



WHITEPAPER

LOW-LIGHT TECHNOLOGY

Seeing In The Dark For Around The Clock Safety

Seeing in the dark.

Is capturing high-quality images in very dark scenes a requirement for your next installation? Or do you have an end user you feel could benefit from a camera that captures images in low-light situations? This paper will walk you through Dahua's advanced low-light technology offerings, including Starlight and Night Color technology.

Background

Ask any police officer, security guard or emergency room nurse when they are busiest, and they will likely say that the action increases as the sun goes down. According to 2019 statistics compiled by the Criminal Justice Information Services Division of the FBI and summarized and published in a recent article in Security Magazine, approximately 54 percent of aggravated assaults, two-thirds of murders, and approximately 60 percent of sexual assaults occur between the hours of 6 p.m. and 6 a.m.¹ Most security cameras lose effectiveness as the scene gets darker and may not produce forensic-level detail in near-dark conditions.

A new forecast from International Data Corporation (IDC) estimates the worldwide video surveillance camera market will grow to \$44 billion by 2025, up from \$23.6 billion in 2019, with a healthy five-year compound annual growth rate (CAGR) of nearly 13%.² On the other hand, sales for network cameras without low-light technology are expected to slow over the next few years due to the increased adoption of cameras with low-light sensitivity.

Low-light Camera Technology

Most surveillance camera manufacturers offer their own implementation of low-light technology. However, specifying a security camera for low-light environments isn't a one size fits all solution. Each application has its own set of challenges, lighting constraints and budget requirements. Dahua understands this dilemma, and makes it easy to find the right camera to fit your needs and budget requirements with four low-light tier offerings: Basic Starlight, Enhanced Starlight, Starlight +, and Night Color Technology.

Starlight Technology

Dahua's Starlight offering uses optical, sensor and image processing technologies to provide clear images in dark environments. All cameras with an IR

cut filter (ICR) are designed to switch to night mode when the camera senses that insufficient light is available to reproduce good color images.

When night mode is triggered, the IR cut filter disengages allowing infrared as well as visible illumination to reach the image sensor. Additionally, the camera electronically suppresses any color information providing clear monochrome images down to a certain light level. Many cameras include built-in IR illuminators to further illuminate the scene, reducing noise.



2MP camera with Enhanced Starlight switched to black and white once color images could no longer render a good quality image

Basic Starlight Technology

Basic Starlight Technology offers good low-light performance at a more affordable price and is ideal for moderate dark areas. Basic Starlight is best suited for applications that produce lighting similar to that of a full moon without additional light sources. Basic Starlight offers sensitivity down to .008-.009 lux. Recommended scenarios: parks, stadiums or parking lots with some ambient lighting such as street lights.

Enhanced Starlight Technology

Enhanced Starlight Technology is a step up from Basic Starlight, and exclusively uses broad spectrum 2MP sensors. This provides excellent images in near dark conditions, down to .005-.007 lux.

¹ <https://www.securitymagazine.com/articles/90384-murder-robbery-and-driving-while-impaired-happen-at-night> - Violent Crimes Most Likely to Occur At Night

² <https://www.businesswire.com/news/home/20200714005108/en/IDC-Forecasts-Solid-Growth-for-the-Video-Surveillance-Camera-Market-as-Smart-Camera-Systems-and-Analytical-Software-Enable-New-Use-Cases> - IDC Forecasts Solid Growth for the Video Surveillance Camera Market as Smart Camera Systems and Analytical Software Enable New Use Cases



4K Starlight+ camera with Micro Four Thirds sensor produces rich colors at night with no noise or color distortion

Starlight+ Technology

Starlight+ Technology offers best-in-class light sensitivity, capturing color details in extreme low-light conditions down to 0.0005 lux. Cameras with this technology use a large 4/3" sensor, smart imaging algorithms providing exceptional color detail in the dark with minimal noise.

The lens is a key component of any security camera and one that directly effects the quality of the image. Dahua Starlight+ cameras feature an M43 lens interface, typically found on most SLR cameras. Recommended scenarios: rural or public areas with little or no ambient lighting.

Night Color Technology

Night Color technology offers full color images in low-light and no-light environments, using a host of technologies to produce crisp, clear images in dark environments. Dahua offers a series of Night Color cameras that use a high-performance sensor, enhanced ISP, an achromatic, large aperture lens, and white-light LEDs to produce color images in most low-light environments. Due to the exceptional low-light sensitivity, there's no need for an IR cut filter nor IR Illuminators so these cameras normally remain in color mode 24/7. However, to provide fully saturated colors at least 1 lux of ambient or artificial light is required.



Ambient lighting combined with Dahua's 2MP Night Color camera produces crisp, rich colors at night

In environments with extreme low ambient light levels or no light at all, Dahua offers a Night Color camera that incorporates white-light LEDs that produce full-color images in total darkness, as well as an effective visual deterrent. This technology provides smart illumination where the camera automatically activates the white-light illuminators when ambient light levels fall and adjusts exposure time and LED intensity to prevent overexposing the image.

Low-Light Camera Components

Cameras that produce color images in low-light or no-light environments use a combination of individual components to gather light from ambient sources or to provide their own illumination in near-dark and dark applications.

Back-illuminated CMOS Sensors

The biggest improvement to sensor technology is the optimization of the internal structure of the back-illuminated (or backside illumination) CMOS sensor.

With a conventional front-illumination structure, the metal wiring and transistors on the surface of the sensor's light-sensitive area (photoelectric-diode) impede the amount of light gathered by the chip on the lens. "A back-illuminated structure minimizes the loss of sensitivity due to optical angle response, while also increasing the amount of light that enters each pixel, due to the lack of obstacles such as metal wiring and transistors that were moved to the underside of the photosensitive substrate.

The repositioning of the microchip-lens and the photoelectric-diode between the circuit and the transistor significantly improves the performance of the lighting condition, producing higher-quality pictures under extreme low-light conditions.

Compared to conventional front-illuminated sensors, back-illuminated structures cause a decrease in the signal-to-noise ratio. To overcome this issue, sensor manufacturers have developed a new photo-diode structure and on-chip lens optimized for back-illuminated structures that achieve higher sensitivity and less random noise.

Further refinements to the back-illuminated CMOS sensor during the manufacturing process resulted in improved performance of the on-chip-lens and the processing ability with high-megapixel images. The angle of the on-chip-lens was adjusted to move the photosensitive surface closer to the light. This

adjustment allows more light to reach the sensor's photosensitive surface than the traditional placement of the micro-lens.

Sony was the first sensor manufacturer to introduce the back-illuminated sensor to the security market. Many of the Dahua cameras that offer low-light technology use a Sony STARVIS™ sensor, the back-illuminated pixel technology used in CMOS image sensors for surveillance cameras.

The Dahua cameras with STARVIS™ sensors offer two times the definition of Exview HAD CCD sensors and are capable of illuminating dark environments and incorporating near-infrared light for clear recording at night.

In addition to cutting-edge STARVIS™ imagers, Dahua cameras with low-light technology feature a maximum aperture of f/2.2 to allow as much light as possible to pass through the lens and hit the sensor. A large aperture coupled with advanced ISP technology with propriety Dahua image processing algorithms and STARVIS™ imagers allow these cameras to produce identification-level images in near-dark conditions.

Large Aperture

The aperture is used to control the amount of light that passes through the lens and into the body of the photosensitive surface of the camera. The lens iris controls the size of the aperture. Similar to the photography industry, video surveillance cameras express aperture as f-numbers, or f-stops, as a means to describe the size of the aperture. A smaller f-stop means a larger aperture and a larger f-stop number translates to a smaller aperture.

The amount of light passing through the f/2 aperture is 16 times the amount of light that passes through an f/8 aperture. So, the size of the aperture is key to using as much available light in a particular application to produce the highest-quality color image. A new crop of lenses now feature an aperture of f1.0. Surveillance cameras fitted with an f1.0 "fast lens" captures four times the amount of light than a typical surveillance camera fitted with a smaller aperture lens.

Achromatic Lens

An achromatic lens is far superior to a traditional lens used in surveillance cameras for several reasons. This type of lens is a combination of

concave and convex pieces of glass that focus the different color wavelengths into a single plane.

Without an achromatic lens, high megapixel cameras suffer from color fringing and sharpness. It can also complicate installation of a manual focus camera, because you can focus it in the daytime, but may become blurry at night. This is common with cheap lenses that are not IR corrected, thus will have higher chromatic distortion.

Most Dahua cameras include achromatic lenses, allowing them to extract the highest image quality possible from the camera under a wider range of conditions.

Smart ISP Upgrade Enhancement

The Image signal processor (ISP) converts an image to digital form while performing operations to obtain an enhanced image or to extract useful information.

The ISP performs many roles and augment other processes, including Autofocus, Auto exposure and White balance. It additionally can correct for Imperfections in sensor and lens uniformity.

ISPs are also called upon to perform noise reduction and contrast enhancement such as Wide Dynamic range.

White-light Illuminators

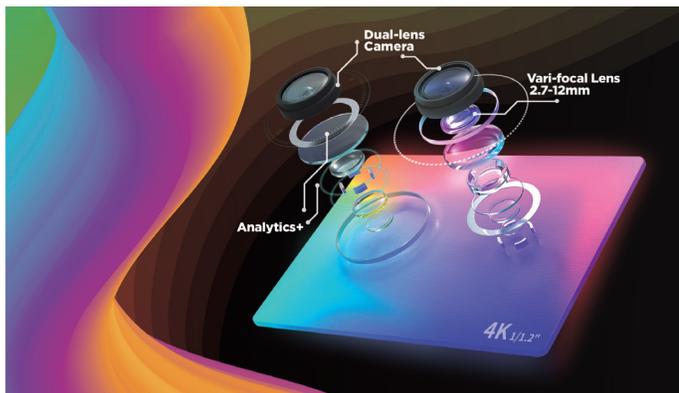
Surveillance cameras that operate in near-dark (less than 1 lux of ambient light) or completely dark environments require on-board illuminators to produce full-color images. Typically, these cameras employ white-light LED illuminators that activate as the ambient light level falls. Cameras with white-light usually provide a smart illumination algorithm, where the camera automatically activates the white-light illuminators when ambient light levels fall and adjusts exposure time and LED intensity to prevent overexposing the image.

Night Color Fusion Technology

The latest addition to the low-light technology portfolio are cameras with two lenses and two sensors that collect and process different light data. These next generation cameras use Dual Light Fusion Technology to collect visible-light

color detail from one lens/sensor combination and light intensity data (using an IR illuminator) simultaneously from the other lens/sensor. To ensure accuracy, manufacturers use a high-precision active alignment process that minimizes image sensor tilt and rotation, and places the center of the sensor at the lens optical axis. This process ensures images are sharp and crisp, even in the corners.

Then, using pixel-level frame-by-frame mapping, the camera combines these images to produce a vivid color image from near-dark environments without the need for white-light illuminators.



Application and Effect

Cameras with low-light technology are the ideal choice for dark or near-dark applications both indoors and outdoors. These cameras offer exceptional light-gathering technology and use image processing algorithms to enhance the available light. In these environments, it is hard for the naked eye or regular cameras to distinguish fine details, but cameras with low-light technology bring the day to the night, producing exceptional image details 24 hours a day (or night).

Several environments stand to benefit from the increased security that cameras with low-light technology can achieve. Starlight technology is ideal for applications with a low-light or no light environment, in a bar or a club for example. Typically illumination is weak inside these locations where normal security cameras fail to produce usable images. Starlight cameras, on the other hand, capture clear images with little noise and artifacts at a much lower minimum illumination threshold.

Applications with a source of ambient light from a street lamp or from a lighting fixture are ideal for



2MP camera image with Starlight technology in low-light scene



2MP camera image with Night Color technology in low-light scene

Night Color technology, including parking lots, city streets, and the interior and exterior of schools, bars, museums and casinos.

Applications that exist in environments where no light is available are ideal for Night Color cameras that feature white-light illuminators, including indoor passages or basements and remote outdoor spaces.

Night Color technology increases the chances of gathering forensic-level color images without the need for IR illumination.

Night Color Comparison

Night Color cameras share much of the same technology that Starlight cameras use to produce clear images in near-dark environments. Night Color cameras, in addition, employ a combination of these low-light technologies to deliver crisper and clearer full-color images in all environments:

- Large CMOS Sensor (at least 1/1.8-in.).
- Achromatic lens.
- Aperture with an f-stop of 1.0.
- White-light illumination

Night Color cameras deliver images with vivid color representation and more detail long after most typical surveillance cameras switch to monochrome mode.

Cameras with Advanced low-light Technology

Consumers want it all -- and with low-light technology becoming more advanced and more widely used, there is a demand for this technology coupled with 4K resolution, for full-color images with low ambient light levels, and intelligent video functionality integrated with low-light cameras. Having it all comes with costs, both in money and in image quality.

Low-Light Technology with 4K Resolution

Network cameras with 4K (8MP) resolution are becoming more the norm rather than the exception in many surveillance applications. The widespread adoption of the H.265 compression standard has ushered in the next wave of high-resolution cameras. Higher resolutions bring wide-angle scenes, with a single camera able to provide surveillance coverage over a large area. The next step in camera development is to couple 4K cameras with low-light technology to extend the reach of ultra-high resolution cameras to dark scenes and nighttime applications.

To handle these demands, Dahua developed an optimized implementation of the H.265 codec, Smart H.265+, to reduce bitrate and ensure that the camera and the network can handle the demands of Starlight image processing. As a result, Dahua's Smart H.265+ codec can save up to 80% on bandwidth and storage when compared to standard H.264.

One caveat to consider when coupling Starlight technology with higher megapixel cameras is that low-light performance favors camera sensors with large pixel sizes. Large pixels are inherently more light sensitive than smaller ones, and require simpler ISP hardware. Therefore, the 2MP Enhanced Starlight and Starlight + (4/3" sensor) cameras have the best low-light sensitivity.

Newer, Night Color 2.0, high sensitivity 4MP and 8MP sensors coupled with more powerful ISPs now allow ultra-high resolution images at lower light levels. 8MP network cameras equipped with a 1/1.2-inch image sensor increases the pixel size by 110%, compared with conventional 8MP cameras. This larger image sensor allows the camera to capture real-time 4K color images even in extremely low-light environments.

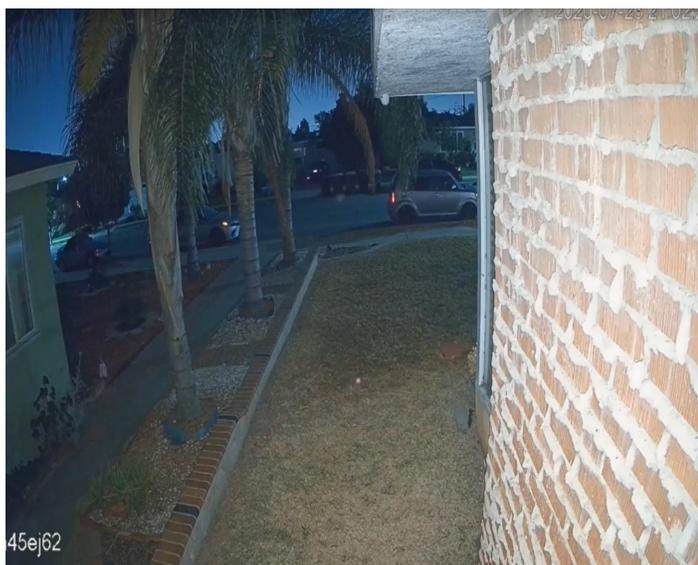




Typical 4MP camera with IR at night.



The same scene with the 4MP N45EF63 Night Color Camera



The same scene with the 4MP N45EJ62 Night Color Camera with white-light illuminators

Night Color Technology

Night Color cameras offer 24-hour color video surveillance. Depending on the type of Night Color technology, the camera produces full-color images with advanced optics that require at least 1 lux of ambient light or with white-light illuminators that work in complete darkness. No matter the technology, Dahua Night Color cameras deliver crisp, clear color images suitable for identification-level monitoring.

The images on the left illustrate the benefit of using a Night Color camera. The top image is a night scene from a typical 4 MP network security camera without Night Color technology. The middle image is the same scene taken with Dahua's N45EF63 4 MP Night Color camera with advanced optics and with at least 1 lux of ambient light. The final image is the same scene again, but taken with Dahua's N45EJ62 4 MP Night Color camera that uses white-light illuminators to brighten the scene. As you can see, the differences between the scenes taken with Night Color cameras are dramatically improved compared to the scene shot with a typical surveillance camera.

Analytics and Low-light Cameras

Many cameras with low-light technology come with video analytics at the edge, requiring no additional investment or license fees from the customer. Analytics make high-quality images more useful by adding sense and structure to video data. Video analytics enable users to stream only what's relevant, retrieve evidence quickly and simply, and trigger alarms when needed, eliminating the need to process hours of video data. Dahua low-light cameras include built-in intelligent video system analytics (IVS), and specific cameras offer advanced analytics with no need for additional licenses or firmware upgrades.

These cameras offer a full complement of analytic functions for comprehensive, human-oriented analytic solutions, including perimeter protection, smart motion detection, vehicle and crowd density statistics, video metadata, and advanced people counting with heat map functionality. In addition, certain Dahua Night Color cameras allow different analytic functions depending on the time of day, extending the usefulness of the camera and increasing return on investment.

Buying a Camera with Low-light Technology

Cameras with low-light technology have proven themselves so far. The detailed images produced in near-dark environments (indoor and outdoor) by this technology allows surveillance around the clock. There are certain criteria to consider when purchasing a camera with Starlight or Night Color technology.

First, determine if the application environment offers at least 1 lux of ambient light (street light or other security lighting). If the environment does offer a minimum of 1 lux of light throughout the day and night, then consider a Dahua Night Color camera for covert surveillance that delivers color identification-level images with low power consumption.

If the environment cannot guarantee at least 1 lux of ambient light, then opt for Dahua Night Color cameras that employ white-light illuminators for color images in total darkness. Otherwise, Dahua Starlight cameras are a good option for all lighting conditions if color images are not a priority. When considering a Starlight camera, use the following criteria:

Resolution: The sweet spot for resolution of low-light technology is 2MP. Low-light image quality degrades as the camera's resolution increases above 2MP.

Maximum Aperture: A Starlight camera should have a maximum aperture of at least F2.2; of course the lower the f-number the more light will hit the sensor.

Minimum Illumination: Look for a minimum illumination of at least 0.009 lux for color images and down to 0.0005 lux for monochrome images. Dahua offers three tiers of Starlight performance

For comparison, a sunny day without clouds produces between 10,000 lux to 25,000 lux while a moonless clear night produces an luminance of approximately 0.002 lux.

These criteria for Night Color and Starlight cameras are general guidelines for comparing cameras with low-light technology. There is no substitute for diligent research and savvy comparison shopping when considering cutting-edge technology purchases.

Conclusion

Seeing in the dark is no longer the challenge it once was for video surveillance installations. While IR illumination has its place, this older technology forced illumination on a scene, resulting in washed-out monochrome images or grainy color images at best. Low-light technology enhances the available light in a scene to produce stunning color images in near total darkness, far past the threshold where conventional cameras would produce only monochrome images. Dahua Night Color and Starlight cameras consist of a high-end sensor, larger aperture lens, and special Dahua algorithms to provide round-the-clock, forensic-level video in both indoor and outdoor low-light environments. Just as Full HD supplanted standard resolution as the industry standard (with 4K fast on its heels), cameras with low-light technology are starting to replace conventional cameras. As this technology advances, costs will decrease and support of higher resolution cameras will improve. As a result, these cameras will become the industry standard and chase the darkness away with available light.

Dahua Technology USA offers a wide-range of cameras with Night Color or Starlight technology for challenging low-light applications. Dahua low-light Technology is available on select IP and HDCVI cameras.