The basics of **image resolution/raster resolution**

Nowadays, data handling is playing an increasingly important part in the workflow of a printing house. The staff member must be able to create the print data without any error in order to achieve a given quality in the end product. A crucial factor in this context is that he/she must know the basics of image resolution, image depth, the conversion from a pixel image to a separate raster image and the resolution of the imagesetter.

First of all, an image on the monitor generally consists of many pixels. The dimensioning of the image is dependent on the number of pixels in terms of height and width.

In our example, the image is 3008 pixels wide and 2000 pixels high. The number of the existing pixels depends on the resolution of the camera or scanner. The higher this number, the more pixels can an image contain.

Image resolution

In everyday speech in prepress, people talk of a minimum image resolution of 300 ppi. However, this value must always relate to a specific image size. Our exemplary image has an image resolution of 300 ppi in an actual image size of 25.47 cm x 16.91 cm. If you assumed, for instance, a resolution of 200 ppi, the image would have an actual image size of 38.2 cm x 25.4 cm with the existing pixel number of 3008 x 2000 pixels.

Image size:

3008 pixels : 300 ppi	= 10.03 Inch
10.03 ppi x 2.54	= 25.47 cm
2000 pixels : 300 ppi	= 6.67 Inch
6.67 ppi x 2.54	= 16.91 cm

The minimum image resolution required in offset printing depends on the raster frequency in printing and the quality factor. Here, the motto is: "The resolution

Photoshop screenshot

should be as high as necessary." An excessively high image resolution increases the data volume as well as the computing time, whereas it does not improve the quality since the resolution during the subsequent printing process conforms to the pre-set screen ruling. When the image resolution is too low, this may produce jaggies and images with a course resolution.

Minimum image resolution	= Screen frequency x QF
QF= quality factor	= 2 (colour images)
	= 1.5 (grey scale images)

Example: Four-colour offset printing 60-line screen (152L/ Inch):

Minimum image resolution

= 60 L/cm x 2.54 x QF 2	= 304.8 ppi
= 70-line screen	= 355.6 ppi
= 80-line screen	= 406.4 ppi

Therefore, generally speaking, a minimum image resolution of 300 ppi has established itself in every-day routines with data. The tolerance range in practice is approx. 75-150% of the calculated minimum resolution. For web applications, the standard is still at least 72 ppi. This value, however, is still based on the lower output resolution of older output monitors. In large-format printing, too, the minimum resolution can be reduced to 150 ppi or less depending on the output format and the viewing distance.

Colour depth

The colour or image depth specifies how much information is hidden behind a pixel. A bit is the smallest data unit and describes exactly two states, i.e., dot or no dot. The higher the number of bits, the more different grades can be represented per colour. Normally, images are encoded with an image depth of 8 bit. This means the codes 1 or 0 eight times per pixel, i.e., in total 2^8, hence a palette of 256 different colours. For instance, for strong image corrections in photography, images can also reasonably be used with an image depth of 12 or 16 bit in the RAW data format.

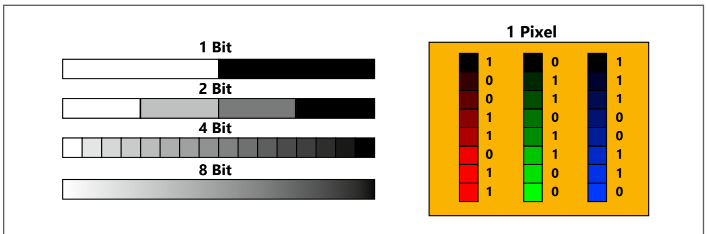
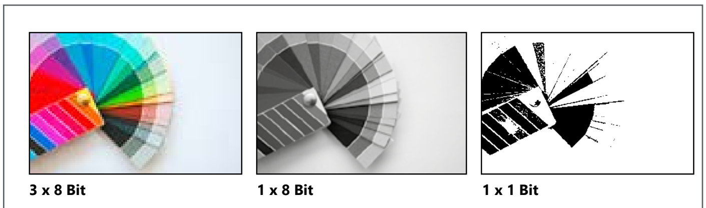


Image depth

So, in the RGB colour space, 3 channels are encoded with 8 bit each. This sum is equivalent to 16.7 million different colour coding possibilities. Since different encodings may produce the same colour, this is only an indication of what is possible from a technical point of view, not how many different colours can in fact be represented in a colour space. In the CMYK colour space, there are presumably 16.7 million colours, since, according to the subtractive colour mixing, only the colours CMY are responsible for the colour definition. Black is only added for black generation and does not produce any new colours.



Examples for colour depth

From the pixel image to the printing screen

Following prepress, the pixel image is separated in the RIP and converted into screen dots. Now, the kind of dot, the dot shape, the screen ruling and the screen angle are stored. The conversion from pixels to screen dots above all depends on the pre-set screen ruling and the resolution of the imagesetter. The screen ruling is specified in lines per cm (L/cm) and/or lines per inch (lpi).

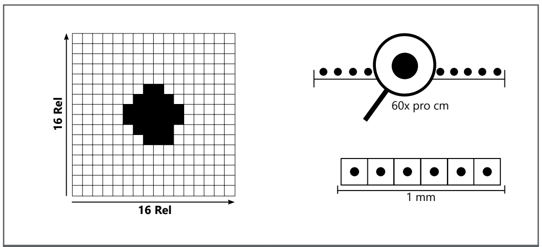
The pixel images in the CMYK colour space with an 8-bit colour depth, i.e., with a storage requirement of 4 x 8 bit equalling 8 byte per pixel, are converted into four different 1-Bit-Tiff data in the RIP. This means, a separate Tiff file with an information depth of one bit, i.e. dot or no dot, is created for every colour and/or printing plate. Depending on the tonal value of the pixel, the dot size (AM) and/or area coverage is generated. The smallest unit that can be exposed in an imagesetter is a single recorder element (1 Rel). An imaged recorder element is called dot. The dot is surrounded by an elementary square which is composed of 16 x 16 Rel, i.e. 256 Rels, in the case of a colour depth of 8 bit. The higher the pre-set screen width, the more lines are on one centimetre (inch) and the smaller is the elementary square. However, this also means that the imagesetter should have an adequately high resolution in order to be able to reproduce smaller Rels and/or elementary squares.

Imagesetter resolution: Screen width x ($\sqrt{}$ number of grey scales)

60 L/cm (152 L/ Inch) = 2540 dpi min. imagesetter resolution
70 L/cm (178 L/ Inch) = 2845 dpi min. imagesetter resolution
80 L/cm (204 L/ Inch) = 3252 dpi min. imagesetter resolution

If the imagesetter resolution for the pre-set screen width is too low, discontinuities of hues may occur during the imaging process.In the printing industry, images with a depth of 8 bit, i.e. 256 reproducible grey scales, are absolutely sufficient in terms of quality. With a higher image depth, the required imagesetter resolution would rise extremely.

Screen frequency



Imagesetter resolution

A practical example:

60-line (152 L/ Inch) raster in offset printing / 8-bit colour depth

60 L/cm x ($\sqrt{256}$)	=	1000 imagesetter pixels / cm		
	=	**2540 dpi minimum imagesetter resolution**		
10% tonal value	=	10% of the 256 Rels per elementary square		
	=	26 exposed Rels	=	**26 dots**
Elementary square	=	10 mm : 60 dots		
	=	**0.166 mm grid constant per dot**		
	=	0.166mm x 0.166 mm	=	**2.77 mm²**
Dots per mm	=	1 mm : 0.166 mm	=	**6 dots per mm**
Rel size	=	1 cm : 60 L/cm : 16 Rels	=	**~ 10 µm / Rel**

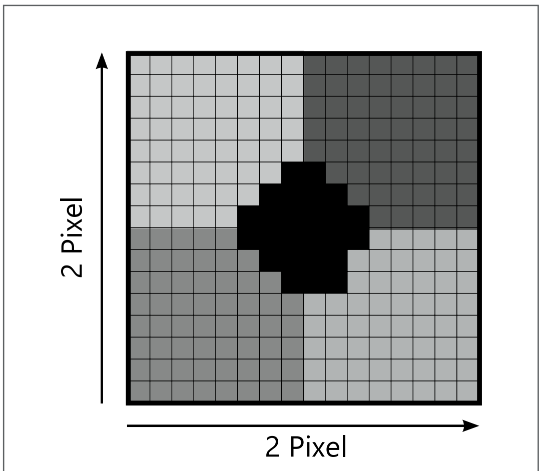
In our example, the result is a ten percent tonal value from 26 dots, i.e., 26 exposed Rels. The 16x16 Rels are spread on an area of 2.77 mm² per elementary square. The result is a size per Rel of approx. 10 µm in the AM screen. For an FM screen, approx. 10-20 µm per dot are needed. This means that the FM screen would also be possible with an imagesetter resolution of 2540 dpi. The human eye distinguishes from a viewing distance of 25 cm just 3 dots on one millimetre. Therefore, at least 6-7 dots should be spread in sheet-fed offset printing and in newspaper printing at least 3-4 dots per mm. The same quality grading is also used in digital printing. An inkjet printer with a resolution of 1440 dpi and a 10x10 matrix, for instance, reproduces 5.7 printing dots per mm. This is equivalent to more or less the quality of photo-realistic offset printing.

Quality factor

If 1 pixel were directly converted into one printing dot (RIP) and, vice versa, directly into one pixel (scan), the so-called sampling and/or scanning errors would occur due to the Nyquist-Shannon-sampling theorem, which prevents a 1:1 conversion. Due to the screen angles and/or sampling errors, ragged lines and/or jaggies will occur after screening.
Therefore, what is needed in the scanning process and in the RIP is still

Quality factor (sampling factor) 2!

This means that within a specific frequency the image is scanned twice in order to get four pixels and that during the conversion from the pixel to the printing dot a screen dot consisting of 4 pixels is produced. The tonal value information of 4 pixels is used to calculate a medium value and then to determine the equivalent size of a screen dot. The tonal values differ depending on the number of exposed dots. Due to the high computing performance, the quality factor can be reduced to 1.5 in practice. A quality factor of more than 2 does not contribute to an improvement in quality.



Quality factor

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