
Making sense of DPI, PPI, Megapixels and Resolution

Many people confuse DPI with PPI. Even though the terms "dots per inch" (DPI) and "pixels per inch" (PPI) are used interchangeably by many, they are not the same thing. In many instances the term DPI is used when in fact PPI is what is really meant.

Dots vs. Pixels

Monitors display pixels. Printers produce dots.

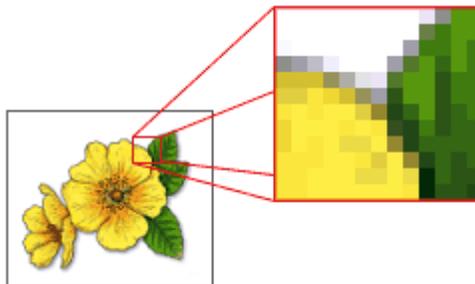
An inkjet print, or even a glossy print in a magazine or on a poster, is made up of lots of individual dots of ink. These dots are very tiny, and when printed close together our eyes perceive them as continuous color images.

A 200 dpi print means that for each inch of that printed material, it takes about 200 dots to make the picture.

Thus, a 'high dpi' image means that it has so many dots tightly printed together with less space between them than a 'low dpi' image. Images with high dpi value appear sharper and colors appear to blend better than images with low dpi value. In sum, DPI is a measure of how an image is printed to a medium such as paper (or conversely, scanned from paper).

Digital Image

Unlike prints that are made up of small dots, a digital image is made up of a grid of individual, tiny pixels with each representing a color in the image. A pixel is like a square dot without gaps. If you zoom in on one of these images (see example) on your computer you'll be able to see the individual squares of color.



Megapixels and Resolution

Many digital camera specifications mention the number of horizontal and vertical pixels that it can produce. For example, some digital SLR cameras are advertised as capable of producing up to 2,592 pixels wide and 3,888 pixels tall. You can find out the number of megapixels by multiplying the horizontal and vertical pixels.

In this case, it is equivalent to $2,592 \times 3,888 = 10,077,696$ pixels (≈ 10.1 megapixels)

An image with a lot of pixels is also called high resolution. An image with a low number of pixels is called low resolution. This is why the terms megapixels and resolution are sometime used to mean the same thing.

The quality of output is determined by how many pixels there are in an image. For example, assuming using the same recording device, an image that is recorded in 60 pixels wide by 60 pixels tall is higher quality than an image that is recorded in 10 pixels wide by 10 pixels tall. See the picture here.



10 PPI: Image appears as a block of colored squares.



30 PPI: Object in the image is starting to emerge.



60 PPI: Image is sharper and colors blend better.

PPI or pixel density

Now that you know about megapixels and the number of horizontal and vertical pixels in an image, how does that translate to PPI?

Screen resolution

- A higher resolution monitor is a monitor with greater pixel density. The pixels in the high resolution monitor are smaller and there are a lot more pixels in this high resolution monitor than the low resolution monitor.
- A screen with a higher resolution will render a smaller image than a screen with a lower resolution because each pixel in a higher resolution monitor is smaller than the pixel in a lower resolution monitor so 1,000,000 small pixels take less space than 1,000,000 large pixels.

Why do I always see “72 dpi”?

By default, some cameras save digital images in arbitrary values as 72 dpi (or 180 dpi in some cases), this number is confusing in many ways. First, actually the correct term is ppi because a digital image has nothing to do with printing (or “dots”). The appearance of 72 ppi does not mean that your digital photo is of low quality. But the camera just assumes that you want to display that image on a computer monitor which traditionally has been 72 ppi (a 72 pixel by 72 pixel image should take up about one inch of space on the screen)¹. With new monitor models constantly released, of course they are packed with ever more pixels in each square inch so there are actually more than 5,184 pixels (72 pixels wide x by 72 pixels high) in every square inch but the camera manufacturers still follow convention of 72 ppi.

Scanning with a digital camera – Optics and megapixels count

When digital cameras are used as a scanning device, the factors that determine image quality are:

- a) **The quality of the recording device** (camera’s optics and sensor, scanner’s sensor)
The better quality the optics → the better the image quality
- b) **The size in pixels of the digital image.**
The more pixels an image has → the better the image quality

Notes

- A camera with a high megapixel count but poor optics will take high resolution, poor looking pictures.
- The megapixel count is still an important factor in choosing the right camera but don’t blindly pick a camera by just looking at its megapixels.
- A digital SLR camera, due to its better optics, almost always produces images that are superior to those produced by point-and-shoot cameras – even the ones with more megapixels.

Effective DPI

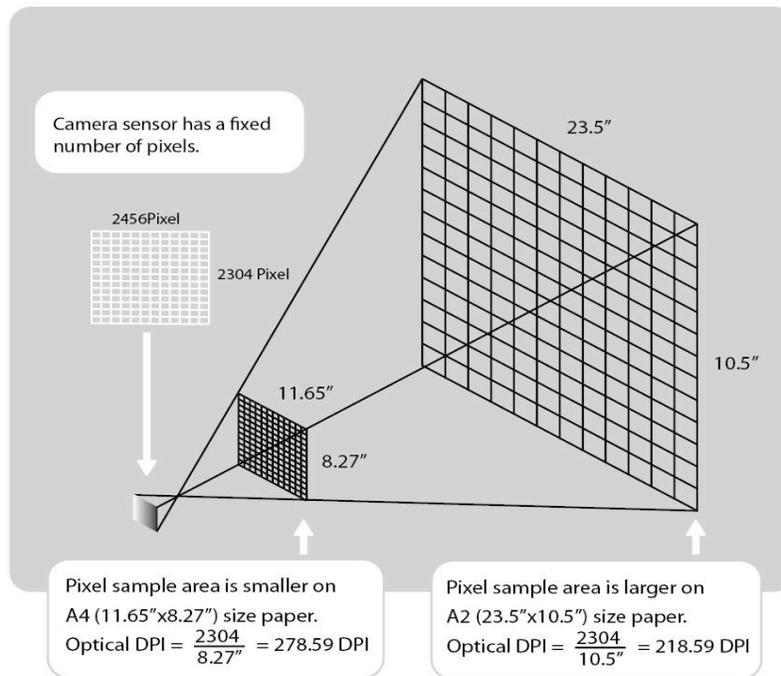
With a digital camera, you have a fixed number of pixels which is the maximum your camera is able to capture. It is however many pixels wide by however many pixels tall. You can’t change that.

The table below compares the effective optical DPI of images when “scanning” different size pages with a range of digital SLR cameras. It shows that the optical or effective DPI of an image is dependent on both the page size and the camera’s megapixel rating.

¹ This of course also depends on what resolution the monitor is set to.

OPTICAL DPI TABLE					
Page Size	Canon EOS 350D/XT 8 MP (2304 x 3456)	Canon EOS 400D/XTi 10.1 MP (2592 x 3888)	Canon EOS 20D, 30D 8.2 MP (2336 x 3504)	Canon EOS 5D 12.7 MP (2913 x 4368)	Canon EOS 1Ds Mark II 16.6 MP (3328 x 4992)
A2 (16.54" x 23.5")	139	157	141	176	201
A3 (11.69" x 16.54")	197	222	200	249	285
Legal (8.5" x 13.82")	250	281	254	316	361
A4 (8.27" x 11.69")	279	313	282	352	402
Letter (8.5" x 11")	271	305	275	343	392
B5 (7.17" x 10.12")	321	362	326	406	464
B4 (10.14" x 14.33")	227	256	230	287	328
Tabloid (11" x 17")	203	229	206	257	294

Page Size and Optical Resolution



If you are scanning an A3 (11.69" by 16.54") size page and your goal is just to digitize the image and perform an OCR, 200 ppi would sufficiently do the job.

How many megapixels do you need for that?

$$\begin{aligned}
 11.69 \text{ inches} \times 200 \text{ pixels} \quad \text{by} \quad 16.54 \times 200 \text{ pixels} &= 2,338 \text{ pixels} \times 3,308 \text{ pixels} \\
 &= 7,734,104 \text{ pixels} \\
 &= 7.7 \text{ Megapixels}
 \end{aligned}$$

A camera that is higher than 7.7 megapixels will do the job.