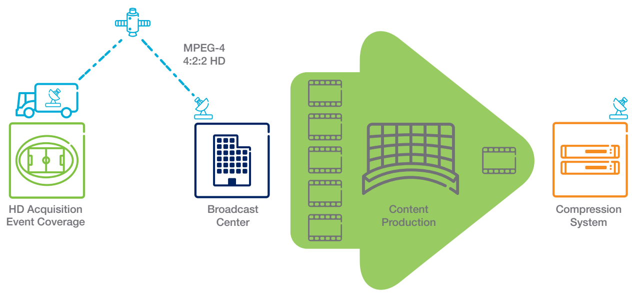
IN SEARCH OF ULTIMATE VIDEO QUALITY - MPEG-4 4:2:2 AVC

Broadcasters and content distributors are continually responding to demands to deliver higher quality video. As technology continues to evolve, new solutions that provide useful video quality improvements become possible. Ericsson continues to be at the forefront of those developments.

It is widely accepted in the video compression industry that 4:2:2 chroma sampled video gives useful improvements in video quality. Recent developments in MPEG-4 AVC compression and Fidelity Range Extensions associated with MPEG-4 AVC 4:2:2 lead to new conclusions as to how 4:2:2 technology should be applied.

4:2:2 Chroma Sampled Applications

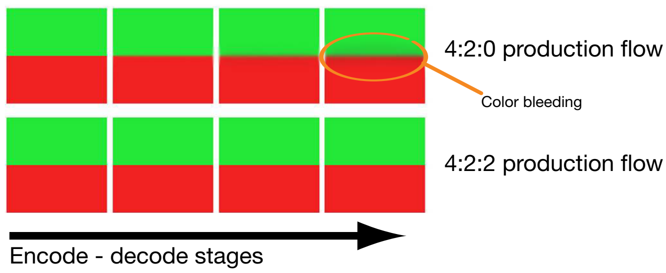
It is well accepted that 4:2:2 video should be used for Contribution applications – where high quality is key and where the content will subsequently pass-through down-stream editing, Chroma Key work, have on-screen graphics applied and pass-through multiple encode-decode stages through the content food chain to reach the end consumer. Each of these requirements place demands on the video quality to ensure that the content is not significantly degraded by these content flow processes. 4:2:2 chroma sampled video ensures that degradations are kept to a minimum.



4:2:0 Chroma Sampled Video vs 4:2:2 Video

4:2:2 chroma sampled video offers improved overall video quality because this format inherently contains greater chroma resolution than 4:2:0 video. There are however additional properties to 4:2:2 formats that ensure video quality is maintained throughout an end-to-end system.

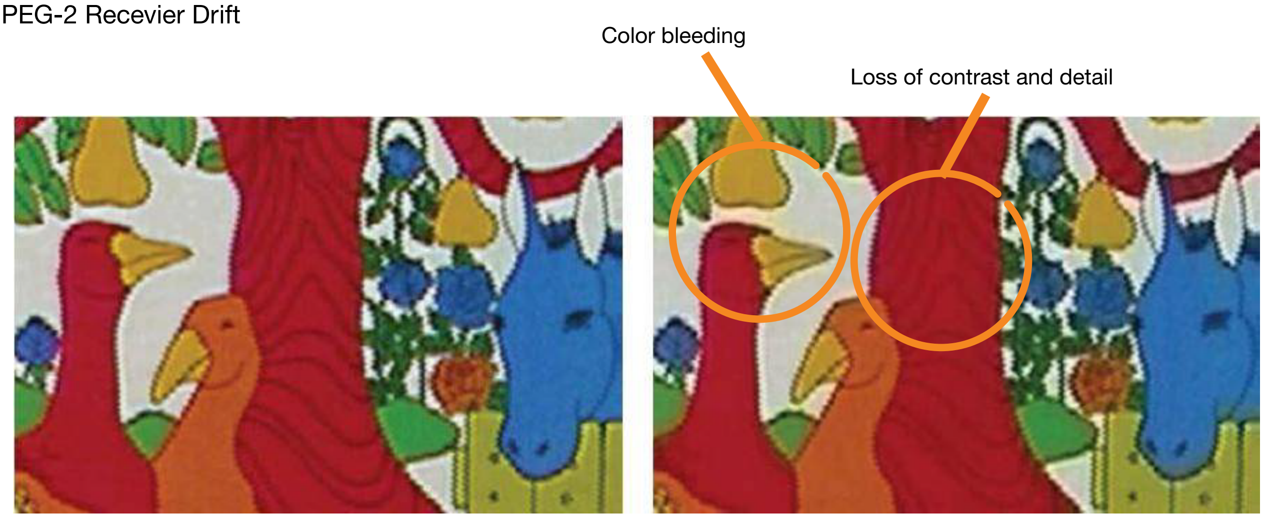
MPEG-2 4:2:0 video is particularly sensitive to "Receiver Drift" where successive encode – decode stages become affected by vertical colour bleeding. This phenomenon occurs because the MPEG-2 4:2:0 specification does not adequately define a mechanism to ensure complete alignment of chroma and luma samples over an encode – decode process. Over successive encode – decode stages these alignment errors can grow to a level where video quality noticeably deteriorates.



MPEG-4 AVC 4:2:0 includes mechanisms to limit the effect of Receiver Drift to ensure that multiple encode-decode stages are not as susceptible to chroma misalignment as older MPEG-2 systems.

The additional chroma resolution that 4:2:2 video provides is particularly valuable for Chroma Key work. In this application keying work performed on 4:2:0 video can result in very noticeable jagged edges on interface between the subject and the green screen background and subsequent overlaid image.

MPEG-2 Recevier Drift



Original

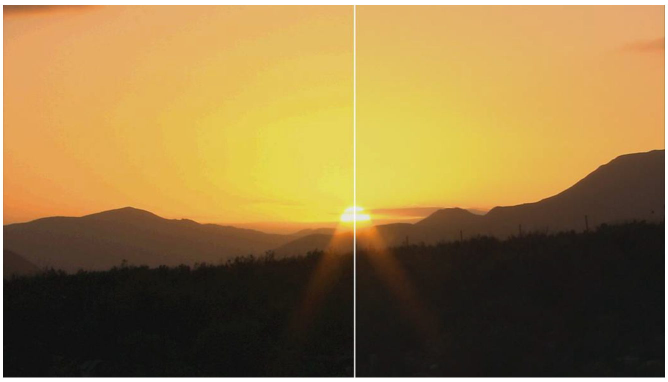
MPEG-2 4:2:0 after 4 encode-decodes

How MPEG-4 AVC 4:2:2 Improves on MPEG-2 4:2:2

The main headline benefit of MPEG-4 AVC compression over MPEG-2 has always been the bit rate saving that the more efficient MPEG-4 AVC compressions scheme offers. MPEG-4 AVC can offer up to a 50% reduction in bit rate compared to MPEG-2. This benefit holds true even for 4:2:2 video. There are however additional video quality improvements that MPEG-4 AVC provides for 4:2:2 chroma sampled video.

MPEG-4 AVC 4:2:2 and FRExt

As (HD) SDI is natively 4:2:2 with 10 bit precision, MPEG-4 AVC had been designed to offer compression modes that involve no down-sampling of pixel resolution. Clearly MPEG-4 AVC 4:2:2 offers equivalent chroma resolution to the 4:2:2 native SDI interface but additionally the MPEG-4 AVC specification allows for a 10 bit precision mode as a Fidelity Range Extension (FRExt). This 10 bit precision mode matches the precision of SDI and provides a useful video quality enhancement compared to 8 bit modes that are available.

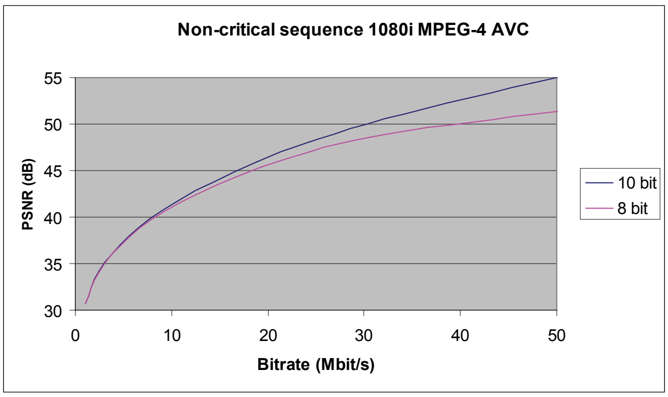


8 bit 10 bit

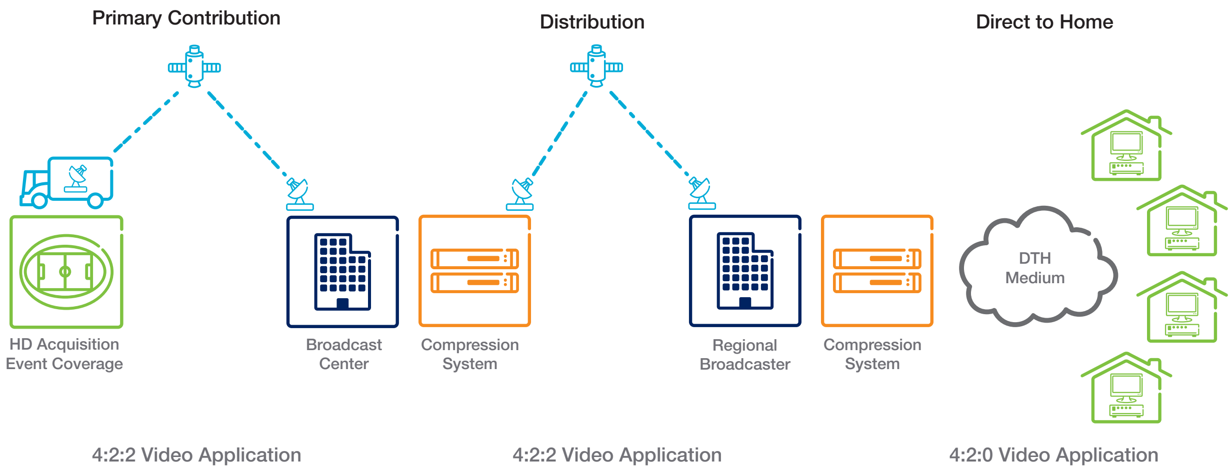
The loss of precision from 8 bit precision compression systems can be particularly noticeable on video sequences that contain areas of smooth graduation in luminance. In such situations posterization effects become noticeable showing discernable contours (or banding) around areas of similar luminance. This effect is more prominent in MPEG-4 AVC compared to MPEG-2 because DCT inaccuracy and mismatch control mechanisms in MPEG-2 work to introduce a certain amount of noise on the image acting to dither the edges of the contour bands and so hide the degradation that results from 8 bit precision.

Picture quality improvements for “Free”

Whilst most methods of improving video quality inherently lead to an increase in bit rate, employing 10 bit precision in MPEG-4 AVC 4:2:2 mode does not require any additional bit rate to deliver video quality enhancements. As 10 bit precision improves fidelity on areas of similar or slowly transitioning luminance, these sections of a video frame naturally occur in less challenging sequences (to the video compression algorithm). In challenging or “busy” sequences where there is more movement or high frequency detail present the 10 bit tool adds very little video quality enhancement as it gets quantized out in the encoding process.10 bit precision should therefore be used where ever possible as it can deliver increased video quality with no bit rate penalty for its use.



The Video Content Chain



When to Use MPEG-4 AVC 4:2:2

Ericsson offers a full range of equipment supporting all compression standards – MPEG-2, MPEG-4 AVC, 4:2:0 and 4:2:2 up to and including the very latest MPEG-4 AVC 4:2:2 10 bit precision through the Ericsson CE Contribution Encoder, Voyager II DSNG encoder and RX8200 Advanced Modular Receiver. With this flexibility on offer to the user it becomes important to understand which technology should be applied and when.

Primary Contribution applications which form the very start of the video content food chain provide the most obvious contender for 4:2:2 use - where that content will subsequently pass through multiple encode – decode stages, where it will be subject to post-processing and editing work.

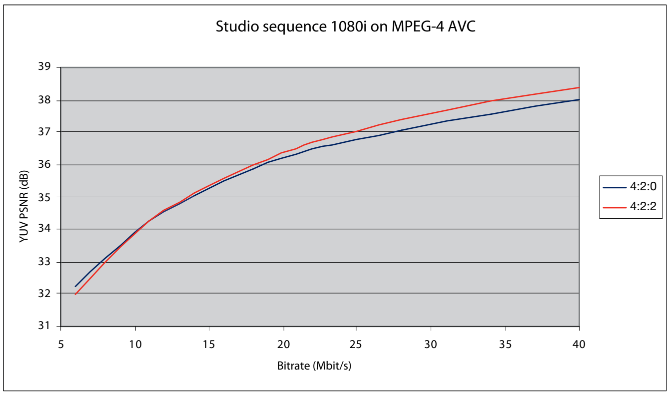
Distribution operations were often considered to be on the boundary of the 4:2:2 vs 4:2:0 choice because these broadcaster to broadcaster applications are often bit rate / bandwidth constrained applications. Because MPEG-4 AVC offers increased compression efficiency compared to legacy MPEG-2, MPEG-4 AVC 4:2:2 now falls within easy reach of these applications and should be actively considered. The improvements that MPEG-4 AVC 4:2:2 10 bit brings provide a compelling case for Distribution applications that require decoding back to baseband video at receive locations.

Final Direct to Home applications will of course stay as 4:2:0 applications because the receive equipment base neither demands such high quality video nor can withstand the cost of consumer 4:2:2 equipment deployment.

What Bit Rate for 4:2:2?

It is a near universal truth that no two video applications are the same and certainly every broadcaster has a different perceived threshold for video quality. It is therefore very difficult to make a hard recommendation for required bit rate to support a high quality 4:2:2 service - especially when taking into account the varying demands that different content puts on compression algorithms, where for example sports content can be more demanding than movie content.

However, Ericsson has performed some analysis on “typical” high definition video content to determine the bit rate threshold where MPEG-4 AVC 4:2:2 compression delivers a video quality improvement over MPEG-4 AVC 4:2:0. The video bit rate threshold where 4:2:2 compression out-performs 4:2:0 is lower than one might imagine. The below graph demonstrates that for bit rates as low as 12Mbps MPEG-4 AVC 4:2:2 delivers better video quality than MPEG-4 AVC 4:2:0.



One can take the information from the above graph and progress to making a rather general conclusion that MPEG-4 AVC 4:2:2 can be used to deploy compression systems that deliver good quality video (and certainly better quality video than MPEG-4 AVC 4:2:0 can achieve) at bit rates in the region of 20Mbps. For those demanding the ultimate in video quality then there is clearly a benefit in operating at data rates much higher but it is clear that MPEG-4 AVC 4:2:2 10 bit compression will always deliver superior quality video compared to older MPEG-2 4:2:2 technology.

Voyager II DSNG

RX8200 Advanced Modular Receiver

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