

White Paper

Network Camera with P-iris Lens



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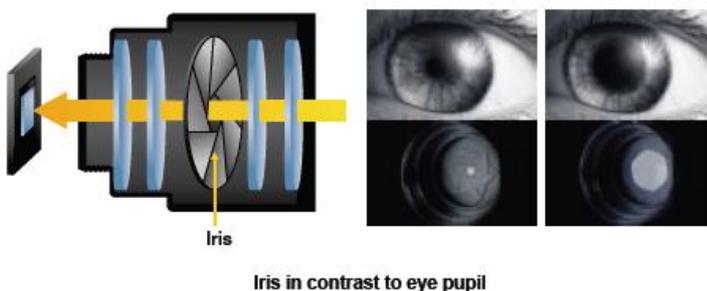
Introduction

The VIVOTEK IP8151P and IP8162P incorporate a next-generation lens, called a P-iris lens. This type of lens provides superior performance characteristics—particularly for cameras using high pixel count sensors, as is the case with the IP8162P. This white paper describes P-iris technology, covering relevant background, the rationale for its development, its design objectives, its mode of operation, and its specific advantages over other types of iris.

The function of an iris

Analogous to the eye’s iris, a camera’s iris is an opaque structure with an adjustable opening, called the aperture (though for the sake of clarity of the equivalent term “iris opening” will be used throughout this document), that controls the amount of light entering the lens. All other factors being constant, the larger the iris opening, the more light that is allowed in and the brighter the resulting image will be.

Just as the eye’s pupil contracts in bright light, so the camera’s analogous iris opening should shrink when high levels of light are present so that the final image will maintain the proper brightness. If the iris opening did not change in size, images from the camera would become washed out as ambient light levels increased, and grow murky as they decreased.



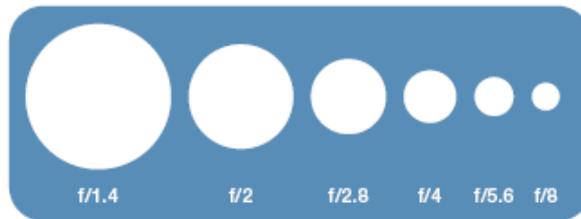
The size of the iris opening also affects many other aspects of image quality. For example, a wider iris opening reduces the depth of field in a scene. Depth of field refers to the distance over which objects in a scene appear in sharp focus. Having good depth of field is extremely important in many surveillance applications, as it allows more of the monitored environment to be clearly visible.

Overall image sharpness is also influenced by the size of the iris opening, as optical aberrations that are produced by all lenses when the full lens surface is used are reduced at smaller apertures. However, while a smaller iris opening generally results in sharper images, there is a threshold to this effect. Too small an opening causes blurring due to diffraction.

This problem typically occurs in bright outdoor environments when the iris opening is contracted beyond the point where diffraction effects dominate. When diffraction occurs, light that should fall on a single sensor pixel is instead dispersed over multiple pixels, resulting in blurring and distorted colors, compromising image quality. Unfortunately, this problem is aggravated in more advanced cameras with megapixel sensors, as such sensors typically have smaller individual pixels.

Quantifying iris properties

Since the absolute size of an iris opening is of little interest in and independent of the properties of the lens, the F-number is used to quantify the effect of iris size. The F-number is a dimensionless value that expresses the ratio of the focal length of the camera's lens to the diameter of the iris opening. Thus, for a constant focal length, the F-number increases as the size of the iris opening decreases—that is, the F-number is inversely proportional to the size of the iris opening.



Relationship between F-number and aperture

F-number	1.4	2	2.8	4	5.6	8
Exposure ratio	32	16	8	4	2	1

F-number and corresponding exposure ratio

With that in mind, we can examine the relationship between the size of the iris opening, expressed through the F-number, and image quality in the figure below:

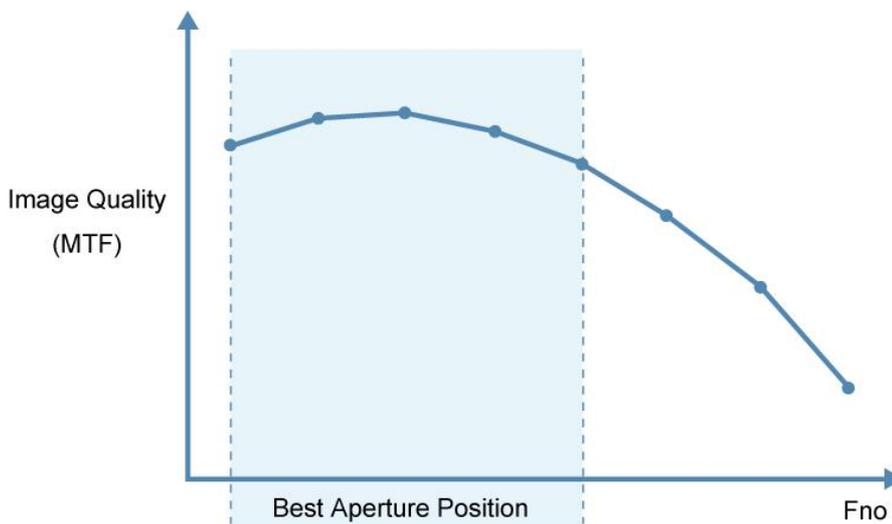


Image quality is plotted along in the vertical dimension using MTF, a widely accepted technical measurement of the level of detail captured in an image and the clarity with which it is rendered (due to its complexity, the particulars of how MTF is defined are omitted here). F-number is plotted along the horizontal dimension, remembering that “aperture” and “iris opening” are equivalent terms, and noting that the abbreviation “Fno” is used instead of “F-number” in the x-axis label.

The graph in the figure vividly illustrates that while image quality improves with increased F-numbers (again, corresponding to smaller iris opening sizes), at higher F-number values, image quality rapidly deteriorates as diffraction effects emerge. The graph also shows the relatively narrow range of F-number values where optimum image quality is achieved for any given lens and set of conditions (including focal length and light levels).

Types of iris

An iris can be classified based on how its opening is controlled. At the most general level, an iris can be either manual or auto.

Manual iris: In a manual iris, the aperture is adjusted by hand, by rotating a ring around the lens. In surveillance cameras, it is generally used only for applications where light levels are constant, as is the case with some indoor environments, since adjustments require user intervention.

Auto iris: Auto iris is a general term for various types of iris that possess a mechanism for adjusting the opening in response to changing levels of light without human intervention. An auto iris is generally required for surveillance cameras used outdoors, since light levels change frequently.

- **Video iris:** A video iris uses a motor to adjust the size of the iris opening in response to changes in light levels. An analog signal, typically a video signal, is converted to control signals that drive the motor that controls the position of the iris to increase or decrease the opening size. The control circuitry resides in the lens mechanism itself, making lenses built with this technology more expensive.
- **DC iris:** A DC iris is similar in concept to a video iris, except that the control circuitry driving the motor adjusting the opening is in the camera proper, rather than in the lens mechanism itself.

The **P-iris** is designed to remedy a basic weakness of two conventional types of auto iris—the video iris and DC iris.

Weakness of conventional auto-iris designs

While an auto iris allows a camera to adjust the iris opening in response to a change in light levels without the need for human intervention, this convenience carries a serious weakness. For the sake of simplicity, the following discussion refers only to the DC iris, though the points are equally applicable to a video iris.

While a DC iris can adjust the size of the iris opening in response to changes in light levels, it only accounts for this single parameter, and does not take into account the impact of iris opening size on other picture quality variables other than brightness. For example, while the size of the iris opening directly affects depth of field, a DC iris simply adjusts the iris opening to achieve the right level of brightness in the image, without allowing for the possibility that depth of field might be severely compromised.

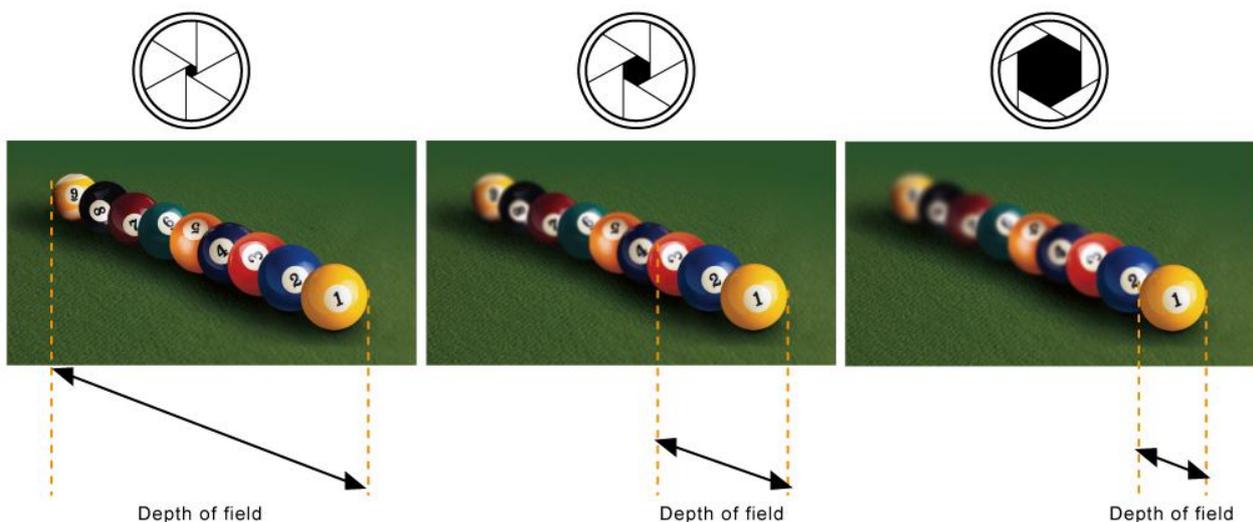
The reason for this limitation is that a DC iris uses a relatively simple mechanism that does not relay any data about iris position to the camera. Such information would allow a camera with the appropriate supporting capabilities to adjust the iris opening to optimize overall image quality.

How a P-iris works

As alluded to earlier, it is this fundamental shortcoming of the conventional iris that a P-iris was conceived to overcome. While a P-iris is also a type of auto iris, it offers not just automatic adjustment of the iris opening, but also precise control over all aspects of image quality. Rather than being limited to a narrow focus on light levels as the sole determinant of iris opening size, a P-iris works in coordination with software to automatically determine and set the iris opening size that will produce the best picture quality. In addition, a P-iris uses a sophisticated stepping motor to adjust the position of the iris with extreme precision.

A P-iris also takes advantage of electronic manipulation of parameters such as gain (amplification of signal intensity) and exposure time to achieve this extra level of optimization, while avoiding picture quality degradation due to optical phenomena such as diffraction that occur at boundary conditions when the iris size becomes very small. In a very bright environment, a camera with a P-iris is programmed to halt the contraction of the iris opening before diffraction effects are induced. So while an ordinary auto iris would result in blurred images in this situation, a camera equipped with a P-iris would avoid this side effect of diffraction while using other means to correct for the additional light that passes through the lens because the iris opening is not contracted to the same extent.

The relationship between iris opening (aperture) and depth of field



A superior solution

By realizing more granular control over image quality, and especially by avoiding diffraction, the P-iris design provides compelling advantages over other auto iris types. It is especially valuable for cameras used in outdoor environments, for demanding surveillance applications, or in any usage scenario where

light levels are highly variable. Moreover, its benefits are most evident in megapixel-class cameras, as the generally smaller pixels in their sensors make them even more prone to diffraction effects. A sophisticated interplay of software and hardware, the P-iris is a revolutionary advance in lens design for video surveillance cameras, giving these increasingly important security devices a dramatic improvement in picture quality in multiple dimensions, including depth of field, clarity, and level of detail—and not only brightness. Unlike some advances in image technologies where the improvements are only easily apparent to the expert eye or under extraordinary conditions, the advantage of P-iris over the conventional DC iris is readily evident even to the casual observer, as the following figure illustrates:

Comparison of images shot with conventional iris and P-iris lenses



Conventional Lens



P-iris Lens

Just as importantly, the P-iris enables cameras to deliver the necessary standard of picture quality reliably, even in light conditions that other types of auto iris cannot adequately handle. Already clearly the best design, the P-iris lens is widely expected to become the mainstream choice and industry standard as surveillance cameras steadily increase their pixel counts and users demand ever better picture quality.



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