NEF File Format

preliminary draft v0.1

Copyright Notice

License

Disclaimer

Trademark Acknowledgements

Overview

Structure of this manual

tbd

Intended audience

tbd

Conventions

tbd

NEF file layout

NEF files are often referred as a proprietary format, but this is not completely true: indeed they are compliant with the TIFF 6.0 specifications. Basically TIFF files are composed by a set of Image File Directories (IFD), which are small data blocks describing the contents of the file (not only graphics information such as resolution, size and so on but even photographic information such as shutter speed, aperture, comments, copyright notices and so on). They usually contain a single image, but they can hold more than one (most of times the secondary images are thumbnails, reduced-size copies of the main image which can be previewed quickly). Manufacturers can add proprietary tags, which Nikon did, so the proprietary part in NEF files is actually a small part.

Indeed the most important information is about the way pixels are coded. They can be coded in many ways, and TIFF supports the notion of Color Filter Array (CFA), that is the way most digital sensors capture data: r-g-b components are not recorder for each pixel, but only one primary at a time (not necessarily r-g-b). The image has to be interpolated to be viewed.

The example values in the following tables come from a NEF file shot with a Nikon D100 v2.00, edited with Nikon Capture Editor v3.5.

Primary IFD

The primary IFD is placed at offset 8, just after the header. It mainly describe the thumbnail, even if some information apply to the actual image. It also contains pointers to the EXIF data and to the IFD which describes the actual image.

#	#hex	Field	Example	Description
254		NewSubfileType	1	This image is a thumbnail
254		NewSubfileType	1	(repeated)
256		ImageWidth	160	The width of the thumbnail
257		ImageHeight	106	The height of the thumbnail
258		BitsPerSample	8,8,8	The number of bits for each sample of the thumbnail
259		Compression	1	The thumbnail is not compressed
262		PhotometricInterpretation	2	The thumbnail is a RGB image
270		ImageDescription		Empty
271		Make	NIKON CORPORATION	The manufacturer's name
272		Model	NIKON D100	The camera model name
273		StripOffsets	8872	The offset, in the NEF file, of raster data for the thumbnail
274		Orientation	1	The thumbnail is landscape-oriented.
277		SamplesPerPixel	3	Each pixel of the thumbnail is made of three samples.
278		RowsPerStrip	106	The raster of the thumbnail is coded in a single block of data representing all of the 106 rows.
279		StripByteCounts	50880	The size of the thumbnail raster data in bytes.
282		XResolution	300	The horizontal resolution of the thumbnail.

#	#hex	Field	Example	Description
283		YResolution	300	The vertical resolution of the image thumbnail.
284		PlanarConfiguration	1	"Chunky format": the RGB components of the thumbnail are stored interleaved.
296		ResolutionUnit	2	Resolutions in fields #282 and #283 are measured in inches.
305		Software	Ver.2.00	The camera firmware version.
306		DateTime	2003:07:01 12:29:36	The date of this image (specifications allow this field to be changed by editing software).
330		SubIFDs	1570	The offset for the secondary IFD, which will describe the real image.
532		ReferenceBlackWhite	0/1,0/1,0/1	The normalized range for RGB channels.
34665		EXIFIFDPointer	1014	The offset of the IFD which contains EXIF data.
34675		InterColorProfile	Raw bytes	The embedded ICC color profile of the actual image.
36867		DateTimeOriginal	2003:07:01 12:29:36	The date of this image (this field cannot be changed by any editing software).
37398		TIFF_EPStandardId	1,0,0,0	The version of the information.

Secondary IFD

The secondary IFD is placed at offset 1570 (just as the field #330 said) and describes the actual photo raw data:

#	#hex	Field	Example	Description
254		NewSubfileType	0	This is the actual image.
254		NewSubfileType	0	(repeated)
256		ImageWidth	3034	The width of the actual image in pixels.
257		ImageLength	2024	The height of the actual image in pixels.
258		BitsPerSample	12	Each sample of the actual image is made of 12 bits.
259		Compression	1	The image is not compressed.
262		PhotometricInterpretation	32803	The data is encoded in a Color Filter Array.
273		StripOffsets	326998	The offset of the raster data of the image.
274		Orientation	1	The image is landscape-oriented.
277		SamplesPerPixel	1	Each pixel is made of a single sample.
278		RowsPerStrip	2024	The raster is encoded in a single block holding all of the 2024 rows.
279		StripByteCounts	9211224	The size of the raster block in bytes.
282		XResolution	300	The horizontal resolution of the image.
283		YResolution	300	The vertical resolution of the image.
284		PlanarConfiguration	1	
296		ResolutionUnit	2	The resolution at fields #282 and #283 is measured in inches.

#	#hex	Field	Example	Description
33421		CFARepeatPatternDIM	2,2	The Bayer Pattern is sized 2x2 pixels.
33422		CFAPattern	1,0,2,1	The Bayer Pattern is G-R-B-G
37399		SensingMethod	2	The sensor type is "OneChipColorArea"

EXIF IFD

At the offset 1014, as pointed out by the field #34665 in the primary IFD, there is the IFD with EXIF data:

#	#hex	Field	Example	Description
33434		Exposure time	'0.003125	The shutter time (1/320 sec.)
33437		Fnumber	'2.8	The aperture.
34850		ExposureProgram	4	Shutter priority.
36867		DateTimeDigitized	2003:07:01 12:29:36	
36868		DateTimeOriginal	2003:07:01 12:29:36	
37380		ExposureBiasValue	'0.0	The exposure bias.
37381		MaxApertureValue	'3.0	The max. aperture of the lens in APEX units.
37383		MeteringMode	5	Pattern metering
37384		LightSource	9	Fine wheater.
37385		Flash	0	Flash did not fire
37386		FocalLenght	'180.0	The focal length of the lens.
37399		SensingMethod (??)	2	
37500		MakerNote	1820	The offset of the Maker Note
37510		UserComment		
37520		SubsecTime	80	Subsec. Sampling for the DateTime field.
37521		SubsecTimeOriginal	80	Subsec. Sampling for field #36868
37522		SubsecTimeDigitized	80	Subsec. Sampling for field #36867
40961		ColorSpace	1	The color space is sRGB
40964		RelatedSoundFile	Blanks	
41728		FileSource	3	The image was recorded by a DSC
41729		SceneType	1	The image is a direct photo.
41730		CFAPattern	0,2,0,2,1,0,2,1	The description of the Bayer pattern (the first four bytes are the pattern size, 2x2)
41985		CustomRendered	0	Normal user processing
41986		ExposureMode	0	Auto exposure.
41987		WhiteBalance	1	Manual white balance
41988		DigitalZoomRatio	'1.0	No digital zoom was used
41989		FocalLenght35mmFilm	270	The focal lenght of a 35mm lens having the same angle of view of the lens on our D100. Here you see the "crop factor 1.5x".

#	#hex	Field	Example	Description
41990		SceneCaptureType	0	Standard scene.
41991		GainControl	0	No gain.
41992		Contrast	0	Normal contrast.
41993		Saturation	0	Normal saturation.
41994		Sharpness	0	Normal sharpness.
41996		SubjectDistanceRange	0	Distance is unknown.

Maker Note

The Maker Note is the first really proprietary block of data. It describes all of the options set by the camera, as well as information annotated by editing software such as Nikon Capture Editor.
Note: currently only D100 and partial D1X information is included.

#	#hex	Field	D1	D1X	D1H	D100	D2H	Example	Description
1	0x1	FirmwareVersion		✓		✓		'0200'	The firmware version of the camera.
2	0x2	ISO		✓		✓		0 400	The ISO used to take the photo.
3	0x3	Unknown		✓					*Colour mode?*
4	0x4	Quality		✓		✓		RAW	This is a RAW file.
5	0x5	WhiteBalance		✓		✓		SUNNY	The white balance as set in the camera. Note that the value is right padded with blanks.
6	0x6	Sharpening		✓		✓		NORMAL	The sharpening as set in the camera. Note that the value is right padded with blanks.
7	0x7	FocusMode		✓		✓		AF-S	The focus mode used to take the photo. It can be: AF-S: autofocus, single AF-C: autofocus, continuous (do not confuse this with AF-S lenses!) MANUAL: . Note that the value is right padded with blanks.
8	0x8	FlashSetting				F			It can be: NORMAL.
9	0x9	FlashMode				F			It can be: NEW_TTL *empty* if the flash unit is not recognized or not used.
11	0xb	WhiteBalanceFine		✓		✓		0	Fine adjustment of white balance *as set in the camera*. The range is [-3..+3].

#	#hex	Field	D1	D1X	D1H	D100	D2H	Example	Description
12	0xc	WhiteBalanceRB Coefficients		✓		✓		2.25882352, 1.76078431, 0.0, 0.0	The first two numbers are coefficients to multiply red and blue channels according to white balance *as set in the camera.*
13	0xd	Unknown		✓		✓		0,1,6,0 (hex)	
14	0xe	Unknown		✓		✓		0,1,c,0 (hex)	*Exposure difference?*
17	0x11	Unknown		✓		✓		6942	
18	0x12	FlashCompensation				F			
19	0x13	ISO (2)				✓			Looks like the same information of field #2.
129	0x81	ToneCompensation		✓		✓		NORMAL	The tone compensation *as set in the camera.* It can be: AUTO: the value should be dinamically computed by the viewing software; CS: custom, the curve defined by field #140 should be applied; LOW: low: HIGH: high; NORMAL: normal. Note that the value is right padded with blanks.
131	0x83	LensType		✓		✓		0	The type of lens used. It can be: 0: AF non D lens; *1: manual* 2 AF-D or AF-S lens. *6: AF-D G* *10: AF-D VR*
132	0x84	Lens		✓		✓		180.0,180.0, 2.8,2.8	A pair of focal/max-fstop values that describe the lens used.
135	0x87	FlashUsed		✓		✓		0	It can be: 0: flash unit did not fire 4: flash unit unknown 7: flash unit is external *9: flash unit is on camera*
136	0x88	Unknown		✓		✓		0,0,0,0	*AF Focus position?*
137	0x89	Unknown		✓		✓		0	*Bracketing?*
139	0x8b	Unknown		✓		✓		48,1,c,0 (hex)	
140	0x8c	Curve		✓		✓		A lookup table	The contrast curve *as set in the camera.*
141	0x8d	ColorMode		✓		✓		MODE2	The color mode *as set in the camera.* It can be MODE1, MODE2, MODE3. Note that the value is right padded with blanks.
142	0x8e	Unknown		✓					

#	#hex	Field	D1	D1X	D1H	D100	D2H	Example	Description
144	0x90	LightType		✓		✓		NATURAL	It can be: NATURAL SPEEDLIGHT Note that the value is right padded with blanks.
145	0x91	Unknown		✓		✓		Array of bytes	
146	0x92	Hue		✓		✓		0	The hue adjustment *as set in the camera.*
149	0x95	Unknown				✓		OFF	*Noise reduction?*
151	0x97	Unknown				✓		Array of bytes	
152	0x98	Unknown				✓		Array of bytes	
153	0x99	Unknown				✓		1517 , 1012 (dec)	
154	0x9a	Unknown				✓		7.8, 7.8	
3585	0xe01	CaptureEditorData				C		Array of bytes	A large block of settings by Nikon Capture Editor.
3600	0xe10	Unknown				✓		7036 (dec)	

F – only with a flash unit attached
C – only if the image was saved by Nikon Capture Editor

Capture Editor Data

tbd

Raster Data

Raster data is coded as a sequence of 12-bits values packed in bytes for saving space. In facts 3034 * 2024 * 12 / 8 = 9211224, which is the raster size in bytes declared by field #279. But there is something to take care of. The D100 produces images with field #259 set to 34713. This is the same value that you can find in NEF compressed files, but it doesn't necessarily mean the file is actually compressed. If the field #279 is set to the value 9844736, the file is actually **padded**: every 10 samples (12x10 = 120 bits = 15 bytes) there is a padding byte (to a 16-byte block), and after every row there are other 10 padding bytes. But there's no compression at all. File re-saved by Nikon Capture Editor are not padded. I've not tried the real compressed RAW format yet.

Even rows are made by sequences of G-R-G-R-G-R... colors, while odd rows are composed by sequences of B-G-B-G-B-G colors. Here you can see an enlarged version of the original picture, cropped around the bird eye and loaded without applying any demosaicing algorithm. In other words you're seeing **exactly what the camera captured**, with no ICC profile applied; I just tweaked levels to improve readability. If the image looks greenish to you, that makes perfectly sense: since in any 2x2 pixel pattern there are **two** green components and only **one** red and blue components, the resulting image is clearly unbalanced. And this also explains why the sensor looks green.

Processing workflow

tbd

References

EXIF official specs:
http://www.exif.org/specifications.html

Gottfried Hogh's page about D1 NEF:
http://zulle.pair.com/ghogh/Computers/comp_NEF.html

Dave Coffin's "Raw Digital Photo Decoding in Linux"
It offers some useful information, including the source of a C program able to convert (with some limitations) more than 60 raw formats.
http://www2.primushost.com/~dcoffin/powershot

Various Maker Note specifications:
http://www.hugsan.com/EXIFutils/Documentation/EXIFutilsUserGuideWin.htm

Table of Contents