Flash Photography with Canon EOS Cameras - Part II.

Version 1.6. February 11, 2004.

http://photonotes.org/articles/eos-flash/

Back to Part I.

EOS flash photography modes.

The four main Canon EOS "creative" zone modes (P, Tv, Av and M) each handle flash metering in very different ways. These differences are probably one of the primary sources of confusion in the world of Canon EOS flash photography.

Here are a few important terms and concepts that you need to know before understanding how these confusing points originate.

Subject and Background in flash photography.

The typical flash photograph is assumed to have two basic regions. The *foreground* or *subject* is the area around the autofocus metering point - perhaps a person. *Background* ambient lighting is just everywhere else.

This is an important distinction because all portable flash units have a limited range. As noted in the FAQ section, you can't expect a small flash unit on your camera to illuminate the Eiffel Tower or the Grand Canyon or even a large space such as a ballroom. The camera, therefore, handles the subject and background metering differently and independently.

Fill flash.

Flash photography takes on two very basic forms. In regular flash photography, the flash is the primary light source for the photo. Flash metering is done for the foreground subject, and the background is metered by the camera's regular exposure metering system. This can lead to the background being underexposed and dark if ambient light conditions are low. This is how most people think of flash - as a way of taking photos in dark places.

However, flash can also be used in bright locations or in daylight to lighten shadows, reduce the harsh contrast of full sunlight or brighten up dull images without being the primary light source for the photo. This is called "fill flash." And it's often a source of surprise for non-photographers, who don't expect to see photographers using flash units outdoors on sunny days on in brightly lit settings. In such situations the fill flash is being used as a sort of portable reflector - shining a little extra light in certain areas.

A typical example might be a person who's wearing a hat outdoors on a sunny day. Hat brims often cast dark shadows over the subject's face, and a little flash can lighten up this shadow nicely. A backlit subject is another common use for fill flash - you can't simply crank up the exposure compensation to expose the subject correctly as then the background lighting would be too strong. Or perhaps you want a little sparkle of light reflecting back from a person's eyes - the "catchlight." Sometimes wildlife photographers use flash units at great distances from their quarry for the same reason - they aren't using the flash to illuminate the animal but to provide a lively catchlight to the eyes.

In all these cases you are, from the point of view of the camera, using two light sources at the same time. There's ambient lighting, which is all the available light around you - reflected light from the sun or artificial light sources. And there's the light from the flash unit, which is supplementing this existing light. As always, ambient light levels hitting the film are governed by the lens aperture and shutter speed and flash levels are governed by flash metering. By adjusting the output of the flash unit you're essentially adjusting the ratio between flash-illuminated and ambient light-illuminated scene.

In fact you could argue that the two cases I present above - flash as primary light source and ambient light as primary light source - are an artificial distinction and that all flash photography is fill photography in a sense; just that in the first case the ambient lighting is so low as to be insignificant, whereas in the second case it's the reverse. This is true enough, but I think the distinction is useful to make, particularly in terms of the way full auto and P modes work versus Tv, Av and M modes.

Unlike certain other camera systems (particularly Nikon), Canon EOS cameras always default to fill flash mode when the camera is in Tv, Av and M modes. They also perform fill flash in P mode if ambient light levels are high enough. There's no separate switch or pushbutton to engage fill flash. For details have a look at the section on EOS flash photography confusion below.

Fill flash ratios.

The "fill flash ratio" is commonly described in terms of the ratio of ambient light plus fill flash combined, compared to the fill flash alone. Canon EOS gear, however, usually lets you adjust the fill flash in terms of stops of flash output, in either 1/2 or 1/3 stop increments. What's the relationship between the two ways of describing fill flash?

- A ratio of 1:1 would mean that the flash unit is the sole source of light (0 ambient + 1 flash) and therefore you wouldn't have a fill flash situation.

- A 2:1 ratio would mean that the ambient light and flash are at the same level (1 ambient + 1 flash). That basically means 0 stops of compensation given a fairly flat-lit scene, and usually results in rather unnatural looking fill flash.

- A ratio of 3:1 means that there is twice as much light from the ambient source as the flash (2x ambient plus 1 of flash). Such a ratio requires a -1 stop fill flash setting on the flash unit, since each stop means a doubling or halving of the amount of light.

- A ratio of 5:1 means that there is four times as much light from the ambient source as the flash (4x ambient plus 1 of flash). This is a -2 stop difference. Typically photographers use between 1 and 2 stops of fill flash to lighten shadows without creating a phoney flash-illuminated look.

However, the term "ratio" is confusing and seems to mean different things to different people. Sometimes people talk about a 1:1 ratio when the ambient and fill lights are of equal intensity. So a 2:1 ratio might mean -1 stop fill flash and 4:1 would mean -2 stop fill flash. In this case they're talking more about the light output than they are about the reflected light.

The concept of ratios works well in studio situations where you have total control over the lighting. You can turn off the main light and measure the fill lighting with a meter, you can move lights around to vary their strength, etc. But if you're taking a candid photo outdoors you have no such control. You can hardly turn off the sun, and automated TTL flash is going to have its own ideas as to what constitutes correct lighting.

For those reasons I prefer not to deal with ratios at all for non-studio flash photography but just in terms of the number of stops compensation used by the flash. Note that the term "ratio" is also used in flash photography in conjunction with multiple flash setups, particularly multiple wireless units in the case of wireless E-TTL flash.

Auto fill reduction.

Also called "automatic reduction of flash output" in some Canon documentation. Canon EOS cameras automatically use regular flash exposure with no compensation when ambient light levels are low - 10 EV or lower. However, when ambient light levels are brighter - 13 EV or higher - the camera will switch to fill flash mode and reduce the flash unit's output level. It does so in TTL mode by dropping flash output by 1.5 stops. Between 10 and 13 EV the camera will smoothly lower the flash unit's output by half a stop for each EV.

E-TTL flash works in a similar fashion, though apparently flash output will be lowered by as many as 2 stops when ambient lighting is bright. Canon have not, however, divulged their secret E-TTL fill reduction algorithm, so it's total guesswork exactly how it works. Apparently, though, the algorithm compares the brightness level of each zone both before and after the preflash, in part to compensate for highly reflective areas.

Some mid to high end EOS cameras allow you to disable this auto fill reduction by means of a custom function. See the section on flash exposure compensation for details. Note that any flash compensation you may apply manually is in addition to this auto fill flash reduction, unless of course you've disabled it via a custom function.

Slow shutter sync.

There are two basic ways in which a camera can take a flash photo when light levels are low. The camera can either use a short shutter speed to minimize camera motion blur and have the flash blast out enough light to illuminate the foreground objects whilst leaving the background dark, or the camera can extend the shutter time to allow more of the background to show up and flash-illuminate the foreground subject. This latter technique is called slow sync, slow shutter sync or "dragging" the shutter.

It's only possible in Tv, Av and M modes - you can't use it in P mode or most of the PIC (icon) modes. The one exception is the night scene PIC mode on many EOS cameras, which uses slow shutter exposure with first-curtain flash.

A typical example is a tourist snapshot of someone standing in front of a famous landmark at night. If you keep the shutter speed fast then you'll have a nice flash-illuminated photo of your friend against a pitch black backdrop, unless the landmark is extremely brightly lit or unless you're using very fast film. However, by slowing down the shutter speed you can take a photo of the person standing against a properly exposed background.

The drawback is obvious, of course. By slowing the shutter speed you're going to need a tripod to avoid blur induced by camera movement, especially with long shutter speeds like 1/15 second or slower.

Sometimes slow shutter sync is used to provide a dynamic motion effect in flash photos. A photo taken with flash and a slow shutter speed can provide an interesting mix of flash-illuminated subject and ambient-light-illuminated motion blur. The effect is difficult to predict, but can be very striking and exciting when it works.

Take my photo of fire performers for example - the flash freezes the motion of the performers but the slow shutter captures the swirling motion of their fire chains. Have a look at the discussion of colour temperature theory to find out why the right-hand flash-illuminated performer has a bluish tinge to his skin whereas the rest of the photo is illuminated with very yellow-orange light. Steve Mirarchi also has some interesting examples on his Photo.net article on concert photography.

X-sync (flash sync) speed.

Timing is critical for flash photography. The burst of light from a flash unit is extremely brief (in milliseconds), and must occur when the shutter is fully open. If the flash burst occurs when the shutter is still opening or closing then the shutter itself may prevent the entire image area from being fully exposed.

Modern SLR camera shutters are equipped with a pair of moving curtains which wipe across the opening to the image area. They travel vertically because the travel distance is less than if they travelled horizontally, and there are two curtains to make fast shutter speeds possible. At high shutter speeds the opening is actually an open slit between the two curtains, travelling the height of the image area.

This presents a problem with flash photography. If you have only a slit exposed at the time the flash happens to go off then you won't be able to illuminate the entire image area with the flash burst. An electronic flash burst is always much briefer than the fastest shutter speed motion that the shutter mechanism can achieve.

Different cameras have different shutter designs - some are faster than others. But each camera will have a maximum shutter speed at which a flash burst will expose the full image area of the film. This maximum flash-compatible shutter speed is called "X-sync speed." X-sync and flash sync are the same thing on modern cameras, since they all use electronic flash.

Maximum X-sync speed and EOS bodies.

1/90 second.
All low-end Canon EOS cameras. These are cameras of the Rebel series in North America (eg: Rebel G, Rebel 2000), the Kiss series in Japan (eg: EOS Kiss, Kiss III), and the EOS three-digit series (eg: EOS 300, 500 but *not* the EOS 100, 600 series or 750/850) and all EOS four-digit series (eg: EOS 1000, 3000) elsewhere.

Note, however, that some users report that their Rebel/EOS three/four-digit cameras are actually physically capable of attaining a 1/125 second X sync. That is, the shutter mechanism can sync that fast but the camera's computer has been deliberately programmed not to allow flash sync at speeds faster than 1/90 second. It's not clear why Canon did this. One theory is that it was an intentional move on Canon's part to cripple their low-end cameras for marketing reasons. (ie: so that they compete less with midrange models) Another theory is that this was done because of flash duration tolerances - Canon decided to play it safe and ensure that their low-end shutters always can record a full flash burst.

Either way you can't override the camera's programming and perform flash sync with any dedicated flash unit which meters through the lens. But if you're using an externally triggered flash with an optical slave or adapter cable you may be able to take advantage of this higher sync speed if your camera falls into this category (non-dedicated flash units do not communicate with the camera concerning flash exposure and thus the programmed 1/90 sec limit is not an issue). Unfortunately empirical testing is the only way to find out.

1/125 second.
Mid-range EOS cameras. These are EOS two-digit cameras (eg: EOS 10 and 50) and the Elan series in North America (eg Elan II, Elan 7). Most of the first generation EOS cameras (600, 630, 650, 750 and 850) also have a 1/125 sync, as does the original Elan/EOS 100.

1/200 second.
Semi-pro EOS cameras. These are the single-digit EOS cameras that aren't in the 1 series - the EOS 3 and 5 (A2 in North America). The digital D30 and D60 also have an X-sync of 1/200 sec as does, surprisingly enough, the APS IX. (apparently the smaller physical dimensions of the IX shutter allow it to reach a higher X-sync speed)

1/250 second.
Top of the line professional EOS cameras - the EOS 1, 1N, 1V, 1Ds and 1D mark II. The one odd one out is the EOS 620, an old camera from the late 80s which nonetheless could sync at 1/250 sec as well.

1/500 second.
The digital 1D camera has a startling 1/500 sec X-sync and a 1/16 000 sec top shutter speed. This is because both X-sync and shutter speed are normally handled electronically by the CCD and not by a mechanical shutter. The 1D does have a mechanical shutter but it's used for bulb mode. Note, however, that the CMOS-based 1Ds has a top X-sync speed of 1/250 like the 1V upon which it's based - the higher X-sync speed of the 1D derives from its use of a CCD image sensor.

All EOS cameras will deliberately prevent you from exceeding the X-sync value for shutter speed when you're using non-FP flash.

Note the first exception - if you have an E-TTL flash on a type A body with FP mode flash enabled you're fine. You can exceed X-sync at the cost only of lowered flash output. But there is a possible second exception, and that is if you're using third party flash gear, particularly studio flash units that use optical slaves or generic flash units. Such a setup likely won't notify the camera properly of your use of flash, so be careful.

EOS flash photography confusion.

The main area of confusion in EOS flash photography is the fact that P, Tv, Av and M modes handle flash illumination differently, especially when ambient light levels are not bright. Here's a summary of how the modes basically work when you have a flash unit turned on. This summary assumes that you do *not* have FP mode flash enabled if that option is available to your particular camera and flash unit combination.

Mode	Shutter speed	Lens aperture
P	Automatically set from 1/60 sec to the camera's maximum X-sync speed.	Automatically set according to the camera's built-in program.

Tv	You can set any shutter speed between 30 seconds and the camera's maximum X-sync speed.	Automatically set to match the shutter speed you have set.
Av	Automatically set between 30 seconds and the camera's maximum X-sync speed to match the lens aperture you have set.	You can set any lens aperture you like.
M	You can set any shutter speed between 30 seconds and the camera's maximum X-sync speed.	You can set any lens aperture you like.

And here are the details:

Program (P) mode flash.

The overriding principle of Program (P) mode in flash photography is that the camera tries to set a high shutter speed so that you can hold your camera by hand and not rely on a tripod. *If that means the background is dark, so be it.*

Program mode operates in one of two modes, depending on the ambient (existing) light levels.

1) If ambient light levels are fairly bright (above 13 EV) then P mode assumes you want to fill-flash your foreground subject. It meters for ambient light and uses flash, usually at a low-power setting, to fill in the foreground.

2) If ambient light levels are not bright (below 10 EV) then P mode assumes that you want to illuminate the foreground subject with the flash. It sets a shutter speed between 1/60 sec and the fastest X-sync speed (see above) your camera can attain. The aperture is determined by the camera's built-in program.

Because the camera tries to keep the shutter speed at a reasonable speed for handholding the camera you will end up with dark or black backgrounds if you take a flash photo in P mode when ambient light levels are not bright.

On most if not all EOS cameras, P mode is not shiftable when flash (internal or shoe-mounted Speedlite) is used. Note also that DEP mode cannot work correctly with flash - its metering settings basically revert to P mode if you try it.

Tv (shutter priority) mode flash.

In this mode the camera lets you change the shutter speed. It then automatically chooses an aperture setting to expose the *background* correctly. Flash duration (flash output) is determined by the flash metering system. In other words, the camera always works in fill flash mode when it's in Tv mode - it always tries to expose the background adequately, unlike P mode.

If the maximum aperture value of your lens starts flashing in the viewfinder it means the *background* of the scene you're shooting is too dimly lit. If you want to try and expose the background then you should decrease the shutter speed to compensate. Otherwise the camera will just try and expose the foreground with flash and the background will come out dark. Naturally at slower shutter speeds you'll need to use a tripod to avoid blurring caused by camera shake.

As always, the camera will prevent you from exceeding its built in X-sync speed unless FP mode is available to you and engaged. If the minimum aperture value of your lens starts flashing then your scene is too brightly lit. You must then either engage FP mode if it's available or perhaps put a neutral density filter on the camera or use slower film. Or turn off flash altogether and simply use a reflector of some type to bounce ambient light onto the subject.

The 420EZ and 430EZ flash units will operate in A-TTL mode in Tv mode, but the 540EZ works only in TTL mode. Note also that some people have reported that in this mode their type A camera bodies underexpose the background by up to a stop when light levels are low and an E-TTL flash unit is engaged. If this is the case try testing by comparing the aperture setting with M mode, which does not do this. You may need to apply exposure compensation if this effect exists on your camera and is undesirable.

Av (aperture priority) mode flash.

Av mode lets you set the depth of field by specifying the lens aperture. The camera then chooses a shutter speed ranging from 30 seconds to the camera's X-sync speed, in order to expose the *background* correctly. *If that means the shutter speed is some really low value so that you need to use a tripod to avoid camera-shake blur, so be it.* In dark conditions, therefore, Av mode works in slow sync mode.

Flash duration (flash output) is determined by the flash metering system. Like Tv mode the camera always works in fill flash mode when in Av mode.

There is one exception to this. A number of EOS cameras have a custom function you can set to ensure that the shutter speed in Av mode when using flash is locked to the X-sync speed. The EOS 10/10s and Elan II/EOS 50, for example, have such a custom function, which lets your camera behave more like P mode when in Av mode. However this custom function will only lock the camera to X-sync in Av mode and will not choose a shutter speed from 1/60 sec to X-sync, the way P mode does.

As always, the camera will prevent you from exceeding its built in X-sync speed unless FP mode is available to you and engaged. If the shutter speed value of 30" flashes in the viewfinder then there isn't enough light to expose the background correctly and you'll need a larger aperture or faster film. If the camera's X-sync flashes in the viewfinder then you'll need to decrease the lens aperture, engage FP mode if it's available or use slower film.

The 420EZ and 430EZ flash units will operate in A-TTL mode in Av mode, but the 540EZ works only in TTL mode. Note also that some people have reported that in this mode their type A camera bodies underexpose the background by up to a stop when light levels are low and an E-TTL flash unit is engaged. If this is the case try testing by comparing the shutter speed setting with M mode, which does not do this. You may need to apply exposure compensation if this effect exists on your camera and is undesirable.

Manual (M) exposure mode flash.

In manual exposure mode you specify both the aperture and shutter speed, and your exposure settings will determine how the background (ambient lighting) is exposed. The subject, however, can still be illuminated by the automatic flash metering system since the flash can automatically calculate flash output levels for you. This is a marked contrast to the olden days, when photographers would carry around little flash exposure tables with them in order to work out manual flash settings.

This is how flash works in manual mode. Note that we're talking about the manual *exposure* mode setting only, which can use automatic TTL flash metering (it will not use A-TTL metering in manual exposure mode). Also, we *aren't* talking about setting the output of the flash manually - that's manual flash and a different topic altogether.

- Set your camera to M for manual exposure mode.
- Set the aperture and shutter speed to expose the background correctly.
- Press the shutter button down halfway if your flash has a rear-panel LCD (liquid crystal display). The flash coupling range will appear in the flash unit's LCD. This range is the distance that can safely be covered by the flash.
- If your lens has a distance scale you can check the current focussing distance to ensure that the distance to your subject falls within this range. Otherwise you'll have to estimate.
- If the "flash ready" lightning bolt symbol appears in the viewfinder you can press the shutter all the way to take the photo. The flash's TTL or E-TTL system will determine the flash exposure level of the subject.

If your flash lacks a rear-panel LCD you won't have a preview of the flash coupling range, of course. Also, LCD-equipped flash units will not calculate the flash coupling range if you're using bounce flash, and the coupling range will not necessarily be correct if you have a diffuser on the flash head.

Some Speedlite flashes, such as the 540EZ and 550EX, can display the coupling range in either feet or metres, depending on which measurement system has been set by the small switch in the battery compartment. Others, such as the 430EZ, are hardwired to one measurement system or the other, depending on where the flash was sold. US market flashes used feet and all other countries on the planet* had only metre flashes available to them.

* Trivia note - even countries such as Canada and the UK which are officially metric but which are nonetheless full of people who still use imperial measurements. Also Yemen, Rwanda, Burundi and Burma, which used to stand proudly with the USA as the planet's only officially non-metric countries and which have now given up and are switching over to metric. Liberia is the only holdout I can find, and even there it's only the government - apparently businesses and schools use metric.

Multiple flash units.

As noted above, the basic problem with balancing ambient light and shutter speed requirements is that the output from a flash unit is only sufficient to illuminate the foreground, unless you're in a small interior space in which you can bounce the light.

If you're in a larger space or an area in which you can't bounce light effectively you could consider using multiple flash units - a unit or two for subject illumination and another unit or two for the background. Such a setup gives you increased range and affords more control over the lighting.

There are three common ways to do this - wired, optical slaves and wireless.

Wired multiple flash.

With a wired system you buy the necessary connecting cords and adapters to hook up more than one unit to your camera. Each flash unit fires simultaneously when you take a photo, and you can use TTL metering or configure the output for each flash unit manually (assuming the unit in question has the ability to have its output set manually). For details check out the extension cord section.

Optical slave multiple flash.

With optical slaves you position your various flashes - big AC-powered studio flash units or small battery-powered units - around the scene and connect tiny optical sensors to each one. These sensors respond to a flash being fired and trigger their own flash units immediately. For more information have a look at the slave flash section.

Wireless multiple flash.

Finally, you can use a wireless control system to trigger your flashes. A number of companies manufacture radio remote systems that let you do this - the Pocket Wizard Multimax and the Quantum Radio Slave being popular products. These third party systems have a long range and can be used in conjunction with optical slave units if necessary.

The most recent option is Canon's own wireless E-TTL, which lets you set up multiple Speedlite flash units and trigger them remotely using light pulses. (ie: this system does not use radios) The Canon system essentially requires E-TTL and supports all associated features - FP flash, FEL and so on. On certain camera bodies, ratio control between different flash units and modelling flash is also available. For more information consult the wireless E-TTL section.

Metering patterns for the background when using flash.

EOS cameras have different metering patterns, depending on the model. These metering patterns include evaluative (varying number of zones from 3 to 35), partial (from 6.5% to 10.5%, sometimes centred around the active focus point), centre-averaged and spot. When you aren't using a flash these metering patterns are used for metering the *subject* of a photo.

However, in flash photography the camera needs to meter for the *background* and not the subject, so the metering pattern should change when possible. This varies from camera to camera.

EOS cameras with single zone ambient metering such as the T90 and the original Rebel/1000 cameras use centre-weighted average metering for TTL and A-TTL flash. EOS cameras with multiple metering zones for ambient metering use the outer segments of their evaluative metering sensor for TTL and A-TTL flash. (their evaluative sensors are divided into patterns depending upon the number of zones and the segments closest to the edge of the frame are selected)

Note that most EOS cameras with partial metering buttons won't use the outer evaluative zones for ambient metering when the button is pressed. Instead they use partial metering patterns for ambient light metering in flash photography as well. The T90, EOS 1, 700, 750 and 850 are exceptions - they do not let you switch to partial metering for flash.

Unfortunately, the way in which E-TTL meters ambient lighting has not been publicly documented by Canon, so far as I know.

Flash metering patterns.

As above, information on flash metering patterns is fairly scarce, particularly for E-TTL flash.

TTL and A-TTL flash metering patterns:

The flash metering pattern is determined by the type of flash sensors built into the camera. If the camera has only one focussing point then it will have a single zone flash sensor. Flash metering is conducted using this sensor in a centre-weighted averaging pattern.

If the camera has multiple focussing points then it will have multiple zones; what Canon call their AIM system. The number of flash metering zones depends on the camera model. For instance, the EOS 10/10s has three focussing points and three flash metering zones, and flash metering uses whichever corresponding autofocussing point or points are active. However, the EOS 5/A2 uses the same sensor as the 10/10s so it too has 3 flash metering zones even though it has 5 autofocus points. The Elan II/EOS 50 has 3 AF focussing points and a 4 segment/3 zone flash sensor. (this latter means that the flash sensor has 4 segments but it chooses two consecutive segments, yielding 3 possible zones)

These multiple zone flash sensors let the camera bias the flash exposure to the currently selected AF point. When you focus manually the camera does not bias any flash zone but chooses the central zone instead.

Note that the A2/5 is somewhat different from other multiple AF point cameras in that it will only bias flash exposure correctly to the nearest AF point if that point was manually selected. In automatic and ECF modes it apparently always chooses the centre zone.

E-TTL flash metering patterns:

The camera uses its evaluative metering system to meter the flash output, based upon the preflash. When in autofocus mode most EOS bodies which do not use E-TTL II bias flash metering toward the currently selected AF point, but always in an evaluative mode pattern - they don’t use spot or partial metering patterns. When in manual focus mode it appears that at least some EOS bodies switch to centre-weighted averaging.

Note, however, that this biasing of E-TTL metering to the active point is potentially problematic, since it means that the flash metering is done in almost a spot-metering fashion. Many user complaints regarding flash metering problems in E-TTL mode appear to be linked to this issue. If the camera happens to be over a dark object, for example, flash metering can be considerably overexposed, and vice-versa. The standard answer to this problem is to use FEL and meter off something mid-toned, but this is clearly not a solution for rapid-shooting situations such as weddings and sports. Another approach is to set the camera lens to manual focus, since the body apparently switches to centre-weighted average metering in that mode, but that’s obviously not a useful answer much of the time either.

Users of the digital D30 and D60 have been particularly unhappy with E-TTL flash metering. The 10D apparently reduces this problem by defaulting to a centre-weighted averaging metering pattern in E-TTL, even when the lens is set to autofocus.

E-TTL II addresses this problem by altering flash metering considerably. It examines each evaluative metering zone before and after the E-TTL preflash. It then calculates the weighting for each zone independently, biasing against those zones with high reflectivity in the preflash. This means that E-TTL II does not have a flash metering pattern as such, since it's calculated dynamically.

Note that since I've been unable to find definitive published statements from Canon on this topic it isn't as authoritative as it could be. Please contact me if you have further information about E-TTL flash metering.

Do not focus and recompose.

The fact that the camera biases flash exposure to the nearest focus point, if the camera has multiple focus points, is important to keep in mind. If you're in the habit of using the old "focus, lock AE and recompose image" technique, be sure not do this when taking flash photos.

Flash metering occurs *after* ambient light metering, so in this case you're locking AE but not flash metering, and therefore recomposing messes up your flash metering. Instead, select the focus point that's closest to your subject in order to bias flash exposure to that area.

There are two exceptions to this rule, however. First there are type A bodies which support FEL. You can use FEL in such situations to lock flash exposure to a given area of your photo before recomposing. Second, cameras with support for E-TTL II are supposedly less vulnerable to this problem because they can include distance data in flash metering.

Flash terminology.

Here are a number of other terms and concepts related to EOS flash photography and flash photography in general. For more information on the principles of electronic flash, check out Toomas Tamm's page.

Strobe and flash.

We have a little UK/US terminology problem here. In the UK a "strobe" is something which emits blinking pulses of light whereas in the US a "strobe" is any electronic flash unit, whether it fires once or continuously.

We also have the additional confusion that arises from "flash" having four meanings - a verb meaning to produce a pulse of light, a flash of light, flash-based photography in general and a flash-producing device. Finally, we have "Speedlite" and "Speedlight," which are the tradenames used by Canon and Nikon respectively for their series of electronic flash units.

So. In this document I adopted the following convention:

- I don't use the word "strobe" at all in order to minimize confusion.
- I refer to electronic devices designed to emit pulses of light for photographic purposes as "flash units" if there's any possibility for ambiguity with any other meaning of the word. Yes, that leaves me vulnerable to crappy adolescent jokes. Oh, well.
- I refer to electronic flash units that are emitting pulsating flashes of light as "stroboscopic."

- Finally, speaking of UK/US stuff, I've used the antiquated convention of referring to corporations in plural form (as groups of people) rather than independent entities. Since everyone assumes I'm just making a grammatical error rather than a feeble ideological point I might change that...

Inverse square law.

Light dropoff from a light source always seems very rapid. Consider a campfire at night - a pool of light surrounded by darkness. Or a flashlight (electric torch in the UK) being shone into the night sky - a bright bar of light that rapidly fades to nothing. You might think that when you double the distance from a light source you get half as much light, but it doesn't work like that - you actually get just a quarter as much light.

Space is three dimensional, so imagine a sphere drawn around a light source that's producing photons. As you get further away from the light source this imaginary sphere increases in size. The surface area of the sphere also increases, but it's being illuminated by the same amount of light - the same number of our photons. It's not a simple 1:1 relationship - the sphere is not twice as large when you get twice as far from it.

The actual relationship between distance from the light source and size of the imaginary sphere can be described mathematically as the *inverse square law*. It states that light output is proportional to the inverse square of the distance. (ie: divide 1 by the distance, then square the result) So if you double the distance you get $1/2^2$, or one quarter as much light. If you quadruple the distance you get $1/4^2$, or only one sixteenth as much light.

All light sources follow this rule, which is why light from a flash unit tends to drop off in intensity pretty rapidly. It also explains why you don't necessarily gain much more flash range when you buy a moderately more powerful flash unit, and why foreground objects are much more brightly illuminated by your camera-mounted flash unit than distant objects.

Guide number.

The maximum distance range of a flash unit is indicated by its guide number. If you use automatic flash metering you may never have to deal with guide numbers at all, except when you're shopping for a flash unit and want to know how powerful each one is. But guide numbers are critical for all manual flash work.

The guide number is used in flash calculations to determine the appropriate aperture required to cover a certain distance or vice-versa. Note that technically the guide number describes the distance coverage of a flash, *not* its actual power output as such. Because of the inverse square law of light falloff, a flash unit has to have four times the power output in order to throw light twice as far.

To find the aperture (*f* stop number) required to take a photo of a subject you divide the flash unit's guide number by the distance to the subject. To find the maximum distance that can be reasonably illuminated using the current aperture setting you divide the guide number by the *f* stop number. In each case it's the distance from the flash to the subject that's important, *not* the distance from the camera to the subject. These two distances may be the same with on-camera flash, but not with off-camera flash or when using bounce flash.

> *f*-stop number = GN / distance
> distance = GN / f-stop number

Canon's guide numbers are measured in metres and are for ISO 100 film. Their Speedlite product names, for example, include the highest guide number of the flash (which is the guide number for the flash when on maximum zoom in the case of zooming flashes) multiplied by 10 - eg: 550EX. Note, however, that Canon USA express guide numbers in feet in their material, so always double-check the measurement system. For example, US advertising material says that the Elan 7's built-in flash has a guide number of 43, which sounds quite remarkable until you realize that that translates to a metric guide number of 13. (the built-in flash units in EOS cameras typically have a guide number of 12 or 13 unless they have a zoom motor)

I refer solely to metric guide numbers in this document. Here are approximate metric conversion values:

1 metre = 3.3 feet
1 foot = 0.3 metres

An important point is that the guide number is rated for ISO 100 film. So if you're using film of a different speed you have to factor that in to your calculations. Once again the math is based on the inverse square law - quadruple the film speed and you double the guide number. Thus the maximum range possible with your flash unit increases when you use faster film. Here's a quick way to do the conversion if you want to avoid thinking about square roots:

Film speed doubles: GN x 1.4
Film speed halves: GN x 0.7

Another thing to remember when comparing flash units is that zooming flash heads affect the advertised guide number. For instance, the 480EG flash contains more powerful flash tubes than the 540EZ, even though the former has a guide number of 48 and the latter a maximum guide number of 54. This is because at 35mm coverage the 540EZ's guide number is only 36. However, the 540EZ's zooming head can concentrate the unit's light output at longer focal lengths, whereas the 480EG's non-zooming head essentially wastes light by illuminating areas not covered by lenses with focal lengths longer than 35mm, except when an optional lens is installed. Such flash extenders, which can concentrate the light to a tighter area and thus throw light even further distances, are available as add-on accessories for other flash units as well.

As noted above, the guide number does not describe the amount of light output as such. Flash unit capacity is also described in terms of light output units such as beam candlepower seconds (BCPS) or effective candlepower seconds (ECPS) or in terms of energy capacity units such as joules or watt-seconds. None of these measuring systems are commonly used with portable electronic flash units, so I'm not going to cover them here. They also measure different things and are, therefore, not convertible or interchangeable units.

Finally, a fair bit of subjectivity goes into determining the guide number, which is presumably why it's called a "guide." After all, how is an "adequately exposed" subject determined? Guide values are, therefore, not a very reliable way to compare flash units built by different manufacturers. Particularly since manufacturers tend to be wildly and cheerfully optimistic when it comes to assigning guide numbers to their products.

Exposure value (EV).

The sensitivity of camera gear at autofocussing or determining correct exposure metering is rated in terms of EV - exposure value - for a given lens type and film speed.

Since the amount of light hitting the surface of film is determined by exposure time (shutter speed) and lens aperture, exposure values are simply combinations of shutter speeds and apertures. For example, f4 at 1/30 sec has an EV of 9, which is the same EV as f2 at 1/125. Toomas Tamm has a complete EV table on his Web site.

Both speed/aperture combinations let the same amount of light hit the film - the only differences between the two are depth of field and type of motion recorded. Depth of field decreases as the aperture increases and subject motion blur increases as shutter speed decreases.

However, it's only meaningful to compare exposure values when they're rated for the same film speed. Canon rate EV values in their documentation for a standard 50mm f1.4 lens using ISO 100 film.

Dedicated or non-dedicated flash units.

In the olden days of electronic flash, when the flash sensor was self-contained in the flash unit itself, the flash trigger controlled by the camera was the only control the camera had over the flash. The output level and shutoff time were both determined by the flash unit itself since two-way communications between camera and flash unit were not possible. For this reason a lot of generic flashes were sold and basically worked the same way on every manufacturer's camera.

However, by the 1980s camera makers started designing dedicated flash systems which would only work with their own cameras, in order to achieve more precise control over the final results. (and also probably to sell more of their product by discouraging third-party sales) Canon's Speedlite flash units are, therefore, dedicated flash units since they can communicate digitally with EOS cameras. They can work on other cameras in the most basic of ways, but advanced through the lens metering and other features reliant on two-way communication will not work on cameras built by another manufacturer.

Some makers of third party flash units, such as Metz and Sigma, get around the dedicated interface problem by figuring out the camera system-specific protocols and either building generic units with custom flash adapters designed to work with specific camera makes or else building different flash models for each camera make.

Shoe mount.

Most SLRs today have a squarish slide-in socket on the top of the prism or mirror housing which accommodates external flash units. These are called hotshoe mounts - "hot" because they contain a flash-triggering electrical contact. (though it should be noted that no modern camera lacks this contact, so this term exists now for historical reasons) Despite the dramatic name the contacts do not carry any significant electrical current when a flash unit is not installed, so there's no risk of electrocution from a hotshoe.

EOS cameras have shoe mounts containing 4 additional small contacts in addition to the large central flash-triggering contact. These small contacts carry digital signal data, proprietary to the Canon EOS system, to the flash. They aren't compatible with flashes made by Nikon, Pentax, Minolta, etc.

Another Canon feature is the presence of a small hotshoe locking pin on most EOS flashes.

This pin extends out when the tightening wheel is rotated, fitting into a small hole on most EOS bodies and preventing the flash from sliding accidentally out from the shoe. The pin is spring-loaded so the flash will still fit in hotshoes which lack the locking pin hole.

Note that the plastic shoe of external flash units isn't quite as sturdy as it should be. It's a bad idea to pick up a camera and flash by the flash unit. Pick up the camera body to be on the safe side.

The redeye effect.

Redeye, the common bane of snapshots, occurs when the light from the flash unit bounces off the blood vessels lining the retina of a person's eye and makes it back to the camera. The result is the familiar evil satanic glowing red eye effect that shows up disconcertingly often with point and shoot cameras. It happens a lot in restaurant and living room photos because the low ambient light levels mean that the subject's pupils tend to be dilated fairly wide to let in more light. The problem doesn't occur in daylight partly because the pupil of the eye contracts and reflects less light and partly because the relative brightness of flash illumination to ambient light is much lower during the day.

The problem of redeye is intensified the further you are from your subject and so becomes very apparent when shooting portraits using telephoto lenses. The greater the distance from the subject the further you have to lift the flash away from the lens to eliminate redeye. This is because it's an issue of how narrow the angle between the subject-flash and subject-lens distances is. The smaller this angle - whether because you're a long way away from the subject or because the flash is too close to the lens or both - the greater the chance of redeye. Built-in flash units, located very near to the lens, are thus extremely likely to cause redeye.

Interestingly enough, flash photography of cats and dogs can involve a similar, but slightly different, problem. Cats and dogs have a reflective membrane in their eyes called the tapetum lucidum, which helps their night vision. The tapetum reflects light from a flash unit very efficiently, and tends to colour it green, yellow or blue. The membrane also explains why the eyes of animals like cats or deer by the side of the road at night are clearly visible as brilliant points of light. Humans lack this layer and so we don't have tapetal reflections.

Redeye reduction.

There are a number of ways of dealing with redeye. The first, and generally most effective, way is to move the flash as far away as possible from the lens or point the flash head away from the subject (ie: bounce the light). As noted above, the closer the flash source is to the lens axis the worse redeye is going to be. So if you detach the flash unit from the camera and lift it up in the air a short distance you're likely to reduce redeye considerably. This is one reason why wedding and news photographers tend to mount their flash units on external metal brackets attached to the camera itself - flash brackets. And bounce flash eliminates redeye by definition.

One drawback with moving the flash, aside from the inconvenience of moving the flash unit, involves low-light photography. When light levels are low the pupil of the eye will dilate to let in more light, just like a lens diaphragm. If you take a photo of a person with flash their irises don't have enough time to react to the burst of light, so their pupils will remain dilated. The result is a photo of someone with huge pupils, as if they were on drugs.

Another way of reducing redeye (and also minimizing the huge pupil problem) is to have the subject look at a bright light shortly before taking the flash photo. This usually sort of works because the person's pupils will contract in response to the bright light, reducing the amount of light reflected back from the retina to the camera. For this reason many EOS cameras have bright white lamps built into them which the photographer can illuminate at will.

On some EOS cameras, such as the Elan/100 or Elan II/50/55, the redeye reduction lamp is mounted in the built-in flash housing and cannot work with external flash units. On other cameras, such as the D30, the redeye reduction lamp is mounted lower on the body and also works with external flashes. On other bodies the redeye reduction lamp won't work with external flash units even though it's body mounted. However, redeye reduction lamps aren't so useful with external flash units anyway, as they tend to be raised fairly high off the lens axis and are often used in a bounce mode which spreads light across a wide area. And if the subject is some distance away the redeye lamp won't be of much use. It's for this reason that no Speedlite external flash unit has any form of redeye reduction lighting system - it's really just a feature for point and shoots and built-in flash.

The downside to redeye reduction lights is quite severe - people tend to look stunned and glazed after staring at an intensely bright light for a few seconds. Stunned and glazed or evil and satanic - with onboard flash photography, the choice is yours!

You can also colour over the redeye with a black pen on the final prints or scan the image into a computer and use an image editing program to correct the redeye, but obviously these are rather clumsy ways to solve the problem.

The first curtain sync problem.

As noted in the section on X-sync, Canon EOS cameras (and basically all SLRs) have two moving "curtains" in the shutter mechanism. The first curtain opens the shutter and the second curtain closes it.

Let's say you take a flash photo of a static object combined with a long shutter speed. Normally the shutter opens, the flash fires, time passes and then the shutter closes. Now let's say you're taking a photo of a moving object. The object is illuminated enough to leave light trails recorded on the film as the object moves along. But if you fire the flash immediately *after* the shutter opens then you've got a bit of a problem, since the light trails will appear to be moving in front of the flash-illuminated object. The object will actually sort of look like it's moving backwards.

Second-curtain sync.

To solve the first-curtain sync problem mentioned above, and to get the light trails looking like they're following behind the moving object as they should, you need to fire the flash right *before* the shutter closes. This is called second curtain or rear curtain sync flash since the flash is fired about 1.5 milliseconds before the second curtain of the shutter starts to close. The result is a photo which expresses motion nicely - it will show light trails *following* the moving object. The Canon T90/Speedlite 300TL was apparently the first camera/flash combination to support this feature.

The drawback to second curtain sync is that it can make it harder to take a photo if you've got a really long shutter period. With first curtain sync you can see the moving object in the viewfinder and can thus trigger the shutter at the exact moment. But with second curtain sync you a) can't see the moving object when the shutter is open, because with SLRs the mirror flips up out of the way and b) you have to predict accurately whether or not the object will still be in the frame at the end of the exposure period. For these two reasons EOS cameras ship with first curtain sync as the default.

There's one minor issue to be aware of if you use E-TTL flash with second-curtain sync. The E-TTL preflash occurs prior to the shutter opening, and so the flash will visibly fire twice when you're using long shutter speeds and second-curtain. (the preflash always fires before the shutter opening - it's just that with a long shutter speed and second curtain sync, the time delay between the two flashes is increased and thus more noticeable)

This delay between preflash and subject-illuminating flash usually doesn't have any negative side-effects, but there are two cases in which it might be a problem. First, if the subject is moving then the preflash metering obviously won't be right for the final exposure - FEL may be required. And second, the preflash might confuse human subjects if they're expecting just one flash. They might assume you've taken the photo and walk off or look away from the camera.

See the section on how to enable second-curtain sync, if it's available on your particular camera and flash combination.

Colour temperature theory.

(nb: this section gets pretty detailed, but it's a useful basis for understanding colour shifts in photography)

The human eye (or, more accurately, the brain) is extremely adaptable. If you look at a sheet of white paper in a room lit only by an overhead incandescent tungsten lamp, the paper will look white. If you carry the same sheet of paper outdoors and look at it in sunlight it'll still look white. But tungsten light and sunlight produce very different types of light - tungsten light is orange in tone whereas sunlight is quite blue.

This is because they are light sources of different colour temperatures - so called because they represent the colour of light produced by a theoretical "black body" object that's heated to a certain temperature, measured in degrees Kelvin. (Kelvin is similar to the Celsius scale but uses absolute zero, -273°C, as the starting point rather than the freezing temperature of water) Note that some of the terminology is a bit confusing here. In colloquial English we say that reddish light is "warmer" than bluish light. But in terms of the colour temperature model, light becomes more blue as the colour temperature *increases*. Note also that we're talking about a photographic colour temperature model, which by dealing just with red and blue light is a huge simplification of the colour temperature model used by physicists.

Regular incandescent tungsten light has a theoretical colour temperature of about 3200 degrees Kelvin, though household bulbs are often a bit lower at about 2900°K. (they go down in colour temperature as they age or when supplied with lower voltages, such as from a dimmer circuit) Tungsten halogen bulbs (usually just called "halogens" even though they have tungsten filaments just like regular incandescent bulbs) and non daylight-corrected photoflood bulbs are usually slightly higher, sometimes reaching 3400°K. The light from a candle flame is quite low in temperature, hovering at around 1400-2000°K.

Daylight has a colour temperature of between 5000°K and 6000°K; often given as 5500°K for the midday sun. Naturally these values can vary. Just as regular light bulbs drop in colour temperature, as noted above, the colour of daylight varies at different times of the day and because of different weather conditions. In fact, natural light can vary from around

2000°K at sunset to over 20 000°K in blue evening shade. Skylight, or the sun's light scattered by the atmosphere, is extremely blue in colour.

Normally the human brain compensates for these differences in colour temperature automatically. One of the few times they become really noticeable is when you encounter both types of light at, for example, dusk. If you're outside looking at the windows of a building you'll see that the tungsten light of a household lamp looks quite orange-yellow in tone and the sky and your surroundings look quite blue.

Colour temperature and film.

Colour temperature isn't a purely theoretical issue. It's a real problem for colour photography, because film records light as it sees it, does not offer interpretation and cannot automatically adapt. So film has to be formulated from the start to assume a certain colour temperature is white.

This is what is meant by “daylight” film and “tungsten” film - they're film types designed to assume that daylight and regular tungsten light bulbs are white, respectively. You'll get weird colour shifts if you shoot with the wrong type of film. A tungsten-lit room shot on daylight film will look quite orange and a daylight-lit room shot on tungsten film will look quite blue. So it's important to use film which matches your lighting conditions. It's not normally essential to be absolutely precise about this, but pros who need exact colour will buy expensive colour meters to determine the exact type of colour in a given scene.

Colour casts also occur from lighting types other than incandescent tungsten bulbs. Other forms of artificial light yield strange colour casts on daylight film as well. Most fluorescent lamps tend to result in a somewhat greenish tinge unless a special magenta filter is put over the lens, though there are significant colour differences between manufacturers. (indeed there are now daylight-balanced fluorescent bulbs which avoid this problem) High pressure mercury and sodium lamps used for industrial lighting result in somewhat unpredictable colour casts depending on the formulation of the bulbs being used. Note that the term “colour temperature” does not technically apply to fluorescent and high-pressure lamps. However, approximate equivalent colour temperature numbers are often supplied by manufacturers as a convenience. Finally, daytime colour temperature varies throughout the day and depending on weather conditions. A snowy evening can be very blue and a dusty sunset very orange.

Colour temperature issues are one area in which digital photography has a significant advantage over chemical-based photography. Most good digital cameras let you set the white balance - the assumed white point - of your subject at will. The EOS 1D, D30, D60 and 1Ds cameras all let you use auto white balance settings or preset settings for common lighting situations. This sort of adjustment isn't possible with film-based photography since the colour temperature balance (white balance information) is permanently built into the film emulsion chemistry at time of manufacture and cannot be altered afterwards. All you can really do with film is to put filters in front of the lens to cut out certain wavelengths of light or perform various filtration tricks in the darkroom when printing - or scan the pictures and alter them in a computer.

Colour temperature and flash photography.

Since most photography is done with the sun as a light source, most film is balanced for daylight. Until recently, in fact, tungsten-balanced film was only widely available as slide/transparency film (as two types - the rare tungsten A and the more common B, which have slightly different colour temperatures - 3400°K and 3200°K respectively). And for that reason flash units also have bulbs designed to produce light approximating midday sunlight in temperature. However, since sunlight is more blue than tungsten, light from a camera flash will look quite blue compared to the orange-yellow light of indoor tungsten light.

This difference in colour temperature is particularly noticeable with slow shutter sync photography. If you take a photo indoors using slow shutter sync with flash and daylight-balanced film, you'll get a normally coloured subject with strange orange-yellow fringing. This results from the subject being illuminated brightly by the daylight-balanced flash and then any motion blur from the slow shutter being illuminated dimly by tungsten light.

You can also exploit these differences in colour temperature to achieve certain effects. For example, shooting with flash and tungsten-balanced film can yield blue-tinged results. Or you could take a photo of someone outdoors with tungsten film and an orange tungsten-light compensation filter on the flash head. The result would be a normal coloured person with a cold, bluish background.

Colour filters.

There are specific filters you can use to perform this type of colour temperature conversion when you take a photo; the type of filter depending on the kind of effect you want to achieve. You might want to balance the light of a flash unit to match ambient lighting, for example. Or you might want deliberately to make the two types of lighting very different in colour for creative effect.

You can put the filters in different places. For instance, if you want to affect the look of the entire scene you could put a filter over the lens. To affect the output of a specific lamp you could buy a gel filter and put it over the lamp only. Or you could tape a filter or coloured diffuser over your flash unit's head to affect just the light it produces.

A great way to alter the light colour from a flash unit on the cheap is to go to a theatrical lighting store and ask for a Lee or Rosco gel swatch booklet. This is a little bound collection of gel filter samples - each coincidentally just large enough to cover the lens of a typical flash unit. The booklet lists the exact properties of each gel, and quite often you can get one for free.

This sort of colour temperature conversion can go in either of two ways, of course. If we want to go from yellow-orange light (tungsten) to blue light (daylight) we want a *cooling* filter. To go the other way we want a *warming* filter. As noted earlier these are somewhat confusingly named since cooling involves an increase in colour temperature and vice-versa, but the names reflect ordinary casual usage of the words and not colour temperature theory. Naturally, cooling filters are blue and warming filters orange-amber (light orange-yellow filters are sometimes called "straw").

Limitations of filters.

One important thing to remember about filters is that they cannot shift colours over along the spectrum, as it were. All a filter does is simply prevent certain wavelengths of light passing through - hence the name. So by definition colour-correction filters always cut the amount of light entering the lens.

Filters can change the colour of white light since white light consists of colours from across the spectrum, as Newton discovered with his famous prism experiments. But if you're taking a photo of a scene illuminated by, let's say, pure red light you can't simply slap a filter on the lens to make everything a different colour. Filters can't add light of any wavelengths or convert incoming light to a different wavelength.

Taking photos of scenes illuminated by yellow-orange sodium and mercury vapour streetlights is a real problem for this reason. Such lamps produce light of very narrow spectral bands. You can't alter this light much by putting a filter on your lens, since filtering out the yellow light doesn't leave much else.

This problem of filtration limits your colour-correction choices considerably when dealing with chemical-based photography. There are ways of doing colour alteration in the darkroom, but they're expensive and cumbersome. So again, moving your images into the digital realm has real advantages. Once your photo is inside a computer you can alter the colours as much as you like.

Mireds.

Colour temperature of light is usually measured in degrees Kelvin. But another unit you often see in photography is the mired, for "micro reciprocal degrees," and pronounced "my-red." To obtain the mired value for a colour temperature simply divide 1 million by the colour temperature. So, for instance, 5500°K is the same as 182 mired, since 1 000 000 / 5500 = 182.

Mireds are commonly used for converting light from one colour temperature to another using a colour conversion filter. For example, let's say we want to take a photo using electronic flash but we have tungsten film in our camera. So we need to tape a coloured gel over the flash head. The question is, what kind?

Let's assume the light from the flash unit is 5500°K and the tungsten film wants 3200°K light. These are 182 mired and 312 mired respectively, so the difference we want to make up is about +130 mired, our mired shift value. (a positive number is a warming filter; a negative number a cooling)

Now we consult a gel filter catalogue or swatch book (as noted above, available from theatrical lighting shops) and see what the closest filter to a +130 mired shift is. If we went with Rosco we could buy a "Roscosun CTO" gel that performs a +167 mired shift. Or if we went with Lee Filters we could go with a "Full C.T. Orange" gel to get +159. Neither gel is precisely the same as our calculation, but they're close enough for print film, where you can always do some adjustment in the lab. And when using slide film you might want to overcompensate on the side of warm like this anyway, unless you're deliberately looking for a cool blue look. But this is all assuming the flash unit actually has a colour temperature of 5500°K - it's probably slightly higher.

Of course, lots of filter companies simply specify the colour temperature conversion range so you can avoid the whole conversion to mireds altogether if you're just doing a simple tungsten to daylight conversion, say. But the mired model is useful for more complex colour conversion tasks where multiple filters are involved.

Wratten numbers.

Many filter companies follow the Wratten series of numbers to describe their colour conversion products. Frederick Wratten was a British inventor who developed a fairly arbitrarily-numbered series of colour filters a century ago. His company was bought by

Kodak in 1912, though Wratten-branded filters are now sold by Tiffen.

80 series: blue-coloured cooling filters. For daylight film with tungsten light sources.

Wratten number	Colour temperature increase	Typical light source to be converted	Approximate mired shift
80A	3200-5500°K	Tungsten	-131
80B	3400-5500°K	Non-blue photofloods	-112
80C	3800-5500°K	Old flash bulbs	-81
80D	4100-5500°K		-56

85 series: yellow/amber-coloured warming filters. For tungsten film with daylight.

Wratten number	Colour temperature decrease	Typical use	Approximate mired shift
85	5500-3400°K	Converting type A tungsten film	+112
85B	5500-3200°K	Converting type B tungsten film	+131
85C	5500-3800°K		

These filters are fairly dark and cost 1 stop (80 series) to 2/3 stop (85 series) of light.

There are also more subtle and commonly used filters for cooling and warming, such as the 81 warming filters and 82 cooling filters. These filters aren't used for colour conversion but for less extreme applications - minimizing unwanted colour casts. For example, an 81B is useful for reducing the blue cast of daylight film shot in the shade.

German manufacturers use their own system in which KB is a cooling (blue) filter and KR is a warming (orange) filter.

Trigger circuit voltage.

Old flash units - both studio and hotshoe-mount - used pretty high voltages between the camera and the flash - often from 25 to 250 volts. This is because the flash units were fired by simple switches - electrical contacts.

Modern cameras, however, rely on electronic circuitry rather than electric switches. This allows for more flexibility and the possibility for computerization, but the circuits can't withstand high trigger circuit voltages (anything above 6 volts, in the case of EOS cameras, according to Canon) and can be damaged by units with high trigger voltages.

Note that this 6 volt limit does not necessarily apply to PC sockets. Canon states that its 1D digital camera, for example, is capable of withstanding trigger voltages of up to 250 volts when firing flash units with its PC socket. The 6 volt limit applies to the camera hotshoe only. Unfortunately Canon doesn't always state what trigger voltage the PC sockets on all of its PC-socket-equipped cameras can withstand, so if this information is not supplied in the manual you should probably contact Canon.

Anyway. If you intend to connect an old flash to your EOS camera's hotshoe be absolutely sure that its trigger voltage does not exceed 6 volts. You can measure this with a voltmeter. Various accessories, such as the Wein Safe-Sync HS hotshoe unit, can be used to protect the camera from these high voltages if you want to use such a flash. Even safer are optical triggers, since there are no physical connections between the camera and flash unit at all.

Note that the damage to the camera can be subtle and cumulative - simply hooking up the flash and seeing if it works is no guarantee that the high voltage isn't slowly damaging your camera's flash circuit - arcing and pitting connectors and breaking down internal components. (of course, Canon is probably being a bit conservative with its 6 volt limit, so you might not be taking a huge risk if the voltage of your flash unit is a tiny bit over) Note also that the power supply used by the flash is irrelevant - it has no bearing on the trigger voltage. Many Canon Speedlite flash units, for example, can use high voltage battery packs but they still have low trigger voltages. And portable battery-powered flash units may require 6 volts in battery power but nonetheless may step up the trigger voltage considerably.

An additional problem is that some older flash units have reversed polarity. EOS cameras all have a negative ground and a positive centre pin on the hotshoe itself, though some pro models have polarity-detecting PC connectors that can work with either type of flash unit.

Finally, some flash units have all-metal hotshoes. This can be a problem if they inadvertently short out any of the four small data contacts on EOS cameras. If you have such a camera you could cover up the contacts with electrical tape or use a PC cord adapter so the flash unit doesn't plug directly into the camera's hotshoe mount at all. The same applies if your flash unit has a really large central contact. EOS cameras have fairly small hotshoe central contacts with four tiny data contacts below it. If your flash unit's hotshoe contact is so large that it shorts out any of the data contacts you may damage your camera.

The old Canon EOS FAQ also has a great deal of information on the subject of trigger voltages, and Kevin Bjorke maintains a comprehensive table of trigger voltages for various flash units.

Slave flashes.

Slave flashes are simply self-contained flash units which respond to external triggers of some kind. They're frequently used in studio situations. For example, you might have a multiple-flash setup - one flash to illuminate the subject and another unit or two to illuminate the background separately.

Many slave flashes are triggered by light: optical slaves. They have small sensors built in or attached that detect the light pulse from another flash unit and then trigger immediately themselves. Since they respond so rapidly, the time delay between the trigger flash and the slave flashes going off does not affect the exposure of the photo. The Wein Peanut, a tiny and inexpensive accessory, is a popular optical trigger that's basically compatible with most flash units out there. (though ironically not entirely compatible with a lot of Canon Speedlites - see further down in this section for details)

Since the sensors watch for flash bursts, you use one flash unit as the triggering flash - typically the built-in flash unit on your camera or an external unit connected to the camera's hotshoe or PC connector. The triggering flash can be set to a low power output so that it doesn't affect the scene if you want - optical slaves are usually sensitive enough. The slaves are also usually sensitive to infrared energy, so another popular trick is to tape an infrared filter gel over the internal flash unit. This lets you trigger the flash units with a burst of energy that's invisible to the human eye and to most types of film.

Canon E-TTL flash metering poses a problem for optical slave setups, since standard analogue optical slaves are likely to be triggered by the flash unit's metering preflash rather than the actual flash. And since the slave flash requires time to recharge it may not have enough power to fire in response to the actual flash. The usual solution to this is to switch over to regular TTL flash in lieu of E-TTL. There are two problems to this approach, however. For more details have a look at the section on disabling E-TTL mode. The other option is to use FEL to trigger the slaves once, then wait for them to recharge and then take the photo. (or use FEL to trigger the slaves, immediately use FEL again, before the studio units recharge, to set the correct flash exposure lock and *then* take the photo) This can be rather inconvenient, however.

Standard optical slaves are also a problem outside the controlled environment of the studio. They're a real nuisance in wedding photography when, for instance, Uncle Charlie's point and shoot camera flash triggers your optical slaves. Situations like that call for expensive radio-controlled wireless systems or, if battery-powered slaves have enough power output for your needs, Canon's E-TTL wireless system. An alternative is the new generation of optical slaves, such as the Wein Digital Smart Slave products, which are capable of distinguishing between a preflash and a genuine scene-illuminating flash and only respond to the latter.

A significant problem with multiple slave flash photography (at least, one which doesn't rely on automated metering like Canon's wireless E-TTL) is that it's difficult to preview or visualize the final result without a lot of testing and experience. Usually each flash unit has to have its output set manually. In fact, unless you're replicating a predetermined lighting formula that works for you or you're configuring a fairly simple one or two flash setup with a light meter, I'd say that it's pretty well a requirement that you have a Polaroid back for your film camera or a digital camera to do this sort of thing well. Digital is particularly beneficial here since you can take dozens of test photos at no cost and determine exactly how the various flash units are illuminating your scene, where the shadows fall, etc.

However, using cheap optical slave flash units can be an affordable way to set up your own studio. Buy a few old battery-powered Vivitar 283s or second-hand studio units, slap some cheap optical triggers onto them and you're in business.

Canon do not build any flash units specifically intended for use as studio equipment. However, you can buy hotshoe adapters - optical or wired - to turn any flash you want into a slave, and the 480EG can be slaved via the optional Synchro Cord 480. Hotshoe adapters aren't always reliable with every camera and flash unit combination, so it's worthwhile doing some testing first. In particular, a lot of people have reported problems with small optical slaves not being able to trigger Canon Speedlite flash units more than once without the flash being turned off and turned on again between each shot. The Ikelite Lite-Link is one device designed to work with Canon flash units that apparently does not have this problem. It also has a sort of simulated TTL feature - it can cut the light from the slave flash as soon as the master flash has quenched its light, rather than simply firing at full power.

Finally, Canon state in their literature that a sync speed of perhaps 1/60 or 1/125 is required for studio flash. There are two reasons why they suggest speeds this low, even if the camera's capable of higher flash sync with TTL-metering portable Speedlite flash units.

First, many older studio units take quite a while to attain full brightness or have slight colour shifts depending on the flash duration. And second, the triggering delay (the time that elapses between the camera triggering the flash and the flash unit actually firing) with slaved studio flash units is often longer than the very brief and known triggering time with TTL flash units.

For these reasons you're probably best off doing a series of tests with a new slaved flash unit setup at different shutter speeds to determine what the top shutter speed for your configuration is going to be. Particularly with optical and radio slave units or older flash units.

Note that Canon do sell a number of flash units that can serve as slave units in a wireless E-TTL setup - see the section on wireless E-TTL for details.

Flash meters.

Regular light meters cannot measure the split-second burst of light from a flash unit. For that you need a specialized flash meter, though of course many devices can meter for both ambient and flash light.

These are useful in studio situations, when you're using flash units that don't have any TTL or E-TTL capabilities. You might, for example, have a large studio flash unit bouncing light onto the subject by means of a flash umbrella. You could use the handheld flash meter to determine accurately the correct flash output settings to expose the subject properly.

Since this article deals primarily with automated through-the-lens metered flash I don't deal with flash meters. There are many other online resources and books to help you learn more about flash metering, however.

Flash sync trivia.

I haven't been able to find out why shutter sync with electronic flash is referred to as "X" sync. Some random reason lost in the mists of time, no doubt. Really old cameras also had M-sync connectors, which were designed for non-electronic single-use flash bulbs (the kind of bulbs which contain a metal filament or piece of metal wool which burns out).

Unlike electronic flash, which achieves maximum brightness almost instantaneously, old electric flash bulbs required a longer period of time to reach maximum brightness. So with "M-sync" the shutter opening was delayed by 20 ms or so after the bulb was fired, to provide adequate time for the light output to build. No EOS camera has M-sync capabilities, since hardly anybody uses electric flash bulbs these days. Apparently the M stood for "medium" speed flash bulbs.

On to Part III.

Back to Part I.

- NK Guy, tela design.

Disclaimer and copyright:

Please send feedback if you find this article to be of interest or value or if you have any comments, corrections or suggestions.

Please also consider making a donation to help defray some of the costs of building and maintaining this site. Thanks!

Back to Photo notes.