



Quadra Video Quality Report

QUADRA RELEASE 5.2.0

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1. Document Outline

This document presents the quality evaluation results for NETINT's family of Quadra products.

Quadra is evaluated using various settings in AcopVC, HEVC, and AV1 codecs. The results are compared against x264 and x265, Nvidia's H.264 and H.265 hardware encoder, and the SVT-AV1 software encoder, these being used as anchors. Target bit rates in these tests were 1, 3, 5, 7 and 10 Mbps.

2. Evaluation Results

The quality performance of Quadra uses the following datasets:

- **NETINT's QuadraBringUpFILM dataset**
 - YUV 4:2:0 sequences
 - Resolution: 1080p
 - Frame rate: 25 and 50 FPS
- **NETINT's VITS2021SmallSet:**
 - YUV 4:2:0 sequences
 - Resolution: 2160p
 - Frame rate: 30 and 60 FPS
- **NETINT's QuadraBringUpCGI:**
 - YUV 4:2:0 sequences
 - Resolution: 1080p
 - Frame rate: 60 FPS
- **NETINT's QuadraSimpleGaming:**
 - YUV 4:2:0 sequences
 - Resolution: 720p
 - Frame rate: 60 FPS

Quadra is evaluated using x264, x265, SVT-AV1, and FFmpeg with dual pass and low latency configurations. To help replicate these results and for references, the following versions are used:

- x264: Version 0.152.2854 e9a5903
- x265: Version 3.5+1-f0c1022b6
- FFmpeg: Version 4.3.1-static
- SVT-AV1 v1.2
- NVIDIA-SMI 515.65.01, Driver Version: 515.65.01, CUDA Version: 11.7

2.1. High Quality Dual Pass Configuration

Dual pass configuration uses QuadraBringUpFILM and VITS2021SmaSet datasets. Anchors are created with the following commands:

- **x264/x265**
x264 --tune psnr --aq-mode 0 --no-scenecut --bframes 3 --b-adapt 0 --rc-lookahead 16 --input-res 1920x1080 --fps 50.0 --bitrate 5833 --vbv-buFSIZE 11666 --keyint 100 --min-keyint 100 --preset fast --frames 500 -o [path to output file] [path to source file]
- **Nvidia**
ffmpeg_nvidia -y -vsync 0 -hwaccel cuda -s:v 1920x1080 -r 25.0 -i [path to source file] -c:v h264_nvenc -pix_fmt yuv420p -preset p4 -rc cbr -bufsize [buffer size] -tune hq -bf 3 -b_ref_mode middle -b_adapt 0 -rc-lookahead 15 -vsync 0 -b_qfactor 1 -spatial-aq 0 -temporal-aq 0 -b:v 32708333 -maxrate 32708333 -minrate 32708333 -profile:v high -g 50.0 -spatial-aq 0 -temporal-aq 1 -vsync 0 -vframes 690 [path to output file]

NOTE - *buffer size* varies depending on the bitrate: $\text{buffer size} = (2 * \text{bitrate} / 1000)K$
- **SVT-AV1**
SvtAv1EncApp --rc 1 --preset 10 --keyint 50 -w 1920 -h 1080 --tbr 32708 --lookahead 16 --passes 2 --lp 1 --fps 25.0 -n 690 -b [path to output file] -i [path to source file]

Sequences used to compare to the anchors are generated using the following commands:

- **RDOQ enabled**
FFmpeg -y -vsync 0 -s 3840x2160 -r 60.0 -i [path to source file] -c:v av1_ni_quadra_enc -xcodec-params level=0:frameRate=60:RcEnable=1:vbvBufferSize=2000:bitrate=8000000:intraPeriod=120:gopPresetIdx=-1:entropyCodingMode=1:lookaheadDepth=16:cuLevelRCEnable=0:rdoLevel=3:EnableRdoQuant=1 -vframes 600 [path to output file]
- **RDOQ disabled**
FFmpeg -y -vsync 0 -s 3840x2160 -r 60.0 -i [path to source file] -c:v av1_ni_quadra_enc -xcodec-params level=0:frameRate=60:RcEnable=1:vbvBufferSize=2000:bitrate=8000000:intraPeriod=120:gopPresetIdx=-1:entropyCodingMode=1:lookaheadDepth=16:cuLevelRCEnable=0:rdoLevel=3:EnableRdoQuant=0 -vframes 600 [path to output file]

2.1.1. High Quality Dual Pass Results

Quadra H.264 compared against x264 presets and Nvidia H.264.

Quadra H.265 compared against x265 presets and Nvidia H.265.

Quadra AV1 compared against x265 presets and SVT AV1 Preset 10 and 12.

High Quality Dual Pass test uses QuadraBringUpFILM and VITS2021SmallSet datasets configured with RDOQ enabled and RDOQ disabled. For more information on the RDOLevel and RDOQ please refer to the **Integration Programming Guide** provided inside the Quadra release package.

H.264 RDO levels are not shown as all levels provides the same values.

H.265 RDO level set to 1, 2, and 3.

AV1 RDO level set to 1, 2, and 3 with RDOQ disabled.

The tables below show the Quadra encoder output compared against the presets, Nvidia, and SVT AV1 Presets.

PSNR BD Rate Savings %	RDOQ	RDO Level	ultrafast	superfast	veryfast	faster	fast	medium	slow	slower	veryslow	Nvidia	SVT AV1 Preset 10	SVT AV1 Preset 12
Quadra AVC	0	-	-58.74	-23.8	-17.2	2.28	7.45	2.74	7.88	28.5	30.05	-8.97		
Quadra AVC	1	-	-61.48	-28.94	-22.77	-4.68	0.08	-4.01	0.82	19.48	20.93	-15.12		
Quadra HEVC	0	1	-27.72	-21.86	-0.05	-0.03	3.9	9.72	25.65	33.43	36.42	-8.1		
Quadra HEVC	0	2	-31.65	-26.07	-5.42	-5.4	-1.67	3.83	18.87	26.25	29.06	-12.92		
Quadra HEVC	0	3	-33.86	-28.38	-8.29	-8.27	-4.58	0.73	15.43	22.63	25.36	-15.53		
Quadra HEVC	1	1	-32.07	-26.47	-5.37	-5.36	-1.56	3.76	18.79	26.23	29.01	-13.07		
Quadra HEVC	1	2	-36.01	-30.62	-10.57	-10.55	-6.84	-1.87	12.56	19.65	22.28	-17.85		
Quadra HEVC	1	3	-38	-32.73	-13.33	-13.31	-9.73	-4.88	9.01	15.84	18.38	-20.27		
Quadra AV1	0	1	-27.86	-21.9	0.19	0.21	4.27	9.88	25.78	33.59	36.55		5.55	-11.52
Quadra AV1	0	2	-31.03	-25.38	-4.59	-4.57	-0.76	4.55	19.53	26.92	29.69		0.26	-15.8
Quadra AV1	0	3	-33.04	-27.5	-7.42	-7.4	-3.69	1.48	16.02	23.19	25.88		-3.04	-18.5

Table 1: High Quality Dual Pass - Average PSNR BD Rate Savings (in percent) for VITS2021SmallSet dataset

PSNR BD Rate Savings %	RDOQ	RDO Level	ultrafast	superfast	veryfast	faster	fast	medium	slow	slower	veryslow	Nvidia	SVT Av1 Preset 10	SVT AV1 Preset 12
Quadra AVC	0	-	-53.6	-20.55	-15.42	0.05	4.13	7.54	12.54	18.59	19.98	-3.71		
Quadra AVC	1	-	-55.99	-24.56	-19.69	-4.94	-1.11	2.08	6.82	12.39	13.7	-8.66		
Quadra HEVC	0	1	-18.28	-10.67	-0.58	-0.49	6.32	7.01	21.15	27.96	30.89	-2.88		
Quadra HEVC	0	2	-22.48	-15.16	-5.51	-5.43	1.05	1.7	15.1	21.51	24.25	-7.55		
Quadra HEVC	0	3	-24.25	-17.02	-7.54	-7.46	-1.06	-0.48	12.69	18.96	21.65	-9.47		
Quadra HEVC	1	1	-22.35	-14.91	-5.1	-5.02	1.67	2.26	16.04	22.5	25.34	-7.16		
Quadra HEVC	1	2	-26.55	-19.42	-10.05	-9.97	-3.63	-3.08	9.88	15.95	18.61	-11.84		
Quadra HEVC	1	3	-28.35	-21.31	-12.12	-12.05	-5.8	-5.3	7.4	13.33	15.93	-13.79		
Quadra AV1	0	1	-17.24	-9.55	0.56	0.65	7.51	8.23	22.54	29.22	32.15		10.99	-6.66
Quadra AV1	0	2	-20.77	-13.4	-3.77	-3.69	2.8	3.48	16.96	23.26	25.99		5.99	-10.71
Quadra AV1	0	3	-22.82	-15.54	-6.16	-6.07	0.29	0.91	14.08	20.22	22.89		3.36	-12.99

Table 2: High Quality Dual Pass - Average PSNR BD Rate Savings (in percent) for QuadraBringUpFILM dataset

2.2. Low Delay Configuration

Low delay (low latency) configuration uses QuadraBringUpCGI (gaming sequences) and QuadraSimpleGaming datasets. Anchors are created using the following commands:

- **x264/x265**
x264 --tune zerolatency --aq-mode 0 --no-psy --no-scenecut --input-res 1920x1080 --fps 30.0 --bitrate 7000 --vbv-buFSIZE 14000 --keyint 60 --min-keyint 60 --preset fast --frames 650 -o [path to output file] [path to source file]
- **Nvidia**
FFmpeg_nvidia -y -s:v 1920x1080 -r 60.0 -i [path to source file] -c:v hevc_nvenc -pix_fmt yuv420p -preset p4 -zerolatency 1 -b_adapt 0 -bf 0 -vsync 0 -rc-lookahead 0 -spatial-aq 0 -temporal-aq 0 -rc cbr -tune ull -bufsize [buffer size] -b:v 1000000 -maxrate 1000000 -minrate 1000000 -profile:v main -g 120.0 -vsync 0 -vframes 252 [path to output file]

NOTE - buffer size varies depending on the bitrate: $\text{buffer size} = (2 * \text{bitrate} / 1000)K$

- **SVT-AV1**
SvtAv1EncApp --rc 1 --preset 10 --keyint 120 -w 1920 -h 1080 --tbr 7500 --mbr 7550 --pred-struct 2 --lp 1 --fps 60.0 -n 400 -b [path to output file] -i [path to source file]

Sequences used to compare to the anchors are generated using the following commands:

- **RDOQ enabled**
FFmpeg -y -vsync 0 -s 1920x1080 -r 60.0 -i [path to source file] -c:v h264_ni_quadra_enc -xcoder-params level=0:frameRate=60:RcEnable=1:vbvBufferSize=2000:bitrate=1000000:intraPeriod=120:gopPresetIdx=3:entropyCodingMode=1:lookaheadDepth=0:cuLevelRCEnable=1:rdoLevel=3:tolCtbRcInter=0:tolCtbRcIntra=0:EnableRdoQuant=1 -vframes 400 [path to output file]
- **RDOQ disabled**
FFmpeg -y -vsync 0 -s 1920x1080 -r 60.0 -i [path to source file] -c:v h264_ni_quadra_enc -xcoder-params level=0:frameRate=60:RcEnable=1:vbvBufferSize=2000:bitrate=1000000:intraPeriod=120:gopPresetIdx=3:entropyCodingMode=1:lookaheadDepth=0:cuLevelRCEnable=1:rdoLevel=3:tolCtbRcInter=0:tolCtbRcIntra=0:EnableRdoQuant=0 -vframes 400 [path to output file]

2.2.1. Low Delay Results

Quadra H.264 compared against x264 presets and Nvidia H.264.

Quadra H.265 compared against x265 presets and Nvidia H.265.

Quadra AV1 compared against x265 presets and SVT AV1 Preset 10 and 12.

Low Delay test uses QuadraBringUpCGI and QuadraSimpleGaming datasets configured with RDOQ enabled and RDOQ disabled. For more information on the RDOLevel and RDOQ please refer to the **Integration Programming Guide** provided inside the Quadra release package.

H.264 RDO levels are not shown as all levels provides the same values.

H.265 RDO level set to 1, 2, and 3.

AV1 RDO level set to 1, 2, and 3 with RDOQ disabled.

The tables below show the Quadra encoder output compared against the presets, Nvidia, and SVT AV1 Presets.

PSNR BD Rate Savings %	RDOQ	RDO Level	ultrafast	superfast	veryfast	faster	fast	medium	slow	slower	veryslow	Nvidia	SVT AV1 Preset 10	SVT AV1 Preset 12
Quadra AVC	0	-	-45.59	-13.86	-10.01	4.95	12.73	2.97	7.4	21.55	22.11	6.92		
Quadra AVC	1	-	-48.7	-18.36	-14.66	-0.48	6.92	-2.18	2.03	15.21	15.75	2.03		
Quadra HEVC	0	1	-34.95	-23.95	-12.38	-12.37	-9.68	-7.51	4.02	11.26	14.49	-6.78		
Quadra HEVC	0	2	-37.36	-26.69	-15.52	-15.51	-12.91	-10.78	0.3	7.28	10.38	-10.12		
Quadra HEVC	0	3	-38.05	-27.47	-16.41	-16.4	-13.83	-11.7	-0.73	6.17	9.25	-11.05		
Quadra HEVC	1	1	-37.85	-27.17	-15.8	-15.8	-13.17	-10.87	0.22	7.22	10.33	-9.9		
Quadra HEVC	1	2	-40.09	-29.74	-18.74	-18.75	-16.21	-13.96	-3.27	3.43	6.4	-13.08		
Quadra HEVC	1	3	-40.75	-30.47	-19.58	-19.58	-17.08	-14.83	-4.25	2.39	5.34	-13.99		
Quadra AV1	0	1	-27.92	-16.41	-3.98	-3.99	-1.06	1.26	12.96	20.27	23.45		-3.82	-26.49
Quadra AV1	0	2	-29.36	-18.2	-6.06	-6.07	-3.22	-0.92	10.44	17.38	20.43		-6.59	-28.64
Quadra AV1	0	3	-29.84	-18.74	-6.69	-6.7	-3.87	-1.59	9.65	16.52	19.52		-7.4	-29.25

Table 3: Low Delay - Average PSNR BD Rate Savings (in percent) for QuadraBringUpCGI dataset

PSNR BD Rate Savings %	RDOQ	RDO Level	ultrafast	superfast	veryfast	faster	fast	medium	slow	slower	veryslow	Nvidia	SVT Av1 Preset 10	SVT Av1 Preset 12
Quadra AVC	0	-	-38.9	-18.5	-17.02	-14.71	-1.74	-1.29	3.67	4.11	6.95	8.12		
Quadra AVC	1	-	-44.39	-24.93	-23.41	-21.22	-9.09	-8.68	-4.11	-3.74	-1.12	1.32		
Quadra HEVC	0	1	-32.76	-18.05	-8.43	-8.28	-5.5	-6.33	5.74	9.31	12.12	-12.25		
Quadra HEVC	0	2	-37.35	-23.25	-14.15	-14	-11.41	-12.2	-0.84	2.51	5.15	-17.55		
Quadra HEVC	0	3	-38.97	-25.06	-16.13	-15.99	-13.48	-14.24	-3.16	0.1	2.68	-19.37		
Quadra HEVC	1	1	-37.68	-23.16	-13.84	-13.69	-11	-11.83	-0.14	3.33	6.06	-17.22		
Quadra HEVC	1	2	-41.42	-27.43	-18.58	-18.44	-15.9	-16.7	-5.7	-2.44	0.12	-21.58		
Quadra HEVC	1	3	-42.78	-28.98	-20.31	-20.17	-17.68	-18.47	-7.72	-4.54	-2.03	-23.17		
Quadra AV1	0	1	-23.32	-7.09	3.53	3.7	6.74	5.81	18.94	22.76	25.79		26.61	1.13
Quadra AV1	0	2	-25.83	-10.22	-0.03	0.14	3.04	2.15	14.74	18.36	21.26		22.51	-2.18
Quadra AV1	0	3	-26.92	-11.59	-1.62	-1.45	1.37	0.52	12.86	16.39	19.23		20.65	-3.53

Table 4: Low Delay - Average PSNR BD Rate Savings (in percent) for QuadraSimpleGaming dataset

2.3. High Quality Dual Pass Configuration Capped CRF

Dual pass configuration uses QuadraBringUpFILM dataset. Anchors are created using the following commands:

- **x264**
FFmpeg -psnr -i [path to source file] -c:v libx264 -preset medium -x264-params "keyint=120:bframes=3:log-level=full:crf=19:rc-lookahead=10:vbv-maxrate=6000:vbv-buFSIZE=6000" [path to output file]
- **x265**
FFmpeg -psnr -i [path to source file] -c:v libx265 -preset medium -x265-params "keyint=120:bframes=3:log-level=full:crf=19:rc-lookahead=10:vbv-maxrate=6000:vbv-buFSIZE=6000" [path to output file]

Sequences used are generated using the following commands:

- **RDOQ enabled**
FFmpeg -y -vsync 0 -s 3840x2160 -r 60.0 -i [path to source file] -c:v av1_ni_quadra_enc -xcoder-params gopPresetIdx=5:RcEnable=0:crf=19:intraPeriod=120:lookAheadDepth=10:EnableRdoQuant=1:rdoLevel=1:cuLevelRCEnable=1:vbvBufferSize=1000:bitrate=6000000:tolCtbRcInter=0:tolCtbRcIntra=0:zeroCopyMode=0 -vframes 600 [path to output file]
- **RDOQ disabled**
FFmpeg -y -vsync 0 -s 3840x2160 -r 60.0 -i [path to source file] -c:v av1_ni_quadra_enc -xcoder-params gopPresetIdx=5:RcEnable=0:crf=19:intraPeriod=120:lookAheadDepth=10:EnableRdoQuant=0:rdoLevel=1:cuLevelRCEnable=1:vbvBufferSize=1000:bitrate=6000000:tolCtbRcInter=0:tolCtbRcIntra=0:zeroCopyMode=0 -vframes 600 [path to output file]

2.3.1. High Quality Dual Pass Capped CRF Results

Quadra H.264 compared against x264 medium preset.

Quadra H.265 compared against x265 medium preset.

High Quality Dual Pass test uses QuadraBringUpFILM dataset configured with RDOQ enabled and RDOQ disabled. For more information on the RDOLevel and RDOQ please refer to the **Integration Programming Guide** provided inside the Quadra release package.

The encoder displays competitive performance in several key areas. The gains show Quadra delivering consistent video quality across different scenes, irrespective of their complexity. This consistent quality underscores our encoder's robustness, ensuring viewers get a dependable visual experience.

H.264 RDO levels are not shown as all levels provides the same values.

H.265 RDO level set to 1, 2, and 3.

AV1 RDO level set to 1, 2, and 3 with RDOQ disabled.

The tables below show the Quadra encoder output.

PSNR BD Rate Savings %	RDOQ	RDO Level	medium
Quadra AVC	0	-	-7.41
Quadra AVC	1	-	-7.98
Quadra HEVC	0	1	-3.78
Quadra HEVC	0	2	-7.91
Quadra HEVC	0	3	-9.55
Quadra HEVC	1	1	-5.97
Quadra HEVC	1	2	-7.69
Quadra HEVC	1	3	-9.35
Quadra AV1	0	1	-3.78
Quadra AV1	0	2	-7.51
Quadra AV1	0	3	-9.2

Table 5: High Quality Dual Pass Capped CRF - Average PSNR BD Rate Savings (in percent) for QuadraBringUpFILM dataset

3. Appendix

3.1. Video Sequences

This section will list the video sequences in the datasets used for this report. These sequences are taken from YouTube UGC Dataset (<https://media.withyoutube.com>) and Derf's collection (<https://media.xiph.org/video/derf>).

QuadraBringUpFILM Dataset:

blue_sky_1920x1080p25_420
crowd_run_1920x1080p50_420
ducks_take_off_1920x1080p50_420
in_to_tree_1920x1080p50_420
old_town_cross_1920x1080p50_420
park_joy_1920x1080p50_420
pedestrian_area_1920x1080p25_420
riverbed_1920x1080p25_420
rush_hour_1920x1080p25_420
station2_1920x1080p25_420
sunflower_1920x1080p25_420
tractor_1920x1080p25_420

VITS2021SmallSet Dataset:

construction_field_3840x2160_p30_420
fountains_3840x2160_p30_420
marathon_3840x2160_p30_420
tall_buildings_3840x2160_p30_420
Bosphorus_3840x2160p60_420
Fortnite_4k_1_3840x2160p60_420
Jockey_3840x2160p60_420
ShakeNDry_3840x2160p60_420

QuadraBringUpCGI Dataset:

CSGO_cut_280_879_1920x1080p60_420
DOTA2_cut_1735_2285_1920x1080p60_420
EuroTruckSimulator2_cut_500_993_1920x1080p60_420
Gaming_1080P-6530_1920x1080p60_420
Gaming_1080P-72c8_1920x1080p60_420
Gaming_1080P-7a1e_1920x1080p60_420
GTAV_cut_1104_1403_1920x1080p60_420
GTAV_cut_2700_2999_1920x1080p60_420
WITCHER3_cut_2334_2585_1920x1080p60_420
WITCHER3_cut_450_849_1920x1080p60_420

QuadraSimpleGaming Dataset:

Amongus-01a1_1280x720p30_420
Amongus-02b2_1280x720p30_420
Biped-01c1_1280x720p30_420
Biped-03c3_1280x720p30_420
Biped-05c5_1280x720p30_420
Genshin-04e4_1280x720p30_420
Genshin-02f2_1280x720p30_420
RAFT-01h3_1280x720p30_420
Runescape-05g5_1280x720p30_420
Runescape-06g9_1280x720p30_420
Stumble-7ae5_1280x720p30_420
Stumble-7bg2_1280x720p30_420

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