VITEC HEVC GEN2
ENCODING CORE

VITEC
VIDEO INNOVATIONS

White Paper

Table of Contents

1. ABSTRACT..2

2. INTRODUCTION..3

3. ENCODER DESCRIPTION...4

   3.1 BRIEF INTRODUCTION TO HEVC.......................................4

   3.2 THE BENEFITS OF HARDWARE-BASED ENCODING...................5

   3.3 VITEC GEN2: EXPLOITING ALL HEVC FEATURES......................5

   3.4 READY FOR NEXT-GENERATION APPLICATIONS......................8

4. QUALITY ASSESSMENT 9

   4.1 CODEC: RAW CODING EFFICIENCY STUDY..........................9

   4.2 ASSEMENT OF HEVC-BASED ENCODER PRODUCTS................11

5. CONCLUSION..20

6. REFERENCES..21

1. ABSTRACT

It has been four years since the prominent High Efficiency Video Coding (HEVC) standard was finalized. This new video compression standard, also called H.265, is rapidly being adopted by users from all industries with the goal of reducing bandwidth utilization required for various video applications and/or increasing video quality and resolution using existing network pipes previously used in conjunction with H.264/AVC video compression. Despite several success stories, the transition is not complete due to factors including licensing and infrastructure, as well as an expected additional gain in video quality and bandwidth efficiency by the market. After discussing these factors, this paper will introduce the new VITEC HEVC hardware encoding core, called GEN2, which has been designed to bring users the remaining expected improvement over H.264/AVC.

This white paper demonstrates the strong compression performance of the GEN2 encoding core, which features 20% higher efficiency when compared to the leading open source software encoder. The second section of this paper provides a detailed comparison, using common professional video quality assessment tools, between VITEC's flagship MGW Ace HEVC Encoder and other popular off-the-shelf HEVC encoding products in the market.

2. INTRODUCTION

After introduction of the VITEC GEN2 HEVC encoding core, the main goal of this document is to assess the video quality of various hardware HEVC encoders or ASICs available on the market. This assessment provides the foundation for an overview of the performance maturity of encoders today, four years after finalization of the HEVC standard.

This study is focused on live hardware encoders and consequently does not include software-based encoders. The criteria - particularly regarding latency and power consumption - are very different for software-based solutions, in part because software encoders target other types of applications. Nevertheless, the open source software encoder x265 has been included in the comparison to offer readers a known quality reference.

In the first edition, dated April 2017, the comparison includes the following technologies and products:

- High Model (HM) HEVC reference model (software)
- x265 (software)
- VITEC MGW Ace encoder using GEN2 from VITEC (VITEC algorithm on FPGA)
- VITEC MGW Vision encoder using M31 from Socionext (ASIC 28nm)
- Haivision Makito HEVC encoder (NGCodec algorithm on FPGA)
- Reference HEVC encoder from the broadcast field (algorithm on FPGA)

The assessment scope includes testing of both progressive and interlaced encoding modes as HEVC/H.265, being a highly flexible, cross-market codec that is being used in both modes in the field. While this paper uses HD resolutions in the tests, the results are expected to be applicable for UltraHD encoding using the same products and algorithms due to the hierarchical approach of the standard when creating UltraHD pictures.

In the coming months VITEC shall expand the study by adding additional encoding configurations as well as additional products to the test scope. New hardware-based HEVC encoders or ASICs also will be added as requests for measurement are received. Feel free to contact VITEC at **hevc@vitec.com** if you wish to participate in the next revision.

3. ENCODER DESCRIPTION

3.1. BRIEF INTRODUCTION TO HEVC

HEVC (High Efficiency Video Coding) is the latest video compression standard by ITU-T VCEG and ISO/IEC MPEG. Issued in January 2013, it was designed by companies and institutions that have been involved in video coding as part of the Joint Collaborative Team on Video Coding (JCT-VC) since 2010.

As widely presented [1], HEVC brings up to 50% bitrate savings at similar visual quality over its predecessor, H.264/AVC. This improvement comes incrementally from several tools including a smarter coding block structure, an increase of Intra-prediction modes, a better motion vector prediction and a new in-loop filter called Sample Adaptive Offset (SAO). These are reported in Figure-1, which shows an HEVC encoder scheme.

In addition to these tools, HEVC eases implementation with benefits such as a significantly better CABAC throughput, limiting of vertical block dependencies, simplifying of deblocking filter processing with a grid of 8x8 samples, instead of 4x4 in H.264/AVC, and by using a simple but adequate way to deal with interlaced content. The profile-handling simplification and the release of a Main 10 profile with 10-bit processing support in the first standard version [2] are two other great advantages of HEVC. This early Main 10 inclusion within the standard ensured wide support of 10-bit decoding in set-top boxes already in use today. As a result, the benefit of 10-bit should spread over several applications including entertainment TV, thereby yielding an enhanced video experience.

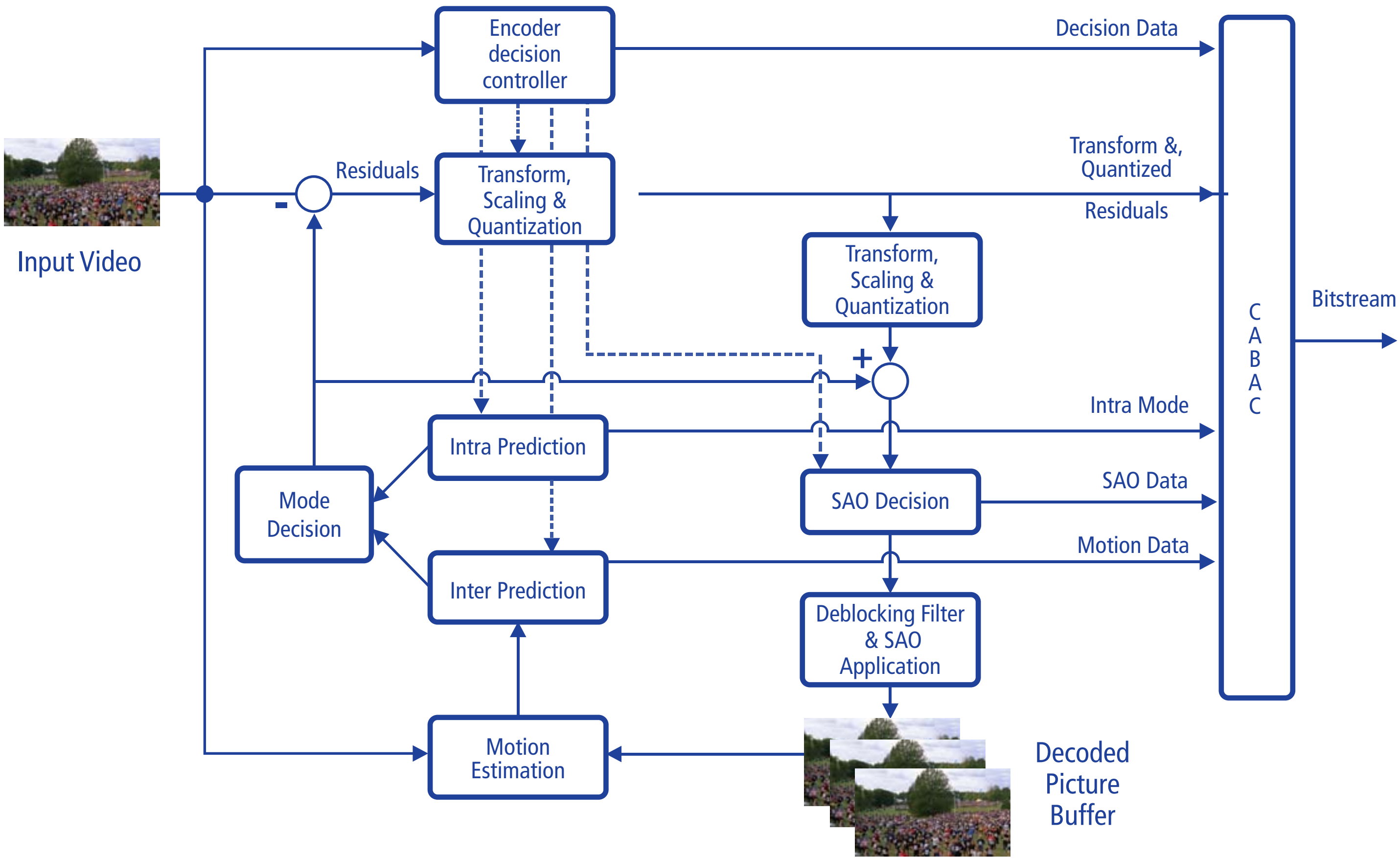

Figure-1. HEVC encoder scheme

HEVC adoption has gained traction slowly but surely since 2013. Most recent mobile devices and TVs natively support HEVC decoding, and new services based on HEVC are increasing, thanks to interest in UltraHD and the quest for a better video experience (HDR, HFR, etc.) and also to the continued desire for the reduction of video bandwidth utilization. Nevertheless, large-scale adoption has been hampered by patent instability, the progress of the earlier H.264/AVC encoder implementation and existing installations of equipment without HEVC support. Those points are not relevant, however, in markets such as point-to-point communications, in which HEVC immediately brought an effective improvement.

3.2. THE BENEFITS OF HARDWARE-BASED ENCODING

Another explanation for slow HEVC adoption is the limited quality of early encoder implementations. Those encoders were mainly software-based products, and they were challenged by HEVC’s complexity when attempting to perform live encoding of high video resolutions. To realize the full benefit of the HEVC standard, it is essential to evaluate several coding decisions among all the combinations proposed by HEVC. While performance has been logically improved during the past year, thanks to use of complex parallel computing architecture and to low-level code optimization (assembler), it remains limited. These limitations are revealed by a study of the preset configuration of the reference open-source HEVC software encoder, x265, which is used primarily in encoding products. The software encoder did not leverage all the relevant coding modes until its fifth speed preset, which is not relevant - lacking real-time encoding - for high-resolution live encoding on a classical blade architecture.

By releasing MGW Ace, the first fully hardware-based HEVC live encoding product in April 2015, VITEC laid the foundation for great encoding performance. With its second HEVC hardware codec generation VITEC leads the HEVC revolution by pushing the tools supported and the coding mode exploration capabilities to a level never before reached by a real-time hardware or software encoder. Thanks to the flexibility of FPGAs, the MGW Ace encoder can be upgraded to the GEN2 encoding core.

In addition to providing historic benefits, the hardware-based encoder implementation has become more and more flexible. For instance, within GEN2, VITEC has developed a smart and original way to leverage processing flexibility much like the way a software-based solution works. The goal of this feature is to enable full exploitation of hardware processing power capacity when dealing with resolutions and frame-rates below high encoder capacity. Consequently lowest resolutions benefit from an extra encoding performance while keeping the required performance.

3.3. VITEC GEN2: EXPLOITING ALL HEVC FEATURES

Built upon a comprehensive HEVC toolset with both smart and efficient searches for the best coding decisions, VITEC GEN2 is the most complete encoding core which addresses a diverse set of industries and applications. The various applications and use cases VITEC focuses on along with the specific technical challenges tackled with GEN2 are described in this section.

Live Broadcast and Contribution Applications

First, the encoder targets highest quality with 10-bit, 4:2:2 color sub-sampling support. Particular attention has been given to an efficient 10-bit implementation that takes advantage of this higher bit-depth. As reported in [3] -an average bitrate savings of 5% is achieved by use of the Main 10 profile rather than Main profile as well as several subjective improvements, such as banding reduction. Consequently, Main 10 is proposed by default in the different encoding configurations of MGW Ace. The HEVC scheme introduced in Figure-1 is represented in Figure-2 with all the enhancement modules required for a comprehensive professional encoder marked in red. These additional modules include rate control, adaptive quantization controller, pre-processing tools, and picture analysis such as detection of scene cut, fade and flash effects. Modules have been specifically designed and tuned for HEVC to achieve the best quality for any content type. The details of the R&D resources involved in VITEC's GEN2 project to develop a powerful encoder are also reported in Figure-2. The Hardware group focuses on HEVC processing functions (in blue) such as transform and motion compensation, while the Algorithms group (in green) is essential for achieving the best quality with the appropriate effort required in modules such as motion estimation and Intra predictor decisions.

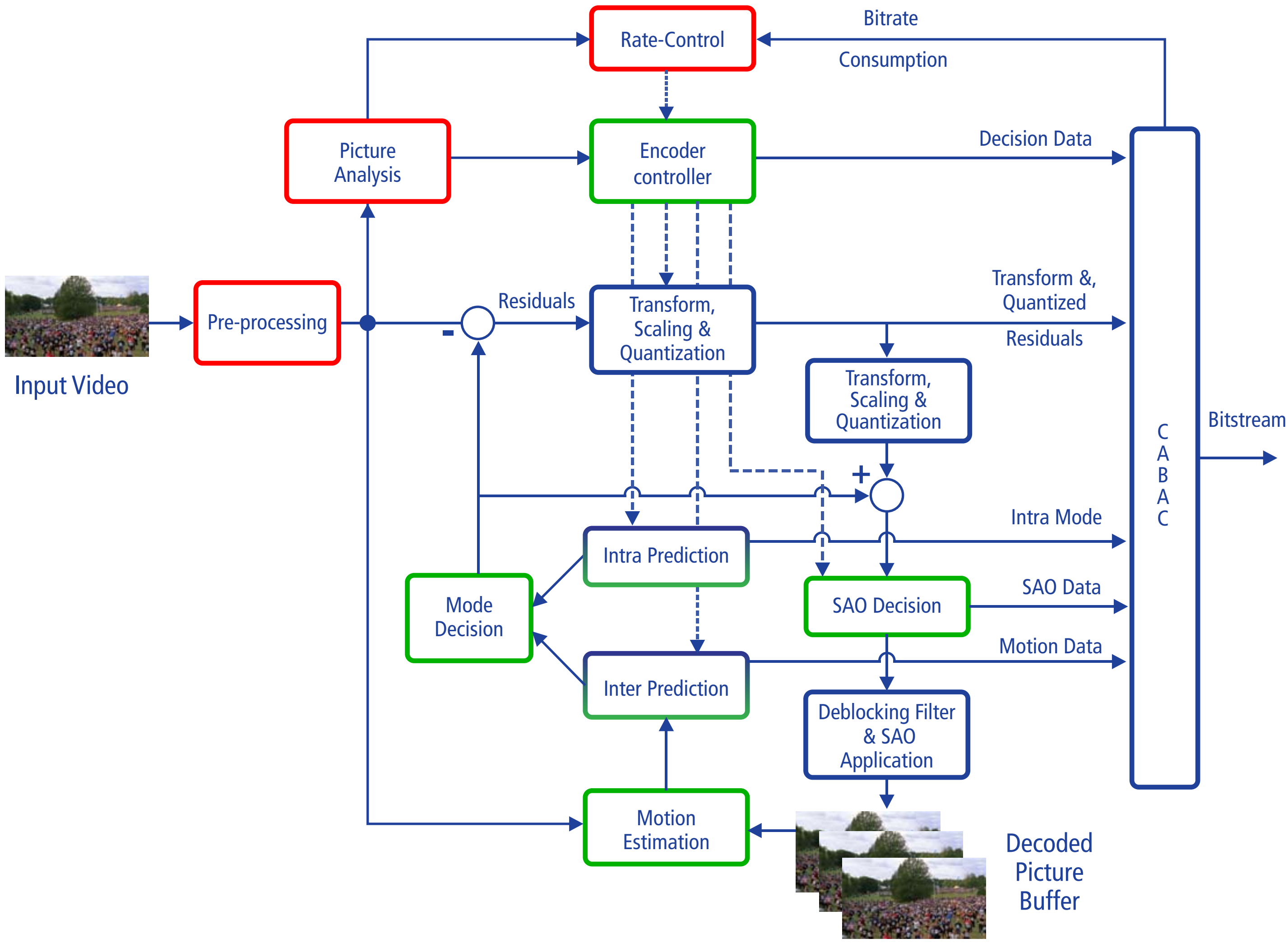

Figure-2. GEN2 HEVC encoding core scheme

The GEN2 encoding core is designed to encode progressive and interlaced content at the highest quality. Due to the fact interlaced footage is still dominant in the broadcast market, specific processing is used to encode each field with an adapted GOP structure. Using this technique, rather than frame-only-oriented encoding, it is possible to achieve better encoding performance for content such as Sports, known to include fast motion and complex scenes.

Streaming over Bandwidth Constraints Networks

The encoding core has been designed from the beginning to efficiently manage video compression at very low bitrates, in the range of 200Kbps to 1Mbps for HD resolutions. Several HEVC tools are particularly suitable for this bit-rate range. Specifically, a great deal of work was done on the HEVC standard to improve motion prediction and Inter mode without explicit transmission of motion vector data [4]. The exploitation of this coding mode, called Merge, which encompasses the high-value Skip mode, has been effectively utilized during the GEN2 codec development. This allows the encoder to avoid using an unsuitable picture skipping option when the bitrate becomes challenging relative to the content. In addition, features such as on-the-fly bitrate or resolution modification have been integrated to provide the user with all the tools necessary to perfectly adapt the encoding to its current available bandwidth.

In addition of the pure coding efficiency at high quantization parameters, rate control is a module critical for achieving relevant low bitrate encoding. For GEN2 core, the number of statistics computed to feed the rate control mechanism has been substantially increased to optimize bits consumption. As a result, VITEC's rate control mechanism prevents bitrate overflowing and effectively avoids highly degraded video quality during difficult scene changes or during transitions from simple to complex scenes.

Low Latency Streaming

For real-time applications, latency is critical. The VITEC GEN2 encoding core specifically targets ISR (INTELLIGENCE, SURVEILLANCE and RECONNAISSANCE) applications that typically require encoding latency under 200ms. Latency is a complex factor that involves the codec itself, the way the actual streaming is performed and the decoding device used. On the codec side, GEN2 has been designed with the flexibility to reduce the latency originated from algorithm cycles while preserving image quality. For encoding in CBR mode, a buffer delay is added due to the bigger size of Intra picture. To solve this issue, a constant picture size is generally used by spreading the Intra refresh over several Inter pictures. In VITEC GEN2, an enhanced intra refresh technique has been developed.

Special attention has been given to improving low-latency coding performance. For instance, in low-latency scenarios the prediction from future pictures is usually avoided in order to remove the additional delay caused by picture re-ordering. In H.264/AVC, this results in the use only of I and P pictures, the B picture's efficiency is consequently lost. In HEVC, the concept of generalized P and B pictures (GPB) has been introduced to improve the coding efficiency of low-latency encoding. The P pictures are coded as B with only past pictures as reference. Consequently, the prediction is enhanced by using bi-prediction between two different references in the past or within the same reference to simulate motion compensation at the precision of 1/8 pixel. The impact on coding efficiency depends on the sequence, but it can reach up to 5% on specific content with slow motion. GPB is one of the enhancements of low-latency encoding used in GEN2 core. This enhancement is also used to replace P pictures in hierarchical IBP configurations for improving video quality in high video quality configurations.

Error Resiliency

By dividing the bitrate by two, HEVC increases the vulnerability of the streaming on unreliable networks. Because the bitrate is smaller than with H.264/AVC, a loss of packets or an error in the stream has a bigger impact on the decoding side. Consequently, several mechanisms and dedicated tools are included in the GEN2 encoding core to improve error resiliency. Three error-resiliency setups are defined with a progressive compromise between robustness and impact on the coding efficiency. Basically, the idea is to reduce the temporal dependencies in the encoded stream to allow for fast picture recovery in the event of packet corruption or loss.

3.4. READY FOR NEXT-GENERATION APPLICATIONS

In addition to doing significant GEN2 design and development work, VITEC is constantly looking for further quality enhancement in optimizations needed for supporting future applications.

The GEN2 encoding core is available in MGW Ace with encoding resolutions of up to 1080p60. It has been designed from the beginning to be scaled for 4K support in the near future. To preserve coding efficiency, the 4K support is expected to be achieved without the help of Tiles. Regarding the improvement of dedicated Ultra HD algorithms, next 4K encoding core will take advantage of the work done by VITEC within the awarded European collaborative project UltraHD-4U[5]. Further resolutions (8K) and frame rate (HFR) challenges will be then tackled through a combination of GEN2 encoding cores.

On top of the resolution growth, the current quest for a higher-quality user experience is being driven by the High Dynamic Range (HDR) revolution. By supporting 10-bit since the beginning, the VITEC compression solution is ready for HDR integration. Due to the multiple HDR formats currently defined (HDR10, HLG, Dolby Vision and SL-HDR1), HDR support becomes especially complex with respect to format conversion along the video chain. This is being studied by the VITEC's research team within the French collaborative project PLEIN PHARE [6] in addition to algorithmic work on fine optimization of the codec for HDR coding. In particular, it has been demonstrated that chrominance and dark areas require specific processing during encoding of HDR content.

Finally, efficient support of VR and 360 applications is achievable within the current GEN2 architecture. In fact, the motion-constrained Tile required for these applications have already been developed.

4. QUALITY ASSESSMENT

The quality assessment of the encoder is divided to two sections. The raw coding efficiency of the GEN2 encoding core is first evaluated to measure the intrinsic quality of the HEVC implementation. Then, the full encoder quality is studied in a live scenario with a comprehensive comparison with HEVC encoders available in the market.

4.1. CODEC: RAW CODING EFFICIENCY STUDY

Evaluation Description

This first evaluation is achieved using 20 standard sequences and common JCT-VC test conditions used during the HEVC standardization process [7]. The Main 10 profile is used to focus on a high quality scenario. A performance comparison using a bit-depth of 8 in Main profile provides almost identical results.

The test is performed using a fixed quantization parameter (QP) ranging from 22 to 37 with a step of 5. Due to the fact bitrate produced by each encoder does not necessarily match the reference bitrate, the QPs used for a given encoder were accordingly modified to ensure a apples-to-apples comparison. With respect to the GOP structure and size, the RA-Main10 structure has been selected with a hierarchical B structure of size 8 to aim at the goal of highest video quality possible.

The aim is to measure the raw difference in coding efficiency with the reference HEVC model (HM) developed during the standardization process to demonstrate the full HEVC capacity. Due to the fact hardware encoders in the market are not adapted for such test due to lack of granularity in configuring parameters, they are not included in this evaluation. Nevertheless, in order to provide a baseline comparison point, the widely adopted x265 has been included. The x265 is an open-source software reference implementation of HEVC that is integrated in various commercial products. Two x265 speed presets relevant for live HD encoding have been tested. Since the metric used is PSNR, x265 is tuned for that metric to be fair. The four HEVC versions used for this test and their configurations are defined below:

- **VITEC GEN2:** the second generation of VITEC HEVC encoding core described in this white paper. The encoder is configured to match HM configuration.
- **HM:** the reference HEVC model, HM 16.14 [8].
- **x265 Medium:** the x265 version 2.2 is used with preset Medium (2.2+22-20217c8af8ac). The full command line template is as follows:
  "--input source.yuv --input-depth 10 --input-res WxH --frames N --input-csp i420 --fps F --profile main10 --preset medium --output output.265 --recon reconstructed.yuv --qp 22 -I 32 --bframes 7 --b-adapt 0 --psnr --tune psnr --csv test.txt"
- **x265 Very Fast:** the x265 version 2.2 is used with preset VeryFast (2.2+22-20217c8af8ac). The full command line template is as follows:
  "--input source.yuv --input-depth 10 --input-res WxH --frames N --input-csp i420 --fps F --profile main10 --preset veryfast --output output.265 --recon reconstructed.yuv --qp 22 -I 32 --bframes 7 --b-adapt 0 --psnr --tune psnr --csv test.txt"

Results

The results are computed using Bjontegaard metric [9], which delivers the percentage bitrate savings at the same quality (PSNR) for the GEN2 encoding core vs. each tested encoder. Negative result (-X%) means the GEN2 encoder required X% lower bandwidth of the tested encoder bitrate for the same quality, while positive result (+X%) means the GEN2 encoder required X% higher bandwidth of the tested encoder bitrate for the same quality. The results are reported for each component (Y, U, V) and are presented according to JCT-VC rules for each class of resolution. The detailed results by sequence are provided for Class B sequences in Luma only (Figure-3) in order to limit the amount of data and keep this document reader-friendly. Full results are available upon request.

As expected for this test, the HM reference software is more efficient than GEN2 and x265. This is due to the implementation simplifications chosen to match specific constraints such as live encoding, size or power consumption. The HM software has been designed to demonstrate the capabilities of the full standard, but not all the tools are usable in a portable, real-time encoder product. HM is consequently a slow, non-real-time encoder. For example, 600 times real time is needed to encode a 1080p sequence at QP 32 on an Intel core i-7 3.60GHz computer.

Among the tested encoders, VITEC GEN2 is the closest to HM performance, regardless of the resolution used, with 20.1% higher bandwidth utilization when compared to HM in Luma component. This is a significant achievement for a live encoder, while the second-ranking encoder (x265 Medium) required 38.0% higher bandwidth than HM to reach same video quality. When comparing VITEC GEN2 with x265 Medium, the average coding efficiency of VITEC GEN2 is respectively equal to -12.7%, -14.6% and -13.7% in Y, U and V component. Moreover, when compared with the x265 VeryFast preset, which is actually better suited for live HD streaming scenario than x265 Medium, the improvement is significantly higher for GEN2 with 19.7% lower bandwidth utilization at same video quality.

Another observation derived during this assessment is that the performance of the tested encoders against HM increases as the resolution increases. The losses are indeed smaller for Class A, B and E, respectively, compared to Class C and D. This originates from the design of the encoding core, which mainly targets higher resolutions to match the HEVC target applications. Additionally, smaller block sizes are more applicable for these high resolutions and its processing is more streamlined vs. larger block sizes due to the high latency loop constraint for smaller block sizes.

	HM			x265 Medium			x265 Very Fast		
	Y	U	V	Y	U	V	Y	U	V
Class A 4K	+10.1%	+29.9%	+33.3%	-11.5%	-17.2%	-13.4%	-17.2%	-19.1%	-16.6%
Class B 1080p	+16.9%	+16.9%	+15.7%	-14.5%	-17.0%	-14.7%	-24.4%	-19.8%	-17.5%
Class C WVGA	+26.7%	+29.3%	+30.4%	-13.2%	-16.2%	-16.4%	-21.0%	-19.4%	-20.0%
Class D WQVGA	+29.6%	+29.5%	+30.2%	-11.6%	-9.8%	-9.9%	-20.5%	-11.5%	-12.4%
Class E 720p	+17.4%	+11.3%	+13.1%	-12.5%	-12.8%	-13.9%	-15.4%	-9.4%	-10.4%
Average	**+20.1%**	**+23.4%**	**+24.6%**	**-12.7%**	**-14.6%**	**-13.7%**	**-19.7%**	**-15.9%**	**-15.4%**

Table-1. Bandwidth utilization required at same video quality (PSNR based) between VITEC's GEN2 and other tested HEVC encoders. RA-Main 10 configuration.

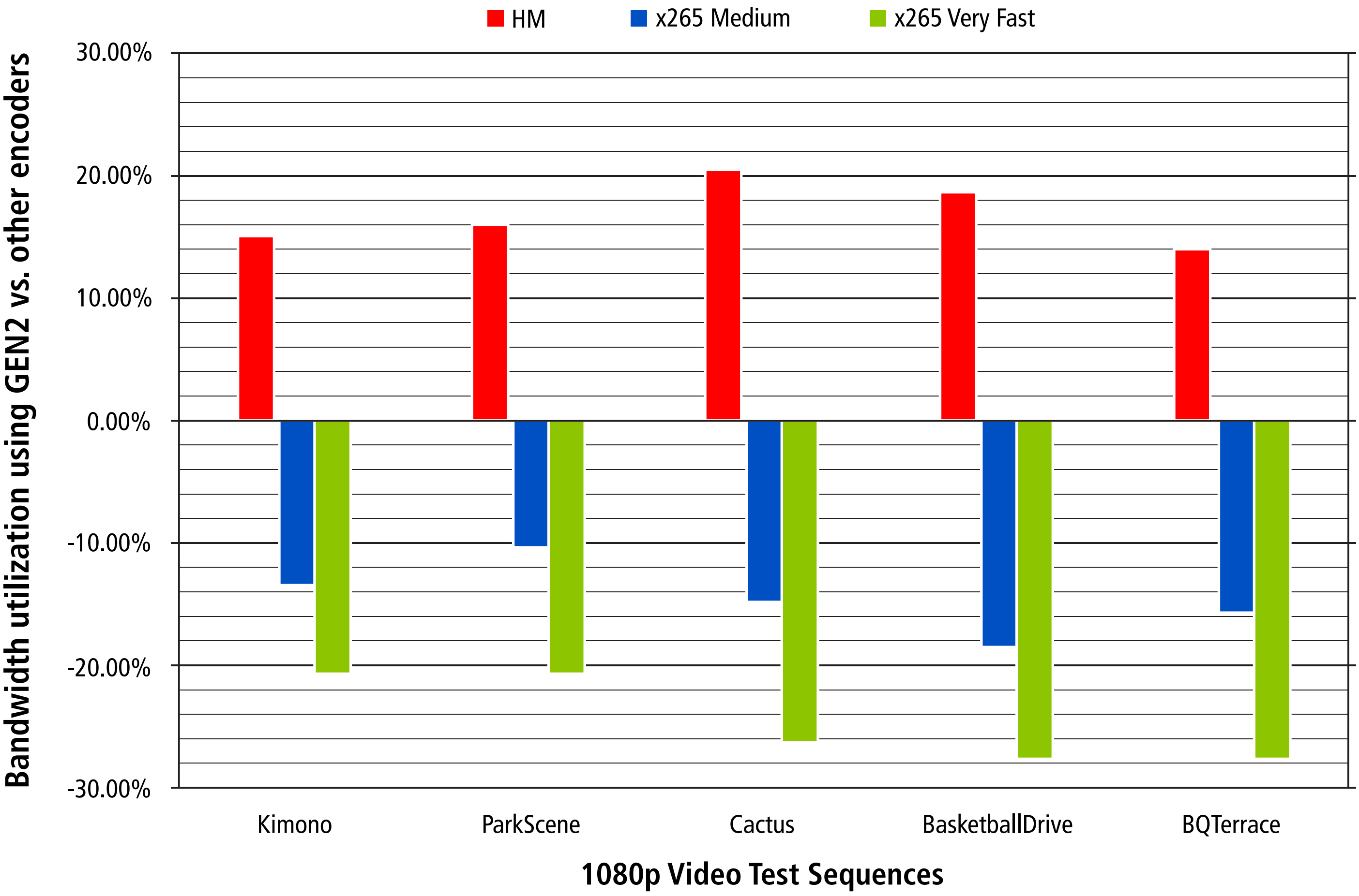

Figure-3. Bandwidth utilization required at same video quality (PSNR based) between VITEC's GEN2 and other tested HEVC encoders for the five 1080p Video Test Sequences. RA-Main 10 configuration.

4.2. ASSEMENT OF HEVC-BASED ENCODER PRODUCTS

Test Description

The second set of tests is designed to assess performance in real-life streaming applications using CBR rate-control. The goal is to compare the quality achieved by live HEVC encoders involving their encoding core and all their additional features such as pre-processing, rate control, frame type decision and adaptive quantization.

The assessment of a live encoder product is a complex task because it is difficult to ensure a fair comparison as opposed to what's possible with a command line controlled codec. For instance, it is hard to produce all the compared streams with aligned GOP or with comparable rate control behavior. The test protocol and each encoder configuration have consequently been done as accurately as possible to what encoder users could use for their own benchmarks.

The test protocol used is as follows:

- ➜ Generate test sequence in AVI format from YUV source.
- ➜ Play out the sequence in a loop with a playback card (BlackMagic Decklink 4K extreme 12G) using HDMI or SDI output.
- ➜ Feed the tested encoder with this source (SDI or HDMI, depending on the encoder input available).
- ➜ Stream using the encoder for a given configuration.
- ➜ Capture the stream with the encoder's own video recording capability or using an external tool. (WireShark has been used.)
- ➜ Extract elementary stream and generate 10 reconstructed YUV sequences from the captured stream.
- ➜ Compute the quality metric for each reconstructed sequence compared with the source and document the metric results. For this first version of the benchmark, an overall YUV-PSNR is used: each Y pixel count as a U or V pixel along the sequence.
- ➜ Compute the averaged metric after removing the two extreme points (minimal and maximal) in order to ignore non-relevant measures.
- ➜ Compute the actual bitrate from the elementary stream itself.

With respect to encoder configuration: Due to the fact the tested encoders do not offer the same capabilities and/or controls - a common baseline configuration was identified. For this test, Main profile is used with an Intra period of one second and bitrate ranging from 2Mbps/s to 8Mbps/s, except for the ISR sequence, where smaller bitrates from 500kbps to 8Mbps are used. The GOP structure is configured to the best of each encoder capability except for the ISR test, where a lower-latency configuration is selected. The tested encoders are listed below:

- **VITEC GEN2:** VITEC MGW Ace encoder using the second generation of VITEC HEVC encoding core described in this white paper. The encoder is configured using the profile ISR - Low bandwidth for ISR test and the profile Broadcast - Broadband otherwise.

- **Encoder A:** Haivision Makito X HEVC, using NG Codec technology, firmware version 2.1.0-35. The encoder is configured with its high quality parameters, using IP GOP structure and with the Partial Image Skip option disabled in order to avoid frame-dropping.

- **Encoder B:** VITEC MGW Vision encoder using Socionext M31 ASIC (version 2.0.0.6992). The encoder is configured with IB GOP structure and a pyramid of 7 B Frames in Open GOP.

- **Encoder C:** Reference HEVC encoder from the broadcast field using proprietary technology. The encoder is configured with High Quality preset with a pyramid of 7 B frames in Open GOP.

With respect to video test content: five sequences are used to cover several applications. Since the goal is to evaluate the encoder in field-like conditions, long sequences with several scene changes and featuring various complexities have been selected. The tested sequences are described below:

- **ISR 720p60:** This sequence resolution is 1280x720 pixels at a frame rate of 60 in progressive format that includes 6240 pictures. It is a concatenation of seven typical ISR scenes including fast-moving camera, high noise scene captured in low luminosity condition and with overlay white text. Because this sequence targets a very specific application, the tested encoders have been configured without reordering pictures in order to limit the latency and to make it comparable to one another. Also, because Encoder 5 mainly targets broadcast applications, it has not been tested for this content. Encoder 3 is used instead.

- **SVT 1080p50:** This sequence resolution is 1920x1080 pixels at a frame rate of 50 in progressive format that includes 500 pictures. It is a concatenation of the well-known SVT sequence [10]: CrowdRun, ParkJoy, DucksTakeOff, IntoTree and OldTownCross. This sequence is a challenging sequence featuring complex content with high motion followed by two easier scenes.
  For this sequence and the following ones, the tested encoders are configured with their High Quality settings.

- **TRAILER 720p60:** This sequence resolution is 1280x720 pixels at a frame rate of 60 in progressive format that includes 2001 pictures. It is a trailer of a typical movie content with nature scenery, action scenes and fast motion sequences that has been adapted to 60 fps by using frame doubling of one picture to two. This sequence is relevant for stressing the encoder rate control due to the multiple scene changes and the frame doubling. The coding efficiency is also challenged by the many dark scenes.

- **NEWS 1080i60:** This sequence resolution is 1920x1080 pixels at a frame rate of 59.97 in interlace format that includes 1001 pictures. The sequence is relevant to cover frame-based encoding interlace content featuring talking-heads sequence with additional overlays.

- **SPORTS 1080i60:** This sequence resolution is 1920x1080 at a frame rate of 59.97 in interlace format that includes 300 pictures. It is a challenging sports sequence with several fixed and moving overlays, as well as camera panning and zooming.

Results

The results are reported in Figures 4 to 8 as rate distortion curves for each tested sequence. The GEN2 encoding core is significantly better for each tested scenario, confirming the great coding efficiency assessment of previous section. The associated bandwidth savings are reported in Table-2, and are computed in the same way as in the first evaluation. GEN2 requires 29.7% less bandwidth than the second best encoder (Encoder B) on average for the tested sequences.

As widely accepted by various experts in the video compression community and advocated by encoding and streaming vendors including VITEC - objective metric doesn't necessarily always represent the reality of subjective assessment but they provide a relevant trend. In a visual comparison of all encoded sequences the same ranking is maintained, while the differences perceived are generally a bit smaller, in particular for Encoder C.

Some specific comments can be made on the results. The sequence “TRAILER 720p60” has duplicated pictures and Encoder A benefits from its IP only GOP structure. Encoder B gains benefits by using only frame-oriented encoding in the sequence “NEWS 1080i60” to have smaller losses on this specific content. Finally, on interlaced sequences, the low performances of Encoder C can be partially explained because it uses half the B pattern size compared to Encoder B or GEN2.

	Encoder A	Encoder B	Encoder C
ISR 720p60	-17.8%	-47.4%	-42.1%
SVT 1080p50	-44.4%	-23.8%	-37.2%
TRAILER 720p60	-19.9%	-27.2%	-39.9%
NEWS 1080i60	-31.4%	-16.0%	-49.7%
SPORTS 1080i60	-44.5%	-34.0%	-63.3%
Average	**-31.6%**	**-29.7%**	**-46.5%**

Table-2. Bandwidth utilization required at same video quality (YUV-PSNR based) between VITEC's GEN2 and other commercially available HEVC encoders.

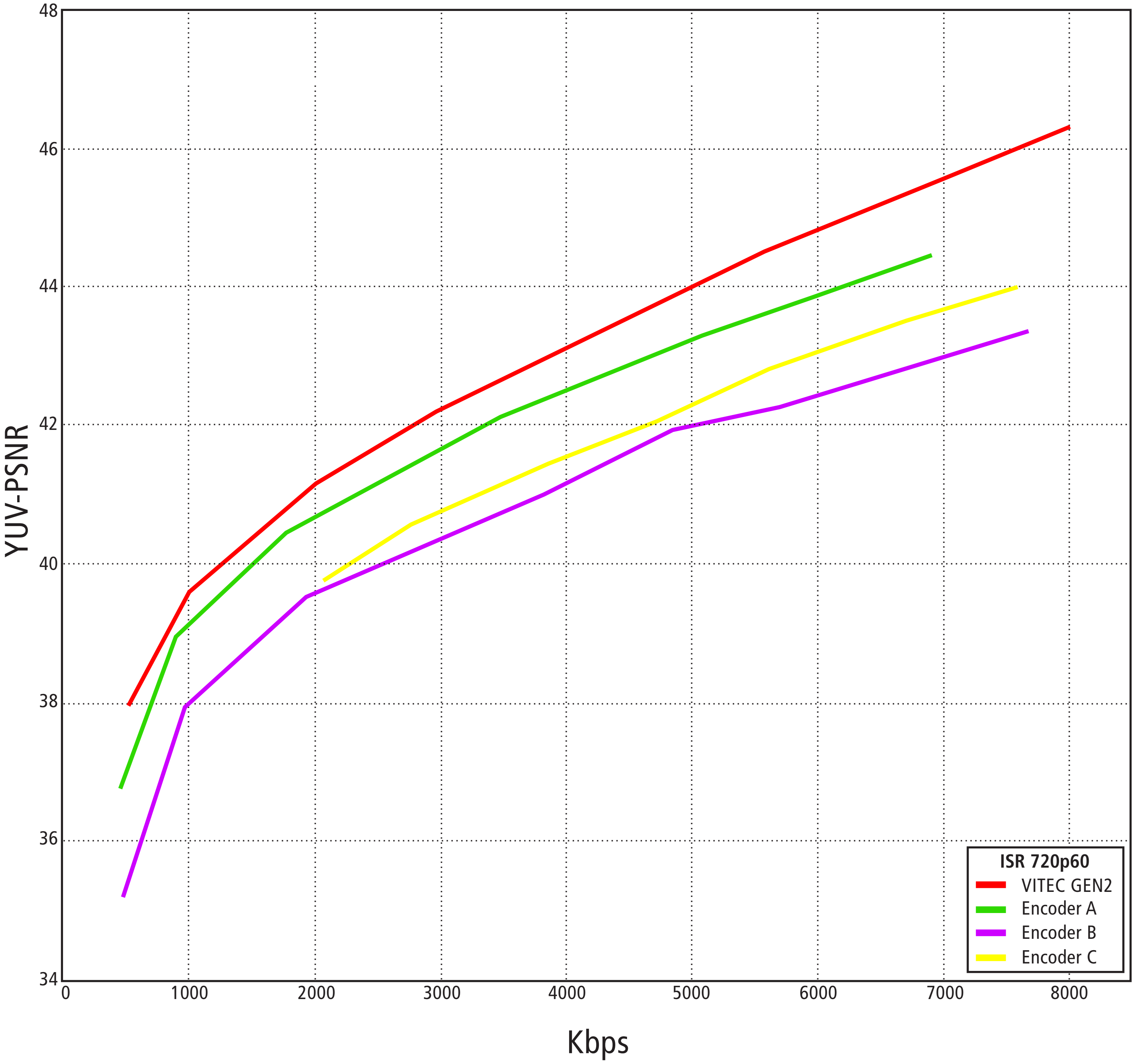

Figure-4. Rate-distortion curve for ISR 720p60 sequence (higher is better)

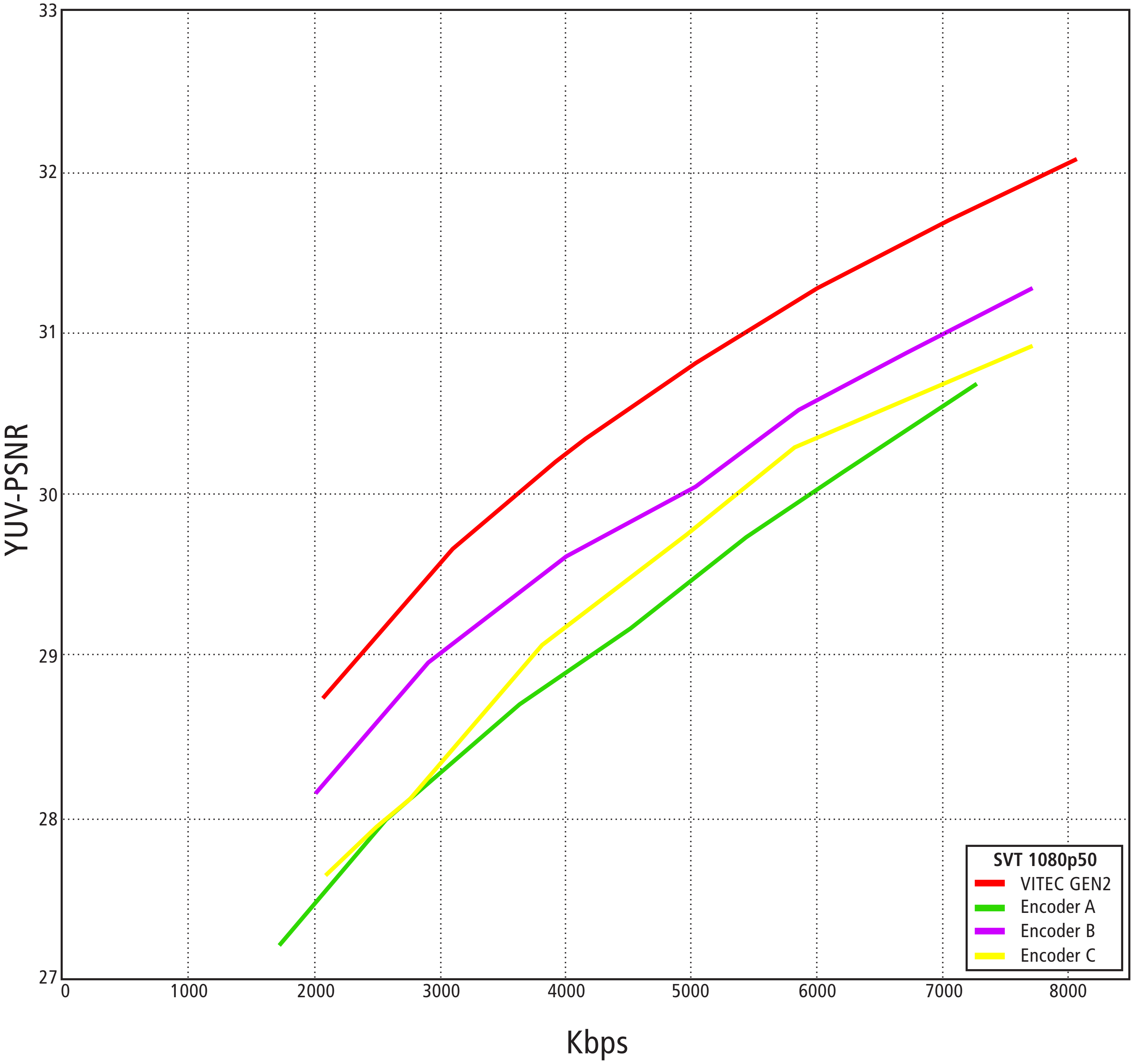

Figure-5. Rate-distortion curve for SVT 1080p50 sequence (higher is better)

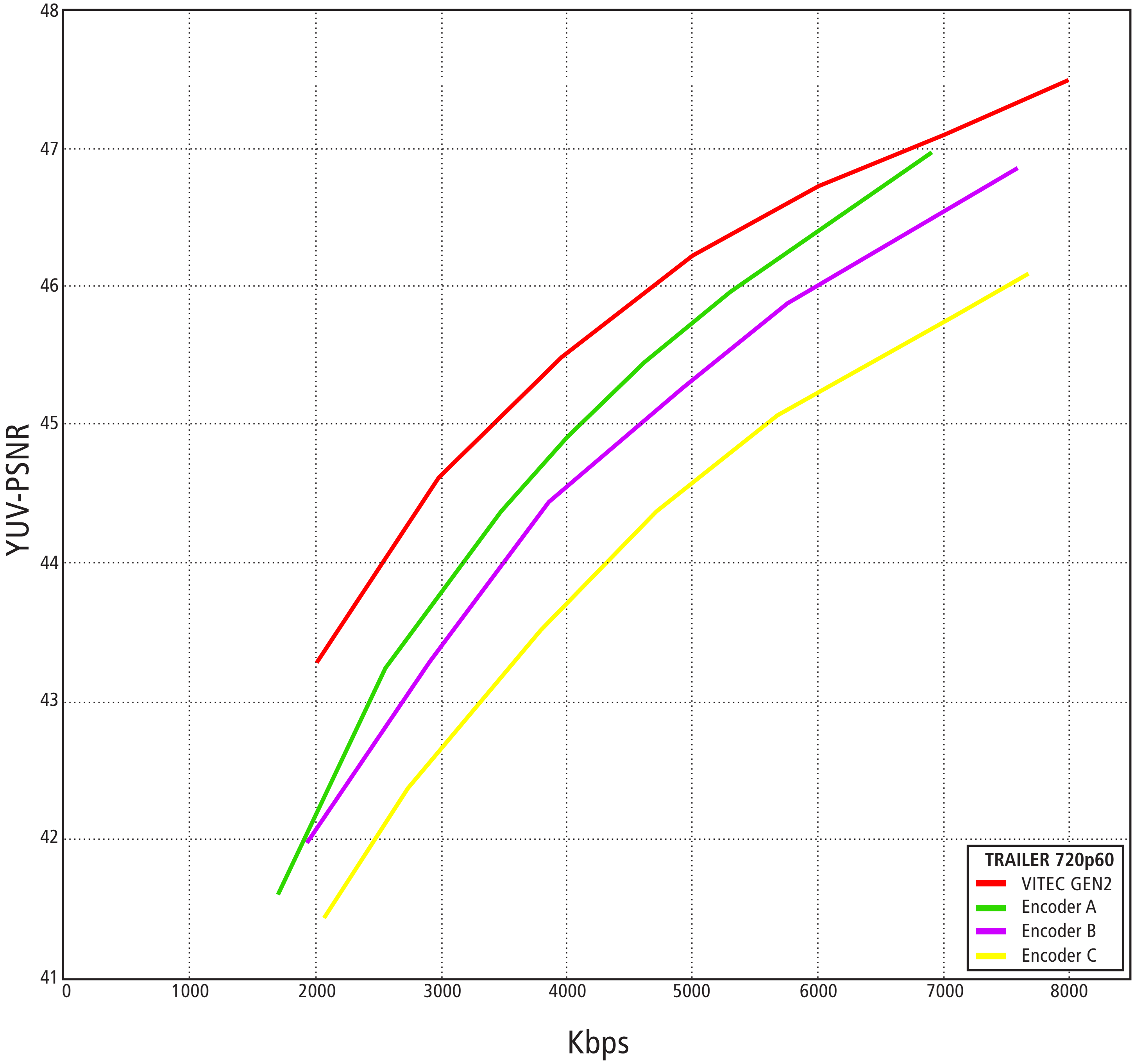

Figure-6. Rate-distortion curve for TRAILER 720p60 sequence (higher is better)

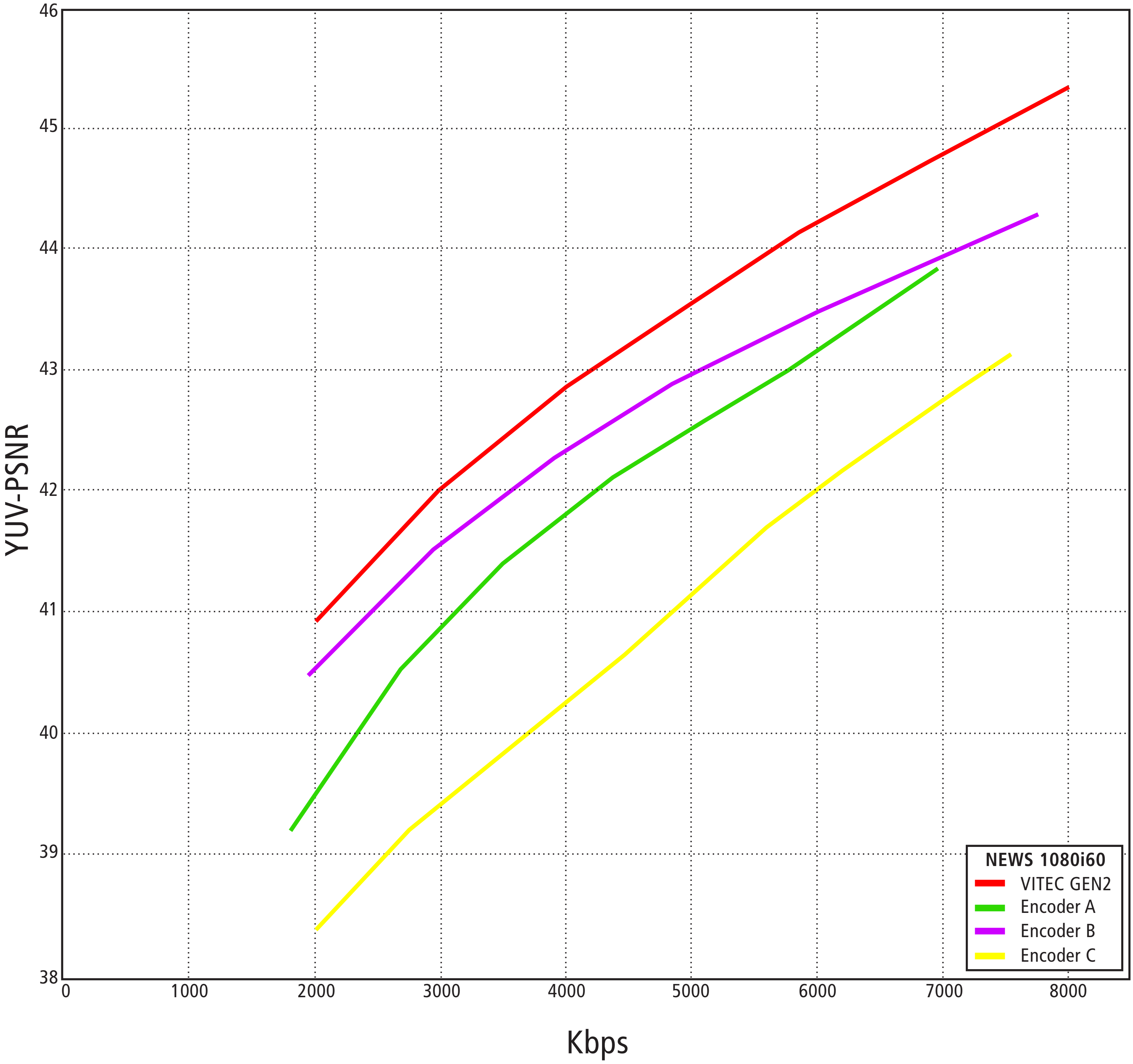

Figure-7. Rate-distortion curve for NEWS 1080i60 sequence (higher is better)

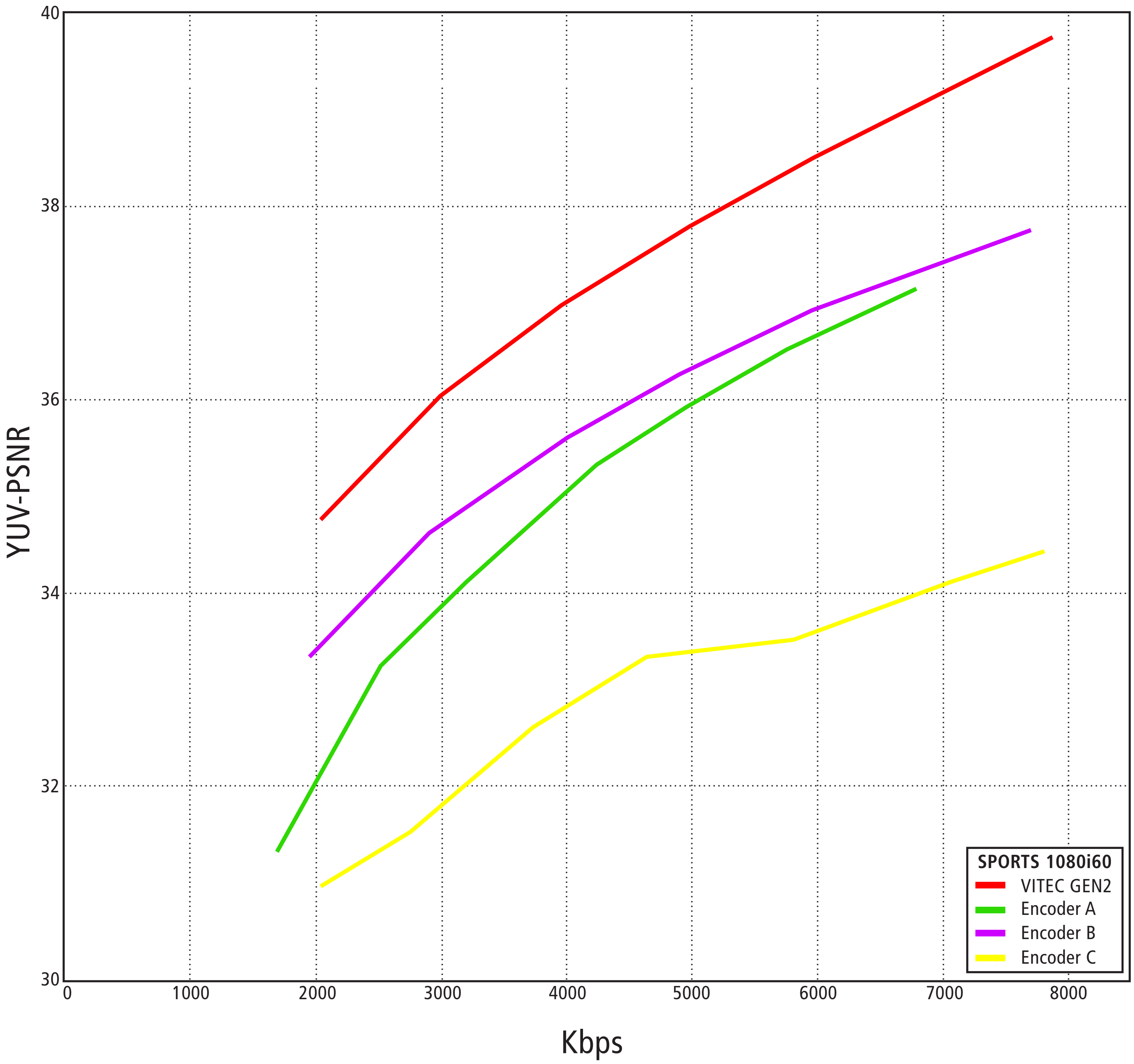

Figure-8. Rate-distortion curve for SPORTS 1080i60 sequence (higher is better)

5. CONCLUSION

This paper introduces the VITEC's GEN2 HEVC encoding core, which is a second-generation hardware-based encoder designed to support an optimal set of HEVC tools associated with smart processing. This new generation of HEVC compression technology sets a higher standard than ever before for real-time HEVC Encoding compared to all commercially available encoders available to date. The HEVC standard has significantly increased in complexity to reach the anticipated improvement vs. H.264/AVC, and earlier implementations are still limited when evaluated against the best H.264/AVC encoders. Despite rapid progress in this domain in recent years, software-based encoding remains constrained in taking full advantage of HEVC tools. Hardware-based encoders already available have been designed with high power consumption or cost constraints and consequently are facing similar limitations. With the GEN2 encoding core, however, VITEC accomplishes a significant milestone for HEVC encoding and is making the technology suitable for an even broader range of applications.

The encoding core has been evaluated with respect to both its intrinsic coding efficiency and in real-world conditions when integrated within the MGW Ace encoder appliance. Regarding the first assessment, strong rough compression performance of the GEN2 encoding core has been demonstrated with 20% higher bandwidth savings compared to the leading open-source software encoder. The second benchmark confirms the higher efficiency of GEN2 encoder implemented in the VITEC’s MGW Ace product when compared against other hardware-based HEVC encoder products available on the market.

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