

Phase One develops digital back with high ISO capture and new levels of performance.

Learn what Phase One R&D did to improve the digital future.



Phase One Patent Pending Sensor+ Explained

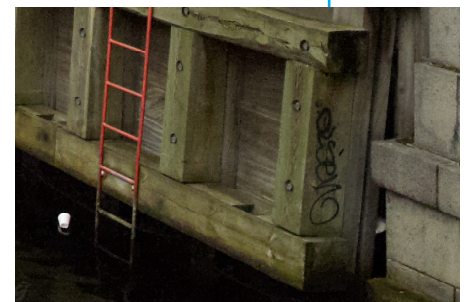
By Walter Borchenko

Phase One's Sensor+ technology is an industry breakthrough. Sensor+ solves a problem that has been eluding researchers for over 30 years. Many industry researchers have been addressing the problem, spending hundreds of millions of dollars in the search for a solution.

What is Sensor+

Sensor+ is pixel scaling (or binning) in color. Although this sounds simple enough, until now, success has been achieved only in black and white. Video cameras, capable of night capture, typically use pixel scaling to produce tinted monochrome video.

Phase One has implemented Sensor+ in the P 65+ digital back. The P 65+ is the first true full frame 645 format back that captures full frame 60.5 megapixels. Simply by selecting Sensor+ mode, the P 65+ supplies full frame 15 megapixel color captures at up to 3200 ISO. In addition there are a number of



Phase One P 65+ 3200 ISO capture using Sensor+

surprising benefits for photographers.

What Sensor+ offers Photographers

The battle between quality and performance is always difficult to balance. Many times, capture speed or high ISO are so important that quality is compromised with the anti aliasing filters of DSLR's. Now, high quality and performance are available by just pressing a button on the P 65+ to invoke Sensor+ mode. It's fast, easy and puts both quality and performance at one's fingertips, in one digital back product.

P 65+	P 65+ with Sensor+ activated
<ul style="list-style-type: none"> • 50 ISO • 100 ISO • 200 ISO • 400 ISO • 800 ISO • Up to 1 FPS • 12.5 f-stop range • 60.5 megapixels • Full frame 	<ul style="list-style-type: none"> • 4X ISO range of P 65+ • 200 ISO • 400 ISO • 800 ISO • 1600 ISO • 3200 ISO • Faster captures up to 1.4 FPS • 12.5 f-stop range • Smaller files • Less moiré • 15 megapixels • Full frame

The Sensor+ mode on P 65+ provides five key benefits for photographers:

- **4x faster ISO**
- **Smaller files**
- **Faster shooting speed**
- **Less moiré**
- **Full frame capture**

ISO 200 vs. ISO 800 with Sensor+ full frame capture



Sensor+ 4 x Faster ISO

Using Phase One's patent-pending process (see Sensor+ Technical Explanation below for details), Sensor+ mode increases the ISO four times the regular setting. Surprisingly, image quality is maintained compared to the lower ISO used without Sensor+.

P 65+ full-res	P 65+ w. Sensor+
ISO 50 quality =	ISO 200 quality
ISO 100 quality =	ISO 400 quality
ISO 200 quality =	ISO 800 quality
ISO 400 quality =	ISO 1600 quality
ISO 800 quality =	ISO 3200 quality

The Sensor+ higher ISO ratings deliver exceptional image quality comparable to results from DSLR's offering similar ISO with two major differences. Unlike DSLR's, Phase One backs do not use anti-aliasing filters and they use larger format sensors compared to DSLR's, taking advantage of medium format optical quality.

Sensor+ Smaller file size

Sensor+ combines the data from 4 pixels into one piece of data. An original 60.5 megapixel capture produces a 60 MB file in IIQ large and a 40 MB file in IIQ small. With Sensor+ enabled, the capture is now full frame 15 megapixels and the file size is 15 MB in IIQ large and 10 MB in IIQ small. The IIQ capture format is Phase One's patented compression format for RAW files.

For many applications in which a larger capture size/higher resolution is not important, the smaller file size is a real benefit, especially since the image quality is being retained. Everyone needs as many advantages as possible to get the shot.

Sensor+ Faster Shooting Speed

Shooting speed is a real advantage that combined with the P 65+'s higher image quality, really boosts performance. In contrast with a top level DSLR like the Canon 1Ds MKIII, the P 65+ with Sensor+ enabled can shoot approximately 86 frames in one minute. The Canon produces approximately 60 frames in one minute.

These tests were done with the P 65+ mounted on the mechanical Hasselblad V series 555 ELD, which attains 1.4 frames per second. With the Phase One camera, speed is slightly lower at 1.20 frames per second, which translates to 72 frames per minute. At first this comparison might seem odd and unbelievable but here is how it works.

The Canon shoots a rapid burst; then it stops until the buffer is dumped. After a few more shots, then the buffer is dumped again and the timing is inconsistent. When shooting fast moving subjects such as in fashion photography, it's impossible to time the shots after the initial DSLR burst. Shooting is totally hit and miss.

The Phase One back keeps shooting at a consistent speed and will keep going until the CF card or computer is full (if tethered). It's much easier to shoot and keep shooting with the consistent captures. Timing is made easier and sequences actually look right and are timed equally.

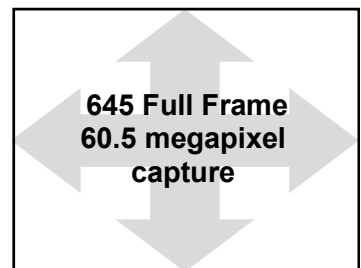
Sensor+ Less Moiré

The moiré advantage in Sensor+ is a little more difficult to explain. First, it's important to keep in mind that the larger the pixel, the more moiré occurs. The pixel size on the P 65+ sensor is 6x6 microns. Sensor+ creates a 12x12 micron data set by combining the data in the sensor using a binning approach. If a comparison is

made to a real capture sensor with 12x12 micron pixels, the Sensor+ pixel is virtually moiré free because the core data is still captured at 6x6 microns.

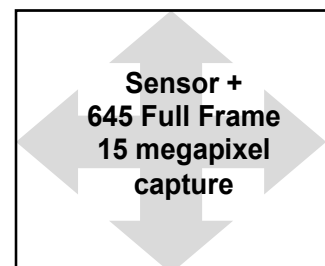
Sensor+ Full Frame Capture

A number of DSLR products and competitive digital backs have offered photographers the option to create smaller files sizes. The penalty with these other solutions has been a reduction in the capture area. For the photographer, changing the capture size should not change the capture area. With the live sensor area reduced in these competitive solutions, lens coverage is no longer the same. This means that camera position must change and the process has a negative impact on production since everything has to stop.



Full frame capture with 60.5 megapixels

The brilliant advantage of Sensor+ is that the full sensor area is utilized. No optical change or production halt is required. One needs only to select Sensor+ mode, adjust exposure accordingly and continue on with the shoot.



Full frame capture with Sensor+ 15 megapixels

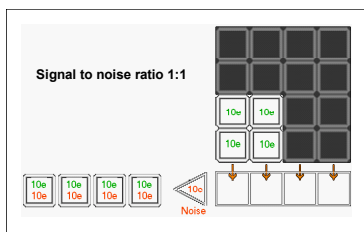
Sensor+ Technical Explanation

The technology discussed here is called color pixel binning or pixel scaling. The results in monochrome have been successful for many years but color has been the industries real challenge. Phase One has had to overcome two key technical problems for the Sensor+ technology to work. Solutions up to this point either produced extensive noise or had a massive reduction in image quality of 1/16th or less, of the original sensor capability when 4 pixels have been combined.

Traditional pixel binning

For this explanation, four pixels are being described. Noise is shown in red and original sensor data is shown in green. Each pixel is described as having ten electrons (10e green) and the noise is also ten electrons (10e red).

With the Normal sensor operation, each pixel is dumped from the sensor through an amplification process that adds noise.



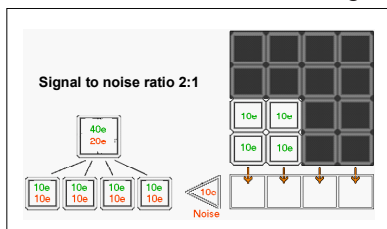
Normal full resolution sensor operation

When the noise is compared to the capture data, both are equal, providing a Signal to Noise (SNR) ratio of 1:1. The important thing to remember is that each final pixel has 10 electrons of noise.

Noise Problem

In the example, the data from the four pixels is being averaged together to create one large pixel. Averaging can reduce the noise in a large pixel by the square root of the number of samples that have been averaged. In this example, four samples are averaged, reducing the noise by the square root of four. The result is 2 or 20 electrons of noise in total. Averaging achieves 40 electrons of signal, providing a Signal to Noise ratio of 2:1 (40 divided by 20).

In normal full resolution sensor operation, each final pixel had only 10 electrons of noise. The averaging solution creates 20 electrons of noise. Although an

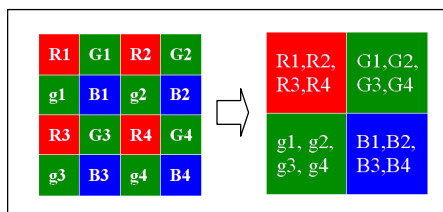


Averaging sensor data with four pixels

accomplishment, this is not nearly enough noise reduction to create the image quality required for a large pixel.

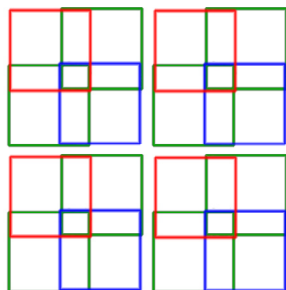
Quality reduction problem

In this traditional binning example, a sixteen-pixel area is used. The original sixteen pixels are all labeled to indicate how the four large pixels are created.



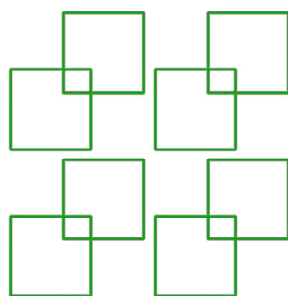
Traditional binning sixteen-pixel example

When the optical centers of the large pixels are represented as an illustration, the information seems even.



Traditional color binning Optical centers, all colors

If only the green layer is considered, large holes exist and some data areas do not even touch.

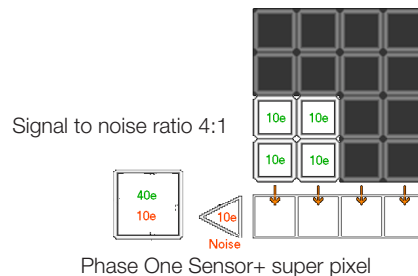


Traditional color binning Optical centers, green only

This creates a lot of problems for image quality. This method of combining four pixels into one produces a far worse result than expected. Instead of getting 1/4 the resolving power of the original sensor, 1/16th resolving power or less is achieved.

The Phase One Sensor+ solution

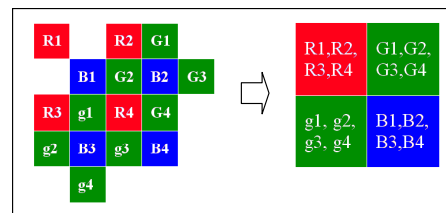
The Phase One Sensor+ solution to the noise problem was to add the pixels together inside the image sensor, before the amplification process. Amplification noise is reduced significantly. This clever solution creates a 4:1 Signal to Noise ratio.



Phase One Sensor+ super pixel

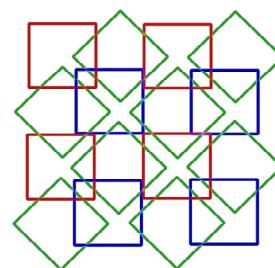
Each super pixel now has 10 electrons of noise, the same as in normal full resolution sensor operation but with four times the sensitivity and signal level. This means that the super pixel noise level is now four times lower than the normal full resolution pixel at the same ISO.

To overcome the image quality issues, the Sensor+ technology organizes the pixel data in a completely unique way to create the super pixel.



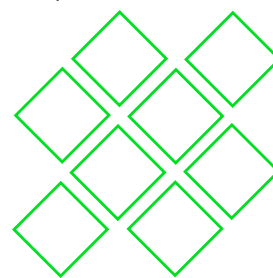
Phase One Sensor+ sixteen-pixel example

The unique sampling pattern is the first step in Sensor+ technology.

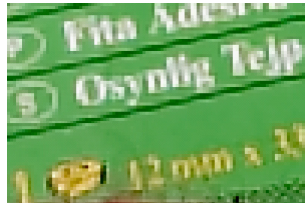
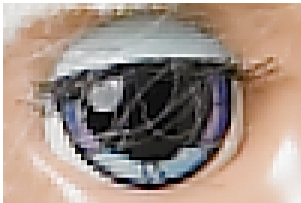


Sensor+ optical centers, all colors

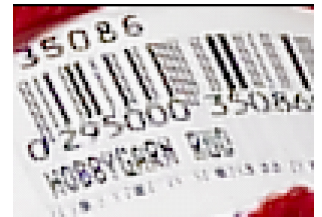
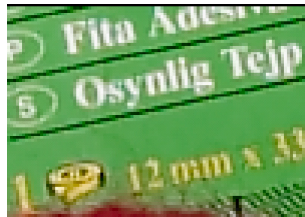
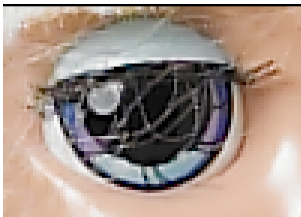
In the second step of Sensor+ technology, the data from the green pixels is changed in orientation so that each super pixel includes data in a much more even pattern.



Sensor+ optical centers, green only



Traditional binning examples



Phase One Sensor + super pixel examples

The Sensor+ method enhances image quality significantly as demonstrated in the above examples.

Conclusion

Sensor+ represents a photo industry technology milestone. The benefit to photographers is full frame 60.5 megapixel captures and, at the touch of a button, 15 megapixel full frame captures with four times higher sensitivity of up to 3200 ISO and a faster capture rate of up to 1.4 frames per second. In addition, Sensor+ captures have less moiré than larger pixel sensors and produce a smaller file size. The real benefit is the versatility to shoot high ISO at high quality and shoot at regular ISO's with 60.5 megapixels, in the same product.

photography. Choose the best tools for the job, whether it be utilizing full tilts and shifts on a view camera or the extreme wide angle capabilities of the architectural technical cameras. Sensor+ adds significantly to one of the most versatile digital capture solutions available for photographers.

The P 65+ with Sensor+ technology further enhances Phase One's modular, open approach to medium format

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Walter Borchenko is a photographer based in Toronto Canada and is also the developer of the independent educational website www.capture-u.com. This site includes both subscription and free public materials with registration. The content is dedicated to Phase One's Capture One software and the focuses on capture over post-production for the creation of final images.

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