

White Paper:

Breakthrough video technology solves persistent image problems with fluorescent lights and LEDs, while maintaining wide dynamic range

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Overview

Video security cameras have a difficult time operating accurately under pulsed lighting sources, which include any ballast-controlled source (fluorescent lighting, mercury vapor lighting) as well as LEDs used so widely in traffic control signals.

The technical problem with video cameras and pulsed lighting sources takes shape in slightly different ways worldwide, but it boils down to a video sampling issue that occurs when there's a difference between the video field capture frequency and local AC power frequency. The only places in the world that are not affected by this frequency mismatch are countries that use the PAL television standard in conjunction with 50 Hz AC power. Areas that are affected by this problem include Japan, some other Asian countries, and most of the Americas.

This mismatch can result in video images whose color shifts every few seconds; video that “beats” so strongly that operators are physically unable to watch it continuously; or video images that include signal indicators that go dark every few seconds. Some of these results are simply annoyances, but others of them can seriously hinder effective security.

In addition, the problems occur frequently in scenes that demand cameras to have wide dynamic range capabilities due to situations with severe back-lighting (common, for example, in transit applications), strong glare or reflections, or in any environment with unpredictable or changeable lighting.

Recently, a technology was introduced that for the first time solves these issues for wide dynamic range cameras. The technology, from Pixim, Inc., is called Enhanced Flicker Reduction (EFR).

The three problems with pulsed lighting

Video security cameras operating in conditions lit by pulsed lighting sources can suffer from the following three problems:

Fluorescent light flicker. Like its name implies, fluorescent light flicker occurs because fluorescent light output – like that of any lighting technology that uses a ballast – is not constant, and in fact flickers. When video fields are captured at a frequency that is significantly different from the AC power supply frequency, the flicker becomes very obvious.

In eastern Japan (including Tokyo), Chile, and some other Latin American, Caribbean, and Pacific Island nations, the AC power frequency is 50 Hz, which differs drastically from the NTSC video capture standard frequency of 60 Hz. Unless the camera is line locked to the AC power source, flickering will be evident in the video capture.

Video captured under this large mismatch in frequency displays a constant beating, strobe-light effect that makes watching the video unpleasant and difficult. As a result, security personnel are physically unable to monitor the flickering video for any length of time, which can lead to unmonitored security cameras. Historically, major compromises were required to reduce the flickering, such as drastically reducing the camera's dynamic range and color accuracy.

Fluorescent color roll. Even regions that use 60 Hz AC power are not immune to video capture challenges in fluorescent lighting. That's because video cameras' NTSC standard of 60 Hz is actually 59.94 Hz. That slight difference is enough to cause trouble.

The spectral characteristics of fluorescent lights change within each AC power cycle as the illumination level changes. If a camera is not AC line locked, the time bases between the 60 Hz AC power and 59.94 Hz NTSC video frequency drift over time, and the camera will capture the spectral changes.

Places where the AC power frequency is 60 Hz and mismatches the NTSC video frequency of 59.94 Hz include western Japan, a number of other Asian countries, all of North and Central America, and most of South America, the Caribbean, and the Pacific Island nations. Because of the small difference between the two frequencies, the camera's image capture system sweeps through the entire illumination cycle of the fluorescent light every 8.325 seconds, causing the color of the fluorescent illumination to appear to change in the captured video. This effect is known as "color roll." In Japan it is sometimes called "irokokyu," or "color breath."

Video cameras displaying changing color every 8 seconds or so might not sound like a serious issue – unless the accurate color of a scene is important for security or evidentiary reasons. Often the color artifact is a burst of bright orange, which is quite distracting.

Frequency-modulated LED blackout. Today, many traffic and signal lights, headlights, flashlights and other devices use light-emitting diodes (LEDs) as their lighting source. LEDs are not continuously powered; rather, their power is modulated, causing the lights to "blink." This power modulation saves energy and extends the life of the LED, but it creates problems for video cameras in ways that are analogous to the fluorescent lighting issues described earlier.

Frequency-modulated LED blackout affects the same geographic regions that are affected by fluorescent color roll. LEDs blink at 120 Hz frequency in most areas that use the NTSC video field rate of 59.94 Hz along with 60 Hz AC power. This frequency mismatch causes the video camera to "see" the LEDs as not continuously illuminated.

In fact, the LEDs appear to go completely dark for some time every 8.325 seconds in the captured video. As a result, LED-based traffic and train signals will not be accurately captured by cameras mounted on moving vehicles such as trains and buses, where it is not possible to line lock to an AC power source. In addition, it is very important to accurately capture the illumination state of traffic and transit signals for forensics purposes (e.g., to tell whether a traffic light or transit signal was showing green, yellow, or red at the moment of a traffic collision).

Other approaches

Previous attempts to address the video sampling issues with fluorescent and LED lights have been limited in both usability and effectiveness. In particular, these other approaches significantly reduce the dynamic range of the video camera for fluorescently lit scenes. This loss of information is not an acceptable trade-off for many video security applications.

Fluorescent color roll and frequency-modulated LED blackout can be solved by using line-locked cameras that are synchronized to the AC power source. Unfortunately, the majority of cameras sold and installed around the world have DC power sources, and line locking does not work with DC-powered cameras. Additionally, line locking is not possible for Internet Protocol (IP) cameras that use Power over Ethernet (PoE) technology, which recent trends are making more common.

In cases where AC line lock is possible, there is the additional problem of the camera capture locking out-of-phase with the AC source, causing a false color cast on the image. This situation can be remedied only manually at the time of field installation by a trained technician.

In cases where AC line lock is not possible due to a lack of a low-voltage AC supply, analog CCD cameras have traditionally used “internal sync.” This mode must be invoked manually at install time by a trained technician, leaving the camera permanently in this mode. The result is reduced color saturation and dynamic range. Also, internal sync modes require an expensive mechanical DC iris lens, which adds cost to the camera.

Fluorescent light flicker cannot be solved for standard CCD sensors. Fluorescent light flicker also is a persistent problem for IP security cameras, which are often powered by DC voltage or PoE, neither of which allow the camera to be line locked to an AC power source.

It should be noted that these video sampling issues are not readily apparent to people looking directly at a scene lit by fluorescent lights or LEDs, thanks to a natural effect known as “eye persistence.” Unlike video cameras, when humans view a scene our brains “fill in the gaps” between fast-flickering lights. The human eye perceives the lighting as constant – in the same way we perceive the rapidly changing individual frames of projected movies as continuous motion.

The EFR solution

Pixim Inc., whose Digital Pixel System® technology represents a genuine breakthrough in video image capture, has solved all three of these video capture issues (fluorescent light flicker, fluorescent color roll and frequency-modulated LED blackout) – while also retaining ultra-wide dynamic range capabilities: allowing true natural color and accurate image capture even under variable lighting conditions. Pixim’s Enhanced Flicker Reduction (EFR) mode, the first real solution to these persistent technical problems, is a feature supported in Pixim’s imaging firmware.

In contrast to all the previous approaches tried for these issues, Pixim offers an automatic solution. Pixim’s EFR mode is available in Pixim’s V3.2 firmware (and above); a 32 Mbit flash is required to support the EFR mode.

In addition to overcoming the fluorescent and LED video sampling issues, it enables video cameras to maintain a full 15 bits of dynamic range for scenes lit by artificial, modulated light with no manual intervention required.

The unique capability of Pixim's EFR video capture mode is another example of the architectural power of Pixim's all-digital solution, which is able to solve practical video capture problems in ways not possible using older analog CCD and CMOS image sensors.



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