AG-DVX200

TECH BRIEF

Sensor Scanning and Field Of View

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4K PROFESSIONAL

Sensor Scanning And Field Of View

One question users may have about the DVX200 is -- why does the field of view change, when you change recording modes? This article will explore how the DVX200's sensor works, and what factors cause a change in field of view.

A Four Thirds sensor

A 16:9 patch from a Four Thirds sensor

First things first -- the DVX200 uses a Four Thirds sensor, with dimensions of 17.3 x 13.0 millimeters. By design, Four Thirds sensors are manufactured to a 4:3 aspect ratio; however, since the DVX200 principally generates video in a 16:9 (or 17:9) aspect ratio, the entire 4:3 surface of the sensor is not used. Instead, the DVX200 uses a common technique known as "windowing"; for 16:9 video the active area of the sensor is a 17.3 x 9.73mm 16:9-shaped patch from the center of the sensor.

This concept of scanning only a windowed area of the sensor will be a crucial element in understanding how the DVX200 creates its many different video modes and aspect ratios, and why the field of view changes in some of them.

There are three principal scanning modes that the DVX200 uses to generate its video modes: Ultra High Definition at 50/60 frames per second, UHD/4K at 24/25/30 frames per second, and Full High Definition. Each mode requires a different approach at the sensor level, and results in some unique aspects for the various recording modes.

Why "Window" The Sensor?

Before we go any further, the first question to answer is: why doesn't it just scan every pixel on the sensor, every time, at all frame rates? And the answer is simple: it can't. There are hardware limitations involved. There are only so many pixels that can be read off the sensor in any given amount of time; the faster the frame rate, the fewer pixels that can be read, and the slower the frame rate the more pixels that can be read. As such, different engineering approaches are taken to get the best performance from each recording mode.

UHD: 3840 x 2160 @ 23.976, 25.00, or 29.97 Frames Per Second

The first mode to discuss is the Ultra High Definition mode. This mode delivers a 16:9 aspect ratio, at a frame size of 3,840 x 2,160, at 24, 25, or 30 frames per second. The wide-angle field of view approximates what a 30.6mm lens would look like on a full-frame camera. This represents a very slight crop from the full potential width of the sensor (which would be a maximum equivalent to the field of view of a 28.0mm lens on a stills photography camera). The width is slightly cropped, in order to accomodate the slightly faster frame rate of 29.97 fps and to maintain as consistent a field of view across as many UHD modes as possible.

This mode uses approximately 12.89 million pixels to make its image. However, the final recorded image is made up of only 8.29 million pixels. Why the difference? The DVX200 uses a process called “oversampling” -- it reads a much bigger patch of pixels, and scales them down to the final image size. In reality the DVX200 is reading a patch of approximately 4,787 x 2,692 pixels, and scaling it down to 3,840 x 2,160 for recording. The result is very, very sharp images, significantly sharper than they would have been had the camera merely read out 3,840 x 2,160 in the first place. Reading out this many pixels does take quite a bit of time, and so this mode is only available at the slower frame rates of 24/25/30, and not at the faster frame rates of UHD 50/60.

4K: 4096 x 2160 @ 24.00 Frames Per Second

The 4K mode delivers a 17:9 aspect ratio, at a frame size of 4,096 x 2,160, at 24.00 frames per second. This mode delivers a slightly wider wide-angle field of view, approximating what a 29.5mm lens would look like on a full-frame photography camera. As compared to the UHD 24/25/30 mode, the height is the same, but the width is slightly expanded to include additional pixels on each side; that wider width gives the sensor the ability to “see” more of the image that the lens is projecting onto it, and the result is a wider image at the same focal length, effectively giving a wider field of view.

Because this mode runs at a slightly slower frame rate than UHD (24.00 fps, vs. 29.97 max for UHD), there’s time to read in some more pixels on the sides of the frame. The total frame size is approximately 13.35 million pixels, in a grid of approximately 5,032 x 2,654. That’s a significant amount of oversampling; the DVX200 in 4K mode is basically operating internally as a “5K” camera; it uses a 5K-sized patch of the chip to create its 4K rendered frame. Because of the oversampling, the DVX200 renders an image that is just about as sharp as a 4K recording can hold.

UHD: 3840 x 2160 @ 50.00 or 59.94 Frames Per Second

When operating in UHD at fast frame rates (50 or 60 progressive frames per second), the sensor has to window in notably. Remember that there’s only so many pixels that can be read off the sensor in any given period of time; when doubling the frame rate, that reduces the number of pixels that can be read in. The UHD mode at 50 and 60 frames per second uses an 8.71 million pixel sensor patch of approximately 3,934 x 2,213 to create a final frame size of 3,840 x 2,160. That smaller patch of the sensor results in a narrower field of view; the UHD 50/60 mode has a field of view equivalent to a full-frame photography camera with a 37.2mm lens.

Even though the UHD 50/60 mode is using fewer pixels than its other recording modes, note that it is still using a fully-sampled field of pixels (8.71 million) to make its 8.29-million pixel frame. The DVX200 is still delivering Ultra High Definition quality footage with as much resolution as some other 4K and UHD cameras. The field of view is narrowed in order to reduce the number of pixels that must be read and processed in time. There is a side benefit to this though -- the UHD 50/60 mode shows significantly reduced “rolling shutter” effect as compared to the 24/25/30 fps modes. Because the total number of pixels read per frame is fewer, the sensor can be scanned faster; the faster the sensor is scanned, the less “rolling shutter effect” that happens.

FHD: 1920 x 1080 @ 23.976 to 59.94 Frames Per Second

When set to Full HD mode, the camera delivers the widest field of view possible (an equivalent to 28.0mm on a photography camera), and it also uses the most pixels to make its image (15.49 megapixels), and it operates at the fastest frame rates, which also means it produces the least rolling-shutter artifacts. How is this all possible?

The answer is that the FHD mode uses a technique called "pixel mixing" to read several pixels out together as one large "superpixel". On the sensor itself, the area used to create the FHD image is approximately 5,248 x 2,952 pixels. That many individual pixels are not necessary for making an HD image (which is, of course, 1,920 x 1,080). In fact, it's almost eight times as many pixels as are truly necessary! That's a tremendous amount of data to read, especially at the higher frame rates. To cope with this amount of data, the DVX200 "mixes" each block of 2x2 same-color pixels together into a "superpixel". In essence, the sensor averages multiple pixels together to create one large pixel that represents generally what the individual pixels had sampled. The camera then only needs to read off the "superpixel" data, rather than the individual pixel data. This reduces the processing load tremendously, allowing the camera to use the full width of the sensor, at the full frame rates, and because the scan happens so quickly, the rolling shutter effect is greatly reduced.

There are three side effects to pixel mixing: reduced resolution, reduced noise, and increased aliasing. The effect of reduced resolution should be obvious: if each group of 2x2 pixels is mixed together to create one super-pixel, then obviously the image won't be as high resolution. The math behind pixel mixing is complex, but it results in sufficient resolution for HD footage, and since pixel-mixing is used only in FHD mode, it is a solid and reasonable engineering choice.

The second effect is a notable reduction in image noise. Since four pixels are being averaged together to create each superpixel, the minor fluctuations in brightness that are caused by noise are also averaged together, which results in the noise being less noticeable. In general you can consider that a "superpixel" will have approximately twice the signal-to-noise ratio that the individual pixels would have. This makes FHD mode footage noticeably less noisy than UHD or 4K footage.

FHD VFR: 1920 x 1080 @ 2 to 120 Frames Per Second

When set to record Variable Frame Rates (VFR), the camera may change its scanning mode and perhaps its field of view, depending on the frame rate chosen.

At frame rates between 2 and 60 frames per second, the camera uses the full width of the sensor and the same pixel-mixing technique as described above. Accordingly, images at these frame rates have the same resolution, sharpness, field of view, and aliasing as standard FHD footage at 23.98, 25.00, 29.97, 50.00 or 59.94 frames per second.

At higher frame rates (i.e., faster than 60 frames per second), the camera has to employ different scanning techniques to achieve those faster frame rates. It uses a combination of pixel mixing, line skipping, and (depending on the frame rate) it may also crop the field of view. These techniques allow the sensor to be read even faster, which results in faster frame rates (and, thus, slower slow motion), but also further reduces the resolution of the video frames.

Pixel-mixing has its advantages, certainly, but if you're looking for the absolute highest-quality FHD footage, that will still be achieved by downconverting 4K or UHD footage in post. Pixel mixing combines pixels and results in lower resolution and somewhat increased aliasing; downconverting supersampled 4K/UHD footage means you'll be able to retain the maximum resolution and most alias-free images possible. Pixel-mixing the FHD footage results in several advantages - wider field of view, faster frame scan rate, minimized rolling shutter effect, and lower noise. Downconverting 4K/UHD footage will result in the same reduction in noise, and higher overall image resolution and fidelity, and an increase in effective color sampling and bit depth, but cannot offer the same reduction in rolling shutter or the expanded field of view offered by the pixel-mixed FHD footage.

Summary

The DVX200 windows its sensor to provide the optimal combination of pixel density, sensor read speed, and field of view for each mode that it offers. The resulting field of view changes slightly between FHD, 4K, and UHD 24/25/30 modes, and results in a notable but necessary crop when going to UHD 50/60 mode. These changes are necessary given the limitations of processing power and sensor read speed capability, and reflect a carefully-engineered balance between resolution, field of view, and rolling shutter possible in each of the modes that the DVX200 offers.

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