1″ Setup for Basler ace Cameras

The trend towards higher resolutions is continuing to grow in many areas of Machine Vision. Not just because of new, inexpensive sensors with 5 or more megapixels, users are increasingly opting for cameras with these resolutions. When switching to a higher resolution, it is important to consider the format of the new sensor, to avoid adverse effects in the image quality. The reasons why switching to such sensors may be worthwhile, which applications this is a suitable approach for, and what factors should be taken into account are explained below in this Product Insight.

Contents

1 Starting Situation

When you switch to higher resolutions, always note the format of the new sensor to be used. The sizes predominantly range from 1/3″ to 2/3″ for sensors with lower resolutions. A wide spectrum of cost-optimized and technically superior lenses is available on the market for these formats.

However, if such a 2/3″ lens is used with a 1″ sensor, this will result in strong vignetting.

Figure 1: Edge shadowing caused by a too small image circle (vignetting).

In some cases, such a combination of lens and sensor can still be worthwhile.

2 Advantages of a 1″ Camera System

A 1″ camera system can meet the requirements for a higher resolution with the same or even increased pixel size. The application can thus display a higher resolution with high sensitivity and provide a high-quality image.

This can be useful particularly in applications that require a precise reproduction of the recorded scene, for example to show quality deficits. Tasks in surface inspection or the semiconductor industry benefit from such a setup, for example.

By using a new 1″ sensor, image quality and speed can be improved, which yields a higher flow-rate with greater recognition rates. This has a positive effect on the costs while improving quality.

2.1 Sample application: Camera option → PYTHON 5000

A Basler pilot area scan camera with the ICX625 CCD sensor from Sony is currently being used for an inspection application. A Basler ace camera with the PYTHON 5000 CMOS sensor from ON Semiconductor can be a new alternative for this process. Table 1 shows a comparison of both sensors based on their EMVA data:

When comparing the EMVA data of the ICX625 and PYTHON 5000 sensors, it becomes clear that the new CMOS generation not only keeps up with the older CCD sensors in terms of image quality, it actually gets better results for individual values.

The 4.8µm pixel makes it possible for the PYTHON sensor to reach a quantum efficiency of 53%, along with a saturation capacity of 7,700 electrons; both of these are higher values than those achieved by the ICX625 sensor.

Sensor	ICX625	PYTHON 5000
Resolution [MP]	5	5
Resolution [pixels]	2456×2058	2590×2048
Optical Size ["]	2/3	1
Pixel Size [µm]	3,45	4,8
Speed [fps]	17	60
Camera Series	pilot	ace
QE [%]	47	53
Dark Noise [e-]	12,7	11,1
Saturation Capacity [ke-]	7	7,7
Dynamic Range [dB]	54,8	56,8
SNR. temp max [dB]	38,4	38,9

Table 1: Comparison of EMVA data of ICX625 CCD sensor and PYTHON 5000 CMOS sensor

In respect to the dynamic range and signal to noise ratio, the sensor from ON Semiconductor also shows benefits. These are also reflected in the comparative images:

Comparative images in a low-light scenario[1]:

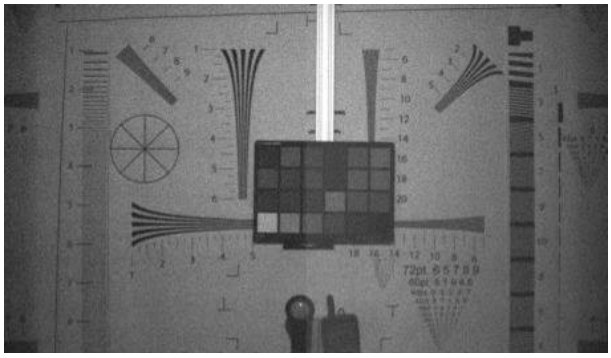

Figure 2: Sony ICX625

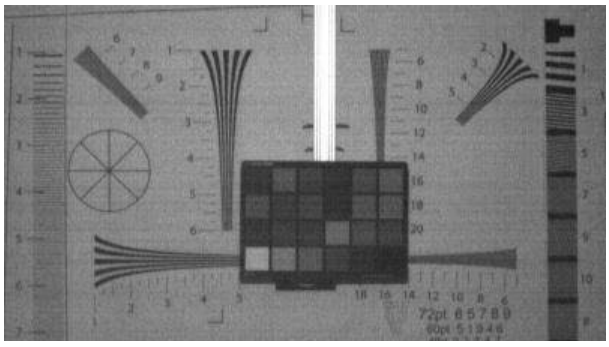

Figure 3: ON Semiconductor PYTHON 5000

The PYTHON 5000 is thus a good alternative to the ICX625. However, aside from the differently-sized pixels, a crucial distinction is the sensor size and its influence on the optics to be applied.

2.2 Optics

When switching from a 2/3" to a 1" camera system, it is important to consider the following points in respect to the optics:

- Select a lens that fits the image circle and resolution of your industrial camera
- Change your system's working distance according to the larger image circle

Our *Lens Selector* is a simple method to select the right lens for your 1" camera system. Based on the entered working distance or the size of the depicted object, it selects the appropriate focal length and calculates a recommendation for a suitable lens for your Basler industrial camera. You can find two lens series for a 1" image circle in our product portfolio.

The lens selector lets you calculate exactly how a larger image circle will change the working distance of your camera system:

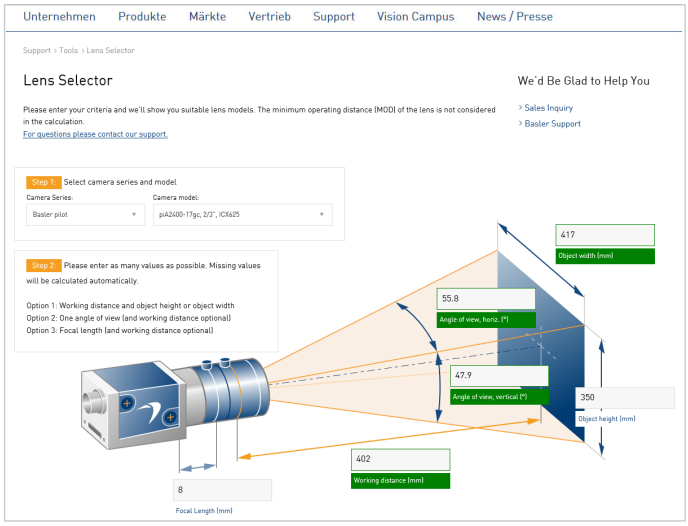

Figure 4: Based on the dimensions of an object, the Basler lens selector determines the ideal working distance between the camera system and object.

[1]**Lighting:**
- White LED light (6500 K)
- Lightintensity 1 Lux (candle light)

Camera and Lens Settings:
- Analog Gain and Digital Shift set in order to achieve a brightness value of 150 gv
- Exposure Time: 10 ms
- F#: 1:1.8

Let's assume that you would like to capture an object with a height of 350 mm and that your existing 2/3" lens has a focal length of 8 mm. For this image, you needed a working distance of more than 400 mm with your previous 2/3" camera system.

But a larger sensor and compatible lens reduce the required working distance: Due to the larger image circle, you can record your examined object with a working distance of less than 300 mm.

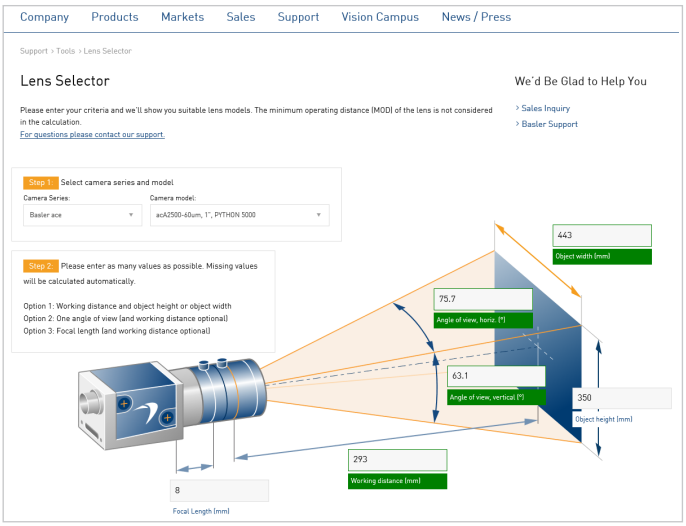

Figure 5: The working distance is significantly smaller with a larger sensor and a 1" lens.

This means that a larger sensor with the suitable 1" lens allows for a much smaller working distance and reduces the necessary design size of your entire application.

You should take a variety of properties into account when selecting the right lens for your camera. The resolution of a lens is specified as lp/mm in the data sheets. You can get the required value by converting your camera's pixels into lp/mm:

Resolution of the lens in lp/mm = 1000 / (2xµm)

Good lenses also stand out by ensuring adequate resolution even at the margins of the image. A utilization of the entire image circle can be very important particularly with larger sensors. We have compiled detailed information on selecting the right lens for you in our white paper *"What Lenses Are Available and How Do You Select the Right Lens for a Camera?*".

3 Offers of 1" Lenses

Since the introduction of cameras with 1" sensors, the range of suitable lenses on the market is gradually increasing. It is significant that most of the lenses available on the market are in the higher-priced segment. Compared to traditional 2/3" lenses, the list prices of 1" lenses are much higher. This can be attributed to the higher manufacturing costs as well as lower economies of scale.

For cameras with PYTHON 5000 sensors from ON Semiconductor, Basler offers two lens series for a 1" image circle:

- the LM-HC 1" megapixel series from KOWA, which is well-established on the machine vision market and
- the 1" TS-MP lens series from a new Japanese lens manufacturer, which is at this point not widely known to the market

Option 1: Choice of the high-quality and well-established *Kowa LM-HC 1" megapixel series*:

Technical key data of the Kowa LM-HC series:

- Lens series: Kowa LM-HC
- Maximum image circle: 1 inch
- Mount: C mount
- Focal length selection: 6 mm to 75 mm
- Aperture range: F1:1.4 – 16
- Resolution in lp/mm: Image center 120 lp/mm, image margin 80 lp/mm (with the example of a 16 mm focal length)

Kowa's LM-HC series stands out with excellent quality, low distortion and good light transmission.

Option 2: Choice of the new "best value for money" *1" TS-MP lens series:*

The new 1" TS-MP lens series available at Basler offers a cost-optimized alternative to the Kowa LM-HC lens series.

Technical key data for the new 1" lens series:

- Lens series: TS-MP
- Maximum image circle: 1 inch
- Mount: C mount
- Focal length selection: 8 mm to 50 mm, excl. 35 mm
- Aperture range: F1:1.4 – 16
- Resolution in lp/mm: Image center 120 lp/mm, image margin 90 lp/mm (with the example of a 16 mm focal length)

3.1 How do I choose the right lens for my new Basler ace camera with PYTHON 5000 from ON Semiconductor?

The first criterion is the reproduction performance of the lens series. The images show photos from a Basler acA2500-60um with the lenses of KOWA LM25HC and TS2514-MP, two products from the alternative lens series with a 25 mm focal length:

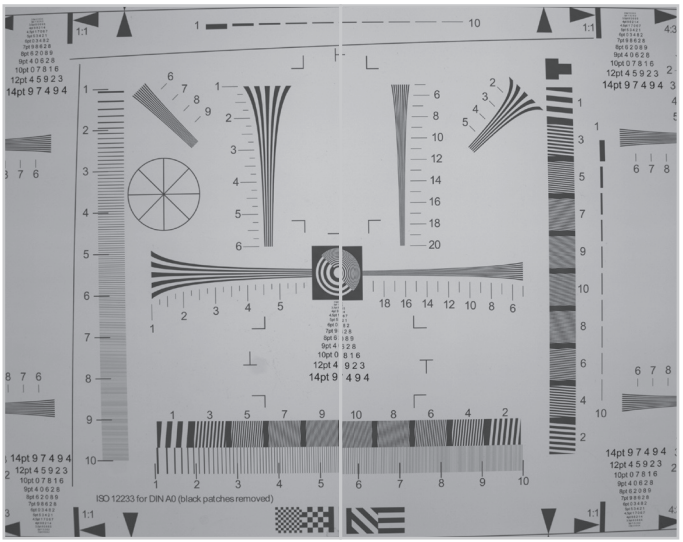

Figure 6: Comparison of Basler acA2500-60um with KOWA LM25HC (left image) and TS2514-MP (right image)[2]

Both lenses show a similar reproduction performance in the image center as well as at the margin. This is confirmed by the values regarding the resolution capacity of the lenses – the LM-HC series from Kowa as well as the TS-MP series have a resolution capacity of 120 lp/mm in the image center and a margin resolution of 90 lp/mm (TS-MP) or 80 lp/mm (Kowa LM-HC).

Aside from the technical fit, the second criterion for the right lens selection is the price – the new TS-MP series stands for a competitive price and offers a "best value for money" setup together with your ace with PYTHON 5000 sensors from ON Semiconductor.

In the end, trust in the products and their manufacturers is the decisive factor. While Kowa offers a well-established and known product line with its LM-HC series, the TS-MP series has been unfamiliar so far and first needs to prove itself. Basler enforces equally high quality standards for its accessories as for its cameras, which is why the resolution and price make the TS-MP lens series an optimal fit for your Basler ace camera with the PYTHON 5000 sensor from ON Semiconductor.

4 Summary

Following the trend towards a higher resolution and/or CCD to CMOS, the PYTHON 5000 sensor from ON Semiconductor has positioned itself as a good option for a variety of applications. In respect to image quality, a comparison with the ICX625 from Sony proves that ON Semiconductor's CMOS technology is state of the art and can certainly compete with older CCD sensors – even surpassing them in several values.

Only a limited number of lenses has been available so far for the 1" format of this sensor. For this segment, in line with the principle of "best value for money", Basler now offers an excellent combination of an attractive price with high quality – for the camera as well as for the compatible lens that plays a decisive role for your image quality.

Combined with the long-established LM-HC 1" lens series from Kowa, your Basler ace with the PYTHON 5000 sensor from ON Semiconductor offers you a high-quality image. You can get a better price/performance ratio with equal quality using a 1" camera system with the new TS-MP lens series

Figure 7: Basler ace acA2500-60um, Kowa LM25HC, TS2514-MP

[2]Camera and Lens settings:• Working Distance: 50 cm • Exposure Time: 2700 µs • f#: 1:2.8

Authors

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Dominik Lappenküper is responsible for Basler's ace, Basler beat and racer cameras series, and oversees market launches for new camera models. He is also the first point of contact when new features are rolled out for these camera families. He is additionally responsible for liaising with the market to better understand its needs.

Dominik started at Basler in 2011 as part of a work/study program in industrial engineering, and successfully earned his Bachelor of Engineering. He has since completed a Master of Science at the Polytechnical University of Wedel alongside his work at Basler.

Xenia Neufeld
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Xenia Neufeld is responsible for the portfolio of lens, cables and other accessories at Basler. Her work involves compiling market requirements and supporting products throughout their entire life cycle, from initial development and market launch through product discontinuation.

Xenia studied industrial engineering at the University of Hamburg from 2011 to 2016, earning Bachelor of Science and Master of Science degrees.

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Basler AG

Basler is a leading manufacturer of high-quality digital cameras and accessories for industry, medicine, traffic and a variety of other markets. The company's product portfolio encompasses area scan and line scan cameras in compact housing dimensions, camera modules in board level variants for embedded solutions, and 3D cameras. The catalog is rounded off by our user-friendly pylon SDK and a broad spectrum of accessories, including a number developed specially for Basler and optimally harmonized for our cameras. Basler has 30 years of experience in computer vision. The company is home to approximately 500 employees at its headquarters in Ahrensburg, Germany, and its subsidiaries and sales offices in Europe, Asia, and North America.

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