Large-Format 4K Image Sensor Approach

August 03, 2016

Studio Camera Technology

Over the past few years, the broadcast industry has been witnessing a fast transition in resolutions from SD to HD, as of now the momentum for 4K or UHD productions continues to climb and later to become 8K in 2020.

4K productions is becoming more and more the de-facto for any sports events. Two years ago, in a rapid progression, professional equipment manufacturers introduced 4K Studio cameras with a different sensor type. Some started their 4K camera with a single 35mm 4K sensor, others adopted 3 x 2/3" CMOS with an HD resolution up converting it to 4K and finally we are seeing 3 x 2/3" 4K native CMOS.

All HD Studio cameras have 2/3" sensor size and a pixel size of 5 to 6 micrometres, and there was as well a good reason why it has been the best technology and the best compromise between sensitivity, dynamic range, and good performance in a reasonably small size. Is this applicable for the 4k, 8k, etc…

Panasonic has a slightly different approach when it comes to new studio camera technology. We look at the market where some broadcasters will be delaying spending on 4K technology and will be trying to figure out where to go next. Some are considering adopting the new 4K technology to be the first driving growth and revenues from such technology. For such transition, Panasonic have identified three main points to adopt a 4K Studio camera:

- Camera Technical Aspect: Good sensitivity, S/N, Dynamic Range and etc.
- Affordable 4K System for early adopters
- Cost effective 4K Studio Camera

Sensitivity and Signal to Noise Ratio(S/N)

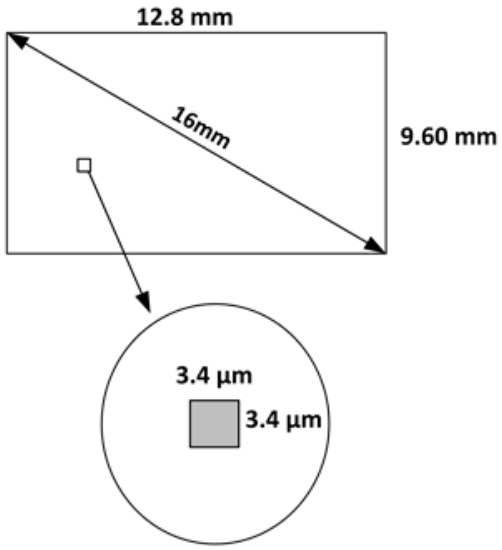
Pixel size is determined by both the image sensor size as well as the number of pixels. Pixel size plays a big role in collecting photons. Larger pixels allow more light to be captured which generally means the more light-sensitive the sensor is. If two sensors have the same resolution (same number of pixels), the larger sensor will have a clearer image.

Due to the larger pixels surface in a single chip 1 inch 4K image sensors, pixels receive a greater flux of photons during a given exposure time, so the light signal is much stronger. For a given amount of background noise, this produces a higher signal to noise ratio as well as smoother pictures.

This phenomenon arises simply because the number of photons landing on an individual pixel is proportional to its area, while the amount of electrical noise remains about the same. Bigger pixels therefore give better sensitivity / signal-to-noise; smaller pixels give poorer sensitivity / signal-to-noise.

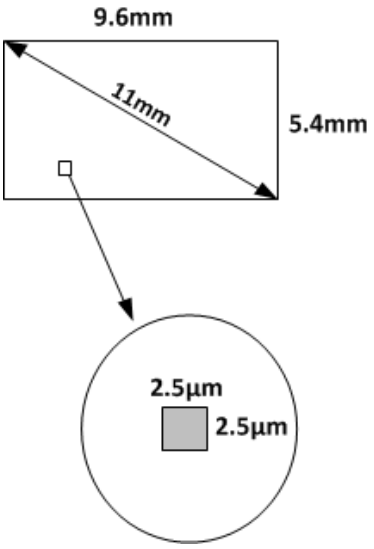
UHD 3840×2160

1 inch format



UHD 3840×2160

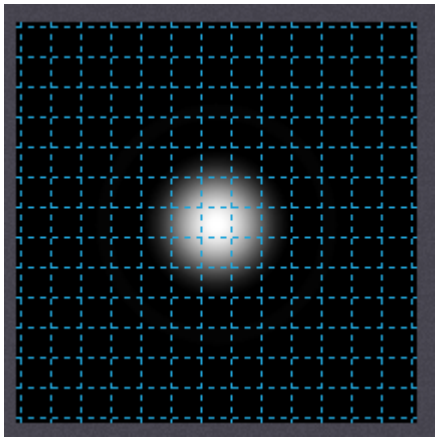
2/3 inch format



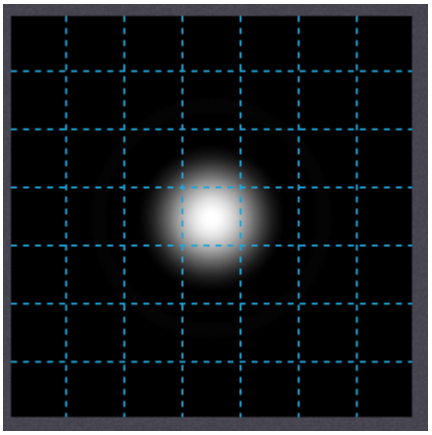
Resolution, Dynamic Range and Iris relationship

Three chips 2/3-inch 4K image sensors achieve high resolution, but lower saturation due to smaller pixel size. A single chip 1 inch 4K image sensor is capable of achieving high saturation (Dynamic range) under equal sensitivity condition compared to 2/3 inch and it is a very important factor for HDR system in UHD.

Furthermore, in three chips 2/3-inch 4K image sensors, IRIS should be opened to avoid blur due to diffraction, to reach very high saturation characteristics. Diffraction limit could be critical, as more pixels may not necessarily provide more resolution for the depth of field requirements. In fact, more pixels could even harm image quality by increasing noise, reducing dynamic range and decreasing resolution by averaging over pixels.



Three chips 2/3-inch UHD



Single chip 1 inch UHD

The effect of diffraction is more severe on the smaller Pixel of the three chips 2/3-inch UHD sensor.

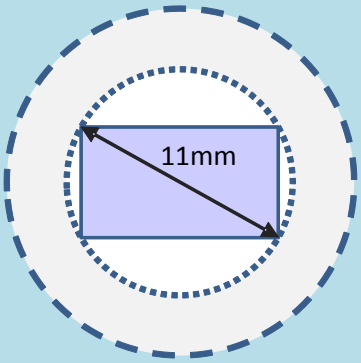
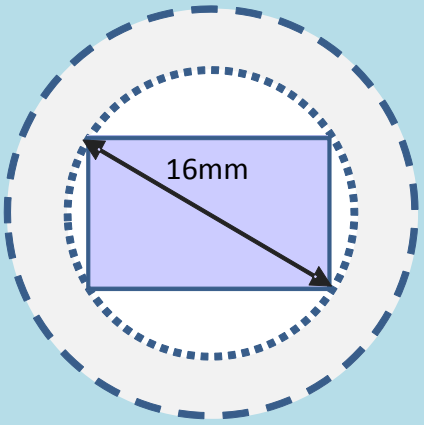
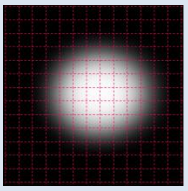
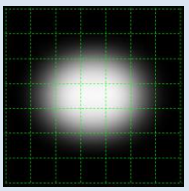
Affordable 4K System for early adopters

During this transition period there will be a wide market potential for the new 4K technology adopters but at the same time the industry will continue to do a series of tests and find out what works and what doesn't, because no one at this point really knows the limitations which lead to the fact that some of the broadcasters might avoid buying and this reinforces what we are actually seeing in the market.

Panasonic noticed that clients cannot afford buying a 4K camera and then in a short cycle of time the products will be obsolete due to some new upcoming standardization. Staying with the 2/3 inch image sensor can reuse your optical system and accessories like large lens adapters. In fact, continuing in the HD domain can save some money in the short term but not in the long term where no upgrade path for 8K could be possible, so replacing to a total new camera concept with reasonable cost for such period could be a smart solution. The approach was to deliver four times the resolution in a product that is virtually at the same price of an actual HD camera. Here comes the role of the single one inch image sensor.

The single one inch image sensor is indicated in this article as the “compromise” format between the three 2/3 inch image sensor and the next generation of large image sensor for the 4K and 8K. The next studio camera generation will be 4K/8K switchable as well the HD.

Comparison between 4K 2/3 and 1 inch camera format

	2/3 inch format	1 inch format
		
Imager	Three chips 2/3-inch 4K image sensors	Single chip 1 inch 4K image sensor
Pixel size	2.5µm	3.4µm
Sensitivity	Low due to the smaller Pixel size	Good due to the larger pixels nearly 1.5 stops
Resolution	Excellent 2000 TVL	Good 1800 TVL
Dynamic range	Fair	Good
Imager development cycle	Almost reach to end with 4K	New path open for 4K and 8K
Diffraction limit	 Significant diffraction loss at small apertures	 Acceptable diffraction loss at small apertures
Shallow depth of focus	Hard to achieve shallow depth of focus for creative effect	Easy to achieve shallow depth of focus for creative effect
Lens Mount type	B4 Mount	B4 Mount

AK-UC3000 a balance between Picture quality and Cost

The single MOS sensor AK-UC3000 outputs a UHD signal at up to 50p, while also delivering superior picture quality in HD. The camera's B4 mount accommodates a full range of 2/3-inch lenses, to maximise return on investment in existing lenses.

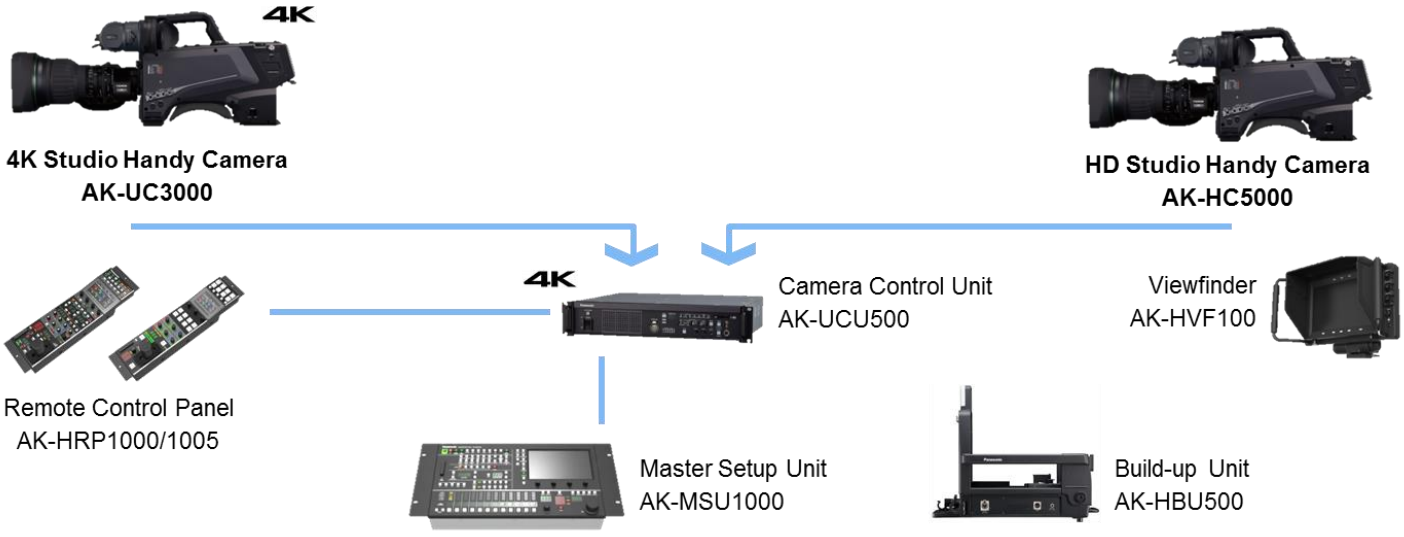
The UC3000 also enables shooting with high sensitivity (F10/2000lx), low noise (S/N 60dB+), high resolution (1800 TV lines/UHD) and a wide dynamic range of 600% (-6dB～36dB). The AK-UC3000 camera system handles UHD as well as HD/SD output simultaneously.

List of supported formats

UHD (3G-SDI x 4)	3840 x 2160/59.94p, 50p, 29.97p, 25p, 23.98p,
HD (3G-SDI)	1080/59.94p, 50p, 59.94i, 50i, 23.98p over 59.94i, 29.97PsF, 25PsF, 23.98PsF, 720/59.94p, 50p
SD	480/59.94i, 576/50i

Common Peripherals

CCU, ROP, VF are the same for UC3000 (4K Studio Camera) and HC5000 (3G 4x Speed Slow motion camera).

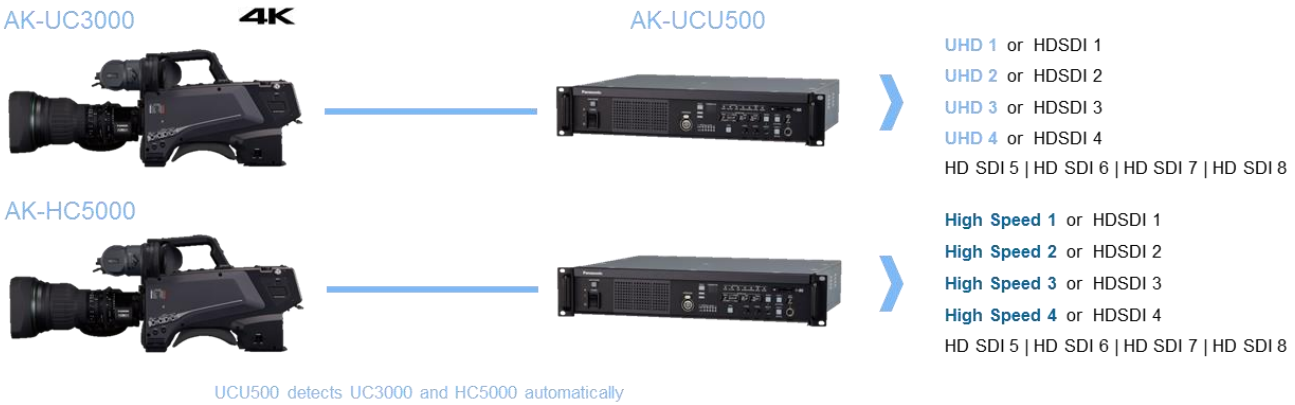


All product line-up are available AK-UC3000 and AK-HC5000

Camera Control Unit

The CCU supports both 4K and HD formats by just changing the camera head. It enables a high-quality, long-distance (approx. 2000) optical fibre transmission camera system to be configured at a reduced cost.

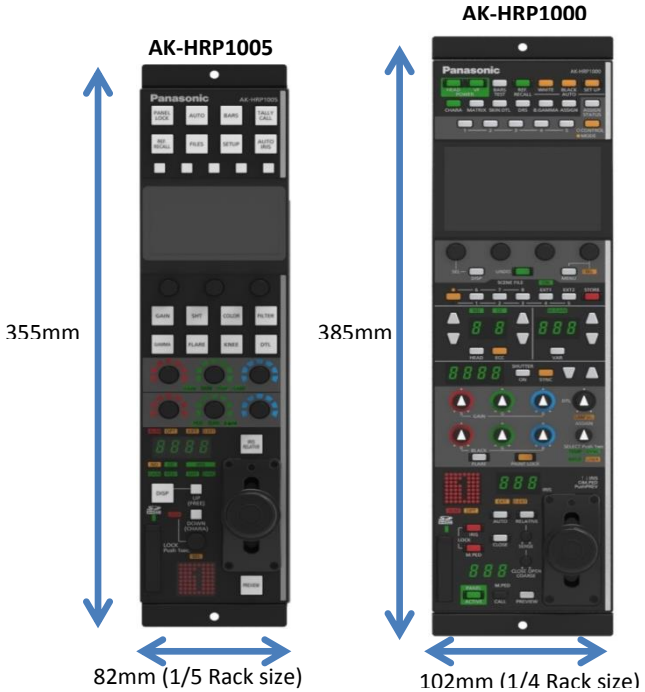
UHD/HD/SD video is output from the AK-UCU500 Camera Control Unit (CCU)



System Mode	SDI 1	SDI 2	SDI 3	SDI 4	SDI 5	SDI 6	SDI 7	8/PM
UHD Mode (w/ UC3000)	UHD Output (3G SDI x 4)				3G/HD/SD		3G/HD/SD	HD/SD
HS Mode (w/ HC5000)	HS Output (3G SDI x 4)				3G/HD/SD		3G/HD/SD	HD/SD
HD Mode (w/ UC3000,HC5000)	3G/HD/SD	3G/HD/SD	3G/HD/SD	3G/HD/SD	3G/HD/SD		3G/HD/SD	HD/SD

Two ROP Models

There are two models: 1/4 rack size (AK-HRP1000GJ) and 1/5 rack size (AK-HRP1005GJ).



Two ROP Models which fits more the operations

Conclusion

In a transition period from HD to 4K where there are no clear standards, and until the 4K technology will be more developed in the next two years, a fundamental trade-off should be made to select the studio camera. A Studio camera with three chips 2/3-inch 4K image sensors is desired due to the results in a higher resolution; a studio camera with a single chip 1 inch 4K image sensor is also desired because of the results it provides in higher dynamic range, signal-to-noise ratio and its cost. Till we reach a combination of all aspects in one system, adoption and investment in 4K Studio camera system will increase, but the client should look to make deliberate decisions about the 4K technology during the next two years.