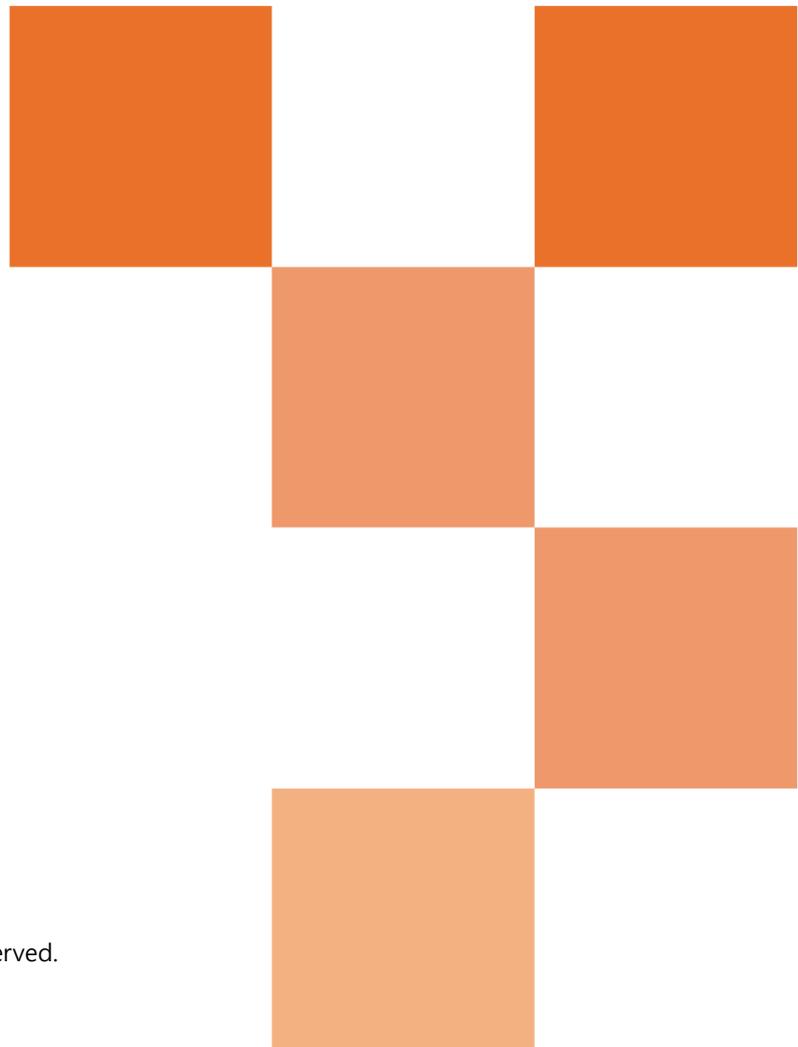


White Paper

WiseIR Technology

February 2026



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1. Introduction

In video security systems, nighttime and low-light conditions account for more than half of total operating hours, and image quality during these periods directly determines overall security effectiveness. Infrared (IR) illumination has become a critical element for enabling true 24/7 surveillance even when visible light is insufficient.

Global video surveillance manufacturers have introduced a variety of IR solutions, and Hənwhə Vision provides high-efficiency IR performance through its WiseIR technology, which integrates advanced circuit design with image processing techniques.

2. Background

In video surveillance, infrared (IR) technology is applied in various fields such as sensing, thermal imaging, temperature measurement, and spectroscopy, but in low-light conditions it is most commonly used as an illumination source. IR illumination is preferred over white-light illumination when there are concerns about light pollution or when discreet surveillance is required. Using IR light means losing color information; however, it reduces bitrate requirements and leverages the image sensor's higher sensitivity to IR wavelengths, which is advantageous for video analytics.

However, several issues can arise when using IR illumination, and various algorithms are employed to address them. One of the most common problems is overexposure or "hotspot" effects, where a subject too close to the camera appears saturated (for example, a completely white face or license plate) while the surrounding area remains dark. This results in a bright center and dark periphery, causing both the subject's details and contextual information in the darker regions to be lost. Automatic exposure (AE) control plays an essential role in managing this issue effectively.

The effective illumination range of IR LEDs typically falls between 10 and 50 meters, but often appears shorter than the specified range in practice. Even if a camera features a long focal length that allows distant viewing, a short IR range means that the light cannot reach far targets, resulting in insufficient reflection and a shorter effective identification distance. Therefore, it is important to match the IR performance to the lens characteristics and adjust the drive current as needed.

When IR output is intentionally reduced to prevent overexposure in low-light scenes, the camera compensates by increasing sensor gain, which amplifies noise. This added noise not only degrades image clarity but also increases encoding complexity, thereby raising the required bitrate and storage capacity. Proper IR control minimizes sensor gain while preserving subject distinction and contrast, improving both image sharpness and storage efficiency — making it a key factor in overall system design.

3. Technology

3.1. IR Built-in Camera

Purchasing a camera with integrated IR eliminates the need for separate lighting equipment in low-light environments, simplifies installation, and ensures power consumption stays within the camera's PoE class — making it highly cost-effective. The camera can independently determine IR activation points, while image saturation and IR LED control are managed through integrated software, enhancing overall usability.

A camera with built-in IR operates by emitting IR light from LEDs, which reflects off subjects, passes through the lens to the CMOS sensor, and is converted into a digital signal for processing by the ISP. The resulting low-light performance is determined by the combination of IR, lens, CMOS sensor, and ISP.

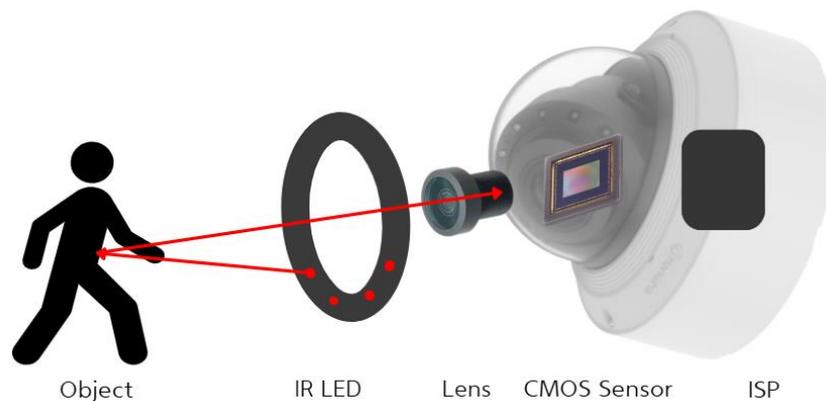


Figure 1: Structure of a camera with integrated IR

3.2. CMOS sensor and IR

The CMOS sensors used in cameras can detect not only visible light (wavelengths from 380 - 750 nm) but also near-infrared wavelengths from 750 to 1100 nm. The human eye cannot perceive wavelengths longer than about 700 nm, so even when IR is turned on, nothing appears visible, while CCTV cameras can still capture the scene. This enables discreet monitoring without unnecessary light pollution.

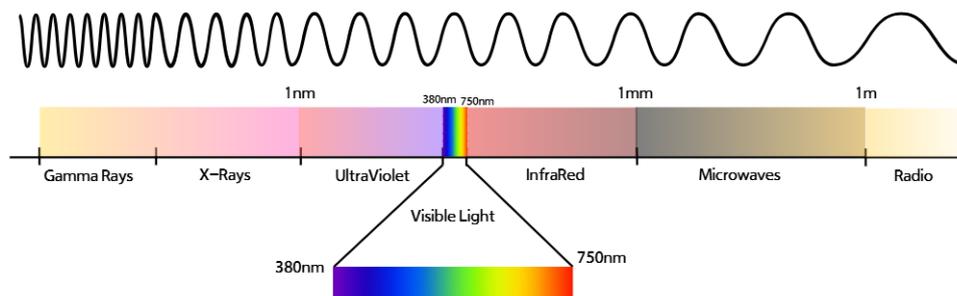


Figure 2: Visible light and IR (Infrared) by wavelength

Each CMOS sensor used in imaging equipment displays RGB (Red, Green, Blue) sensitivity curves by wavelength, with color reproduction varying based on which RGB component dominates. Daytime color imaging using visible light excels in color accuracy and scene understanding, but at night or in low-light indoor settings, insufficient visible light makes color preservation challenging. By extending the sensor's detectable spectrum into the IR band and pairing it with artificial IR illumination, even complete darkness can yield images sufficient for object detection and identification.

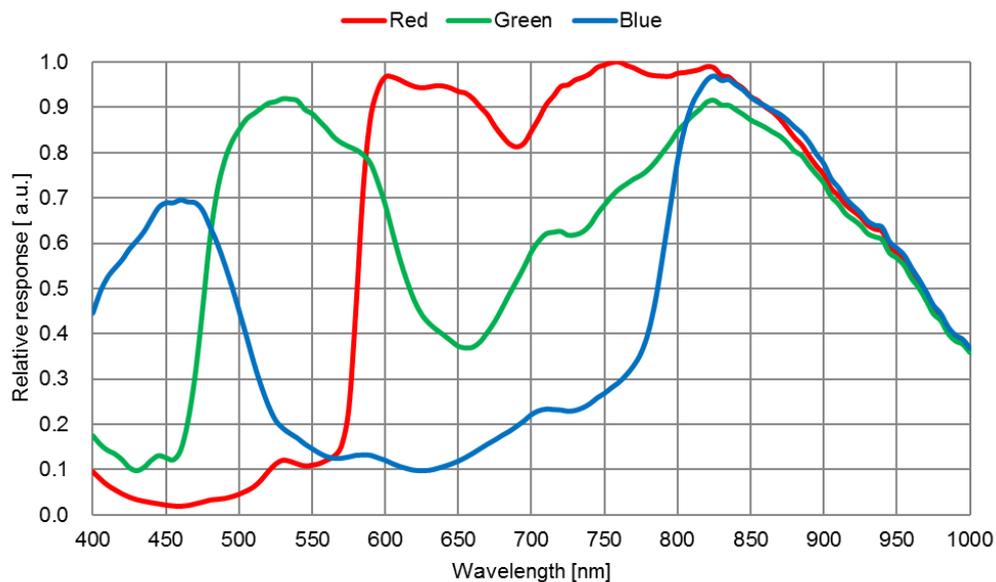


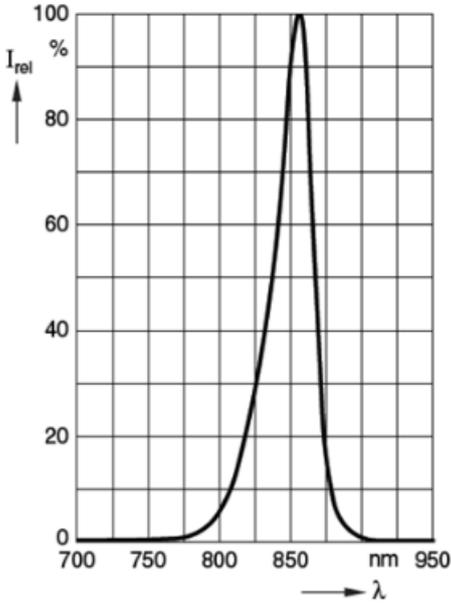
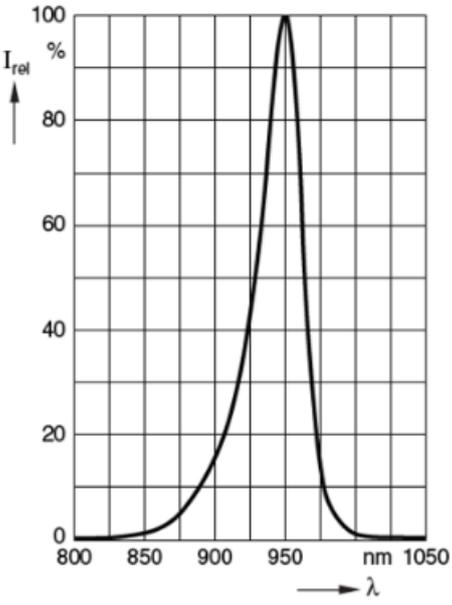
Figure 3: CMOS sensor relative response by wavelength

As shown in the example relative response graph in Figure 3, all RGB channels exhibit high sensitivity in the 800–850 nm band. This indicates that using LEDs at 800–850 nm wavelengths — capturing the reflected light from subjects — will produce clear, high-quality images.

3.3. IR selection

Selecting the appropriate IR is critically important. Key parameters for IR LEDs include radiation angle, wavelength, total radiant flux, radiant intensity, and forward voltage.

The most common wavelength for nighttime IR LEDs is 850 nm. Depending on the manufacturer, an LED specified at 850 nm exhibits a spectrum like the graph below — it does not emit purely at 850 nm but includes shorter wavelength components below ~750 nm¹, producing a faint red glow visible to the human eye. For applications where IR activation must remain undetectable (e.g., correctional facilities, schools, hospitals), 940 nm LEDs are recommended as they emit completely invisible light.

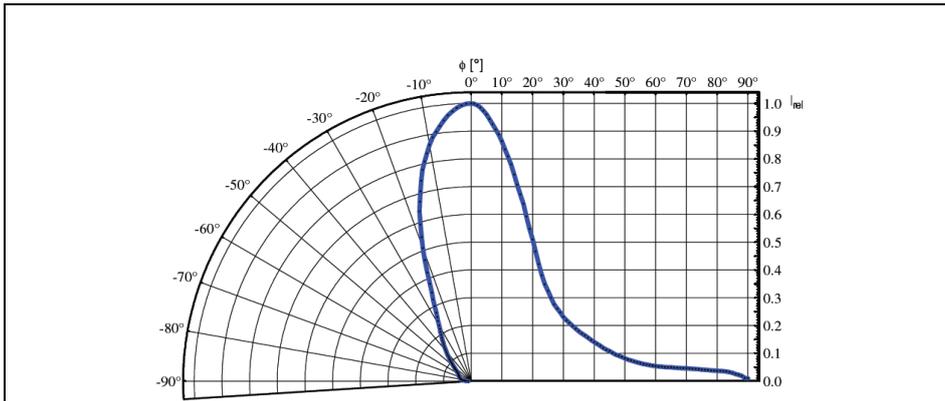
Commonly used IR wavelengths in CCTV	IR used in special applications
 <p data-bbox="221 1323 767 1352">Example emission spectrum of an 850 nm IR LED</p>	 <p data-bbox="831 1317 1361 1346">Example emission spectrum of a 940 nm IR LED</p>
 <p data-bbox="236 1615 753 1695">Camera appearance as seen from outside when IR is on</p>	 <p data-bbox="839 1615 1356 1695">Camera appearance as seen from outside when IR is on</p>

¹ Often described as visible light spillover due to spectral half-width (Spectral Bandwidth)

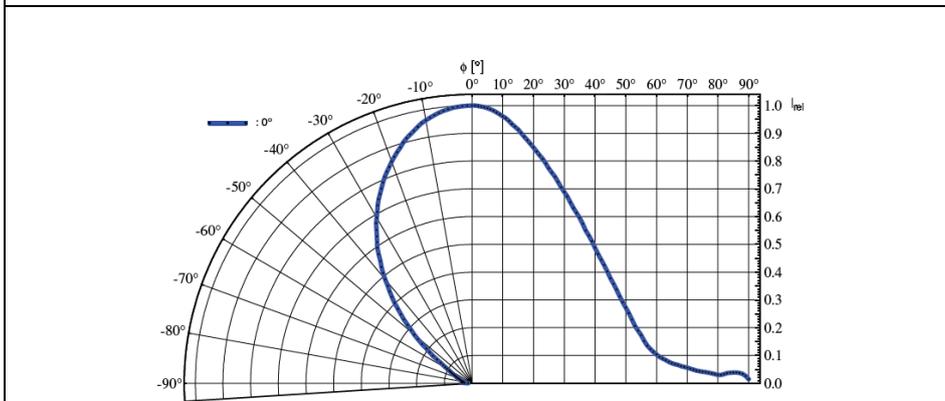
The radiation angle is one of the most critical factors for IR LEDs. Available options range from narrow to wide angles, and the IR LED must be selected to fully cover the lens's field of view (FoV).

For a telephoto lens with an FoV of $\sim 29^\circ$ and observation range up to ~ 70 m, a narrow-angle IR LED is ideal. This avoids wasting light on unused areas, concentrates IR within the required FoV, and extends effective viewing distance.

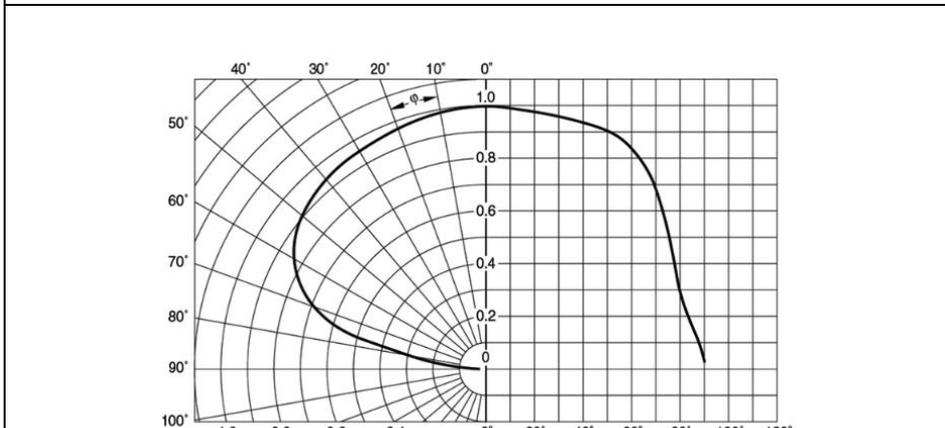
Conversely, for a wide-angle lens with an FoV of $\sim 90^\circ$ and observation range of ~ 17 m, a wide-angle IR LED is optimal. This ensures even illumination to the sensor's outer field edges while preventing unnecessary central saturation.



Radiation Characteristics of Narrow-Angle IR LED (40° Radiation Angle)



Radiation Characteristics of Standard IR LED (80° Radiation Angle)



Radiation Characteristics of Wide-Angle IR LED (150° Radiation Angle)



The number and placement of IR LEDs are also critical, particularly inside dome or vandal-resistant bubble covers. Design-phase simulations must optimize their position and quantity to prevent internal reflections from reaching the lens directly.

IR LED forward voltage is essential for LED driver selection and circuit design, as it directly impacts power consumption at a given current. Though rarely listed in camera specs, excessive IR heat generation causes unnecessary power waste, degrades heat-sensitive components like the CMOS sensor (impacting image quality), and shortens LED lifespan — affecting long-term product reliability.

3.4. AE Tuning for IR

As an object approaches the camera, increasing IR reflection floods the CMOS sensor, enlarging the bright area in the frame. In dark scenes where gain maintains constant overall brightness, sudden expansion of reflective regions triggers excessive gain, saturating the object (turning it white) while darkening the periphery. Software tuning rapidly controls this dynamic for optimal IR performance.

4. Hanwha Vision WiseIR

Hanwha Vision's WiseIR is an integrated IR technology combining IR control for varifocal cameras with advanced noise processing, designed to maximize subject detection and recognition in low-light environments. WiseIR-equipped cameras achieve stable brightness and contrast under rapidly changing conditions through selective IR bank activation, optimized wavelength selection, and smart exposure control.

Additionally, Hanwha Vision leverages its extensive lens design expertise, WDR, and NR technologies to minimize blooming, haze, and overexposure under IR illumination. In particular, optimized IR LED quantity and placement ensures even IR distribution across the entire image, delivering consistently bright performance

	Hanwha Vision	Conventional Solution
Near Object		
Far Object		

4.1. Adaptive IR activation

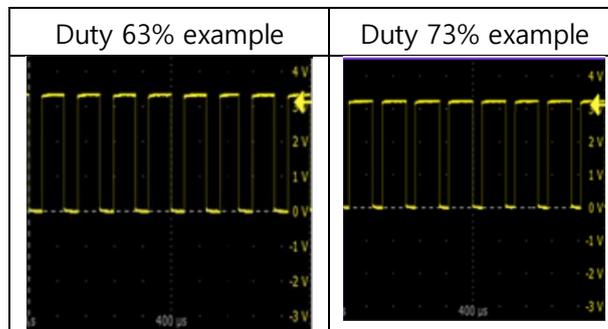
WiseIR transcends basic IR illumination by intelligently linking camera intelligence with LED optics to deliver "the right IR, in the right place, in the right amount."

In varifocal zoom models, IR illumination angle automatically synchronizes with zoom ratio: wide-angle delivers broad, uniform coverage; telephoto concentrates narrow beams for extended range — ensuring uniform exposure across the entire field of view.

For PTRZ (Pan-Tilt-Rotate-Zoom) cameras with dynamic lens positioning, independent external IR banks (mounted outside the dome) enable selective activation: only the bank aligned with the current lens direction illuminates, optimizing efficiency and extending effective IR range.

4.2. Current control

IR LED power consumption is proportional to drive current, typically controlled via PWM (Pulse Width Modulation) dimming from the SoC. By varying the duty cycle (on-time ratio), brightness is linearly adjusted to minimize flicker while achieving precise average light output.



Through optimized waveform generation and linear control, LED output is finely tuned to prevent overly dark images or highlight saturation from nearby reflectors (walls, ceilings, signs), while Hanwha Vision optimizes exposure, gain, and shutter specifically for IR conditions to reduce close-object overexposure.



Figure 4: IR current control by focal length in PNO-A9082R

This current control excels in varifocal/zoom models: as focal length shifts (narrow ↔ wide), current dynamically redistributes — increasing for narrow-angle while decreasing for wide-angle — maintaining optimal illumination.

In PTRZ models (e.g., lens moving from IR Bank 1 to Bank 2), current fades out from Bank 1 while ramping up in Bank 2, efficiently allocating IR precisely where the lens points.



Figure 5: IR bank current control in PNV-A9082RZ



4.3. AE (Auto Exposure) Control

In IR mode, when the sensor detects IR reflections, AE synchronizes with IR LED intensity via histogram analysis — centering mid-tones in the dynamic range and iteratively fine-tuning to prevent overexposure/saturation and flicker.

For objects approaching/receding (where current control alone is insufficient), AE maintains target brightness by comparing current frame luminance against target, then auto-adjusting shutter, iris, analog/digital gain. This ensures distance-uniform illumination and indirectly optimizes grayscale rendition in IR.

Hanwha Vision cameras allow web interface exposure tuning:

- Dark background (vs subject): lower exposure for proper subject rendering.
- Bright background: increase exposure.

Adjustable parameters include brightness level, min/max shutter speed, and AGC (Auto Gain Control) level — amplifying incoming signals to brighten dark scenes

5. IR Application Cases

IR technology excels in shape/contrast-critical scenarios over color fidelity. In high-activity nighttime environments like urban security, industrial sites, logistics hubs, discreet IR monitoring detects intrusions/loitering without disrupting lighting or aesthetics. Low-noise IR images boost AI analytics accuracy (object detection, etc.).

For night traffic monitoring, IR avoids driver glare while clearly capturing license plates/vehicle outlines for speed/lane violation analysis. WiseIR dynamically adjusts for changing detection areas (focal length/angle shifts, moving subjects), optimizing analytics performance.

Prime example: 2nd Gen P-series PTRZ models — lens direction adjustment activates only targeted IR, efficiently controlling power while concentrating output on the lens view.

In 2nd Gen P-series varifocal models (e.g., PNO-A9082R), wide/narrow LEDs selectively activate per focal length:

- Telephoto: narrow LED.
- Wide: wide LED.
- Intermediate: both for full FoV coverage.

WiseIR is standard in most X/P-series varifocal cameras.

When AE responds quickly, even as objects approach the camera and IR reflectivity increases (right image), both the object and background remain sharp. Conversely, without rapid AE response, the object saturates while the background turns black (left image).



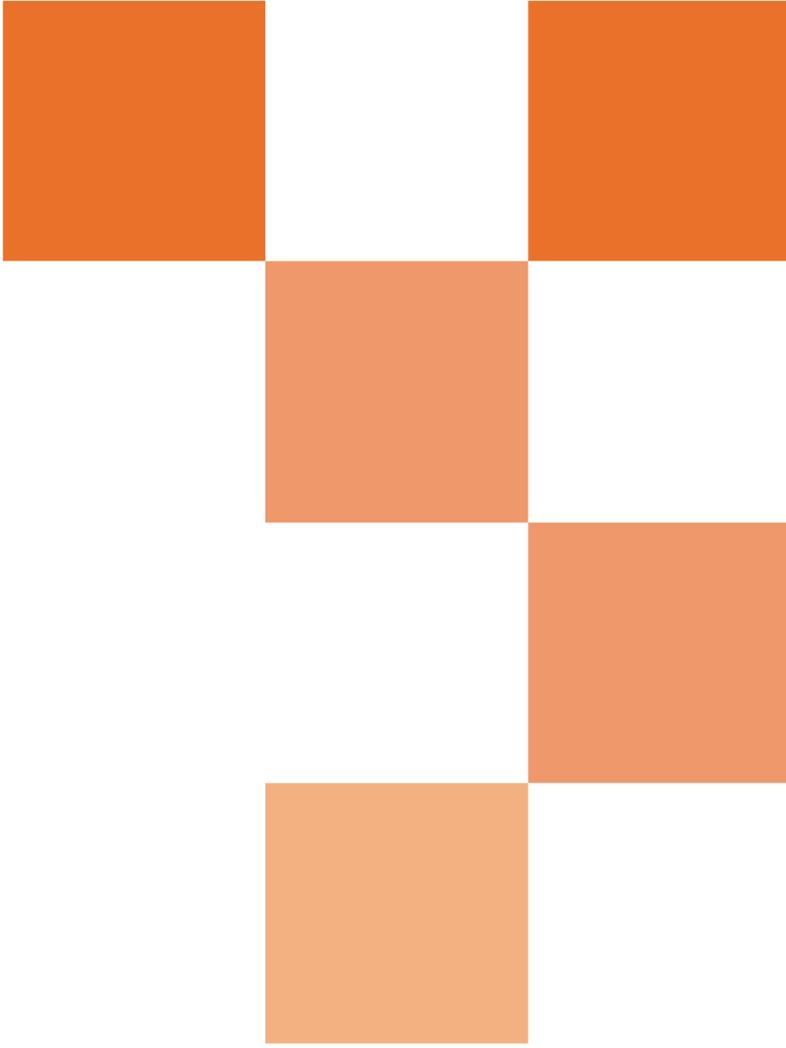
Figure 6: (Left) Poor AE response example; (Right) Fast AE response example



6. Conclusion

Low-light and nighttime environments are no longer blind spots in video security but core battlegrounds for differentiation through mature IR technology. By strategically combining NIR-based Day/Night cameras, thermal cameras, integrated/separate IR illuminators, comprehensive "24/7 visibility" solutions can be achieved across diverse scenarios.

Hanwha Vision's WiseIR aligns with global IR trends while leveraging proprietary optics and image processing expertise to deliver sharper, more efficient nighttime imaging under identical conditions — positioning it as the pivotal technology to simultaneously elevate system performance and operational efficiency in future video security deployments.



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