 323 (143.H)

Type = SHORT or LONG

N = 1
Value = VALUE (any value up to the size of **ImageLength**)

Usage: Main Image

(See **TileWidth, TileOffsets, TileByteCounts)**

5.2.26 TileOffsets

This tag encodes the byte offset(s) from the beginning of the file to the start of each of the image tiles. This tag is mandatory when the image is stored using tiles. Refer to the TIFF 6.0 specification for a full description.

Tag Name = **TileOffsets**

Tag = 324 (144.H)

Type = LONG

N = **TilesPerImage** (for **PlanarConfiguration** = 1)

= **SamplesPerPixel** * **TilesPerImage** (for **PlanarConfiguration** = 2)

Value = VAULE or VALUE_OFFSET
Refer to either **TileWidth** or **TileLength** to determine the value for the derived **TilesPerImage**.

Usage: Main Image

(See **TileWidth, TileLength, TileByteCounts)**

5.2.27 TileByteCounts

This tag encodes the byte count of each image tile. This tag is mandatory when the image is stored using tiles. Refer to the TIFF 6.0 specification for a full description.

Tag Name = **TileByteCounts**

Tag = 325 (145.H)

Type = SHORT or LONG

N = **TilesPerImage** (for **PlanarConfiguration** = 1)

= **SamplesPerPixel** * **TilesPerImage** (for **PlanarConfiguration** = 2)

Value = VALUE or VALUE_OFFSET

Refer to either **TileWidth** or **TileLength** to determine the value for the derived **TilesPerImage**.

Usage: Main Image

(See **TileWidth, TileLength, TileOffsets)**

5.2.28 Compression

This tag encodes the compression scheme used to store the image data. This tag is mandatory and there is no default value. The tag value shall equal “1” for the thumbnail IFD.

Tag Name = **Compression**

Tag = 259 (103.H)

Type = SHORT

N = 1

Value = VALUE (possible values are listed below)

1	No compression. Data is packed as tightly as possible into bytes, padding at the end of the row to assure that each row's data ends upon a byte boundary.
7	TIFF/JPEG compression. JPEG bitstream defines whether Baseline DCT JPEG or other JPEG version is used. TIFF/EP readers are only required to support Baseline DCT JPEG method.
Other Values > 32767	These values are “Vendor Unique” and are not required to be interpreted by others. These “private” values need to be obtained from Adobe Corporation.

Usage: Main Image, Thumbnail Image

(See **JPEGTables)**

5.2.29 CompressedBitsPerPixel

This optional tag encodes the average number of bits per pixel used to store a compressed image.

Tag Name = ***CompressedBitsPerPixel***

Tag = 37122 (9102.H)

Type = RATIONAL

N = 1

Value = VALUE_OFFSET (any valid rational number)

Usage: Compressed Main Image

5.2.30 JPEGTables

This optional tag may be used to encode the JPEG quantization and Huffman tables for subsequent use by the JPEG decompression process. When this is done, these tables need not be duplicated in each segment (strip or tile), thus saving space and processing time. This tag may be used even in a single-segment file, although there is no space saving in this case.

When this optional tag is present, it shall contain a valid JPEG “abbreviated table specification” datastream. This datastream shall begin with SOI and end with EOI. It contains one or more JPEG tables, including:

— DQT (define quantization tables);

— DHT (define huffman tables).

Tag Name = **JPEGTables**

Tag = 347 (15B.H)

Type = UNDEFINED

N = number of bytes in tables datastream (typically a few hundred bytes in length)

Value = VALUE_OFFSET

Usage: Main Image

(See **Compression)**

5.2.31 YCbCrSubSampling

This tag encodes the subsampling factors used for the chrominance components of a YCbCr image. It is mandatory when **PhotometricInterpretation** = 6, and there are no defaults allowed. The two fields of this tag, YCbCrSubsampleHoriz and YCbCrSubsampleVert, specify the horizontal and vertical subsampling factors respectively.

Tag Name = **YCbCrSubSampling**

Tag = 530 (212.H)

Type = SHORT

N = 2

Value = VALUE (possible values are listed below)

Short 0: YCbCrSubsampleHoriz:

1	ImageWidth of this chroma image is equal to the ImageWidth of the associated luma image.
2	ImageWidth of this chroma image is half the ImageWidth of the associated luma image.
4	ImageWidth of this chroma image is one-quarter the ImageWidth of the associated luma image.

Short 1: YCbCrSubsampleVert:

1	ImageLength (height) of this chroma image is equal to the ImageLength of the associated luma image.
2	ImageLength (height) of this chroma image is half the ImageLength of the associated luma image.
4	ImageLength (height) of this chroma image is a quarter of the ImageLength of the associated luma image.

Both Cb and Cr have the same subsampling ratio. Also, YCbCrSubsampleVert shall always be less than or equal to YCbCrSubsampleHoriz.

ImageWidth and **ImageLength** are constrained to be integer multiplies of YCbCrSubsampleHoriz and YCbCrSubsampleVert respectively. **TileWidth** and **TileLength** have the same constraints. **RowsPerStrip** shall be an integer multiple of YCbCrSubsampleVert.

Usage: Main Image

5.2.32 YCbCrPositioning

This tag encodes the positions of subsampled chrominance components relative to luminance samples. Only the "cosited" value is allowed. This tag is mandatory when **PhotometricInterpretation** = 6 and the value shall equal 2. Note that cosited positioning means that the chrominance components are sampled at spatial locations identical to luminance sample locations, while "centred" means the chrominance samples are located at a spatial position between two luminance samples.

Tag Name = **YCbCrPositioning**

Tag = 531 (213.H)

Type = SHORT

N = 1

Value = VALUE (possible values are listed below)

Value	YCbCrPositioning	X and Y offsets of first chrominance sample
2	cosited	Xoffset[0,0]=0, Yoffset[0,0]=0

Usage: Main Image

5.2.33 YCbCrCoefficients

This tag encodes the transformation from RGB to YCbCr image data. It is mandatory when **PhotometricInterpretation** = 6 and there are no defaults allowed. The transformation is specified as three rational values that represent the coefficients used to compute luminance, Y.

Tag Name = **YCbCrCoefficients**

Tag = 529 (211.H)

Type = RATIONAL

N = 3

Value = VALUE_OFFSET

The three rational coefficient values, *LumaRed*, *LumaGreen* and *LumaBlue*, are the proportions of red, green and blue respectively in luminance, Y.

Y, C_b, and C_r may be computed from RGB using the luminance coefficients specified by this field as follows:

Y = (*LumaRed* * R + *LumaGreen* * G + *LumaBlue* * B)

C_b = (B - Y) / (2 - 2 * *LumaBlue*)

C_r = (R - Y) / (2 - 2 * *LumaRed*)

R, G, and B may be computed from YC_bC_r as follows:

R = C_r * (2 - 2 * *LumaRed*) + Y

G = (Y - *LumaBlue* * B - *LumaRed* * R) / *LumaGreen*

B = C_b * (2 - 2 * *LumaBlue*) + Y

The values coded by this field will typically reflect the transformation specified by a standard for YC_bC_r encoding. The following table contains examples of commonly used values.

Standard	LumaRed	LumaGreen	LumaBlue
CCIR Recommendation 601-1	299 / 1000	587 / 1000	114 / 1000
CCIR Recommendation 709	2125 / 10000	7154 / 10000	721 / 10000

Usage: Main Image

5.2.34 ReferenceBlackWhite

This tag encodes a pair of headroom and footroom image data values (codes) for each pixel component. This tag is mandatory when **PhotometricInterpretation** = 6 (YCbCr) and there are no defaults allowed. Additionally, this tag is exclusively used for images having a **PhotometricInterpretation** = 6 (YCbCr). The first component code within a pair is associated with ReferenceBlack, and the second is associated with ReferenceWhite. The ordering of these pairs is that specified by the **PhotometricInterpretation**, i.e. Y, Cb and Cr.

Tag Name = **ReferenceBlackWhite**

Tag = 532 (214.H)

Type = RATIONAL

N = 6

Value = VALUE_OFFSET

NOTE Useful ReferenceBlackWhite values for YCbCr images having **BitsPerSample** = 8,8,8 are:
[0/1, 255/1, 128/1, 255/1, 128/1, 255/1] indicating no headroom/footroom;
[15/1, 235/1, 128/1, 240/1, 128/1, 240/1] CCIR Recommendation 601.1 headroom/footroom.

Using the CCIR Recommendation 601.1 headroom/footroom values, code 15 represents ReferenceBlack and code 235 represents ReferenceWhite for the luminance component (Y). For chrominance components, Cb and Cr, code 128 represents ReferenceBlack and code 240 represents ReferenceWhite. With Cb and Cr, the ReferenceWhite value is used to code reference blue and reference red respectively.

The full range component value is converted from the code by:

FullRangeValue = [(code - ReferenceBlack) * CodingRange] / (ReferenceWhite - ReferenceBlack)

The code is converted from the full-range component value by:

Code = [(FullRangeValue * (ReferenceWhite - ReferenceBlack)] / CodingRange) + ReferenceBlack

For the luminance component (Y), the CodingRange is defined as:

CodingRange = 2**BitsPerSample - 1

For the Cb and Cr components, the CodingRange is defined as:

CodingRange = 127

In the case of no headroom/footroom, the conversion of luminance (Y) can be skipped because the value equals the code. For Cb and Cr, ReferenceBlack shall still be subtracted from the code.

Usage: Main Image

5.2.35 Make

This tag encodes the manufacturer or vendor of the camera or image-capturing device as a null-terminated ASCII string. This is a mandatory tag with an allowed value of " " (null character) indicating "unknown".

Tag Name = **Make**

Tag = 271 (10F.H)

Type = ASCII

N = any (this count includes the null-terminating byte at the end of the string)
Value = VALUE or VALUE_OFFSET

Usage: IFD0

(See **Model, Software)**

5.2.36 Model

This tag encodes the model name or number of the camera. This can also include the serial number of the camera. This is a mandatory tag with an allowed value of " " (null character) indicating "unknown".

Tag Name = **Model**

Tag = 272 (110.H)

Type = ASCII

N = any (this count includes the null-terminating byte at the end of the string)
Value = VALUE or VALUE_OFFSET

Usage: IFD0

(See **Make, Software)**

5.2.37 Software

This tag encodes the name and version of the software or firmware within the camera or image-capturing device used to create the image. This is a mandatory tag with an allowed value of " " (null character) indicating "unknown".

Tag Name = **Software**

Tag = 305 (131.H)

Type = ASCII

N = any (this count includes the null-terminating byte at the end of the string)
Value = VALUE or VALUE_OFFSET

Usage: IFD0

(See **Make, Model)**

5.2.38 ImageNumber

This optional tag encodes the number assigned to an image. This tag is useful when storing a burst of images which are “chained” together within the same **TIFF/EP** file.

Tag Name = ***ImageNumber***

Tag = 37393 (9211.H)

Type = SHORT or LONG

N = 1

Value = VALUE (actual image number)

Usage: IFD0

5.2.39 ImageDescription

A string that describes the subject or purpose of the image is recorded as a null-terminated ASCII string. This tag-field may be additionally used to provide any other type of information related to the image. This is a mandatory tag with an allowed value of “ ” (null character) indicating “unknown”.

Tag Name = **ImageDescription**

Tag = 270 (10E.H)

Type = ASCII

N = any (this count includes the null-terminating byte at the end of the string)

Value = VALUE or VALUE_OFFSET

Usage: IFD0

5.2.40 Artist

This tag encodes the name of the camera owner or image creator.

Tag Name = **Artist**

Tag = 315 (13B.H)

Type = ASCII

N = any (this count includes the null-terminating byte at the end of the string)

Value = VALUE or VALUE_OFFSET

Usage: IFD0

5.2.41 Copyright

This tag encodes the copyright notice of the copyright holder. This is a mandatory tag with an allowed value of “ ” (null character) indicating “unknown”. The complete copyright statement should be listed in this field including any dates and statements of claims. If desired, this tag-field can also list the royalty clearance house.

Tag Name = **Copyright**

Tag = 33432 (8298.H)

Type = ASCII

N = any (this count includes the null-terminating byte)

Value = VALUE or VALUE_OFFSET

Usage: IFD0

5.2.42 ImageHistory

This optional tag encodes a record of what has been done to the image. The current information shall not be erased when adding new information to the image history. As changes are made, the additional information about the changes should be concatenated to the previous string. The new information should be separated by one or more ASCII blank spaces and terminated with a NULL zero byte.

Tag Name = ***ImageHistory***

Tag = 37395 (9213.H)

Type = ASCII

N = any (count includes the null-terminating byte)

Value = VALUE or VALUE_OFFSET

Usage: IFD0

5.2.43 IPTC/NAA

This optional tag may be used to encode relevent information concerning the image that is useful for newspaper photographs. The information is defined in Application Record No. 2 of the IPTC-NAA (International Press Telecommunications Council - Newspaper Association of America) Information Interchange Model and Digital Newsphoto Parameter Record, Version 2, April 14, 1993. A TIFF file with this tag is sometimes called RichTIFF. RichTIFF is defined within the “RichTIFF -- Standardized TIFF File Specification”, Crossfield, Inc., May 1993.

This record includes the following information: Record Version, Object Name, Edit Status, Urgency, Category, Supplemental Category, Fixture Identifier, Keywords, Release Date, Release Time, Special Instructions, Reference Service, Reference Date, Reference Number, Date Created, Time Created, Originating Program, Program Version, Object Cycle, Byline, Byline Title, City, Province-State, Country Code, Country Name, Original Transmission Reference, Headline, Credit, Source, Caption, Caption Writer, Image Type.

Tag Name = ***IPTC/NAA***

Tag = 33723 (83BB.H)

Type = LONG or ASCII

N = any (actual size of the Application Record data in bytes)

Value = VALUE_OFFSET

Usage: IFD0

5.2.44 SecurityClassification

This optional tag encodes the level of security classification assigned to the image. The tag value can either be a single ASCII character or an ASCII string.

Tag Name = ***SecurityClassification***

Tag = 37394 (9212.H)

Type = ASCII

N = 1 or any

Value = VALUE or VALUE_OFFSET

The allowed single characters are T (= Top Secret), S (= Secret), C (= Confidential), R (= Restricted), U (= Unclassified). These definitions are based on the NITF security classifications defined in the NITF (National Imagery Transmission Format) specification (MIL-STD-2500).

The multicharacter ASCII string tag-value can include one or more of the following NITF fields. The NITF fields should appear in the order listed below. Refer to MIL-STD-2500 for a complete description of these fields. A NULL is inserted between each NITF field and its associated value. When multiple NITF fields are used, a NULL character is inserted between each NITF field.

FIELD	NAME	SIZE	VALUE RANGE	TYPE
FSCLAS	File Security Classification	1	T, S, C, R or U	Required
FSCODE	File Codewords	40	Alphanumeric	Optional
FSCLTH	File Control and Handling	40	Alphanumeric	Optional
FSREL	File Releasing Instructions	40	Alphanumeric	Optional
FSCAUT	File Classification Authority	20	Alphanumeric	Optional
FSCTLN	File Security Control Number	20	Alphanumeric	Optional
FSDWNG	File Security Downgrade	6	Alphanumeric	Optional
FSDEVT	File Downgrading Event	40	Alphanumeric	Conditional

Usage: IFD0

5.2.45 GPSInfo

This optional tag-field is used to indicate the position of the camera via data provided by a Global Positioning System (GPS) satellite receiver. The format of this tag-field is a “private IFD”. This means that this tag-field points to the offset of an IFD that holds a group of private ***GPSInfo*** tag-fields which contain the GPS data.

Tag Name = ***GPSInfo***

Tag = 34853 (8825.H)

Type = LONG

N = 1

Value = VALUE_OFFSET (offset to IFD)

The VALUE_OFFSET points to the first byte of the ***GPSInfo*** IFD, which contains the Entry Count representing the number of tags present from Table 2 below.

Table 2 — GPSInfo tags

Tag name	Field name	Dec.	Hex	Type	Count
GPS tag version	GPSVersionID	0	0	BYTE	4
North or South Latitude	GPSLatitudeRef	1	1	ASCII	2
Latitude	GPSLatitude	2	2	RATIONAL	3
East or West Longitude	GPSLongitudeRef	3	3	ASCII	2
Longitude	GPSLongitude	4	4	RATIONAL	3
Altitude Reference	GPSAltitudeRef	5	5	BYTE	1
Altitude	GPSAltitude	6	6	RATIONAL	1
GPS time (atomic clock)	GPSTimeStamp	7	7	RATIONAL	3
GPS satellites used for measurement	GPSSatellites	8	8	ASCII	Any
GPS receiver status	GPStatus	9	9	ASCII	2
GPS measurement mode	GPSMeasureMode	10	A	ASCII	2
Measurement precision	GPSDOP	11	B	RATIONAL	1
Speed unit	GPSSpeedRef	12	C	ASCII	2
Speed of GPS receiver	GPSSpeed	13	D	RATIONAL	1
Reference for direction of movement	GPSTrackRef	14	E	ASCII	2
Direction of movement	GPSTrack	15	F	RATIONAL	1
Reference for direction of image	GPSImgDirectionRef	16	10	ASCII	2
Direction of image	GPSImgDirection	17	11	RATIONAL	1
Geodetic survey data used	GPSMapDatum	18	12	ASCII	Any
Reference for latitude of destination	GPSDestLatitudeRef	19	13	ASCII	2
Latitude of destination	GPSDestLatitude	20	14	RATIONAL	3
Reference for longitude of destination	GPSDestLongitudeRef	21	15	ASCII	2
Longitude of destination	GPSDestLongitude	22	16	RATIONAL	3
Reference for bearing of destination	GPSDestBearingRef	23	17	ASCII	2
Bearing of destination	GPSDestBearing	24	18	RATIONAL	1
Reference for distance to destination	GPSDestDistanceRef	25	19	ASCII	2
Distance to destination	GPSDestDistance	26	1A	RATIONAL	1

Usage: IFD0

This ***GPSVersionID*** tag-value encodes the version of this GPSInfo IFD as a four tier revision number, for example 2.0.0.0, using 4 BYTES. This revision number has the form of w.x.y.z where w=0-255, x=0-255, y=0-255 and z=0-255. The present version is 2.0.0.0, to maintain compatibility with the Exif 2 specification.

The ***GPSLatitudeRef*** tag value is an ASCII value of “N” for north latitudes and “S” for south latitudes relative to the earth’s equator.

The ***GPSLatitude*** tag-value contains 3 RATIONAL values equal to the degrees, the minutes and the seconds respectively of the camera’s latitude. When degrees, minutes and seconds are used, the format is dd/1, mm/1, ss/1. When degrees and minutes are used, and, for example, fractions of minutes are expressed using two decimal places, the format is dd/1, mmmm/100 and 0/1.

The ***GPSLongitudeRef*** tag-value is an ASCII value of “E” for east longitudes and “W” for west longitudes relative to the International Prime Meridian which is located by the astronomical observatory in Greenwich, UK.

The ***GPSLongitude*** tag value contains 3 RATIONAL values equal to the degrees, the minutes and the seconds respectively of the camera’s longitude. When degrees, minutes and seconds are used, the format is ddd/1, mm/1, ss/1. When degrees and minutes are used, and, for example, fractions of minutes are expressed using two decimal places, the format is ddd/1, mmmm/100 and 0/1.

The ***GPSAltitudeRef*** tag value shall contain a one BYTE value of “0”, indicating sea level, for the current version. The altitude reading is given in metres relative to sea level.

The ***GPSAltitude*** tag value contains a single RATIONAL value equal to the camera’s altitude in metres.

The ***GPSTimeStamp*** tag contains 3 RATIONAL values equal to the hours, minutes and seconds respectively of the GPS clock.

The ***GPSSatellites*** tag contains an ASCII string that lists the satellites used to determine the camera position. This tag can be used to describe the number of satellites, their ID number, angle of elevation, azimuth, SNR and other information in ASCII notation. The format is not specified. If the GPS receiver is incapable of taking measurements, the value of this tag must be set to NULL.

The ***GPSStatus*** tag contains a null-terminated ASCII character, where A indicates that the measurement is in progress and V indicates that the measurement is interrupted.

The ***GPSMeasureMode*** tag contains a null-terminated ASCII character, where 2 indicates that a two-dimensional measurement is in progress and 3 indicates that a three-dimensional measurement is in progress.

The ***GPSDOP*** tag contains a RATIONAL value indicating the GPS DOP (data degree of precision). An HDOP value is written during a two-dimensional measurement and a PDOP value is written during a three-dimensional measurement.

The ***GPSSpeedRef*** tag contains a null-terminated ASCII character, where K means kilometres per hour, M means miles per hour and N means knots.

The ***GPSSpeed*** tag contains a RATIONAL value indicating the speed of the GPS receiver.

The ***GPSTrackRef*** tag contains a null-terminated ASCII character indicating the reference for the direction of the GPS receiver. T indicates true direction and M indicates magnetic direction.

The ***GPSTrack*** tag contains a RATIONAL value indicating the direction of the GPS receiver movement, from 0/100 to 35999/100.

The ***GPSImgDirectionRef*** tag contains a null-terminated ASCII character indicating the reference for the direction of the image when it is captured. T indicates true direction and M indicates magnetic direction.

The ***GPSImgDirection*** tag contains a RATIONAL value indicating the direction of the image when it was captured, from 0/100 to 35999/100.

The ***GPSMapDatum*** tag contains an ASCII character string indicates the geodetic survey data used by the GPS receiver. If the survey data is restricted to Japan, the value of this tag is “TOKYO” or “WSG-84”.

The ***GPSDestLatitudeRef*** tag contains a null-terminated ASCII character indicating the latitude of the destination point, where N indicates north latitude and S indicates south latitude.

The ***GPSDestLatitude*** tag value contains 3 RATIONAL values equal to the degrees, the minutes and the seconds respectively of the destination point. When degrees, minutes and seconds are used, the format is dd/1, mm/1, ss/1. When degrees and minutes are used, and, for example, fractions of minutes are expressed using two decimal places, the format is dd/1, mmmm/100 and 0/1.

The ***GPSDestLongitudeRef*** tag contains a null-terminated ASCII character indicating the longitude of the destination point, where E indicates east latitude and W indicates west latitude.

The ***GPSDestLongitude*** tag value contains 3 RATIONAL values equal to the degrees, the minutes and the seconds respectively of the destination point. When degrees, minutes and seconds are used, the format is ddd/1, mm/1, ss/1. When degrees and minutes are used, and, for example, fractions of minutes are expressed using two decimal places, the format is ddd/1, mmmm/100 and 0/1.

The ***GPSDestBearingRef*** tag contains a null-terminated ASCII character indicating the reference for the bearing to the destination point. T indicates true direction and M indicates magnetic direction.

The ***GPSDestBearing*** tag contains a RATIONAL value indicating the bearing to the destination point, from 0/100 to 35999/100.

The ***GPSDestDistanceRef*** tag contains a null-terminated ASCII character, where K means kilometres, M means miles and N means knots.

The ***GPSDestDistance*** tag contains a RATIONAL value indicating the distance to the destination point.

Note that the ***GPSInfo*** tag-field data indicates the position of the camera, not the position of the subject being photographed. The position of the subject of the image can be represented using the GeoTIFF standard, which is a publicly available standard for relating TIFF image data to a projected coordinate system.

5.2.46 DateTimeOriginal

This mandatory tag encodes the date and time when the original image was photographed. This tag should never be changed after it is written in the camera or image-capture device.

Tag Name = ***DateTimeOriginal***

Tag = 36867 (9003.H)

Type = ASCII

N = 20

Value = VALUE_OFFSET (the syntax of the null-terminated string at the specified offset is given below)

YYYY:MM:DD HH:MM:SS , with hours 0-24, a space character between the date and time and a null-termination byte. If the camera has no clock, or the clock is disabled, the time should be indicated as 0000:00:00 00:00:00

Usage: IFD0

5.2.47 DateTime

This mandatory tag encodes the date and time when the image was last modified.

Tag Name = **DateTime**

Tag = 306 (132.H)

Type = ASCII

N = 20

Value = VALUE_OFFSET (the syntax of the null-terminated string at the specified offset is given below)

YYYY:MM:DD HH:MM:SS, with hours 0-24, a space character between the date and time, and a null-termination byte. If the camera has no clock, or the clock is disabled, the time should be indicated as 0000:00:00 00:00:00

Usage: IFD0

5.2.48 TimeZoneOffset

This optional tag encodes the time zone of the camera clock (relative to Greenwich Mean Time) used to create the DataTimeOriginal tag-value when the picture was taken. It may also contain the time zone offset of the clock used to create the DateTime tag-value when the image was modified.

Tag Name = ***TimeZoneOffset***

Tag = 34858 (882A.H)

Type = SSHORT

N = 1 or 2

Value = VALUE

The allowed values are –12 to +11.

SSHORT 0	Time Zone Offset (in hours) of DateTimeOriginal tag-value relative to Greenwich Mean Time
SSHORT 1	If present, Time Zone Offset (in hours) of DateTime tag-value relative to Greenwich Mean Time

Usage: IFD0

5.2.49 ExposureTime

This optional tag encodes the actual exposure time used when the image was captured. The units are (fractional) seconds. For example, an exposure time of 1/60 second is encoded as 1/60. The exposure time may be specified by using a single number, if the exact value is known. Alternatively, two values may be used to indicate the range of uncertainty in the exposure time setting. In this case, the first value shall be the minimum time and the second value shall be the maximum time.

Tag Name = ***ExposureTime***

Tag = 33434 (829A.H)

Type = RATIONAL

N = 1 or 2

Value = VALUE_OFFSET (any valid rational number)

Rational

0	Exact Exposure Time, if only one value is present Minimum Exposure Time of the range of uncertainty, if two values are present
1	Maximum Exposure Time of the range of uncertainty, if two values are present

Usage: IFD0

5.2.50 ShutterSpeedValue

This optional tag encodes the shutter speed value (APEX time value) used when capturing the image. The units are APEX (Additive Systems of Photographic Exposure) values.

Tag Name = ***ShutterSpeedValue***

Tag = 37377 (9201.H)

Type = RATIONAL

N = 1

Value = VALUE_OFFSET (any valid rational number)

Usage: IFD0

5.2.51 FNumber

This optional tag encodes the actual lens f-number (ratio of lens aperture to focal length) used when the image was captured. The f-number may be specified by using a single number, if the exact value is known. Alternatively, two values may be used to indicate the range of uncertainty in the f-number setting. In this case, the first value shall be the minimum f-number and the second value shall be the maximum f-number.

Tag Name = ***FNumber***

Tag = 33437 (829D.H)

Type = RATIONAL

N = 1 or 2

Value = VALUE_OFFSET (any valid rational number)

Rational

0	Exact f-number, if only one value is present Minimum f-number of the range of uncertainty, if two values are present
1	Maximum f-number of the range of uncertainty, if two values are present

Usage: IFD0

5.2.52 ApertureValue

This tag encodes the actual lens aperture (Av) used when capturing the image. The units are APEX. The maximum value is 99.99, the minimum value is 0.0. In APEX units, a value of 0.0 corresponds to f/1.0, and a value of 1.0 corresponds to f/1.4.

Tag Name = ***ApertureValue***

Tag = 37378 (9202.H)

Type = RATIONAL

N = 1

Value = VALUE_OFFSET (any valid rational number)

Usage: IFD0

5.2.53 MaxApertureValue

This optional tag encodes the maximum possible aperture opening (minimum lens f-number) of the camera or image-capturing device, using APEX units. The allowed range is 0.00 to 99.99.

Tag Name = ***MaxApertureValue***

Tag = 37381 (9205.H)

Type = RATIONAL

N = 1

Value = VALUE_OFFSET

Usage: IFD0

5.2.54 BrightnessValue

This optional tag encodes the Brightness Value (BV) that was measured when the image was captured, using APEX units. The expected maximum value is approximately 13.00 corresponding to a picture taken of a snow scene on a sunny day and the expected minimum value is approximately -3.00 corresponding to a night scene. The Brightness Value may be specified by using a single number, if the exact value is known. Alternatively, two values may be used to indicate the range of uncertainty in the Brightness Value setting. In this case, the first value shall be the minimum value and the second value shall be the maximum value.

Tag Name = ***BrightnessValue***

Tag = 37379 (9203.H)

Type = SRATIONAL

N = 1 or 2

Value = VALUE_OFFSET (any valid signed rational)

Rational

0	Exact Brightness Value, if only one value is present Minimum Brightness Value of the range of uncertainty, if two values are present
1	Maximum Brightness Value of the range of uncertainty, if two values are present

Usage: IFD0

5.2.55 ExposureBiasValue

This optional tag encodes the actual exposure bias (the amount of over- or under-exposure relative to a normal exposure as determined by the camera's exposure system) used when capturing the image, using APEX units. The range is between -99.99 and 99.99. The exposure bias may be specified by using a single number, if the value is exactly known. Alternatively, two values may be used to indicate the range of uncertainty in the exposure bias setting. In this case, the first value shall be the minimum value and the second value shall be the maximum value.

Tag Name = ***ExposureBiasValue***

Tag = 37380 (9204.H)

Type = SRATIONAL

N = 1 or 2

Value = VALUE_OFFSET (any valid signed rational)

The value is the number of exposure values (stops). For example, -1.00 indicates 1 eV (1 stop) underexposure or half the normal exposure.

Rational

0	Exact Exposure Bias, if only one value is present Minimum Exposure Bias of the range of uncertainty, if two values are present
1	Maximum Exposure Bias of the range of uncertainty, if two values are present

Usage: IFD0

5.2.56 ExposureProgram

This tag encodes the class of exposure program that the camera used at the time when the image was captured. Typical exposure programs include normal-program (general-purpose auto-exposure), aperture-priority (user sets aperture, camera selects shutter speed to properly expose), shutter-priority (user sets shutter speed, camera selects aperture to properly expose), etc.

Tag Name = ***ExposureProgram***

Tag = 34850 (8822.H)

Type = SHORT

N = 1

Value = VALUE

0	Unidentified
1	Manual
2	Program Normal
3	Aperture Priority
4	Shutter Priority
5	Program Creative (biased toward greater “depth of field”)
6	Program Action (biased toward faster “shutter speed”)
7	Portrait Mode (intended for close-up photos with the background out-of-focus)
8	Landscape Mode (intended for landscapes with the background in good focus)
Other values > 32767	These values are “Vendor Unique” and are not required to be interpreted by others. These “private” values need to be obtained from PIMA.

Usage: IFD0

5.2.57 MeteringMode

This optional tag encodes the metering mode (the camera’s method of spatially weighting the scene luminance values to determine the sensor exposure) used when capturing the image.

Tag Name = ***MeteringMode***

Tag = 37383 (9207.H)

Type = SHORT

N = 1

Value = VALUE

0	Unidentified
1	Average
2	CentreWeightedAverage
3	Spot
4	MultiSpot
Other values >32767	These values are “Vendor Unique” and are not required to be interpreted by others. These private values need to be obtained from the TIFF/EP registry.

Usage: IFD0

5.2.58 Flash

This optional tag encodes whether or not flash was used when the image was captured.

Tag Name = ***Flash***

Tag = 37385 (9209.H)

Type = SHORT

N = 1

Value = VALUE (allowed values are listed below). The meaning of each bit of the 16 bit SHORT value is listed below:

Bit 0: Flash Fire Status bit:

0 = Flash didn't fire

1 = Flash fired

Bits 2 1: Flash Return Sense bits:

00 = No flash return sensing capability

01 = RESERVED

10 = Flash return not sensed

11 = Flash return sensed

Bits 4 3: Flash Mode bits:

00 = Unknown flash mode

01 = Fill Flash mode (always on)

10 = Flash off mode (always off)

11 = Auto flash mode (on for dark scenes only, camera controlled)

Bit 5: Flash Unit Present bit:

0 = Camera has flash unit

1 = Camera does not have a flash unit

RESERVED bits:

Bits 15 ... 6: RESERVED (shall be set to 0)

Allowed values are:

0	Flash did not fire
1	Flash fired
5	Flash fired, Flash return not sensed
7	Flash fired, Flash return sensed
9	Flash fired, Fill flash mode, Camera has no flash return sensing capability
13	Flash fired, Fill flash mode, Flash return not sensed
15	Flash fired, Fill flash mode, Flash return sensed
16	Flash did not file, Flash “off” mode
24	Flash did not fire, “Auto” flash mode
25	Flash fired, “Auto” flash mode, Camera has no flash return sensing capability
29	Flash fired, “Auto” flash mode, Flash return not sensed
31	Flash fired, “Auto” flash mode, Flash return sensed
32	Camera does not have a flash unit

Usage: IFD0

(See ***FlashEnergy)***

5.2.59 FlashEnergy

This optional tag encodes the amount of flash energy that was used when the image was captured. The measurement units are Beam Candle Power Seconds (BCPS). The flash energy may be specified by using a single number if the exact flash energy is known. Alternatively, two values may be used to indicate the range of uncertainty in the flash energy setting. In this case, the first value shall be the minimum value and the second value shall be the maximum value.

Tag Name = ***FlashEnergy***

Tag = 37387 (920B.H)

Type = RATIONAL

N = 1 or 2

Value = VALUE_OFFSET (any rational number)

Rational

0	Exact Flash Energy, if only one value is present Minimum Flash Energy of the range of uncertainty, if two values are present
1	Maximum Flash Energy of the range of uncertainty, if two values are present

Usage: IFD0

See ***Flash***

5.2.60 FocalLength

This optional tag encodes the lens focal length used to capture the image. The lens focal length unit of measure is millimetres. For example, a focal length of 50 mm is encoded as 50/1. The focal length may be specified by using a single number, for a fixed focal length lens or a zoom lens, if the zoom lens position is known. Alternatively, two values may be used to indicate the range of uncertainty in the focal length setting. In this case, the first value shall be the minimum focal length and the second value shall be the maximum focal length.

Tag Name = ***FocalLength***

Tag = 37386 (920A.H)

Type = RATIONAL

N = 1 or 2

Value = VALUE_OFFSET (any valid rational)

Rational

0	Exact Focal Length, if only one value is present Minimum Focal Length of the range of uncertainty, if two values are present
1	Maximum Focal Length of the range of uncertainty, if two values are present

Usage: IFD0

5.2.61 SubjectDistance

This optional tag encodes the distance (in metres) between the front nodal plane of the lens and the position at which the camera was focusing when the image was captured. RATIONAL values are used, so that a subject distance of 8 metres is encoded as 8/1. Note that the camera may have focused on a subject within the scene which may not have been the primary subject. The subject distance may be specified by using a single number, if the value is exactly known. Alternatively, two values may be used to indicate the range of uncertainty in the subject distance setting. In this case, the first value shall be the minimum value and the second shall be the maximum value. A subject distance of infinity is indicated by using -1/1.

Tag Name = ***SubjectDistance***

Tag = 37382 (9206.H)

Type = SRATIONAL

N = 1 or 2

Value = VALUE_OFFSET (any valid rational number)

Rational

0	Exact Subject Distance, if only one value is present Minimum Subject Distance of the range of uncertainty, if two values are present
1	Maximum Subject Distance of the range of uncertainty, if two values are present

Usage: IFD0

5.2.62 SubjectLocation

This optional tag identifies the approximate location of the subject in the scene. The subject location may be specified as a point, a circle or a rectangle. In all cases, the first two values provide the X column number and Y row number that corresponds to the centre of the subject location. If three values are given, the third value is the diameter of a circle centred at the point specified by the first two values. If four values are given, the third value is the width and the fourth value is the height of a rectangle centred at the point specified by the first two values.

Tag Name = ***SubjectLocation***

Tag = 37396 (9214.H)

Type = SHORT

N = 2 or 3 or 4

Value = VALUE or VALUE_OFFSET

Short 0	X column number
Short 1	Y row number
Short 2	If 3 values, this value represents the diameter of a circle centred at the point defined by shorts 0 and 1. If 4 values, this value represents the width of a rectangle centred at the point defined by shorts 0 and 1.
Short 3	This value represents the height of a rectangle centred at the point defined by shorts 0, 1

Usage: IFD0

5.2.63 SelfTimerMode

This optional tag encodes the number of seconds the image capture was delayed from the time the “take picture button” was pressed by the camera operator. If the value is zero, this implies that the self-timer is off.

Tag Name = ***SelfTimerMode***

Tag = 34859 (882B.H)

Type = SHORT

N = 1

Value = VALUE

Usage: IFD0

5.2.64 BatteryLevel

This tag preferably encodes the camera’s battery level as a ratio of fullness at the time of image capture. For example, a full battery level is indicated by 1/1, half-full battery by 1/2, etc. Alternatively, an ASCII string describing the battery level is allowed.

Tag Name = ***BatteryLevel***

Tag = 33423 (828F.H)

Type = RATIONAL or ASCII

N = 1 (if RATIONAL) or any (ASCII string count including null-terminating byte)

Value = VALUE_OFFSET

Usage: IFD0

5.2.65 LightSource

This optional tag encodes the light source (scene illuminant) that was determined to be present when the image was captured.

Tag Name = ***LightSource***

Tag = 37384 (9208.H)

Type = SHORT

N = 1

Value = VALUE

NOTE Bit 15 of this 16-bit word is used as the key to whether or not a colour temperature value is being stored. If bit 15 is 0, then the value described within bits 0 to 14 will provide one of the prescribed colour values depicted in the table below. Otherwise, if bit 15 is 1, then bits 0 to 14 contain the actual colour temperature value stored in units of Kelvin. In this case, colour temperatures are limited to values in the range of 0 K to 32767 K.

VALUES (Bit 15 = 0, Bits 14...0 ==> 0...32767)

0	Unidentified
1	Daylight
2	Fluorescent light
3	Tungsten Lamp
10	Flash
17	Standard Illuminant A
18	Standard Illuminant B
19	Standard Illuminant C
20	D55 Illuminant
21	D65 Illuminant
22	D75 Illuminant
Other values < 32768	These values are reserved for use by TIFF/EP

VALUES (Bit 15 = 1, Bits 14...0 ==> 0...32767)

0 – 32767	Depicts the actual colour temperature of the scene illuminant corresponding to values of 0 through 32767 K, i.e. the value depicted within bits 0 to 14. Value derived by masking off bit 15.

Usage: IFD0

5.2.66 InterColourProfile

This tag encodes an embedded InterColour device profile relating to the camera colour characterization. Refer to "ICC.1:2001, *File Format for Colour Profiles*", for further information on the use of this tag. Note that the ICC Profile Format may be revised in the future and the most recent version of the ICC specification should be used.

Tag Name = ***InterColourProfile***

Tag = 34675 (8773.H)

Type = UNDEFINED

N = any (actual size of the embedded IC profile in bytes)

Value = VALUE_OFFSET

Usage: IFD0

5.2.67 ExposureIndex

This optional tag encodes the camera exposure index setting the camera had selected when the image was captured. The Exposure Index may be specified by using a single number if the exact Exposure Index is known. Alternatively, two values may be used to indicate the range of uncertainty in the Exposure Index setting. In this case, the first value shall be the minimum value and the second shall be the maximum value.

Tag Name = ***ExposureIndex***

Tag = 37397 (9215.H)

Type = RATIONAL

N = 1 or 2

Value = VALUE_OFFSET (any rational number)

Rational

0	Exact Exposure Index, if only one value is present Minimum Exposure Index of the range of uncertainty, if two values are present
1	Maximum Exposure Index of the range of uncertainty, if two values are present

Usage: IFD0

5.2.68 ISOSpeedRatings

This optional tag-field includes the ISO speed and ISO speed latitude values specified in ISO 12232:1998. The first value is the ISO speed rating and the last two values are the minimum and maximum ISO speed latitude values. Some electronic still-picture cameras may not have an ISO speed latitude.

Tag Name = ***ISOSpeedRatings***

Tag = 34855 (8827.H)

Type = SHORT

N = 1 or

Value = VALUE

For the allowed values, see tables indicated above.

Usage: IFD0

5.2.69 OECF

This optional tag allows the “Opto-Electronic Conversion Function” (OECF) values described in ISO 14524:1999 to be stored as a table of values. The OECF is the relationship between the optical input and the image file code value outputs of an electronic camera. The columns of the table can provide the camera OECF values, or the focal plane OECF values, or both.

A simple example of an OECF data table is:

Camera log exposure	Red output level	Green output level	Blue output level
–3,0	10,2	12,4	8,9
–2,0	48,1	47,5	48,3
–1,0	150,2	152,0	149,8

Tag Name = ***OECF***

Tag = 34856 (8828.H)

Type = UNDEFINED

N = any (actual size of the OECF data in bytes)

Value = VALUE_OFFSET

Byte 0-1	Number of table columns (N SHORT values)
Byte 2-3	Number of table rows (M SHORT values)
Byte 4-x	N ASCII null-terminated column headings
Byte x-x+8xNxM	Nx M RATIONAL entries in row major order (all data of row given first)

Usage: IFD0

5.2.70 SpectralSensitivity

This optional tag-field can be used to describe the spectral sensitivity of each channel of the camera used to capture the image. It is useful for certain scientific applications.

Tag Name = ***SpectralSensitivity***

Tag = 34852 (8824.H)

Type = ASCII

N = any

Value = VALUE_OFFSET

The tag-field is an ASCII string compatible with the “New Standard Practice for the Electronic Interchange of Colour and Appearance Data” being developed within an ASTM Technical Committee. The ASCII string consists of a mandatory keyword list followed by the associated data values. Mandatory keywords include NUMBER_OF_FIELDS which equals the number of channels (spectral bands) + 1, and NUMBER_OF_SETS which specifies the number of spectral frequency (wavelength) entries.

Usage: IFD0