

Evaluation report of SDR test sequences (4K5-9 and 1080p1-5)

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Introduction

❑ Evaluation report of SDR test sequences (4K5-9 and 1080p1-5) encoded with HM-16.3 and JEM-4.0

❖ Test sequences:

- We volunteered to test four 4K test sequences (4K5-8) and three 1080p test sequences (1080p2-4).
- However, this document reports evaluation results of five 4K test sequences (4K5-9) and five 1080p test sequences (1080p1-5).

❖ For the objective evaluation:

- Five 4K test sequences (4K5-9) and five 1080p test sequences (1080p1-5) are encoded using HM-16.13 and JEM-4.0 with integer QP and floating QP.

❖ For the subjective evaluation:

- Characteristics of the original sequences as well as the visual artifacts in the decoded sequences of the new test sequences (4K8-9) are investigated.

Test Configurations

❑ Preparation of test sequences

- ❖ Downloaded 4K5-9, 1080p1, 1080p3 and 1080p5 YUV sequences the FTP site.
 - Confirmed that the MD5 checksums of the downloaded YUV sequences are exactly matched with those provided on the FTP site.
- ❖ 1080p2 and 1080p4 test sequences were generated by the SHM DownConverter tool.

Specifications and MD5 checksums of original YUV sequences

Sequence ID	Sequence name	Spatial resolution	Num. of frames	Frame rate	Chroma format	Bit depth	MD5 checksums
4K5	Crosswalk_long	4096x2160	470	60p	4:2:0	10	978a5dea90fe9125f6bce42aade55b61
4K6	FoodMarket2_long	4096x2160	782	60p	4:2:0	10	751cc6cf722c48c4aaa9c2d74439382c
4K7	TimeLapse_long	4096x2160	600	60p	4:2:0	10	64c06dbacf66985142d6b196abfe0e2f
4K8	IceAerial	3840x2160	300	30p	4:2:0	10	b6d6b978ff23a7dbc910bf951c53069
4K9	IceRiver	3840x2160	300	30p	4:2:0	10	a6c41da1fb2e18c0f0f6003bb01de25b
1080p1	Metro	1920x1080	600	60p	4:2:0	10	1030673bd52a31705ccbba36a2959f4f
1080p2	FoodMarket2_long	1920x1080	782	60p	4:2:0	10	7b4a5837a186cf6b84e18c65c9ccb4e7
1080p3	RitualDance	1920x1080	600	60p	4:2:0	10	a3cb399a7b92eb9c5ee0db340abc43e4
1080p4	TimeLapse_long	1920x1080	600	60p	4:2:0	10	6a2828f2fdb7bd967a7f27ed40a2a6f7
1080p5	Runners	1920x1080	300	30p	4:2:0	10	6e4e93faf1a806b0b0930dc72b716301

Test Configurations

❑ Encoding conditions

- ❖ Reference software: HM-16.13, JEM-4.0
- ❖ HM and JEM common test conditions
- ❖ Random Access configuration
- ❖ Intra period: 32 (30fps), 64 (60 fps)
- ❖ GOP size: 16
- ❖ Lambda from QP
- ❖ MV search range: 256
- ❖ Target bitrates for 4K and 1080p test sequences:

Rate point	Target bitrate for 4K test sequence (Mbps)		Target bitrate for 1080p test sequence (Mbps)	
	60p	30p	60p	30p
Rate 1	1	0.6	0.6	0.4
Rate 2	1.5	1	0.9	0.6
Rate 3	2.4	1.6	1.5	1
Rate 4	4	2.7	2.6	1.7
Rate 5	7	5	4.3	2.9

Integer QP encoding results of 4K test sequences

QP	Bitrate for HM-16.13 (kbps)					Bitrate for JEM-4.0 (kbps)				
	4K5	4K6	4K7	4K8	4K9	4K5	4K6	4K7	4K8	4K9
22	20418.05				6842.80					6137.25
23	16295.48	21695.21			5450.96					4772.27
24	13553.38	17817.07			4528.45		15310.39	9015.83		3828.51
25	11692.30	15100.76		12824.63	3896.63		12772.06	7496.83	11729.84	3195.99
26	10001.34	12516.90	7007.82	9683.45	3334.15	8056.37	10448.71	6103.23	8639.26	2691.26
27	8502.35	10545.26	5674.40	7648.54	2923.62	6806.87	8764.30	4904.25	6694.52	2341.63
28	7464.06	9153.21	4763.59	6292.59	2577.13	5927.31	7548.00	4091.46	5362.14	2056.18
29	6684.64	8086.96	4079.85	5342.73	2286.64	5269.19	6622.07	3477.62	4416.93	1818.97
30	5855.74	7020.31	3410.23	4532.23	2017.37	4581.09	5719.08	2892.93	3665.11	1602.64
31	5229.56	6198.29	2916.34	3977.07	1795.25	4086.44	5048.10	2469.41	3179.20	1424.26
32	4597.38	5413.09	2462.65	3496.04	1587.61	3579.40	4415.17	2078.86	2798.31	1267.42
33	4066.20	4774.49	2099.18	3145.70	1417.20	3158.47	3877.03	1764.54	2472.86	1126.14
34	3659.50	4249.33	1811.23	2818.25	1255.32	2811.17	3415.51	1508.93	2196.10	998.49
35	3217.37	3696.69	1525.07	2500.27	1097.93	2470.52	2979.94	1273.57	1940.58	877.62
36	2884.34	3273.25	1318.06	2251.72	969.64	2199.20	2624.44	1093.04	1733.99	776.51
37	2575.16	2881.37	1133.24	2025.18	854.57	1965.05	2325.17	943.50	1572.06	688.37
38	2312.65	2561.09	982.81	1846.36	754.12	1750.43	2046.20	809.26	1407.91	604.74
39	2066.16	2254.96	847.65	1664.21	662.65	1565.80	1816.70	700.57	1282.46	534.52
40	1852.64	1999.24	736.92	1516.35	582.22	1389.61	1588.27	600.08	1150.01	467.59
41	1650.93	1747.80	632.73	1359.34	504.92	1242.39	1406.09	518.78	1043.06	
42	1480.80	1550.04	551.16	1240.68	443.23	1101.15	1228.70	444.27	937.59	
43	1339.77	1370.99	480.13	1120.42		996.74	1097.33	388.05	855.88	
44	1248.23	1244.98	425.27	1031.16		920.97	985.42	340.74	773.89	
45	1176.63	1135.79	376.94	940.95		865.50	902.33	303.12	712.50	
46	1117.00	1047.33	337.54	868.91		813.71	821.04	269.37	647.81	
47	1072.74	965.90	300.65	791.77		773.87		239.82	588.69	
48	1038.58	901.59	272.98	728.22		743.31		215.98	539.18	
49	1012.66	849.48	248.74	671.29		720.49		196.05		
50	1011.82	816.32	229.24	624.13				182.71		
51	1003.26			586.16						

Floating QP encoding results of 4K test sequences

Derived floating QP values for 4K test sequences

Rate point	Floating QP for HM-16.13					Floating QP for JEM-4.0				
	4K5	4K6	4K7	4K8	4K9	4K5	4K6	4K7	4K8	4K9
Rate 1	51.00	46.59	37.99	50.79	39.84	42.74	43.22	36.22	46.48	38.48
Rate 2	41.89	42.32	35.47	44.42	35.81	39.74	40.48	34.48	41.48	34.00
Rate 3	37.59	38.55	32.52	39.47	32.00	35.22	36.74	31.48	36.48	30.00
Rate 4	33.18	34.46	29.47	34.43	27.68	31.74	32.74	28.22	32.48	26.00
Rate 5	28.54	30.08	26.23	29.47	23.52	26.74	28.22	25.74	28.48	22.48

Encoding results of 4K test sequences using HM-16.13 and JEM-4.0 with floating QP

Rate point	Bitrate for HM-16.13 (kbps)					Bitrate for JEM-4.0 (kbps)				
	4K5	4K6	4K7	4K8	4K9	4K5	4K6	4K7	4K8	4K9
Rate 1	593.11	596.55	596.24	599.14	395.05	597.48	597.93	598.35	599.76	398.85
Rate 2	893.32	895.65	894.69	897.91	594.22	899.63	895.64	899.95	900.70	602.24
Rate 3	1493.69	1506.61	1492.15	1486.62	994.65	1491.66	1496.70	1469.51	1497.09	993.25
Rate 4	2621.95	2593.23	2623.39	2599.62	1693.15	2582.48	2602.12	2596.58	2598.70	1693.08
Rate 5	4299.86	4285.66	4301.86	4310.41	2887.95	4299.40	4302.51	4287.47	4286.47	2910.46

Bitrate differences for 4K test sequences

Rate point	Bitrate difference for HM-16.13 (%)					Bitrate difference for JEM-4.0 (%)				
	4K5	4K6	4K7	4K8	4K9	4K5	4K6	4K7	4K8	4K9
Rate 1	-1.1%	-0.6%	-0.6%	-0.1%	-1.2%	-0.4%	-0.3%	-0.3%	0.0%	-0.3%
Rate 2	-0.7%	-0.5%	-0.6%	-0.2%	-1.0%	0.0%	-0.5%	0.0%	0.1%	0.4%
Rate 3	-0.4%	0.4%	-0.5%	-0.9%	-0.5%	-0.6%	-0.2%	-2.0%	-0.2%	-0.7%
Rate 4	0.8%	-0.3%	0.9%	0.0%	-0.4%	-0.7%	0.1%	-0.1%	0.0%	-0.4%
Rate 5	0.0%	-0.3%	0.0%	0.2%	-0.4%	0.0%	0.1%	-0.3%	-0.3%	0.4%

BD-rate results of 4K test sequences

Sequence identifier	Rate point	HM-16.13				JEM-4.0				BD-rate		
		Bitrate (kbps)	PSNR Y (dB)	PSNR U (dB)	PSNR V (dB)	Bitrate (kbps)	PSNR Y (dB)	PSNR U (dB)	PSNR V (dB)	Y	U	V
4K5	R5	6976.69	41.07	46.27	48.49	6981.35	41.72	46.77	49.28	-34.17%	-35.24%	-40.15%
	R4	3972.01	39.59	45.08	46.99	3996.84	40.70	45.82	48.09			
	R3	2387.08	37.81	44.11	45.79	2399.42	39.31	45.04	47.12			
	R2	1490.57	35.83	43.15	44.59	1504.71	37.75	44.24	46.10			
	R1	1003.26	33.31	40.33	41.33	999.92	36.15	43.33	44.94			
4K6	R5	6961.62	39.60	43.47	45.13	7003.11	40.57	44.29	46.17	-31.55%	-36.92%	-40.70%
	R4	3999.87	37.71	42.19	43.72	4004.23	38.99	43.13	44.90			
	R3	2386.63	35.69	41.01	42.47	2397.30	37.21	42.08	43.77			
	R2	1491.59	33.73	40.20	41.55	1499.40	35.43	41.23	42.81			
	R1	990.96	31.90	39.04	40.29	1000.90	33.82	40.40	41.86			
4K7	R5	6975.27	44.82	49.69	50.67	6980.93	45.30	50.39	51.42	-28.46%	-42.49%	-41.54%
	R4	3991.84	43.61	48.29	49.40	3998.81	44.31	49.45	50.48			
	R3	2393.22	42.34	47.02	48.05	2397.87	43.21	48.43	49.45			
	R2	1488.53	40.99	45.89	47.03	1499.44	42.10	47.64	48.76			
	R1	997.77	39.72	45.45	46.43	994.94	41.02	47.03	48.17			
4K8	R5	5000.43	37.59	44.01	44.17	5005.03	38.17	45.40	45.15	-37.59%	-48.93%	-44.72%
	R4	2695.13	36.21	42.03	42.55	2703.04	37.34	44.11	44.04			
	R3	1590.70	34.21	40.19	41.08	1599.85	36.02	42.46	42.68			
	R2	995.10	31.93	38.91	40.12	1000.40	34.22	41.27	41.84			
	R1	593.92	29.08	36.39	38.10	600.27	31.73	39.63	40.70			
4K9	R5	4982.95	43.26	51.14	49.55	4982.58	43.69	52.13	50.30	-34.68%	-50.78%	-47.15%
	R4	2693.52	42.17	49.66	48.22	2691.26	43.02	51.31	49.55			
	R3	1587.61	40.57	48.01	46.72	1602.64	41.89	50.10	48.44			
	R2	995.34	38.79	46.87	45.70	998.49	40.39	49.00	47.46			
	R1	596.74	36.77	45.97	44.93	599.66	38.49	47.80	46.42			

Integer QP encoding results of 1080p test sequences

QP	Bitrate for HM-16.13 (kbps)					Bitrate for JEM-4.0 (kbps)				
	1080p1	1080p2	1080p3	1080p4	1080p5	1080p1	1080p2	1080p3	1080p4	1080p5
21				5207.80					4588.11	
22				4477.08					3940.17	
23				3669.04		5749.12			3213.41	
24				3106.84		5031.99	5581.69		2712.65	
25	5088.32	5854.12		2673.65		4451.20	4932.64		2333.11	
26	4423.12	5075.77		2241.55		3862.66	4277.79		1955.75	
27	3799.54	4353.45	5476.70	1861.80		3320.39	3676.07	4665.81	1621.74	
28	3325.54	3815.49	4826.90	1586.01		2895.91	3216.46	4095.23	1378.72	
29	2938.01	3384.13	4301.86	1371.13		2550.68	2843.85	3653.62	1187.47	
30	2552.35	2938.78	3772.88	1156.40	4392.09	2205.25	2467.40	3194.13	1000.51	
31	2245.54	2593.23	3345.91	996.39	3875.04	1936.71	2177.96	2844.37	861.39	3490.18
32	1948.65	2252.83	2907.75	847.10	3375.69	1689.31	1900.69	2474.23	735.36	3064.14
33	1709.82	1976.17	2543.92	727.03	2986.45	1471.32	1663.27	2168.16	629.52	2681.35
34	1504.66	1744.96	2261.34	628.32	2633.73	1287.24	1458.54	1915.96	540.73	2352.53
35	1298.77	1506.61	1964.14	530.29	2276.11	1111.14	1263.79	1669.10	456.67	2034.83
36	1136.91	1323.93	1731.02	457.42	1993.89	969.16	1107.12	1469.51		1777.78
37	988.55	1156.08	1518.26	392.30	1735.65	851.65	974.89	1295.28		1564.32
38	867.14	1017.34	1335.07	338.49	1527.41	741.86	850.67	1137.64		1360.19
39	753.37	887.73	1169.78	290.64	1325.82	649.60	748.72	1000.23		1195.87
40	656.71	779.46	1024.10	250.92	1162.00	560.18	650.35	871.74		1031.75
41	563.20	674.01	890.37	215.11	994.65	486.58	569.05	764.81		900.67
42	489.37	590.64	777.69	186.68	870.53	416.72	492.55	664.74		774.11
43	423.62	514.51	697.29	161.36	756.60		433.54	598.35		682.89
44	376.38	458.36	646.99	141.17	681.14		383.99			602.24
45	334.85	410.17	609.24	124.11	609.24					546.52
46			578.28		556.65					488.94
47					500.17					438.63
48					456.38					398.85
49					419.31					364.91
50					389.28					

Floating QP encoding results of 1080p test sequences

Derived floating QP values for 1080p test sequences

Rate point	Floating QP for HM-16.13					Floating QP for JEM-4.0				
	1080p1	1080p2	1080p3	1080p4	1080p5	1080p1	1080p2	1080p3	1080p4	1080p5
Rate 1	40.68	41.85	45.36	34.57	49.77	39.22	40.22	43.00	33.22	48.48
Rate 2	37.79	38.88	40.97	31.83	45.25	36.48	37.22	39.48	30.74	44.00
Rate 3	34.05	35.00	37.15	28.68	41.00	32.22	33.22	36.00	27.48	40.48
Rate 4	29.92	31.00	32.87	25.52	37.23	28.22	29.48	31.22	24.22	36.48
Rate 5	26.25	27.16	29.00	22.57	33.28	25.22	25.22	27.22	21.22	32.48

Encoding results of 1080p test sequences using HM-16.13 and JEM-4.0 with floating QP

Rate point	Bitrate for HM-16.13 (kbps)					Bitrate for JEM-4.0 (kbps)				
	1080p1	1080p2	1080p3	1080p4	1080p5	1080p1	1080p2	1080p3	1080p4	1080p5
Rate 1	1003.26	990.96	997.77	593.92	596.74	999.92	1000.90	994.94	600.27	599.66
Rate 2	1490.57	1491.59	1488.53	995.10	995.34	1504.71	1499.40	1499.44	1000.40	998.49
Rate 3	2387.08	2386.63	2393.22	1590.70	1587.61	2399.42	2397.30	2397.87	1599.85	1602.64
Rate 4	3972.01	3999.87	3991.84	2695.13	2693.52	3996.84	4004.23	3998.81	2703.04	2691.26
Rate 5	6976.69	6961.62	6975.27	5000.43	4982.95	6981.35	7003.11	6980.93	5005.03	4982.58

Bitrate differences for 1080p test sequences

Rate point	Bitrate difference for HM-16.13 (%)					Bitrate difference for JEM-4.0 (%)				
	1080p1	1080p2	1080p3	1080p4	1080p5	1080p1	1080p2	1080p3	1080p4	1080p5
Rate 1	0.3%	-0.9%	-0.2%	-1.0%	-0.5%	0.0%	0.1%	-0.5%	0.0%	-0.1%
Rate 2	-0.6%	-0.6%	-0.8%	-0.5%	-0.5%	0.3%	0.0%	0.0%	0.0%	-0.2%
Rate 3	-0.5%	-0.6%	-0.3%	-0.6%	-0.8%	0.0%	-0.1%	-0.1%	0.0%	0.2%
Rate 4	-0.7%	0.0%	-0.2%	-0.2%	-0.2%	-0.1%	0.1%	0.0%	0.1%	-0.3%
Rate 5	-0.3%	-0.5%	-0.4%	0.0%	-0.3%	-0.3%	0.0%	-0.3%	0.1%	-0.3%

BD-rate results of 1080p test sequences

Sequence identifier	Rate point	HM-16.13				JEM-4.0				BD-rate		
		Bitrate (kbps)	PSNR Y (dB)	PSNR U (dB)	PSNR V (dB)	Bitrate (kbps)	PSNR Y (dB)	PSNR U (dB)	PSNR V (dB)	Y	U	V
1080p1	R5	4299.86	40.34	44.68	43.57	4299.40	41.44	45.36	44.11	-23.28%	-26.60%	-22.05%
	R4	2621.95	38.05	42.90	41.82	2582.48	39.16	43.74	42.48			
	R3	1493.69	35.60	41.35	40.30	1491.66	36.75	42.28	41.04			
	R2	893.32	33.44	40.00	39.05	899.63	34.63	40.94	39.75			
	R1	593.11	31.81	39.23	38.35	597.48	32.98	40.24	39.07			
1080p2	R5	4285.66	40.29	43.29	44.62	4302.51	41.67	44.06	45.53	-27.08%	-32.19%	-33.98%
	R4	2593.23	37.94	41.65	42.94	2602.12	39.40	42.64	44.04			
	R3	1506.61	35.41	40.31	41.55	1496.70	36.84	41.32	42.67			
	R2	895.65	33.15	39.22	40.34	895.64	34.56	40.30	41.54			
	R1	596.55	31.45	38.72	39.76	597.93	32.84	39.72	40.84			
1080p3	R5	4301.86	39.62	44.30	44.65	4287.47	41.04	45.11	45.74	-26.06%	-34.82%	-37.41%
	R4	2623.39	37.26	43.01	43.23	2596.58	38.63	43.89	44.35			
	R3	1492.15	34.71	41.78	41.86	1469.51	35.97	42.72	42.99			
	R2	894.69	32.62	40.88	40.77	899.95	33.90	41.92	41.94			
	R1	596.24	30.94	39.88	39.53	598.35	32.24	41.17	41.01			
1080p4	R5	4310.41	47.17	50.46	51.37	4286.47	48.03	51.37	52.29	-23.08%	-35.78%	-38.56%
	R4	2599.62	45.42	49.08	49.91	2598.70	46.31	50.09	51.03			
	R3	1486.62	43.45	47.46	48.54	1497.09	44.41	48.82	49.85			
	R2	897.91	41.61	46.09	47.01	900.70	42.62	47.52	48.62			
	R1	599.14	40.04	45.24	46.29	599.76	41.06	46.79	47.95			
1080p5	R5	2887.95	33.07	36.82	38.29	2910.46	34.09	37.51	38.99	-19.56%	-28.99%	-35.43%
	R4	1693.15	30.78	34.85	36.78	1693.08	31.68	35.70	37.65			
	R3	994.65	28.64	33.70	35.84	993.25	29.48	34.62	36.76			
	R2	594.22	26.64	32.68	35.05	602.24	27.61	33.57	35.91			
	R1	395.05	24.86	31.20	34.11	398.85	25.93	32.30	35.06			

Subjective Evaluation

Original



Frame #299 of decoded IceAerial (4K8) sequence at rate point 2 (1 Mbps):

- Visible blocking artifact on water drops
- Larger size of blocking artifacts in JEM-4.0 compared to HM-16.13

HM-16.13



JEM4-0



Subjective Evaluation

Original



HM-16.13



JEM4-0



Frame #165 of decoded IceRiver (4K9) sequence at rate point 1 (0.6 Mbps):

- Difficult to find coding artifacts, Loss of details on a mountain
- More details in JEM-4.0 compared to HM-16.13
- Requires only 5Mbps at over 43dB for both HM-16.13 and JEM-4.0, which indicates that the sequence is very easy to encode compared to 4K8 test sequence.
- Therefore, it can be noted that 4K9 test sequence is **not an adequate test sequence candidate** for common test conditions.

Conclusion

❑ Objective evaluation:

- ❖ Bitstream generation of five 4K test sequences (4K5-9) and five 1080p test sequences (1080p1-5) using HM-16.13 and JEM-4.0 with integer QP and floating QP was performed.
- ❖ Bitstreams and decoded YUV files for each target bitrate are available to be distributed for the viewing test.

❑ Subjective evaluation:

- ❖ Characteristics of the original sequences as well as the visual artifacts in the decoded sequences of the new test sequences (4K8-9) are investigated.
- ❖ From the point of view of a subjective evaluation (based on the scene characteristics and the coding artifacts):
 - 4K9 (IceRiver) is not adequate for the test sequence candidate.



Thank you