White paper

i-CS lenses

– intelligent lenses improving camera performance.

AXIS COMMUNICATIONS

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1. A new industry standard

An i-CS lens is an intelligent CS-mount lens that contains information about, among other things, its own geometrical distortion and the exact position of its zoom, focus, and iris opening. By reading this information from the lens, the camera knows – for the first time in a CS-mount camera – what type of lens that is mounted on it.

To communicate with the lens, Axis' network cameras with support for i-CS lenses use an open protocol codeveloped by Axis Communications and Computar®. Thanks to the information from the lens and the use of the protocol, the camera can optimize its image quality at all times. Using data from the lens about geometrical distortion, it performs barrel distortion correction (BDC). The lens also contains information that enables the camera to stabilize the image automatically by means of electronic image stabilization (EIS).

i-CS lenses are the result of a joint development between Axis Communications of Sweden and the Japanese lens manufacturer Computar®. The open protocol is freely available from Axis or Computar®. The serial bus used for the communication between the camera and lens is an I^2C bus. The open standard means that manufacturers can develop and manufacture their own i-CS lenses with different features, and these lenses will be interchangeable. With i-CS lenses, a new industry standard is born.

See Section 8, Useful links, for more information on Computar®.

2. Lens options

Lenses can be fixed focal or varifocal, see Figure 1. A fixed focal lens is either a normal, telephoto, or wide-angle view lens. To choose the correct one, the user has to know beforehand the size of the sensor and exactly which focal length that is needed. A varifocal lens, on the other hand, has an adjustable field of view (FoV), offering a range of focal lengths. However, whenever the user changes the FoV, they must also manually refocus the lens.

The user wants to monitor a certain scene, that is, look at it with a specific FoV. To be able to calculate the required focal length, the user needs to know the desired FoV and the sensor size of the camera in use. To calculate this manually is a complex task, but Axis' lens calculator is an efficient tool to help determine focal length. The user only has to choose which camera to use. Since the lens calculator already knows the FoV and sensor size of that camera, it automatically calculates the focal length needed and suggests suitable lenses.

See Section 8, Useful links, for more information on Axis' lens calculator.

Figure 1: Example of a fixed focal (left) and a varifocal (right) lens.

3. Lens mount standards

There are three main mount standards used for interchangeable network camera lenses: S-mount, C-mount, and CS-mount.

S-mount, also known as M12-mount, is common in small cameras such as covert cameras and fixed mini dome cameras. It has an outer thread diameter of 12 mm and a pitch of 0.5 mm. In S-mount lenses, the distance between the lens and sensor is not fixed, so they must be adjusted to focus. Such lenses lack iris control.

C-mount and CS-mount look the same, see Figure 2. They both have a 1-inch thread and a pitch of 32 threads per inch (TPI). CS-mount, which is more common than C-mount, is an update to the C-mount standard that reduces manufacturing cost.

The difference between CS-mount and C-mount is the flange focal distance (FFD), that is, the distance from the mounting flange to the sensor when the lens is fitted on the camera.
> CS-mount: FFD=12.5 mm (≈ 0.49 in, which is ≈ 1/2 in).
> C-mount: FFD=17.526 mm (≈ 0.69 in, which is ≈ 11/16 in).

See Section 8, Useful links, for more information on camera elements and lens mount standards.

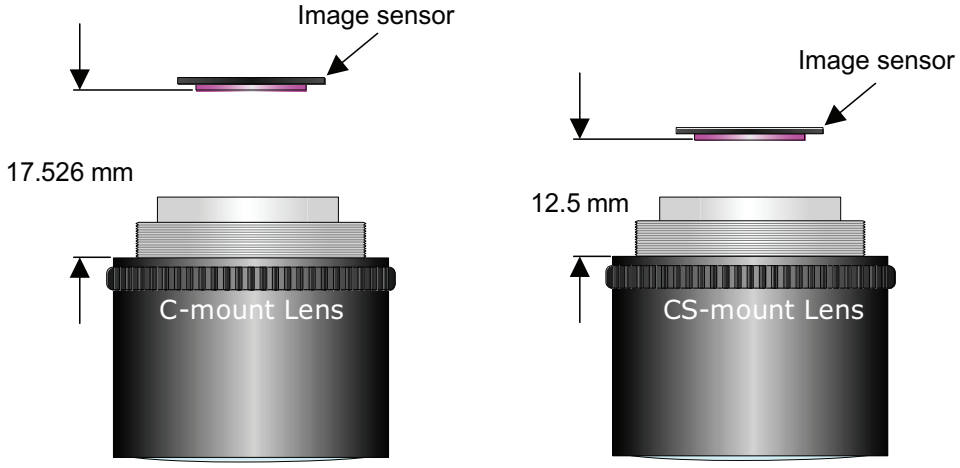

Figure 2: C-mount and CS-mount.

4. Iris control options

A lens can have either a fixed or an adjustable iris opening, and adjustable lenses can be adjusted either manually or automatically. There are three different kinds of automatic iris control:
> DC-iris
> Video iris
> P-Iris

In a manual iris lens, the iris opening must be adjusted by hand. For indoor applications where light levels are constant, fixed or manual iris lenses may be suitable since the iris opening does not need constant adjustment.

In situations with varying light levels, such as outdoor camera installations, a lens with an automatically adjustable iris is a better choice. DC-iris lenses and video iris lenses both use an analog signal that is converted into a control signal. In a DC-iris lens, this conversion takes place in the camera, and in a video iris lens, it is done in the lens. A DC-iris or video iris lens responds only to the light levels in the

scene. It does not take into account the impact of the iris opening on other image qualities such as depth of field. With these types of lenses, the camera only knows whether the iris opens or closes in response to the level of light, it does not know its position.

In precise iris control (P-Iris) on the other hand, the system optimizes the iris opening under all light conditions, resulting in images with better contrast, clarity, resolution and depth of field. A motor precisely controls the position of the iris opening, and specialized software optimizes image quality. With an i-CS lens, the iris opening can be even more accurately controlled using information of other aspects of the lens, for instance zoom and focus.

See Section 8, Useful links, for more information on P-Iris and different types of iris control.

5. How an i-CS lens works

An i-CS lens contains data about its characteristics, as follows:
> The type of model and the manufacturer.
> Geometrical distortion.
> Focal length at a given zoom and focus position.
> F-number at a given zoom and iris position. The F-number is the ratio of its focal length to the diameter of the iris opening.
> Trace, that is, data describing the required position of the focus lens in relation to the zoom lens to get a sharp image of an object at a certain distance.
> Vignetting, that is, the manner in which the light that passes through the lens is reduced depending on the distance from the center of the lens.
> Modulation transfer function (MTF), which describes the resolution of the lens at different zoom and iris positions.

The lens also contains a temperature sensor, and consequently information about its operating temperature range. Today, Axis' network cameras with support for i-CS lenses make use of all these characteristics, except vignetting and MTF.

An i-CS lens has three motors that enable automatic and remote control of all of the features of the lens, for example, zoom, focus, and iris opening. In turn, this control of the lens enables camera features such as BDC and EIS.

A camera can use the motors inside the lens to set generic features, which makes it possible to use an i-CS lens for different purposes. For example, the same i-CS lens can be used on a camera where focus and iris opening are automatically controlled, as well as on another camera where the zoom needs to be readjusted regularly. This way, thanks to the open protocol, an i-CS lens can be used on different cameras with different capabilities.

5.1 Communication between camera and lens

To use an i-CS lens, the camera must have support for this type of lenses. It is not possible to mount an i-CS lens on cameras without support, since its cable contact does not match the camera input. Through the cable, the camera can communicate with the lens. The camera finds out which kind of lens that is mounted on the camera (DC-iris, P-Iris, i-CS, or manual iris). The microprocessor of the lens contains information that the camera can read, and with that information the camera 'identifies' the lens. If it is an i-CS lens, the camera also detects which kind of i-CS lens it is, and which features, such as zoom, focus, iris control, and geometrical distortion that the lens supports.

5.2 Lens adjustments

Most of the adjustments in an i-CS lens are automatic. The user sets the required zoom, and then the camera keeps focus by itself and sets the iris control. If the user has chosen to turn on BDC and EIS, the camera sets these features automatically. Since the camera has information about the setup of the i-CS lens, it can optimize the iris opening for all light conditions.

5.2.1 Electronic image stabilization

The camera interprets specific information from the lens to be able to stabilize the image. Figure 3 shows the EIS in the graphical user interface (GUI) of the camera.

For EIS to work properly, it is important that the focal length of the lens is correct. Setting focal length manually is tricky, but a camera with an i-CS lens eliminates the need for manual setting since it can read the focal length directly from the lens.

See Section 8, Useful links, for more information on EIS.

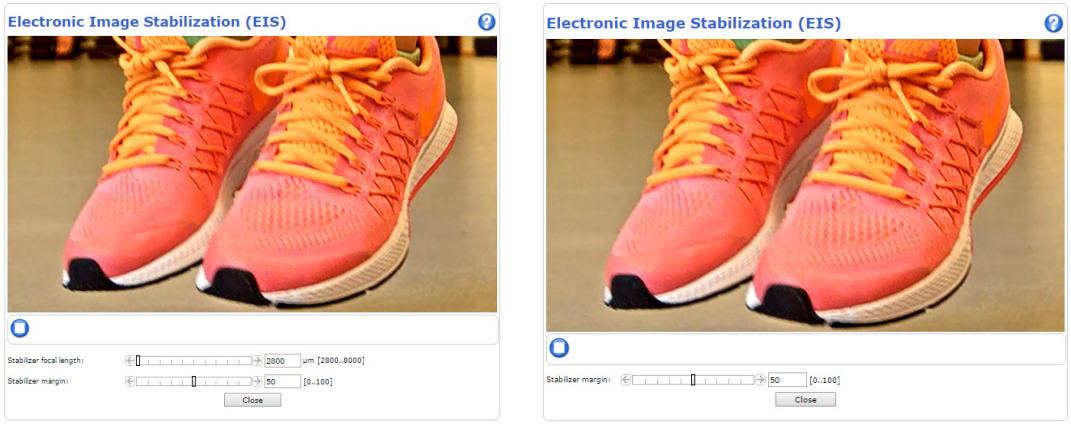

Figure 3: Camera without (left) and with (right) i-CS lens.

5.2.2 Barrel distortion correction

No lens is perfect, and all create some form of aberration or image defects as a result of the limitations. Some of the aberration include barrel distortion where the image of a square object has sides that curve out. Since the i-CS lens contains information about its geometrical distortion, the camera uses that information to correct the barrel distortion, if the user has turned on BDC, see Figure 3.

5.3 Easy installation and use

A camera with an i-CS lens is quick and easy to both install and use, as no manual configuration is needed. As soon as the installer has set the required zoom, the camera automatically sets focus, eliminating the need for manual focusing. Figure 4 shows how the zoom adjustment can be performed remotely from any network-connected computer.

The camera is factory-focused on infinity. When the user sets the zoom level in the GUI of the camera, the camera retains focus on infinity. The user may fine-tune focus, for example, by choosing an area where focus should be kept at all times. When the user presses the autofocus button, the camera sets the best possible focus. If the user wants to focus on something else, manual refocusing is possible. The user can always manually set focus at the desired distance. When the user has changed the zoom level, the camera always keeps focus at that same distance owing to the i-CS lens.

The i-CS lens also facilitates the installation of outdoor cameras, since the i-CS lens does not have any manual setting ring, unlike a varifocal lens. This way the installer does not have to open any hatch to set focus, which both saves time and keeps the inside of the camera dry. Installation time is also kept at a minimum since zoom adjustment is performed remotely, which is especially useful in installations that require that areas are closed down, such as busy highways or intersections.

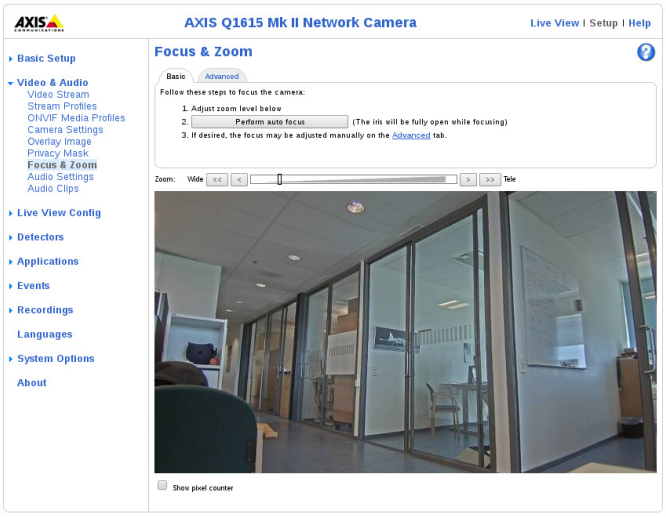

Figure 4: Zoom and focus adjustments on a network camera with i-CS lens.

6. Conclusion

Thanks to the intelligent i-CS lens, installation of the network camera is quick, easy and time-saving. In addition, the freely available, open protocol of the i-CS lens allows network camera manufacturers to develop firmware whose parameters, for example, focus and iris opening can be automatically adapted. Axis will continue to develop cameras with open protocols to drive the market and set new industry standards – innovating for a smarter, safer world.

7. Acronyms and abbreviations

BDC	Barrel distortion correction
EIS	Electronic image stabilization
FFD	Flange focal distance
FoV	Field of view
GUI	Graphical user interface
I^2C	Inter-integrated circuit
i-CS	Intelligent CS-mount lens
MTF	Modulation transfer function
P-Iris	Precise iris control
TPI	Threads per inch

8. Useful links

For more information, see the following links:

Axis Communications – 'Camera elements':
www.axis.com/learning/web-articles/technical-guide-to-network-video/lens-elements

Axis Communications – 'Electronic Image Stabilization':
www.axis.com/technologies/axis-electronic-image-stabilization

Axis Communications – 'Lens calculator': www.axis.com/tools/lens-calculator

Axis Communications – 'P-Iris': www.axis.com/files/whitepaper/wp_p-iris_38023_en_1009_hi.pdf

Axis Communications – 'Types of iris control':
www.axis.com/learning/web-articles/technical-guide-to-network-video/types-of-iris

CBC: http://computar.com/i-CS

67522/EN/R1/1606

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Axis offers intelligent security solutions that enable a smarter, safer world. As the market leader in network video, Axis is driving the industry by continually launching innovative network products based on an open platform - delivering high value to customers through a global partner network. Axis has long-term relationships with partners and provides them with knowledge and ground-breaking network products in existing and new markets.

Axis has more than 2,100 dedicated employees in more than 50 countries around the world, supported by a global network of over 80,000 partners. Founded in 1984, Axis is a Sweden-based company listed on NASDAQ Stockholm under the ticker AXIS.

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