PHOXENE

FLASH TECHNOLOGY

PHOTO TRAFFIC ENFORCEMENT BY PHOXENE

APPLICATION NOTES

PHOXENE

FLASH TECHNOLOGY

For over 10 years, Phoxene has acquired know-how in the technical design, manufacture and sale of flash illuminators for traffic enforcement. Phoxene is glad to share its experience on imaging through the edition of Application Notes dedicated to the use of flash for Traffic Enforcement applications. Theses Application Notes have been organized for maximum ease of use, for both experts and less experienced readers.

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PHOTO TRAFFIC ENFORCEMENT

APPLICATION NOTE **#1**

WHY USE A FLASH

According to local regulations, image capture in a Traffic Enforcement scenario demands different details on images: licence plate, car body, driver's face, and sometimes background.

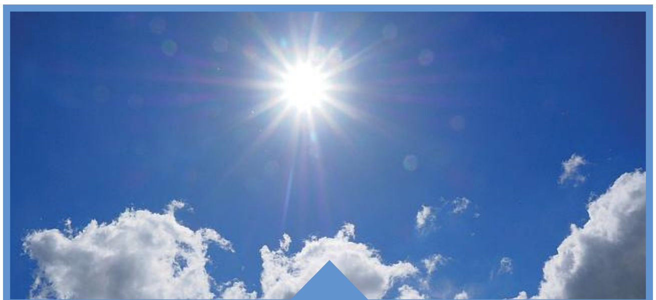
Image capture is light capture. Adequate lighting means better images in terms of lightness, details readability, depth of field or motion blur:

- shadows can darken a licence plate, and make it unreadable,
- clouds reflections can hide a driver's face,
- quality images are possible only when light is mastered.

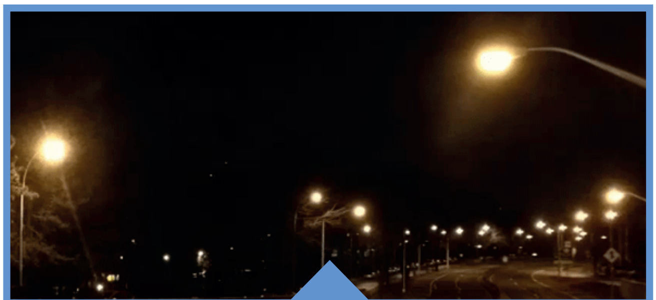
In this document we will detail how a flash does improve image capture and quality by delivering the right light at the right place.

What are the common light sources

Multiple sources can bring light to the scene in a traffic enforcement scenario:



The sun: gives bright light, but is inconsistent in intensity (clouds) and direction (displacement in the sky) creating unmanageable shadows.



Street light: much too weak to capture a clear image of moving objects, and poorly placed (creates adverse shadows).

LED panel: can be placed geometrically to avoid shadows. Perfect for close distance illumination of still vehicles, but much too weak for very short capture times.

Xenon Flash: can be placed geometrically to avoid shadows, produces a very intense light capable to surpass the sunshine at a distance.

Only an appropriate light source can guarantee a high and repeatable image quality: a Xenon Flash

Why use a flash to improve image capture?

#1: TO BRING ENOUGH LIGHT TO THE SCENE

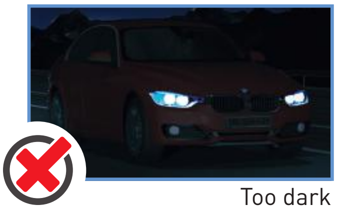
- image capture is light capture: no light means no image.
- camera sensors' sensitivity keeps increasing year after year, but image quality and readability remain vastly dependent on the light level on the subject.
- a flash is a very bright light source capable of revealing more details on an image.

#2: TO FIGHT VARIATIONS IN AMBIENT LIGHT

Ambient light varies greatly over a daytime, and from day to day:

- total amount of light: night / day / clouds.
- position of the sun in a clear sky.
- diffused sunlight by cloudy sky.

Driver's face and licence plate by night



Too dark

Made visible by a flash

A FLASH CAN ENSURE A PROPER ILLUMINATION, BY DAYTIME OR BY NIGHTTIME

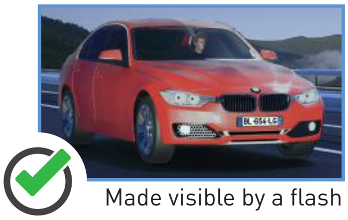
#3: TO MANAGE ADVERSE SHADOWS AND REFLECTIONS

The only way to defeat adverse shadows or reflections is to choose the light source placement:

- sunshine creates shadows that may hide the drivers' face, or darken the licence plate.
- sun or sky reflections on windscreens hide the drivers' face.

Driver's face under daylight

Hidden by reflections



Made visible by a flash

A FLASH IS A MASTERED LIGHT SOURCE ABLE TO DEFEAT ADVERSE SHADOWS OR REFLECTIONS

#4: TO OPTIMIZE CAMERA SETTINGS

More light opens the range of settings in the below parameters:

- lower camera gain creates less "noise" on the images.
- smaller lens aperture (higher f-stop figure) translates in more depth of field, and higher chances for sharp images.
- shorter shutter time means sharper images of moving objects.

A flash is an illumination tool that brings light to the scene in a sufficient quantity and with a defined geometry

- It opens latitude in camera settings and image management

- It improves image readability under a variety of circumstances

APPLICATION NOTE **#2**

INVERSE SQUARE LAW

Theoretical introduction

Place an object close to a light source, and it will receive a lot of light. Place it farther and it will receive less light.

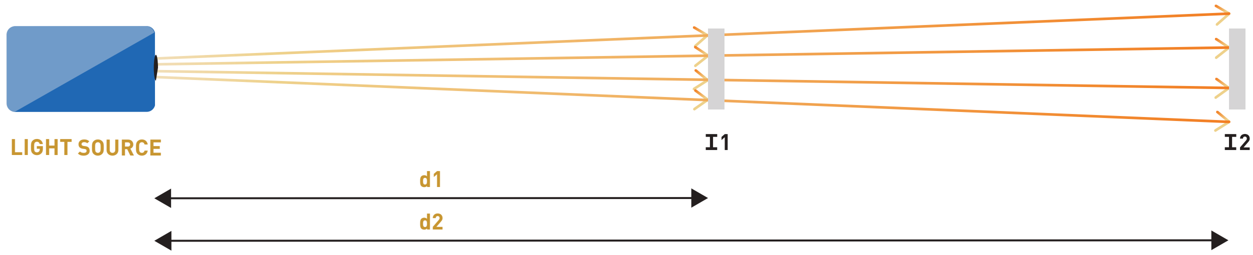
By how much?

The inverse square law states that the "intensity" of lighting (Irradiance) from a point source onto a subject varies in inverse proportion to the square of their distance.

It can be expressed under the convenient form as follows:

$$I = k / d^2$$

where "k" is a constant depending, among other things, on the light source power.
"d" is the distance to the light source.



$$I2 = I1 \times \left(\frac{d1}{d2}\right)^2$$

EXAMPLE: DOUBLING THE DISTANCE BETWEEN ILLUMINATOR AND SUBJECT RESULTS IN A FOUR-FOLD REDUCTION OF THE LUMINOUS ENERGY WHICH HITS THE SUBJECT I.E. 2 F-STOPS (OR -6 dB) UNDEREXPOSURE.

Practical application

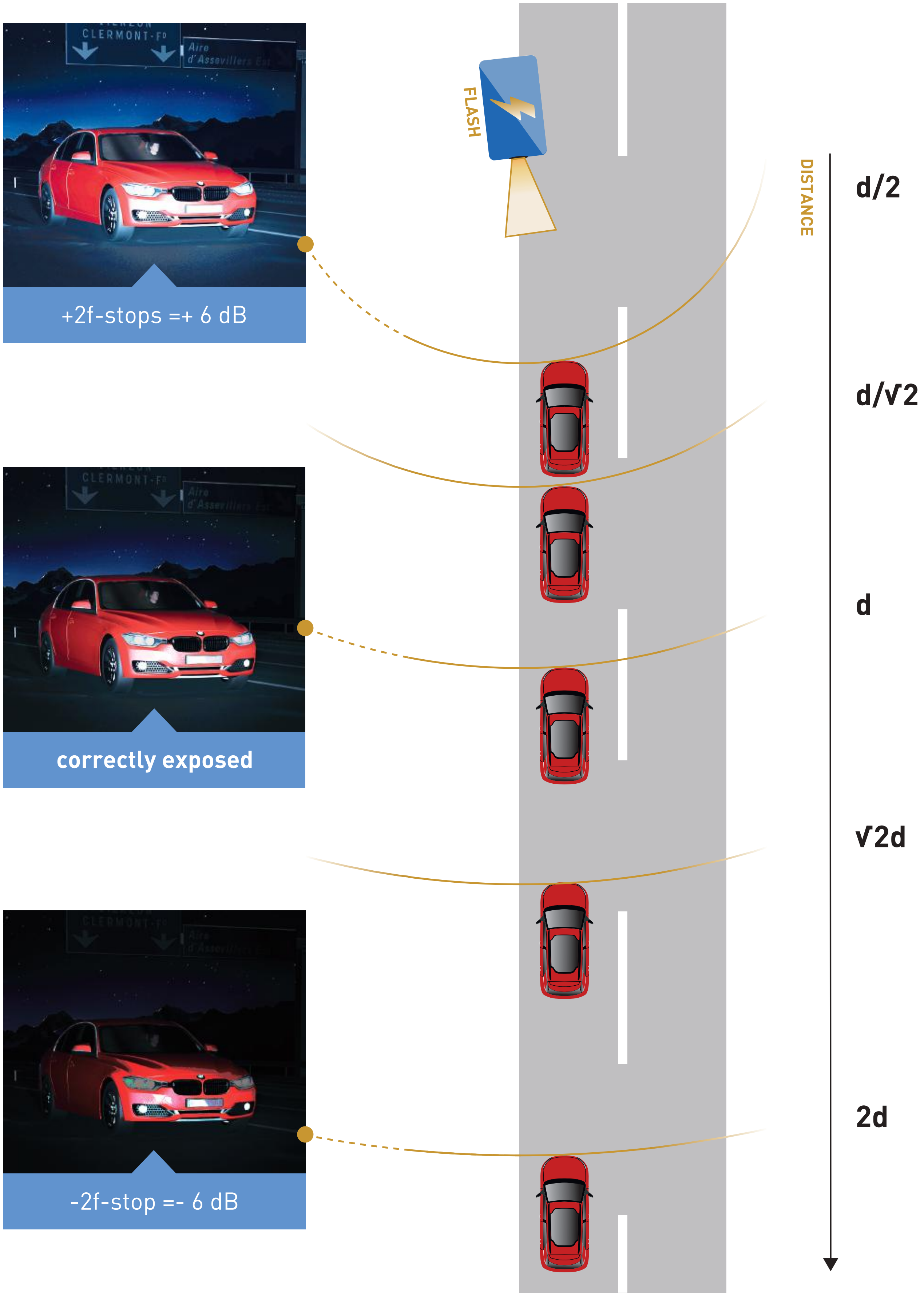


PHOTO TRAFFIC ENFORCEMENT

APPLICATION NOTE **#3**

GUIDE NUMBER

How to know if an illumination device will be able to illuminate the scene you want to capture?

When an illuminator is used to illuminate a scene for image capture, the amount of light reaching the scene depends on multiple factors including:

- the intensity of the beam of light coming out of the illuminator: the more intense, the farther reaching,
- the distance from the illuminator to the scene.

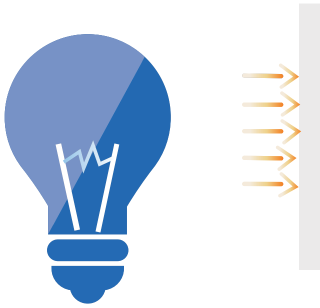
Thus, it is important to quantify the beam intensity.

For continuous light, with a video camera, the **lux** value is important to figure out if a scene is correctly illuminated to expose an image. With a still camera, this translates into an **Exposure Value**.

HOW MUCH LIGHT IS COMING OUT OF THE LAMP?

HOW INTENSE IS THE LIGHT EMITTED IN ONE PARTICULAR DIRECTION?

HOW MUCH LIGHT IS ACTUALLY REACHING THE DISTANT TARGET?



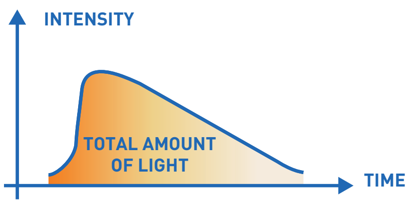
The **luminous flux** is a measure of the overall flow of light emitted by a source.	The **luminous intensity** is the quantity of the luminous flux emitted in a given direction per solid angle (in steradian). The addition of an optical system (reflector, lens...) can increase the figure dramatically.	The **illuminance** is a measure of the concentration of luminous flux falling upon a surface. The illuminance will decrease when the surface is farther from the source.
Unit: ***lumen (lm)***	*Unit:* ***candela (cd)*** ***1 cd = 1 lm per steradian***	*Unit:* ***lux (lx)*** ***1 lx = 1 lumen per square meter (lm/m2)***

EQUIVALENT FOR A FLASH: VALUES ARE INTEGRATED OVER TIME

lumen x second (lm.s)	*candela (cd) x second (cd.s)*	*lux x second (lx.s)*

Why integrate over time?

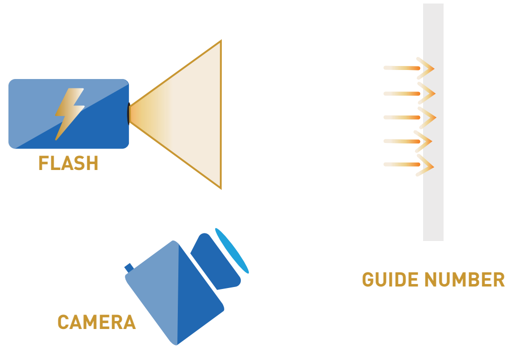
Usually, a flash develops over time with a varying intensity. Thus, on the contrary to continuous light, the peak intensity is no more a relevant value to quantify the emitted light. The total amount of light is best represented by the integration of the intensity over time.



How to quantify the light emitted by a flash?

For a flash, the photometric values are strictly correct, but unpractical.

The Guide Number expresses how much light is seen by the camera on the target.



The **Guide Number** is a value directly coming from the world of photography, and based on the photographic units. It is the product of an aperture (f-stop or f-figure) by the distance between the flash device and the subject usually expressed in metres. It is usually expressed for a sensor sensitivity of ISO 100. Other values and units are possible, but shall be specified (ISO 200, foot...).

GN = f-figure x distance

The table below gives examples of working conditions (distance, and aperture) for a correct illumination with a flash unit featuring a Guide Number of 50 (at ISO 100, in meters):

GN = 50	DISTANCE	DISTANCE	DISTANCE
Aperture	AT ISO 100	AT ISO 200 (*)	AT ISO 400 (*)
f/1	50 m	70,8 m	100 m
f/2	25 m	35,25 m	50 m
f/2.8	17,8 m	25,2 m	35,7 m
f/4	12,5 m	17,6 m	25 m
f/5.6	8,9 m	12,6 m	17,8 m

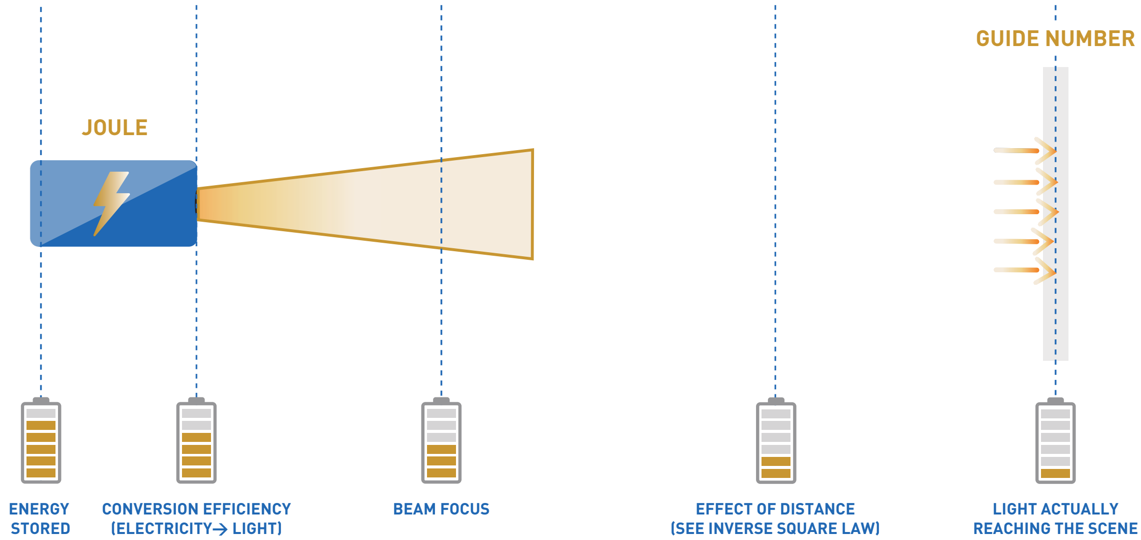
(*): a factor 2 in camera sensitivity leads to a factor √2 in operating distance, all other things being equal. This increase in distance is expressed by the "inverse square law": see the dedicated application note.

Why Guide Number is more relevant than Joule?

Joule (or Watt.second) is the expression of an electrical energy and describes what happens inside the flash unit from the electrical perspective. It does not say anything about light.

Guide Number expresses the amount of light actually reaching the scene. This is the real performance of the flash illuminator.

Consider a flash device as a supply chain where Joule is at the beginning, and Guide Number at the end. There are many factors in-between, reducing the energy level at each step.



APPLICATION NOTE **#4**

EXPOSURE

For image capture in a traffic enforcement application right image exposure is a major key:

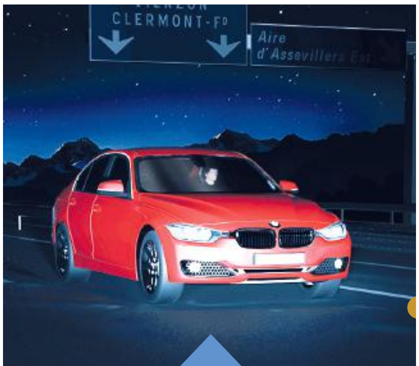
- the issue is the image readability, compatible with legal action,
- hence the need for an illumination suitable in quality and quantity, even at night or in back-light situation.

In this document, we will detail what exposure actually is, and what factors affect it.

What is exposure

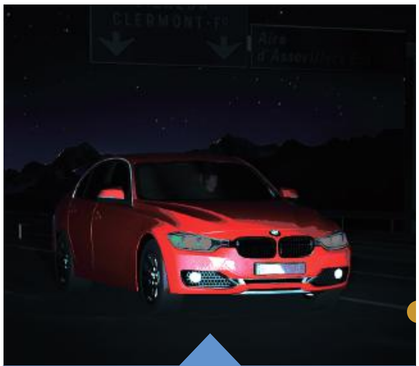
> *In photography, exposure* ***is the amount of light*** *per unit area* ***reaching an image sensor*** *[...]*
> Wikipedia

IN PRACTICE, EXPOSURE TRANSLATES INTO THE LIGHTNESS LEVEL ON AN IMAGE: LIGHTER OR DARKER.



+2f-stops =+ 6 dB

correctly exposed



-2f-stop =- 6 dB

F-Stop and dB are relative measurements. They refer respectively to aperture and sensor's sensitivity (see next page).

Exposure is a compromise

It is sometimes difficult to expose correctly all the details of an image, particularly in case of objects with strong contrast:

- licence plate (particularly with retro-reflective materials),
- car body,
- driver's head behind the windshield,
- surroundings, or distant cars in the background on the same road.

Readable images can be obtained by fine camera settings adjustments

Four factors do affect image lighteness

Factor #1: Shutter time	Factor #2: Aperture
Exposure increases with shutter time, all else being equal. - for image capture of a moving vehicle, short shutter time is mandatory to avoid blur, - a shorter shutter time necessitates a more powerfull light on the scene.	Exposure increases with aperture, all else being equal. A wide aperture (small f-stop figure) lets more light pass through the lens than a narrow aperture (big f-stop figure). - a narrow aperture brings more depth of field: a larger portion of the image is sharp... - ...but more light is needed on the scene to balance a narrow aperture!
Factor #3: Sensor's sensitivity	**Factor #4: Light intensity on the scene**
Exposure increases with sensor's sensitivity / gain, all else being equal. Or, more precisely, less light is needed when sensitivity, or gain, is high. But... - noise on the image – i.e. "bad" pixels - increases with sensor's sensitivity / gain, which impedes image readability and licence plate reading.	Exposure increases with the amount of light available on the scene, all else being equal. More light available means a higher image quality overall: - a correct exposure of the subject - i.e. not underexposed, - less motion blur, because the shutter time can be shorter, - more depth of field, because the aperture can be smaller (big f-stop figure), - better pixels, and noise reduction, because the camera sensitivity (or gain) can be lowered.

PRACTICAL EXAMPLE: 5 WAYS TO DOUBLE THE EXPOSURE

Factors	Exposure X 2
Shutter time	x2 ms
Aperture	+1 f. stop
Sensitivity	x2 ISO
Gain	+3 dB
Light on the scene	x2

Whatever the subject, and whatever the distance to the camera, more light available on the scene means more latitude in the image management, as well as better image readability

PHOTO TRAFFIC ENFORCEMENT

APPLICATION NOTE **#5**

XENON FLASH vs LED

The advent of LED technology a decade ago or so, put a milestone on the way of illumination tools and LEDs are becoming usual sources for many applications such as street lighting, home lighting, industrial vision or even car's headlights.

But illuminating traffic enforcement scene differs from other usages in 2 key aspects:

- to freeze the movement, the image integration time is in the range of 1 ms,
- in that limited integration time, the quantity of light must be sufficient to capture an interpretable image.

The following sections of this document draw a **comparative evaluation of Xenon flash and LEDs technologies.**

Quick technical background

Xenon Flash

Xenon Flash is an electric arc lamp producing intense light thanks to gas ionization. Xenon flash work in pulsed mode only.

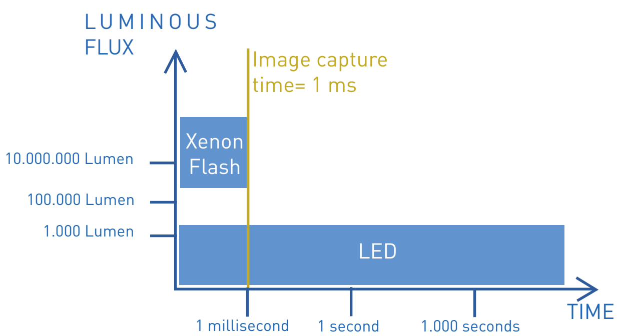
LEDs are semiconductors able to produce light when submitted to a current. They mostly operate in continuous mode.

Power LED

Comparison of luminous flux

Luminous flux (in lumen) is a measure of the total amount of light produced by a device and the luminous efficacy (in lumen / watt) is the ratio of luminous flux to power consumption. By definition, whatever the technology converting electricity into white light, 350 Lm/W is the maximum achievable efficacy .

Typical operating area Luminous Flux / Time : Xenon flash is far more luminous than LED



Practical example: evaluation of the luminous flux generated by 2 devices currently on the market

	LEDs *	Xenon Flash **
Typical power per light source	4,6 W	250 000 W
Typical luminous efficacy	125 Lm/W	50 Lm/W
Luminous Flux (Power x Efficacy)	575	12.500.000

*data from LED Ref CREE XM-L2 Coolwhite- group U2
** data from Xenon Flash Phoxene Fx-1

In 1 ms the Xenon Flash generates about 20 000 times more luminous flux than LEDs

Comparison of overall illuminator dimensions

For a given illuminator, the beam intensity is directly proportional to the light source surface brightness. To balance their lower surface brightness, LEDs are assembled into large panels. The Xenon Flash brighter source leads to smaller illuminator than the LED's one.

Practical example: comparison of sizes of 2 illuminators producing same beam intensity

	LEDs *	Xenon Flash **
Typical surface brightness	35 Lm/mm2	11 250 Lm/mm2

*data from LED Ref CREE XM-L2 Coolwhite- group U2
** data from Xenon Flash Phoxene Fx-1

In 1 ms, for similar beam sizes and intensities, a LED illuminator would be 320 times larger than a Xenon Flash illuminator

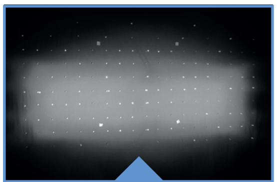
Practical illustration

To confirm the calculations detailed here-above, an experiment was conducted with 2 commercial illuminators designed for Road Traffic applications : one LED and one Xenon Flash.

Illuminators are of comparable size and power
Pictures of both beams projected on a black wall

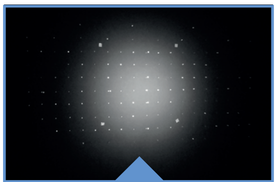
Phoxene Fx-1

Commercial LED illuminator



Xenon flash beam

Image of Xenon flash is **3 times** larger than LED beam one



LED beam

Image amplified **100 times** to simulate a comparable light intensity

Confirmed by experiment, in Traffic enforcement and an integration time of 1ms to freeze the movement, a Xenon Flash illuminator produces 300 times more light than an LED illuminator

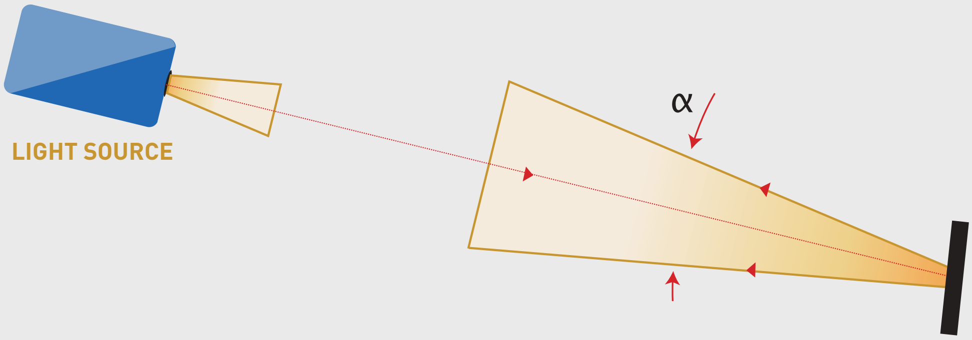
Xenon flash is the designated technology for speed traffic enforcement application:

- **it produces, in a short timeframe, much more light than other technologies,**
- **it meets the requirements of high speed vehicles image capture by freezing the movement in an integration time shorter than 1 ms.**

RETRO-REFLECTIVE EFFECT

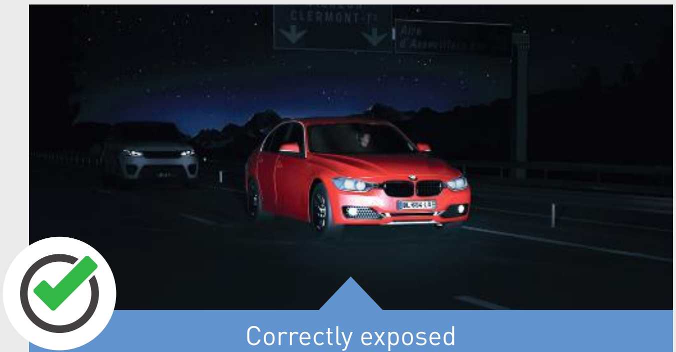
The retro-reflective effect is the property of some materials to reflect light back to its source, within a quite narrow angle of dispersion (here: Ð), almost independently from the angle of incidence on the reflective surface, and independently of the light color (even Infra-Red).

This property is widely used on road signs, bollards, reflective tapes for cars, high visibility clothing (yellow safety jackets), and in some countries... on license plates.



When an image of a retro-reflective license plate is taken with a camera and a flash within the retro-reflection «Ð» angle, the flash reflects back on the plate and makes it overexposed and unreadable.

Overexposed license plate due to retro-reflection



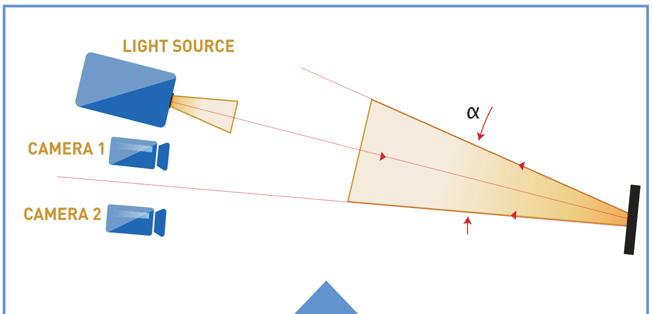
Correctly exposed and readable license plate

MULTIPLE SOLUTIONS CAN REDUCE THE RETRO-REFLECTIVE EFFECT

#1 Geometrical solution: flash and camera placement

The retro-reflective effect disappears if the camera and the flash are in an angle greater than the retro-reflection «α» angle: the license plate looks exposed just as much as the rest of the car body.

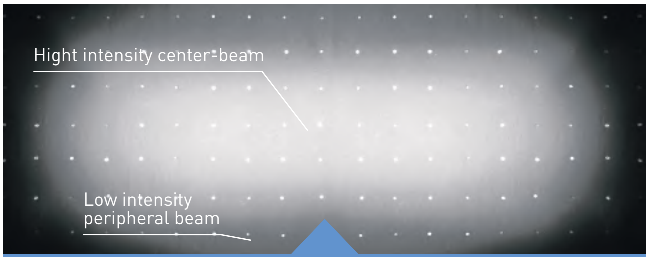
As a reference, in multiple European countries, the retro-reflection effect on license plates seems to be decreasing at about α = 4 to 5°, and almost non-existent at about α = 14°. This implies to separate the flash and the camera by about α/2 = 7° to defeat the retro-reflective effect.



Camera 1: in the retro-flective angle
Camera 2: out of the retro-reflective angle

#2 Geometrical solution: beam orientation

This solution necessitates a flash with a well-defined beam shape, with an intense center-beam and a less intense periphery.



Beam shape projected on the road

Final obtainable image

Important: please note that the A/ and B/ solutions can be combined to maximize the result with minimal difficulties.

#3 Temporal solution: multiple flashes

If the flash device is able to produce multiple shots very rapidly (within approx. 10 ms), and allow a modulation in beam intensity between consecutive shots, two or more images can be captured with more or less intense light.

Strong flash: car well exposed, plate overexposed

Weak flash: car underexposed, plate well exposed and readable

With an intense flash, the car will be correctly exposed, and the plate overexposed. With a less intense flash, the car will be underexposed, but the plate is correctly exposed.

With two images, the car and the plate are visible.

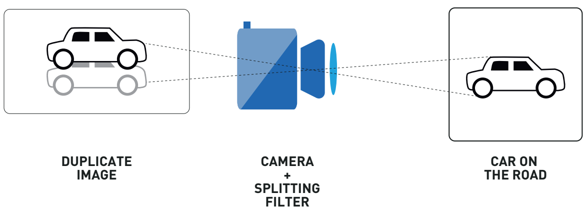
#4 Optical solution: Splitting Filter

Optical solutions can be found, like the «Splitting Filter».

A Splitting Filter is a very special optical filter that can be fitted on optical lenses in front of cameras. It optically splits the image in two: one main image (car well exposed), and one much underexposed «ghost» image (where the plate only is correctly exposed). These two twin images are then optically shifted and superimposed in the camera lens.

As a conclusion, only one image is taken, where the car appears correctly lit, and a duplicate licence plate is readable under the car.

No electronic is involved. No image post-processing is involved. All is optical, and in only one image capture.



Typical image without Splitting Filter. Full exposure.

Typical image with Splitting Filter.
Duplicated plate with reduced exposure.

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PHOTO TRAFFIC ENFORCEMENT

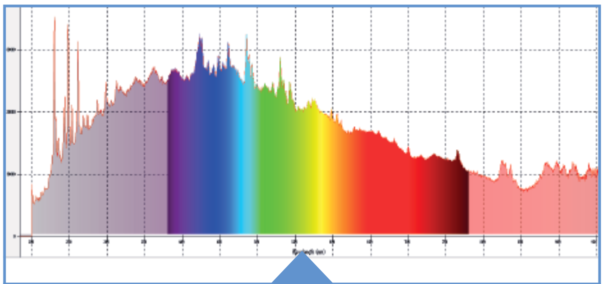
APPLICATION NOTE **#7**

LIGHT COLOR AND PHOTO ENFORCEMENT

For image capture in traffic enforcement applications, local regulations lead to constraints in terms of illuminator light color: bright white light to get well colored illuminated images, soft red light to reduce dazzling effect or IR light to make the flash illuminator invisible. On the other hand enforcement system integrators have to deal with image quality standards including sharpness or color rendering.

After an overview of technical background, this document will detail, through practical cases, possible combinations of cameras and illuminators.

Illuminators - colors and filters



Xenon Flash spectrum

Xenon Flash illuminators produce light essentially in the visible + IR range. UV is usually cut-out by the glass wall itself.

Filters

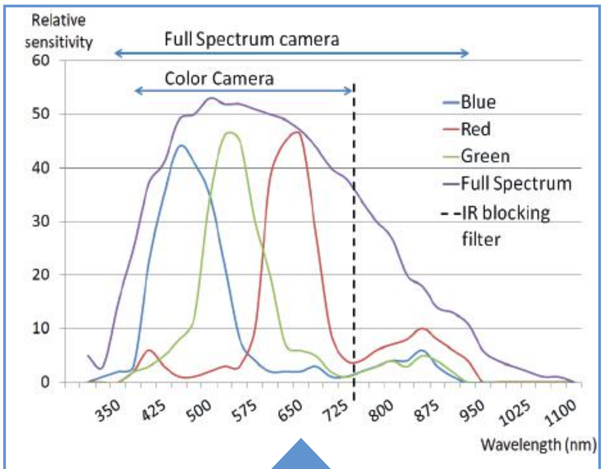
A spectrum can be narrowed by filtering to: Red+IR only, IR only... Filtering causes losses in light intensity.

Cameras' relative spectral sensitivities

A color camera is fitted with a full spectrum sensor but:

- sensitivity is altered because of Blue, Red and Green filters positioned in front of pixels (called Bayer matrix) in order to actually detect color at sensor level.
- wavelength range of image capture is limited to the visible spectrum by an IR blocking filter positioned in front of camera sensor.

A full spectrum camera has a greater sensitivity than a color camera, but images are in grey shades and not in color



A typical camera's sensor is sensitive to a broadband spectrum from about 350 to 1000 nm

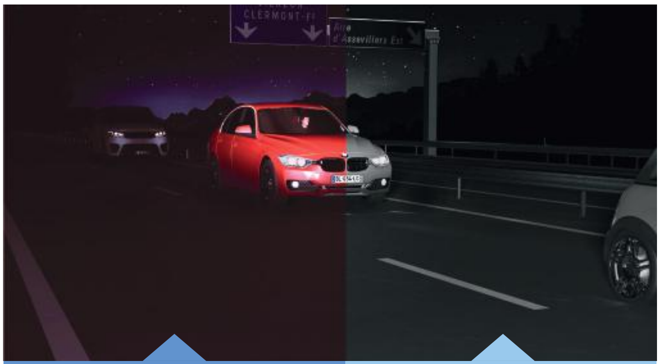
Practical cases of possible combinations of camera and flash

Goal #1: Capture a color image

Night time Full-spectrum flash Color camera	Daytime No flash Color camera

To get a clear color picture, a color camera and a full spectrum flash must be associated.

Goal #2: Avoid dazzling drivers



Night time Red flash Color camera	Night time Red flash Full spectrum camera

To reduce the dazzling effect, the flash spectrum can be limited to its red part, the color rendering being affected because of missing light in the blue region. Such a flash can be then associated with either a full spectrum camera to maximize sensitivity or a color camera.

Goal #3: Work with «invisible light»

Night time Infra Red flash Full spectrum camera	Daytime No flash Full spectrum camera

To make the flash invisible, the flash spectrum must be limited to its infra-red part. Sensitivity of color camera in that spectrum being very limited, a full spectrum camera shall be used.

Goal #4: Maximize sensitivity

Night time Full-spectrum flash Full spectrum camera	Daytime No flash Full spectrum camera

When local regulations entitle grey shades images, it is worth using a full spectrum camera so that the sensitivity is maximized and resulting images are brighter.

APPLICATION NOTE **#8**

GLOBAL AND ROLLING SHUTTERS

For image capture in a traffic enforcement application, a flash is often necessary to produce well lit images. Due to technical differences in their structure, sensors interact differently with flashes, and necessitate different flash features to produce correctly exposed images.

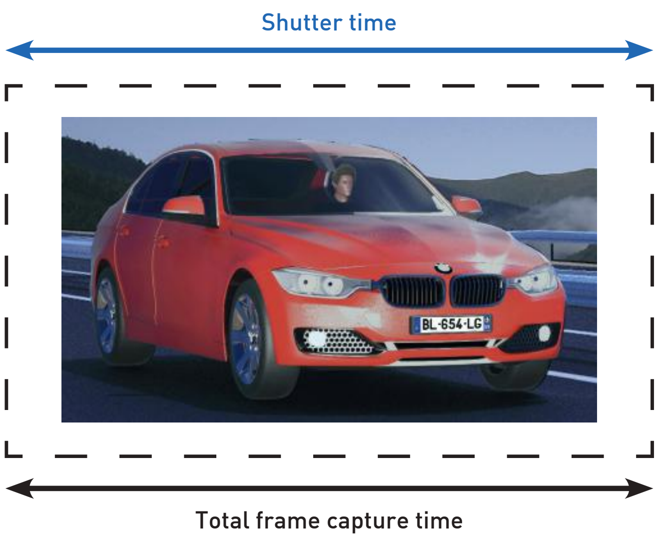
Sensors come in two types known as "Global Shutter" and "Rolling shutter".

In this document, we will detail how these sensor types will interact with a flash.

What are "Global Shutter" and "Rolling Shutter"

The terms **"Global Shutter"** and "**Rolling Shutter**" refer to a way to collect information from a sensor and transfer it to a memory.

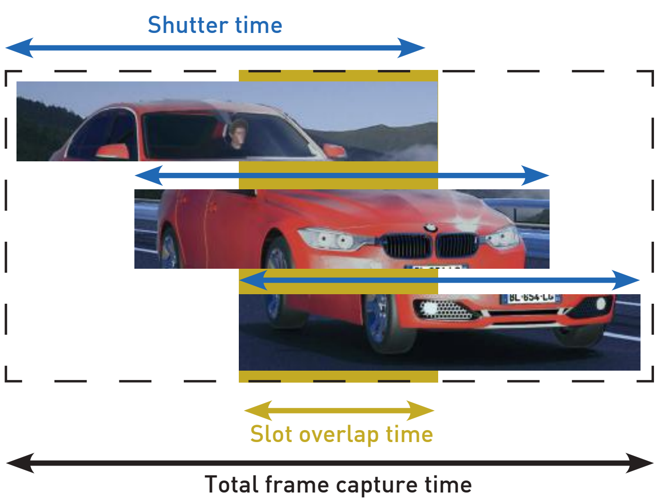
- in "**Global Shutter**" sensors, the information of a whole frame is captured all at once: all the pixels are exposed simultaneously, then all the data is transferred to the memory. Global Shutter sensors are usually of the CCD type. Their sensitivity in low-light conditions is average, and they are commonly found in industrial cameras.



AN IMAGE IS **GRABBED ALL AT ONCE:**

- Total frame capture time = Shutter time

- in **"Rolling Shutter"** sensors, the information coming from the pixels is read sequentially, line by line or "slot by slot". This means that not all pixels of a frame are exposed at the exact same instant: when the first pixels are grabbed, the last ones may be -or may not be- exposed yet. Rolling Shutter sensors are found in CMOS technology. They usually have a high sensitivity and tend to produce high-quality images. They are usually found in photographic still cameras.

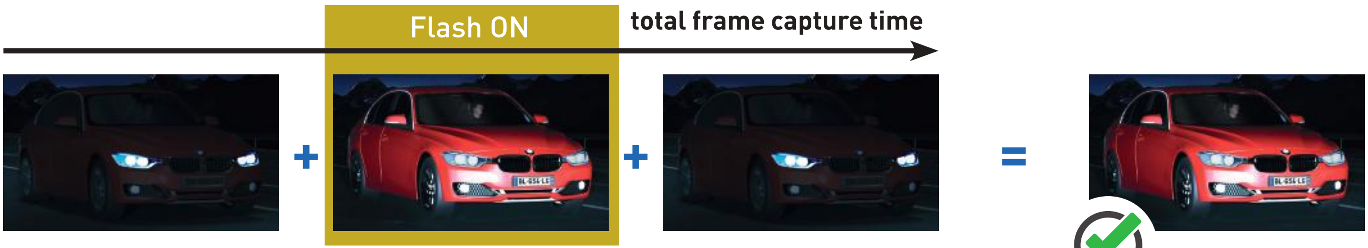


AN IMAGE IS **GRABBED SEQUENTIALLY** (3 slots in this example).

- Total frame capture time > Shutter time
- all the slots are exposed together during a variable (and possibly =0) Slot overlap time
- a long Shutter time implies a long Slot overlap time

How do the two sensor types interact with a flash to capture images?

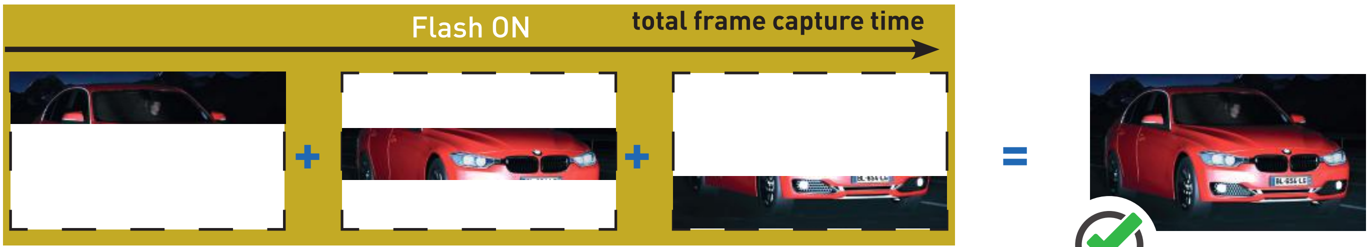
GLOBAL SHUTTER



The short-duration flash freezes the motion, takes less energy to expose the image, and is less dazzling for drivers. The flash unit can be smaller, and have a longer life. Fast sequences are possible (multiple shots per second).

FAIL-SAFE SOLUTION

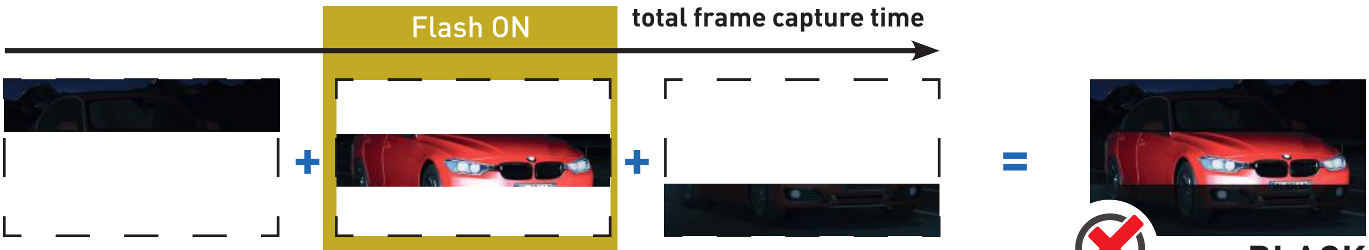
ROLLING SHUTER SHORT SHUTTER TIME LONG FLASH



A long flash can expose all the "slots" even with a short shutter time, but at the cost of a massive light emission resulting in: more dazzle for drivers, larger and more fragile flash units, reduced repetition capability for the flash unit.

POORLY EFFICIENT

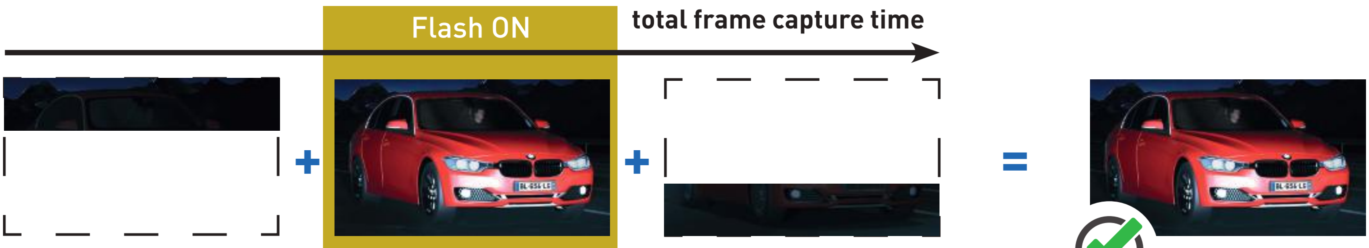
ROLLING SHUTER SHORT SHUTTER TIME SHORT FLASH



Due to the short shutter time, not all "slots" capture light simultaneously (slot overlap time = 0): some of them are not illuminated by a short flash, creating dark strips on the final image frame.

BLACK STRIPS

ROLLING SHUTER LONG SHUTTER TIME SHORT FLASH



With a long shutter time, a short flash (if correctly synchronized) is able to expose all the "slots" of an image and freeze the motion. A long exposure means that ambient light will impact image brightness, create motion blur, and deform the image (rolling shutter effect). The camera's frame rate is reduced due to long shutter time.

POSSIBLE COMPROMISE

APPLICATION NOTE **#9**

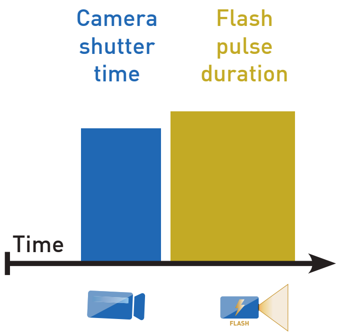
FLASH-CAMERA SYNCHRONIZATION

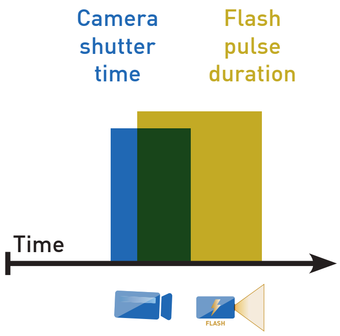
In photography flash-camera synchronization is defined as the adjustment of the time of occurence, relatively to each other, of a flash firing and the activation of a camera sensor. The resulting exposure of a picture relies on the proper management of that synchronization. In the context of photo traffic enforcement such a matter is delicate, because shutter time and flash pulse duration are short in order to freeze vehicles' motion.

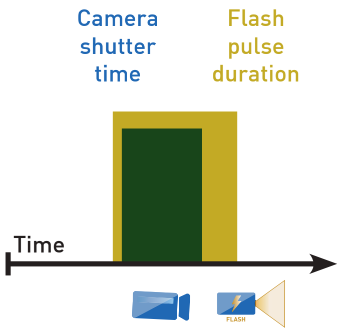
In this document, we will detail what synchronization means, and key aspects of its management.

In practice, what means synchronization?

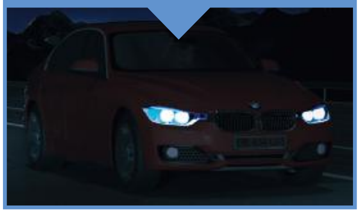
The goal of synchronization is to assure that a flash light emission and an image capture by the camera occur simultaneously.







Light from the flash is not captured by camera sensor



Light from the flash is partially captured by camera sensor

Exposure and resulting image benefit from the flash illumination

Synchronization and system set up

The most common synchronization method is to use a camera output signal as a command to trigger a flash. In that approach, special care has to be taken to the time-lag between the trigger signal and the actual light emission. Camera settings have to be adjusted consequently, with camera latency in mind.

The other approach, basically opposite to the first one, consists in using a flash signal output as a command sent to the camera to start image acquisition, with a latency. Such an approach is made possible by the use of equipment with advanced features: the flash unit shall be able to detect the actual beginning of light emission before sending the trigger signal, and the camera shall have a known time-lag before actually grabbing an image. This is the most reliable set-up in terms of delays and synchronization management.

Why define and adjust synchronization between flash and camera?

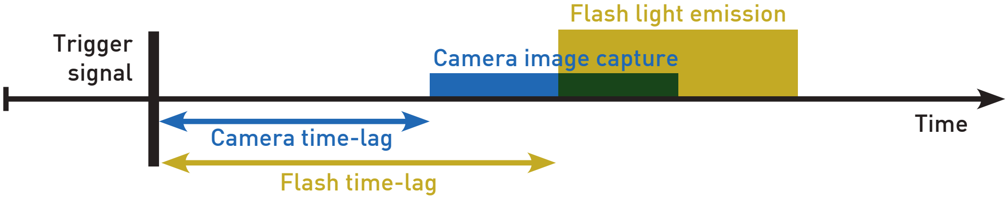
#1: TAKE INTO ACCOUNT THE SYSTEM'S LATENCIES

In a flash unit, there is a time-lag between the trigger signal and the actual light emission (below 100µs for the best flash units).

Cameras too have a time-lag before the beginning of integration. This time-lag is usually long (→ 1 ms) on photographic still cameras, and most often undocumented.

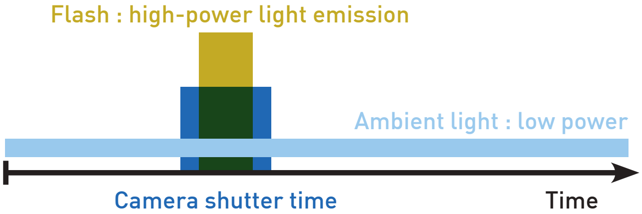
Due to this diversity in time-lag, a flash unit shall not be used to trigger a still photographic camera if optimal synchronization is expected.

In an optimized system, both these time-lags shall be taken into account to ensure that the camera is able to capture all the possible light from the flash.



In this example, the camera ends image capture before the flash emission has ended, wasting light.

#2: MANAGE TIGHT TOLERANCES IN FLASH DURATION AND SHUTTER SPEED



In some cases, the flash duration and camera capture time are very short: tight management is mandatory.

For example, in order to produce images equally bright by day-time and by night, the short but powerful light from a flash must be made predominant over a weaker but continuous ambient light. This is possible when the camera shutter time is set not much longer than the flash duration.

#3: WORK WITH ROLLING SHUTTER SENSORS

In "Rolling Shutter" sensors, the information coming from the pixels is read sequentially, line by line, or "slot" by "slot" (see application note #7 "Global and Rolling Shutters"). During the short time-frame when all the lines or "slots" overlap and are exposed together, a short flash of light can contribute to expose all the pixels of an image. If the shutter time is too short, the lines or "slots" cannot overlap and may not all be equally exposed by a flash.

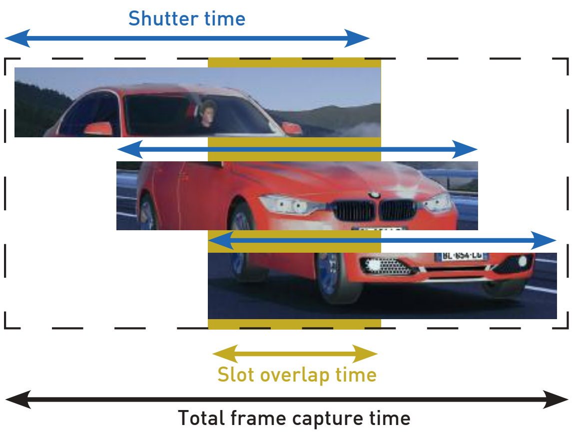


Illustration representing a "Rolling Shutter" sensor capturing an image in 3 slots

The "slots overlap time" is long enough under some conditions :

- **for a still camera,** if the camera's "shutter speed" is set below the "sync speed" specified by the camera's manufacturer. Only a short flash can freeze the image and avoid motion blur: that for, it has to be extremely powerful to surpass ambient light.
- **for a video camera or industrial camera,** shutter time shall be increased (i.e. shutter speed lowered) in order to create a "slot overlap time" long enough to accommodate a short flash. If the flash is longer than the total frame capture time, the light from the flash will be captured anyways.
- **special case:** a few video cameras do start capturing light at the same instant for all the lines, but do not end simultaneously. With such cameras, the flash must be predominant over ambient light, and must be off when the first lines stop capturing light so to avoid an exposure imbalance from line to line or from "slot" to "slot".

APPLICATION NOTE **#10**

ADVANCED SMART FLASH

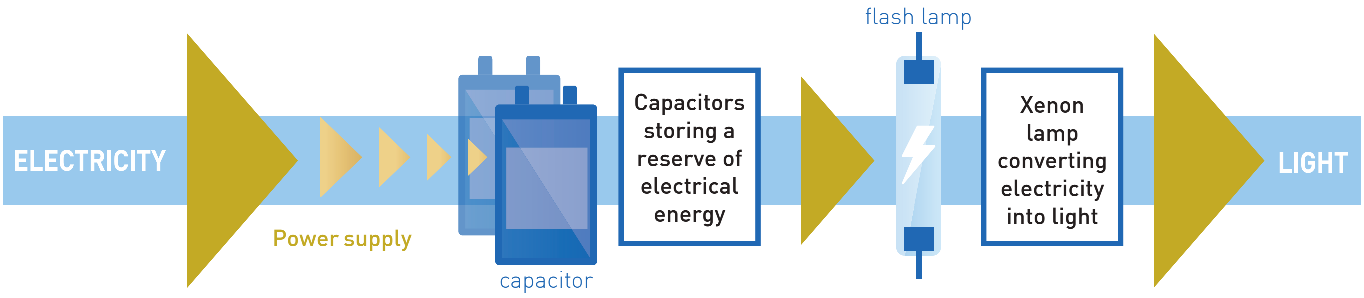
For traffic enforcement, a flash is required to correctly expose a scene and to freeze motion. Beyond the generation of powerful light in a short pulse, other functionalities are often demanded to meet the requirements of enforcement systems, such as:

- fast repetition of flashes,
- reduced loading time,
- control and adjustment of the light intensity,
- system interface.

In this document, we will detail value added features which can be demanded from a Xenon Flash to better serve traffic enforcement applications.

Quick technical background

Simplified diagram of a Xenon Flash



What can be the major differences between an advanced Xenon Flash and a standard one?

Features	Advanced Smart Xenon Flash	Standard Xenon Flash
Partial or total discharge	Partial discharge means burst capabilities, better stability of light emission over lifespan and, last but not least, dynamic adjustment of light intensity	Total discharge is more stressful for capacitors reducing their lifespan and increasing constraints on the power supply (peak current, recharge time)
Trigger inputs	Trigger inputs can be offered in various formats (Dry Contact, TTL) and different inputs can generate different light intensities as programmed levels	One single input signal to trigger the light emission without any control on the latency between trigger and actual emission
Embedded microcontroller	Different energy levels can be managed as well as supervision of flash parameters related to actual light emission, capacitors recharge status, temperature...	No supervision nor control of the energy transfer between the capacitors and the lamp
Interface	Thanks to standard communication protocol such as RS232, system can have a full control of the flash device, read all status and manage a dynamic adjustment of the light intensity	No remote supervision nor control of the device

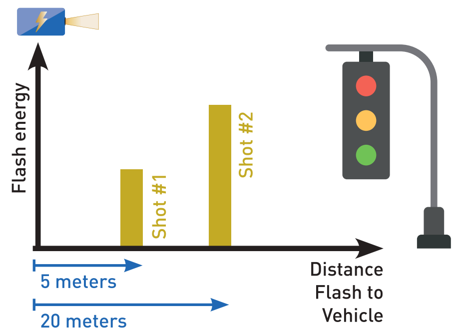
Typical enforcement scenario requiring advanced flash features

Scenario #1: multiple vehicles close to each other

Successive cars

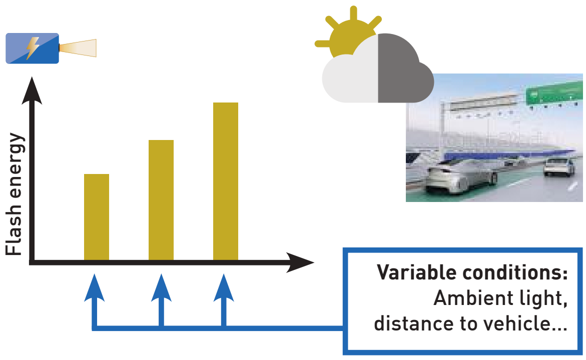
For speed enforcement scenario, system shall be capable of catching fast target vehicules. Advanced Xenon flash are able to generate burst of high power shots 10 ms apart.

Scenario #2: same vehicle but different distances



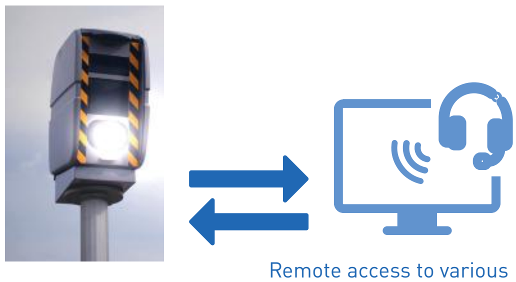
For red-light enforcement scenario, a system may have to catch the same vehicle at two or more distances: at a red-light signal and across a junction. The advanced flash device can be set so that successive shots are emitted at different light power and provide even resulting exposure on pictures.

Scenario #3: dynamic adjustment of emitted light



To adapt exposure parameters to external conditions such as ambient light or distance between camera and car, an enforcement system may use energy adjustment capabilities of an advanced flash. In less than 10 ms, the flash can illuminate the car at a requested energy level thanks to a standard communication interface.

Scenario #4: remote system maintenance



Thanks to communication interface a flash device can be supervised remotely. This enables remote diagnostics, preventive maintenance scheduling or operating parameters adjustment.

Enforcement systems can integrate innovative features thanks to Advanced Smart Flash devices capabilities

- **successive vehicles capture**
- **preventive maintenance**
- **remote control**
- **adaptability to ambient light and distance**