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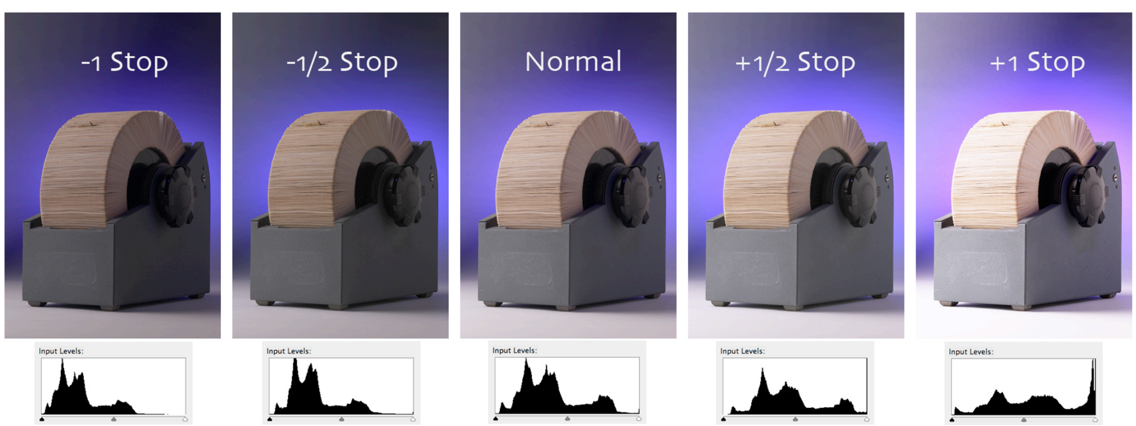
Exposure Strategies for Digital Capture

Regardless of the media choice of film or a digital sensor, understanding how to implement an exposure strategy is one of the most critical concepts that a photographer needs to know. The range of light intensity that a film or sensor is capable of recording is called *dynamic range*, and the extent to which a light sensitive material can be under- or over-exposed, yet still achieve an acceptable result, is called *exposure latitude*. The idea of "an acceptable result" is clearly dependent upon what the artist's intent and personal aesthetic is, so the definition of exposure latitude is in essence very subjective. Nevertheless, the objective of optimizing exposure is for the sake of possessing the best available data during the image's next phase of production, which is typically print output.

Unfortunately, a human eye-brain system and a digital camera system are two completely different methods of seeing light, and it is a common misconception to expect that a digital sensor is going to see, respond, and record light the same. The table below provides a glaring comparison to illustrate this fact.

	Dynamic Range	Exposure Latitude
Human Eye/Brain System	About 20 stops possible	About 7 stops
Digital Camera Sensor	About 6 stops possible	About 3 stops*

As one can plainly see, *dynamic range is not exposure latitude*. If sound is used as an analogy to help make the point, then we can express the idea that a human dynamic range of sound can be from a pin drop to an explosion — yet it's impossible to hear a pin drop and an explosion simultaneously. The latitude of sound that the ear-brain system is capable of hearing is only relative to the situation — a silent room or a quarry. So the same idea applies to how humans and machines, see light: both have limits, but their limits are very different.



Exposure Bracketing

Exposure bracketing is a technique of creating several consecutive exposures that have the same composition, but differ slightly in density — usually a half stop apart. It is an exposure strategy that increases the chance of producing several usable frames from each situation — some have better shadow detail, some have better highlight detail, and usually one exposure has the best of both. The objective is to create a final, printed image that is inclusive of highlight and shadow detail, which means that one must shoot several frames, as illustrated above, and then determine in the edit, the best rendering to process. **If highlight to shadow intensities are within 3-stops, then the scene is optimized for a camera sensor's exposure latitude.*

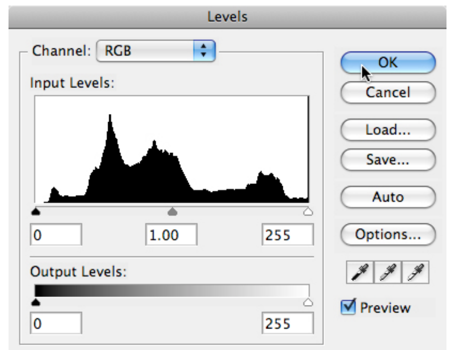
What is a histogram?

A histogram is a graph used in statistics (a univariate frequency distribution) and was originally used in photography by engineers that developed the first digital cameras. Histograms are mysterious characters of photographic culture because they are not fully understood by the average photographer, and therefore they are not used — let alone used correctly. As a digital photographer, the skillful use of a histogram is as fundamental as the skillful use of aperture and shutter speed.

This histogram represents the +½ stop exposure from the bracket illustrated on the first page.

See these companion data sheets:

- Digital Vocabulary Terms (bit depth)
- Linear Gamma White Paper, by Bruce Fraser
- Tungsten Light, ISO, Metering



Every digital image can generate a histogram, either on the camera's preview screen or in image editing software. A histogram is composed of a horizontal, x-axis of luminosity that represents a continuous-tone gray scale — on the left side is **0**, black, and on the right side is **255**, white. Each shade of gray is assigned a numerical value along the x-axis on the graph.

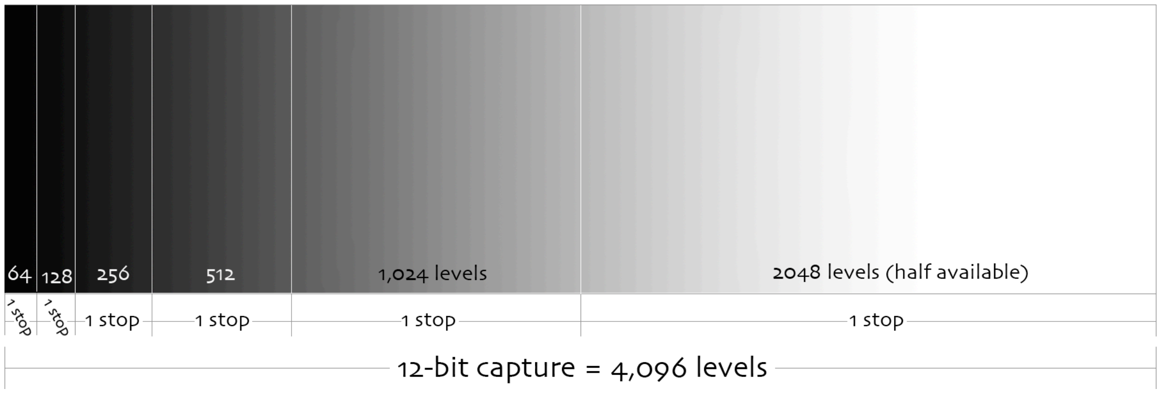
Each pixel received from the image finds its matching position of relative brightness on the x-axis. Every time a pixel of a particular brightness appears in the data, it is stacked with other pixels of the same brightness, thereby creating a vertical y-axis of frequency, for each shade of gray. The result is a graph of very fine vertical lines (bar chart). The lines of varying altitudes can appear as a mountainous profile, a bell shaped curve, or even distorted shapes.

There is no ideal *shape* for the data in a histogram, although there is an ideal *placement* of the data. The histograms that appear under each image on the first page show that even a half stop difference in exposure makes the data change shape. The optimal placement of the data however, is to *skew it to the right* — the highlight area of the graph — *without hitting the wall.* The +½ stop histogram in the above illustration is optimal for post-production because the data favors the mid-tones and highlights — not the shadows. Take special note of the black spike of data that has hit the right wall and has the greatest altitude — this data can most likely be recovered in Adobe Camera RAW with the highlight recovery slider.

The +1 stop histogram indicates a much heavier skew of data toward the highlights, and is perhaps not going to be the best choice for processing — its too overexposed. Contrarily, the -1 stop histogram indicates a heavy skew of data toward the shadows, and if chosen for processing, will most likely produce undesirable noise in the shadow areas during processing.

Knowing the basic properties of a histogram is a great way to judge the overall exposure made in regard to the range of light available in the scene. When shooting in the RAW file format (CRW, CR2, NEF, ORF, RAW, FFF, etc.), implementing an exposure bracket is very, very useful, because it enables you to choose from and manipulate the best quality data the sensor can produce. An advanced exposure technique that enables a composite of data to simulate the exposure latitude of human vision with that of a camera sensor is known as a High-Dynamic Range (HDR) image — HDR allows a camera to see light like a human.

[*] Linear Gamma of Tone with a six-stop dynamic range sensor



Linear gamma refers to the idea of the levels corresponding exactly to the number of photons that can be captured by the sensor. Most digital cameras capture in a 12-bit mode, which means that the dynamic range is capable of producing 4,096 levels of gray. The first 2,048 levels are devoted to the brightest stop. Since 2,048 levels then remain, half of that (1,024 levels) is devoted to the next stop; half of the 1,024 levels remaining (512 levels) are devoted to the next stop, and so on. The darkest stop, the extreme shadows, are represented by only 64 levels (shades of gray). For clarification on bit depth, see the digital vocabulary terms.

Do the Math

Compare the geometric progression of time in the bracket below to that of the value range increments in the gray scale above. The method of math is the same. Note specifically that when a value is doubled, there is a one-stop increase in exposure value (8 sec. to 16 sec.), and contrarily when a value is cut in half (8 sec. to 4 sec.), there is a one-stop decrease in exposure value. Photographic practices are riven with the math of geometric progression — either twice or half as much. The ISO scale for instance, reveals the same math method.

- +1 stop: 16 sec. @ f/22 (overexposure)
- +1/2 stop: 12 sec. @ f/22 (overexposure)
- N 8 sec. @ f/22 (determined as the normal exposure)
- -1/2 stop: 6 sec. @ f/22 (underexposure)
- -1 stop: 4 sec. @ f/22 (underexposure)

If you are someone who use to shoot transparency (slide) film, you were always encouraged to slightly underexpose to avoid overexposing the highlights. But with digital capture, if this practice is continued you are forfeiting a significant amount of data that the camera is capable of seeing, and increasing the risk of introducing noise into the midtones and shadow areas during RAW processing/conversion —maybe even posterizing the image data.

Expose for the Highlights

The information on this page is presented to emphasize the reason why photographers are encouraged to *shoot to the right,* so as to make sure that the histogram data favors the right side — the highlights — as much as possible. See the footnote for more info.

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[*] Illustration and text adapted from the Raw Capture, Linear Gamma, and Exposure White Paper written by Bruce Fraser © 2004. It was adapted from his book Real World Camera Raw, published by PeachPit Press.

Exposure Bracket Examples

Let's say the light meter reading tells you that the normal exposure is 1/30th sec. @ f/8.0. In the example illustrated below, the shutter speed remains at 1/30th sec. for each exposure. A bracket can be exposed in any order, but if exposed consecutively from lightest to darkest, or vice-versa, the editing process is easier when comparing frame-to-frame.

- +1 stop: 1/30th sec. @ f/5.6 (overexposure)
- +1/2 stop: 1/30th sec. @ f/6.7 (f/5.6½) (overexposure)
- N 1/30th sec. @ f/8.0 (normal exposure)
- -1/2 stop: 1/30th sec. @ f/9.5 (f/8½) (underexposure)
- -1 stop: 1/30th sec. @ f/11.0 (underexposure)

Words of Caution Regarding Depth of Field and Motion

A bracket run from f/5.6 to f/11.0, as illustrated above, probably means losing critical focus on select planes of space in the composition — the depth-of-field variable changes (with the size of the aperture opening) radically from one end of the bracket to the other.

If maintaining depth-of-field throughout the exposure bracket is important to the success of the rendering, then adjust the shutter speed so that the aperture remains within a half-stop of normal. The bracket below provides the exact same range of exposures as the previous example, but now, the motion variable is compromised instead of the depth-of-field — if the subject matter is moving during the exposure there is a greater chance of it blurring.

- +1 stop: **1/15th sec.** @ f/8.0 (overexposure)
- +1/2 stop: 1/30th sec. @ f/6.7 (f/5.6½) (overexposure)
- N 1/30th sec. @ f/8.0 (normal exposure)
- -1/2 stop: 1/30th sec. @ f9.5 (f/8½) (underexposure)
- -1 stop: **1/60th sec.** @ f/8.0 (underexposure)

Analysis

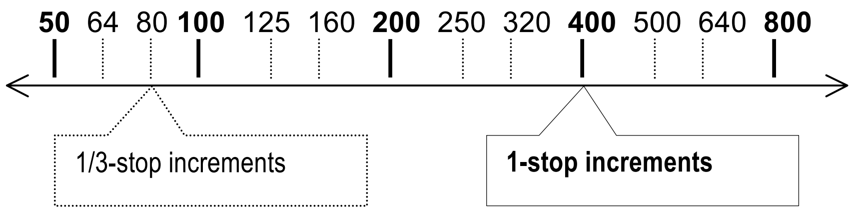
+ 1 stop	**1/15th** sec. @ f/8.0 (More Blur but, maintaining depth of field)
+ 1/2 stop	1/30th sec. @ f/6.7 (f/5.6½) (Slightly decreasing depth of field)
Normal	1/30th sec. @ f/8.0 (Determined by light meter readings and test shots)
- 1/2 stop	1/30th sec. @ f/9.5 (f/8½) (Slightly increasing depth of field)
- 1 stop	**1/60th** sec. @ f/8.0 (Less Blur but, maintaining depth of field)

• The photographer must determine how to use the variables of aperture and shutter speed, and which combination is most supportive to the intended interpretation of the image. Generally speaking, this means that the camera must be operated in a fully manual mode.

• The "right" image is a complex quantitative and qualitative evaluation process as it must take into account both technical and aesthetic intents.

• When preparing a series of exposures to run the High Dynamic Range (HDR) action on, in Adobe Photoshop, the previous exposure bracketing strategy is strongly recommended.

ISO Controls Sensitivity to Light



ISO refers to the International Organization for Standardization. When applying one of these values, as in the case of a film, digital capture sensor, or light meter, this unit of measure defines the device's sensitivity to light.

Each time an ISO value is doubled, you gain one-stop of *speed* — meaning you can use a shutter speed one stop *faster* — from 1/60th to 1/125th for instance. You could choose to close the lens down one-stop instead, to obtain greater depth-of-field — from f/16 to f/22 for instance. Contrarily, when an ISO value is cut-in-half, one-stop of *speed* is lost.

Note that ISO numbers progress in 1/3-stop increments. No values exist in between them, as they are registered standards of manufacturing — they are "known states" of information. Even though there are values above in bold type indicating one-stop increments, we can calculate the difference of one-stop between ISO 80 and ISO 160; or from 320 to 640 also. **Depending on the age of a camera's technical generation, higher ISO settings can produce *noise* in a digital image, which is analogous to hearing static on an AM radio station.**

Three Variables Are Needed to Create Photographs

With ambient light sources there are three camera control variables that make an exposure.

- The variable of **sensitivity** — controlled by the ***ISO value***
- The variable of **time** — controlled by the ***shutter speed***
- The variable of **intensity** — controlled by the ***aperture***

Exposure Values

If a given amount of light produces normal image density with the exposure values in bold type, then the photographer can choose any other column of values to produce a frame of equal density. Each variable is in one-stop increments. ISO remains the same in each case.

Shutter	1/2000	1/1000	1/500	**1/250**	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1 sec.	Time
Aperture	*f/1.4*	*f/2.0*	*f/2.8*	***f/4.0***	*f/5.6*	*f/8.0*	*f/11*	*f/16*	*f/22*	*f/32*	*f/45*	*f/64*	Intensity