

What's the real difference between XDCAM HD422 and XDCAM EX?

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Obviously 4:2:2 offers higher chroma resolution than the 4:2:0 of XDCAM EX, but is it really the case that XDCAM HD 4:2:2 is better at standing up to multi-generation use or more suited to broadcast due to lower compression? This is I believe important to consider when you look at the BBC and Skys regulations regarding HD. They say you cannot use an EX at 35 Mb/s while you can use a XDCAM HD 422 camera at 50Mb/s, as 50 Mb/s is deemed robust enough for broadcast by the EBU.

So what makes a codec "robust". Well there are many factors. The most obvious is compression ratio. With any given codec, the more compressed the image, the more artifacts it will show. Re-compress an image with artifacts and you get more artifacts, this is called concatenation. Another thing to consider is scaling and image size. Some codecs record at a resolution lower than the full frame size, for example HDV is 1440×1080. When edited or re-encoded this will be stretched to 1920×1080 and possibly back down again to 1440×1080. This scaling will have a detrimental effect on the final picture quality. This in itself is not an issue for XDCAM HD422 or EX as both are full frame 1920×1080.

Now: what if I told you that XDCAM HD422 and EX both use pretty much same compression ratio, around 20:1. The only difference between the two is the chroma sampling.

Lets look at some basics for a minute: Y is the luminance or brightness of the image, Cb and Cr define the chroma or colour.

A full resolution Y CbCr image is 4:4:4. Subsampling that image to 4:2:2 is a form of compression. Compression is, in it's simplest terms, taking a big thing and making it fit in a smaller space, whether that is through sub sampling, DCT, quantization or any other method, making a big signal smaller is compression.

4:2:2 is the ratio between the amount of data used to portray the Y (4) Cb (2) and Cr (2) signals. So if you use 8Mb/s for the Y then for it to be 4:2:2 you MUST use 4Mb/s for each of the Cb and Cr and your total bit rate would be 16Mb/s. If you use anything other than this ratio then it is not 4:2:2 but some other ratio.

The simplest way to achieve this ratio is to use the same compression for each channel and simply reduce the sample size by a factor of 2 for Cb and Cr. This is very easy to do. Most 4:2:2 encoding schemes use one encoder to encode the Y and then a second similar encoder running the same coding routine but alternating between one sample of Cb followed by one sample of Cr. In fact a better way to describe this would be 2:1:1 as for every two luma bits of data there are one each of Cb and Cr. This gives us the familiar 4:2:2 encoding ratio that we are all familiar with. The compression ratio is by default the same for each channel while the sample size is halved for each of Cb, Cr.

With XDCAM EX the chroma is sampled at 4:2:0, so there are only half the number of Chroma samples for XDCAM EX compared to XDCAM HD422.

$4:2:2 = (1920 \times 1080 + 960 \times 1080 + 960 \times 1080) \times 30(\text{fps}) \times 8(\text{bits}) = 995\text{Mb/s}$. Divide by 19.9 and we get 50Mb/s

$4:2:0 = (1920 \times 1080 + 960 \times 1080) \times 30(\text{fps}) \times 8(\text{bit}) = 746\text{Mb/s}$. Divide by 21.3 and we get 35Mb/s

So from this we see that the compression ratio for EX is 21:1 and for XDCAM HD 422 20:1. This is extremely close and in terms of compression artifacts means there will be little, if any, difference between the two.

Starting with chroma more samples, ie. 422 over 420 should in theory at least give a marginally better end result as it is slightly easier to accurately decode. However this will depend a lot on the quality of the decoder and the image content. In terms of visible artifacts these are normally most noticeable in the full resolution luma channel and with both XDCAM HD422 and EX this is compressed by pretty much the same amount so there will be little to no difference in most cases. In terms of concatenation there will be very little, if any difference between EX and XD HD422

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material. Visually the difference between 4:2:0 and 4:2:2 is not huge. Especially if you shoot progressive where 4:2:0 subsampling is at least symmetrical which makes it easy to work out what the in between colours should be. In interlace the difference is greater as you can't simply sample every other pixel, every other line because of the field structure within the frame.

So while 4:2:2 will offer greater chroma resolution which is most noticeable on subtle textures such as fabrics and will give slightly better chroma keying performance the difference really is very small in every other respect. In many cases the end viewer will not see the difference. It should be noted that in most countries Mpeg2 or Mpeg4 is being used for HD broadcasts and in almost every case it's 4:2:0 so most of the improved chroma resolution that 4:2:2 offers is lost anyway. In the UK, HD broadcasts are 1440x1080 and not 1920x1080. Blu-ray is 4:2:0 and HD on the internet is also almost always 4:2:0 as well.

In robustness and multi-generation terms, differences in scene content, lighting and camera settings such as detail, gain and aperture will make a much bigger difference than the difference between 4:2:0 @ 35Mb/s and 4:2:2 @ 50Mb/s. The BBC are currently enforcing the 50Mb/s rule, yet don't stipulate gain or detail limits. In the past it was possible to get a dispensation for 35Mb/s with an EX, but last I heard the rules were being much more strictly enforced and it's all but impossible to get permission to use an EX, even for situations where shooting with a larger camera is impossible.

While it's easy enough to add a NanoFlash to an EX and record at 50Mb/s or better still 100Mb/s (BIG improvement in quality at 100 Mb/s) to comply with the rules, to be honest the rules don't make a great deal of sense. The difference between 35Mb/s EX and 50Mb/s XD HD is very small from an artifacts and multi-generation performance point of view. A PDW-700 with a high detail setting or any gain switched in will produce an image that will fall apart quicker in a poor production chain than a well set up EX1. It is arguable that the ultra clean (59db) images from the PMW-350 will hold up better than the noisier pictures from the PDW-700 (54db). My belief is that the BBC have chosen to set the bar at 50Mb/s to prevent or restrict the use of small cameras as they are often operated by people that simply don't know how to use a camera properly in the name of "cost savings". What would make more sense would be to allow 35Mb/s while ensuring that productions use skilled and competent crews.

There will be some application where shooting 4:2:2 will make more of a difference, chroma key is a good example or where a lot of post production will be involved, but for general day to day productions it is my opinion that the end viewer won't notice the difference.

In the past programs would be rejected for poor camerawork, dirty lenses and out of focus shots. These days it seems that provided it meets the correct technical specifications pretty much anything goes.