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Illumination for CCTV systems

A DEFINITION OF LIGHT

Light is of course the main ingredient in order to carry out video shootings. Through camera zoom and sensor, it captures and transmits the information that only the eye is able to give. Physics define light as a type of electromagnetic energy which belongs to the same category of energy transmitters such as radio waves, x-rays and cosmic rays.
Electromagnetic radiation is a definition which includes very different forms of energy. These all have a characteristic wave motion and, although all electromagnetic radiations travel in the same way, every type has a different wavelength (distance between two peaks, measured in meters). Wavelenghts are extremely various, from just some kilometers (radio waves), up to tenthousand millionth millimeter (gamma rays). This is the reason why every radiation has its own characteristics.
The set of all possible electromagnetic waves is called electromagnetic spectrum*.

Visible light

The wavelenght range referred to visible light corresponds to an extremely small section, that is from the shortest wavelength, violet (400nm = nanometers) to the longest one (red) of approximately 750nm (between these two values there are a serious of light emissions ranging from blue, indigo, green, yellow, orange). The human eye cannot see beyond this region. The maximum human sensitivity generally corresponds to 550nm.

*Due to the extreme technical subject, the case is not thoroughly dealt with in this article).

ILLUMINATION FOR CCTV SYSTEMS

In case of video shootings in environments where light is scarce, it is first of all necessary to make a distinction between the following, if we want to choose the right lighting system:
- colour cameras;
- b/w cameras;
- cameras with highly sensitive sensor

COLOUR CAMERAS

In case of colour cameras, the best illuminator to use is the visible light* halogen lamp illuminator. A good lighting must in fact highlight the object details necessary to identify it. Other types of illumination systems, like for instance sodium vapour lamps, mercury vapour lamps, fluorescent lamps, etc. are not appropriate for colour shootings since they all have very different characteristics than those required by CCD sensors (although an automatic white balancing device is nowadays available on almost every camera). For example, lamps containing mercury vapour emit an extremely intense light full of ultraviolet rays and are therefore not very good as lighting source.

*CCD sensors designed to be applied for visible light field use the silicon technology and are able to adequately respond to wavelengths between 250nm and 1150nm, with an optimized reaction at approximately 800nm. These sensors for colour cameras are fitted with a filter which lets in only wavelenghts which correspond to red, green and blue and blocks the entrance of IR radiations. This is the reason why it is not possible to use an infrared illuminator for colour cameras. In case of a day/night camera for colour shootings during daytime and b/w during night time (or when the light is scarce), it is anyway possible to use an infrared illumination. It is important to highlight that b/w cameras with infrared illumination guarantee a better image quality than day/night cameras.

Once we've established to use an halogen lamp visible light illuminator, the necessary power (indicated in Watts) must now be considered. This is a quite difficult subject, since there are different variables to consider (for instance the minimum lighting level required by CCD sensor, shooting distance, shooting field, illuminator positioning, colours on the scene, reflecting surfaces, etc.). It is also important to bare in mind that a higher power equals to a higher power consumption.

As a general indication, we can state the following: for a standard use (4mm/6mm lenses with a 60° horizontal zoom, fitted with a 1/3" highly sensitive CCD) up to approximately 25/30 meters from the camera, a 75W halogen lamp illuminator could be the best solution. It is of course vital to use an illuminator with a light beam as big as the zoom applied (shooting field), otherwise the lighting will not be even.

As for the installation of the illuminator considering the camera position, it is important to note that: 1) the camera reads light reflected from the subject which then bounces back, 2) the best way to light up a subject (in order to identify it and not for artistic purposes) is to position the light source on the same level of the camera and towards the subject itself.
The next step is to establish the distance between light source and subject.

In general it is advisable to install the illuminator as closest as possible to the subject, since a greater light intensity guarantees a better lighting. In practice, this is rarely done. The illuminator is normally positioned in the proximity of the camera or of the housing in case of outdoor installation. This installation is good in principle (same power supply for camera and illuminator) but it has the disadvantage of losing most of its lighting power because the light must travel a longer distance before hitting the subject and bouncing back. In this case and especially when the area to be lit up is quite big, it is always advisable to increase the illumination power e.g. by using more than one lighting source.

B/W CAMERAS

Everything that was previously indicated for colour cameras applies also to b/w cameras but considering the characteristics of b/w CCD sensors, it is possible or necessary to adopt a discreet infrared illumination.

As previously explained, the human eye cannot see beyond the visible light area (from approximately 400nm up to 750nm) whereas the CCD sensor is able to read a wider range (from 250nm up to 1150).

For this reason it is possible to use a infrared light source (above 750nm) as a discreet or invisible illumination source (depending on the frequency range) because visible light and infrared light on b/w cameras are very similar (nearly similar)*.

*Due to the extreme technical subject, the case is not thoroughly dealt with in this article).

Once we've established to use an infrared illumination source, we can identify three main questions to be dealt with:

1) Lamp/source: visible or not visible?

2) Distorted grey tones;

3) Out of focus image.

1) Lamp/source

Depending on the emitted infrared light, if the subject is looked at in front (in this case we advise you to wear sunglasses with very dark lenses) the lamp and/or light deflector is visible or not visible. Using illuminators from 730nm to 850nm, the halogen lamp filament is visible or the inner deflector (with a light red colour) can be made out, whereas at higher frequencies, nothing can be seen. Remember that the optimized reaction to IR light of a standard camera CCD sensor referes to a value of 800nm. If we use for example an illuminator with an emission value equal to 950nm/1100nm, the lamp and/or inner deflector are invisible but the camera cannot adequately read that frequency (low or very low CCD sensor reaction compared to wavelength).

Note: In case we want to use cameras and consequently illuminators for higher frequencies, it is essential to use models equipped with CCD matrix sensors based on semiconductors InGaAs technology which guarantee a great performance within a range from 800nm to 2000nm.

IR illuminators with traditional halogen lamps normally use a cut-off filter which determines the output wavelength. These types of illuminators are subject to an average 2.000 rated hours lamp life. As an alternative, it is possible to use LED illuminators. It is not our intention to deal with the subject in full, but anyway we can indicate that, considering the low power of LEDs, this type of illuminator is generally applied for short distance illumination (8/10 meters, mainly indoor). LEDs also have a decreased performance when the operating temperature increases and if no adequate measures are taken, the more the illuminator is on (warming up), the more the light gets weaker.

For this type of illuminator the same principle as previously indicated can be applied whereby if we want the light source to be invisible, it is necessary to adopt higher transmitting frequency LEDs (above 900nm).

2) Distorted grey tones

Infrared light has some peculiar characteristics that make it versatile for scientific or even artistic applications. It can penetrates mist and light fog much easier and deeper than visible light. It is reflected by the objects in a way which differs from what we are normally used to. At the limits of its wavelenght area it has calorific power (it can be therefore stated that light and heat are very similar). As for video shootings, it is important to note that IR light is almost completely absorbed by water surfaces and by the sky which will consequently look black, whereas it is highly reflected by some organic substances such as chlorophyl inside the leaves. Because of this, grey tones of a B&W image do not correspond to the tones we are used to see under visible light.

3) Out of focus image

When a IR illumination is used, the image appears out of focus when compared to visible light. This happens because infrared light is brought into focus on a different focal level compared to visible light (if we want to focus with IR light we need to consider as if the object was a little bit closer than in reality). On an everyday basis it is impossible to get a focused image both during daylight shooting and during IR shooting unless special lenses (apochromatic or superapochromatic) which are also designed for a constant focus with IR light are applied.

In this case it is generally "suggested" to set up focusing so that the image looks almost focused both during daytime and night time… this would be the same as putting our heads inside the oven and our legs in a freezer and say we are enjoying a perfect average temperature!

In order to solve the problem seriously, we need to:

Use an infrared filter on the lens;

Or, if the camera is for outdoor use, and no filter is available, use a IR filter housing instead of the standard front glass.

The solution to the first point is quite simple. We just need to find a IR filter (with same or decreased cut-off compared to illuminator) of an adequate diameter and fix it directly onto the zoom (if the zoom is not properly threaded, a filter with a larger diameter can be used so that it can be fixed onto the zoom with e.g. silicone).

The solution to the second point is not so immediate because it is not easy to find a similar product. The advantage of this application is anyway that of being able to use different types of lenses because the filter is basically the same. The only necessary thing is to carry out the focusing with the filter onto the zoom, before the housing is closed.

If these indications are followed, there will be no focus shift both during the day and during IR shootings.

If a IR filter is applied, it is also possible to:

- Reduce blinding during day time caused by: light which hits white walls directly, glares coming from reflecting surfaces, back-lighted shots, ect. The image can look maybe a little bit softer but also clearer;
- Cancel or reduce interferences during the night due to lighting sources that negatively contribute to reading/exposition value of the camera (street lamps, garden lamps, disturbing or glaring lights, car lights, etc.). Even if an adequate illuminator is used, the above mentioned lights can interfere with the camera operations so much that the IR emission (coming from the illuminator) is dramatically reduced or even nonexistent, in case of lower power. On the contrary, through an infrared filter all lights that don't emit IR are all cut off (or their intensity is dramatically reduced) and the camera operates more easily.

CAMERAS WITH HIGHLY SENSITIVE SENSOR

Instead of using an illuminator, it is possible to use highly sensitive traditional cameras (e.g. cameras with an ex-view sensor) with a minimum illumination value corresponding to approximately 0,0003 lux (referred to F=1:1.4). This type of camera enables shootings under extreme conditions in which standard cameras are not able to operate. The image is nevertheless quite dark and extremely blurred (snow effect) due to the increased camera gain.

ILLUMINATORS, SERIES LX

On the basis of what previously described, SERINN has developed the following illuminators:
-LX675 (visible light) and LX675IR (infrared light) with halogen lamp;
-LX51LD (infrared light) with LEDs;
The LX675 range is suitable for outdoor use, is made of anodized anticorodal and guarantees a high level of quality and reliability. The photographic aluminium deflector with an embossed finishing for a uniform illumination has a 60° illumination angle. Both ranges are fitted with a 12V-75W halogen lamp and according to various tests are suitable for a 30mt distance (with a good camera sensible also to IR).
The LX675IR range comes with a high quality IR filter (manufactured in glass paste by Shott Glass, Zeiss Group) with a cut-off equal to 780nm*. The particular filter mount guarantees the highest level of protection against cracks in case of high temperature (this is a common problem for many illuminators).
In addition, an IR780/T kit is available only for TUNNEL housings and it comes with an IR filter front glass housing (780nm cut-off) instead of the standard front glass protection (see: out of focus image).

The LX51LD range made of anodized anticorodal uses LEDs with a 875nm cut-off and is suitable for indoor use. It offers a 40° illumination angle and following various tests it is suitable for a distance up to 15 mt. (with a good camera sensible to IR). To assure an excellent illumination, the LEDs are positioned in several rows which are individually powered and kept at a constant temperature through a cooling fan. The illuminator is also equipped with an adjustable twilight switch for automatic switch on/switch off. The twilight switch system is also free from interferences due to infrared reflections (if this didn't happen, the switch would not dim or it would flicker because of infrared returns that hit the photocell). The LED service life is incredibly longer than halogen lamps and for LX51LD amounts to 100.000 rated hours.
It is highly recommended both during installation and operation not to point the beam light directly towards the eyes if the equipment is close.

* Considering that it is not possible to know the single camera characteristics in advance (CCD sensor reaction to infrared light), the above mentioned cut-off value was chosen because it applies to any camera brand or model, from the cheapest to the best one (see: lamp/source).