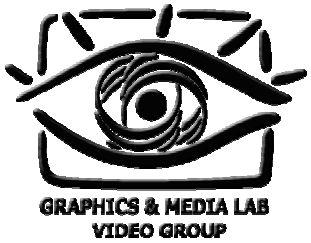

Video Codecs Comparison

Part 2: PSNR Diagrams

Project head: Dmitriy Vatolin
Testing: Sergey Grishin
Translating: Daria Kalinkina, Stanislav Soldatov
Preparing: Nikolai Trunichkin

9 testing sequences!
11 days (260 hours) total compression time!
33 tested codecs!
2430 resulting sequences!

May 2003

CS MSU Graphics&Media Lab

Video Group

http://www.compression.ru/video/

Video Codecs Comparison
Part 2: PSNR Diagrams For All Video Codecs

15 May 2003

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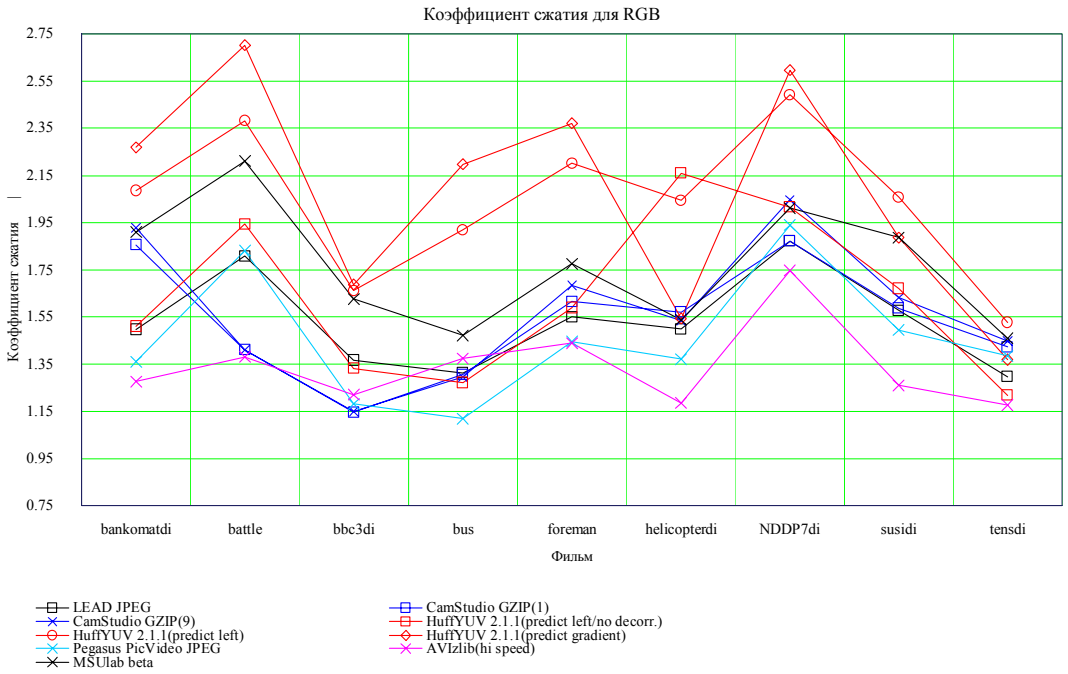
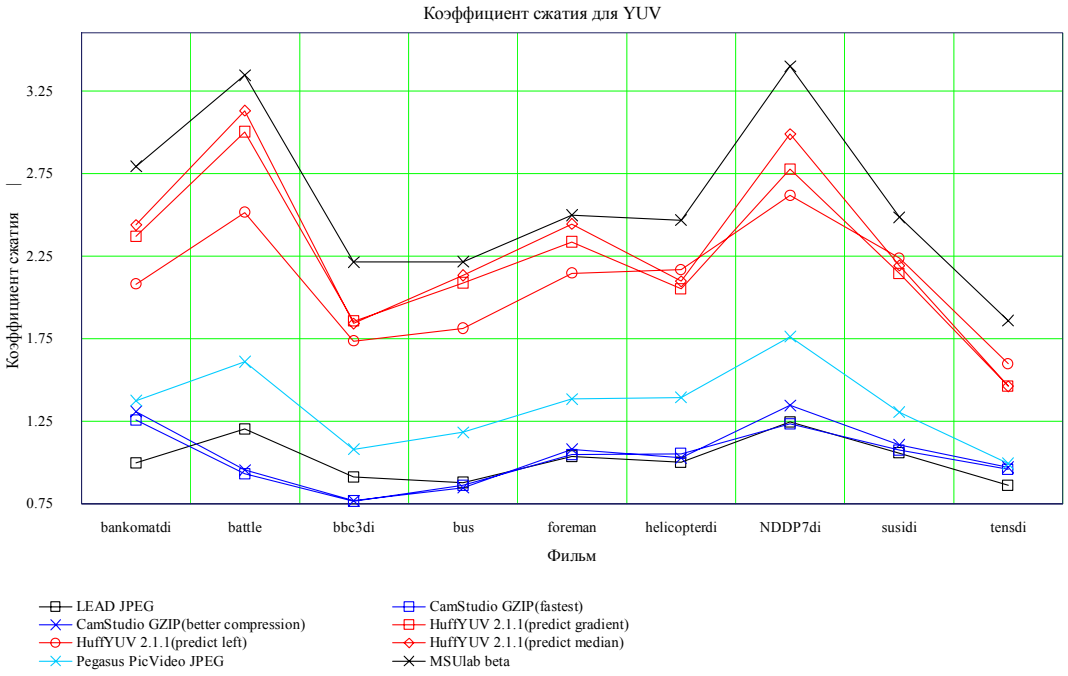
Disclaimer

Attention! For some codecs new versions are available that was not included into this test.

Lossless codecs

Y-axis on the two diagrams given below represents the compression index - that is the size of the source sequence divided by the size of the compressed sequence.

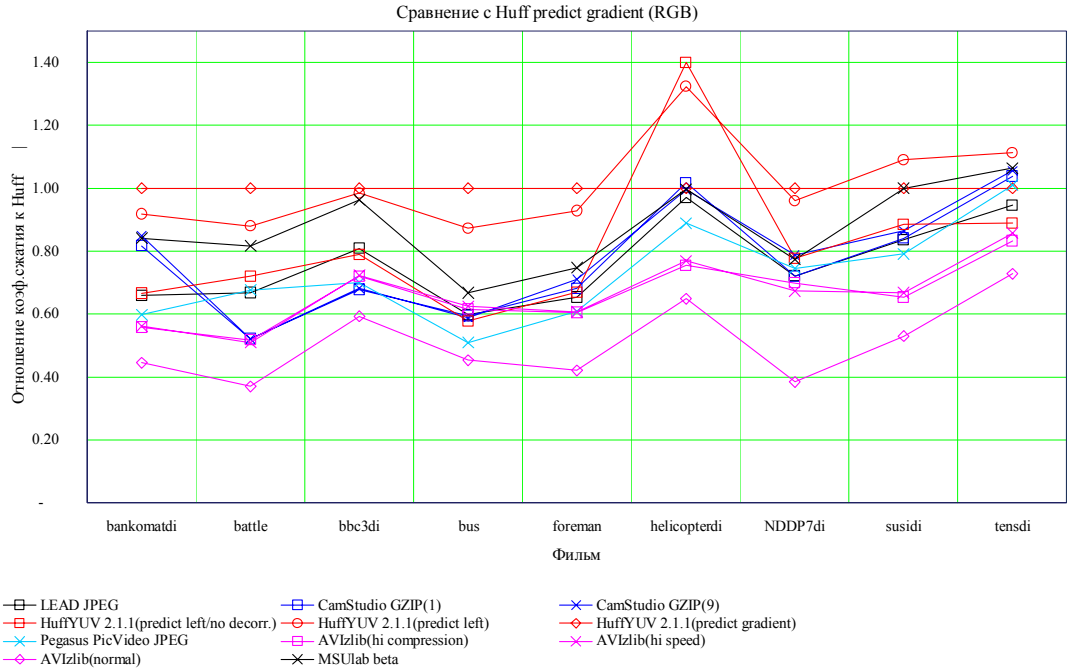


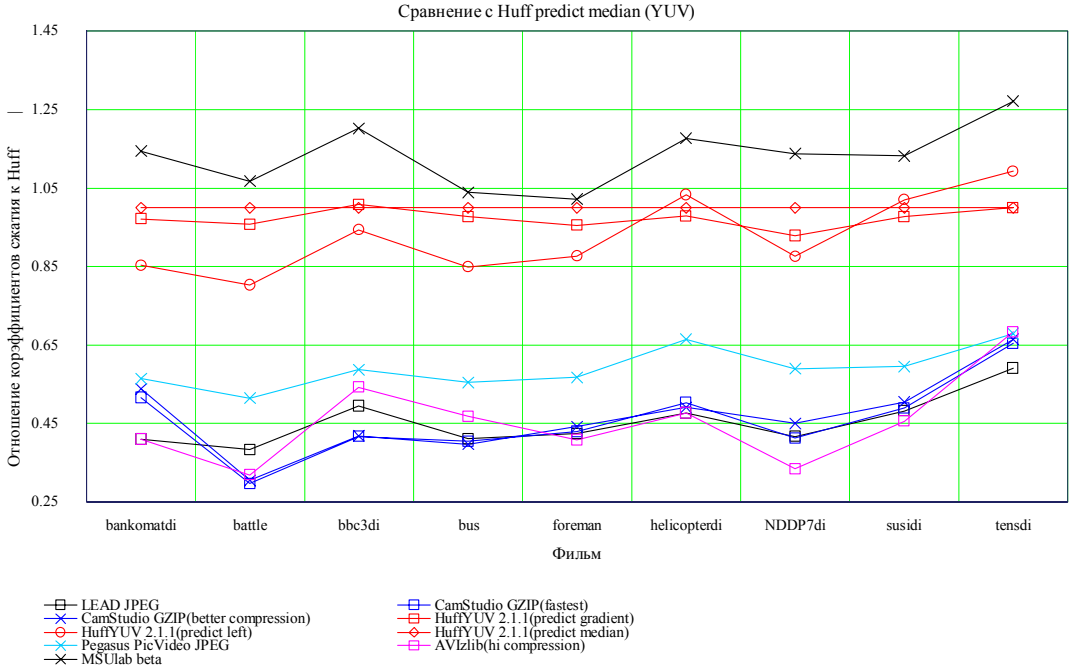


Conclusions:

- In the RGB color space Huffyuv 2.1.1 has a better compression index and in the YUV color space MSUlab beta has a better compression index.

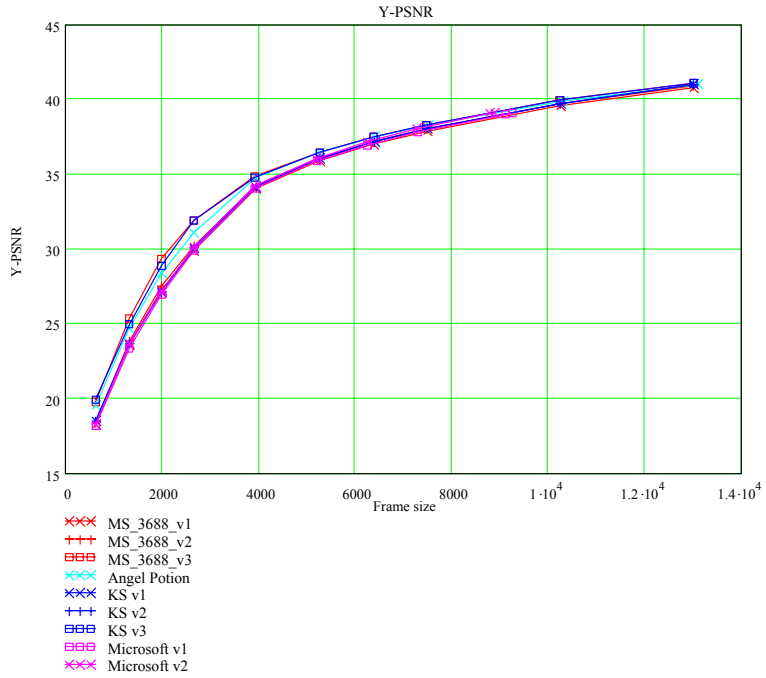
Y-axis on the two diagrams given below represents the compression index of a codec divided by the compression index of the Huffyuv codec. So there it can be easily seen, which codecs on which sequences reach a higher compression index than Huffyuv.

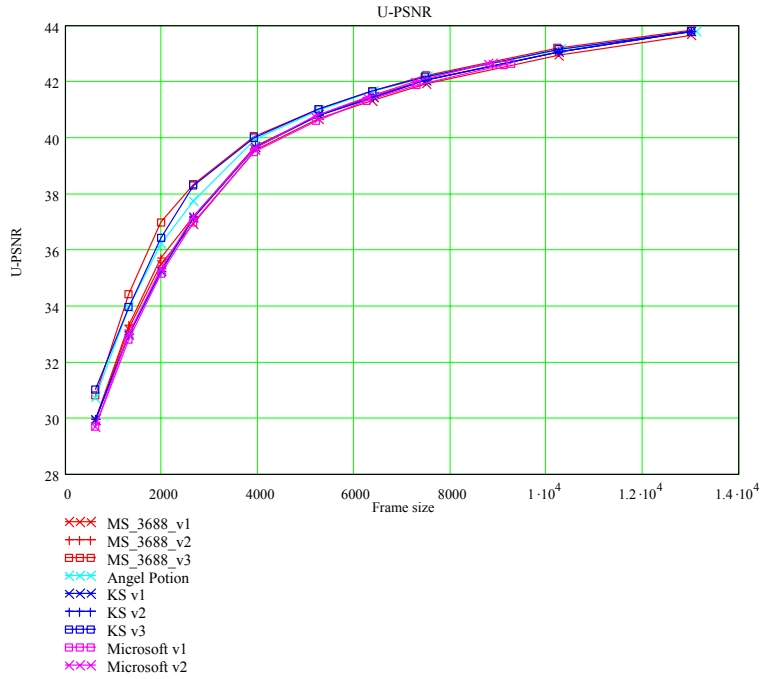


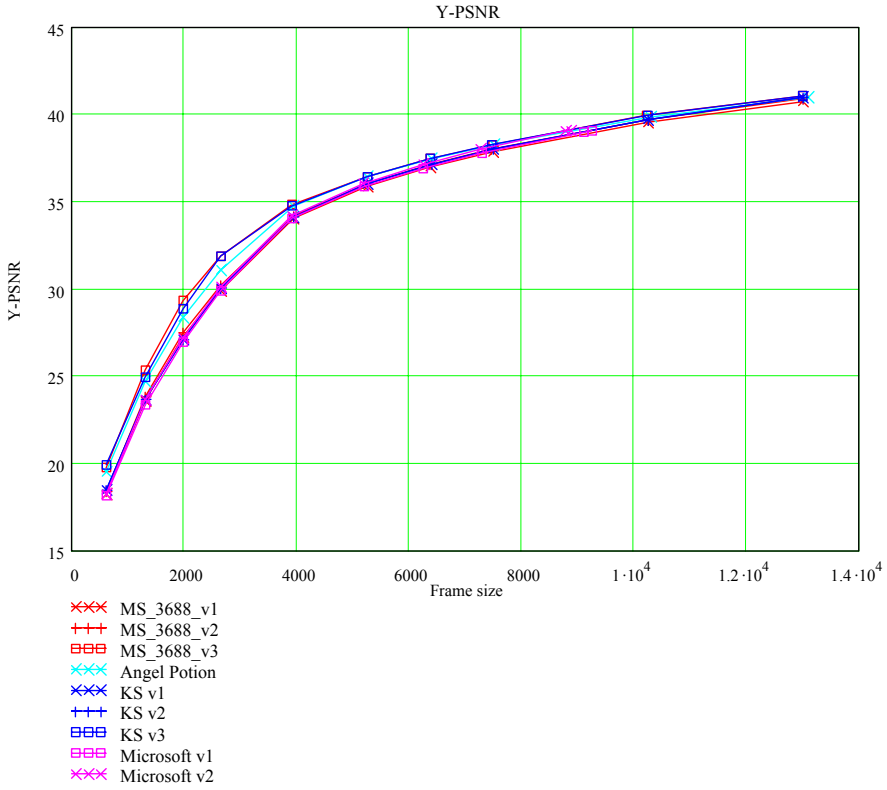


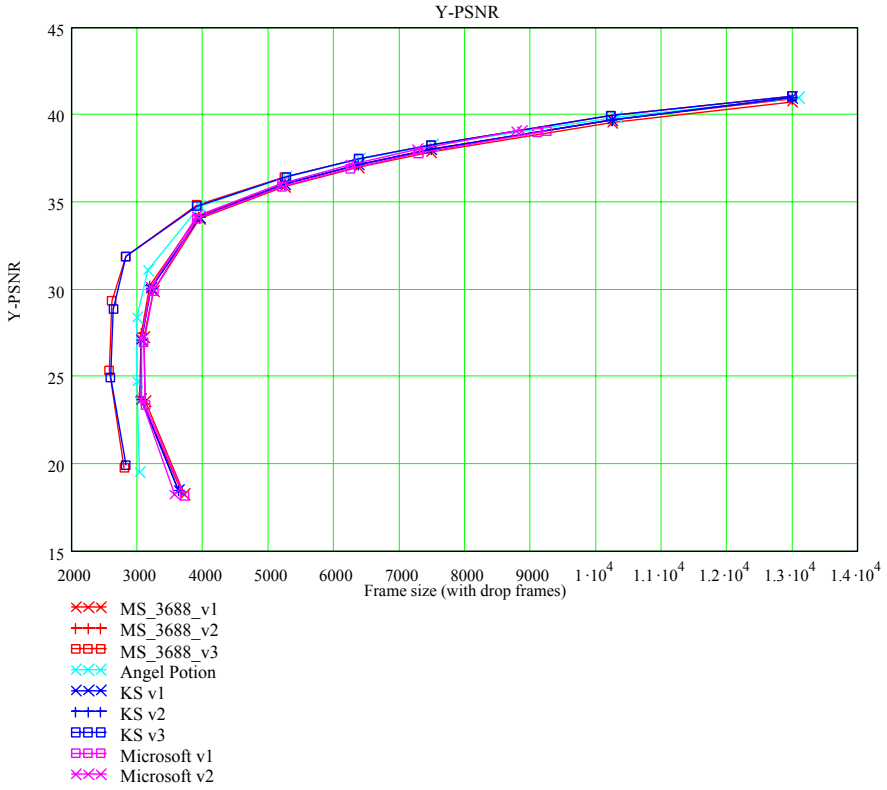
Microsoft codec`s versions

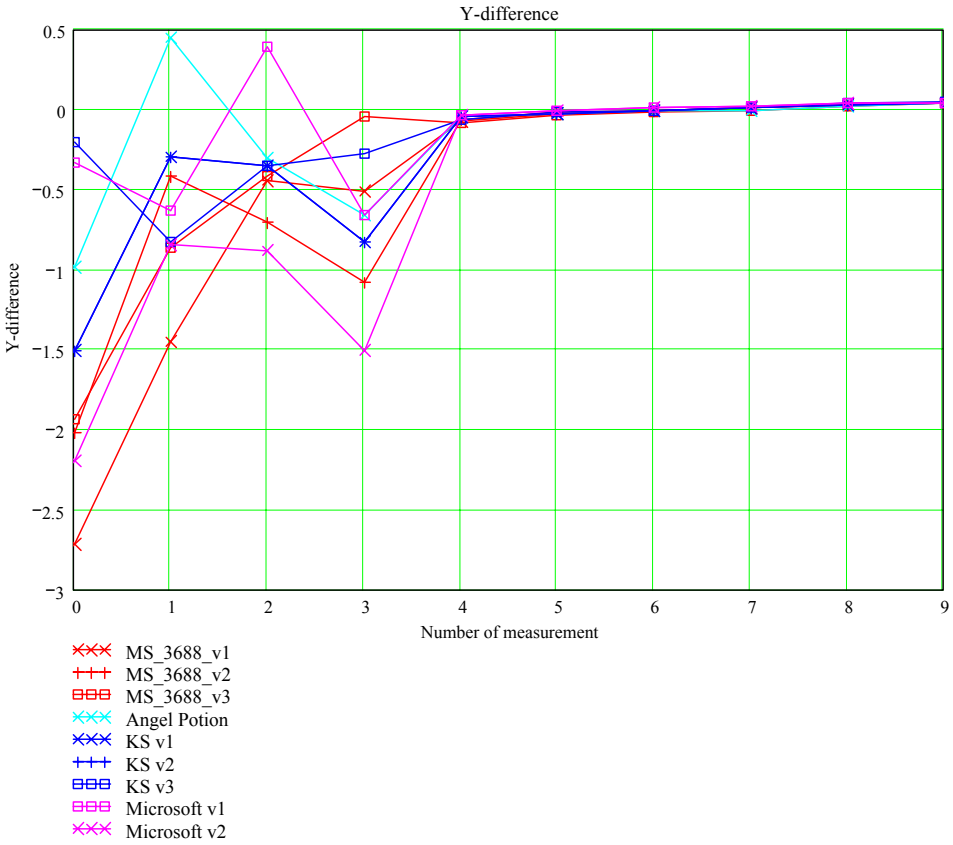
Diagrams given in this section represent different hacked versions of the Microsoft codec. As it can be easily seen, all codecs in this group work almost identically. Small difference is probably caused by the changed default options, what in some cases improved the result.

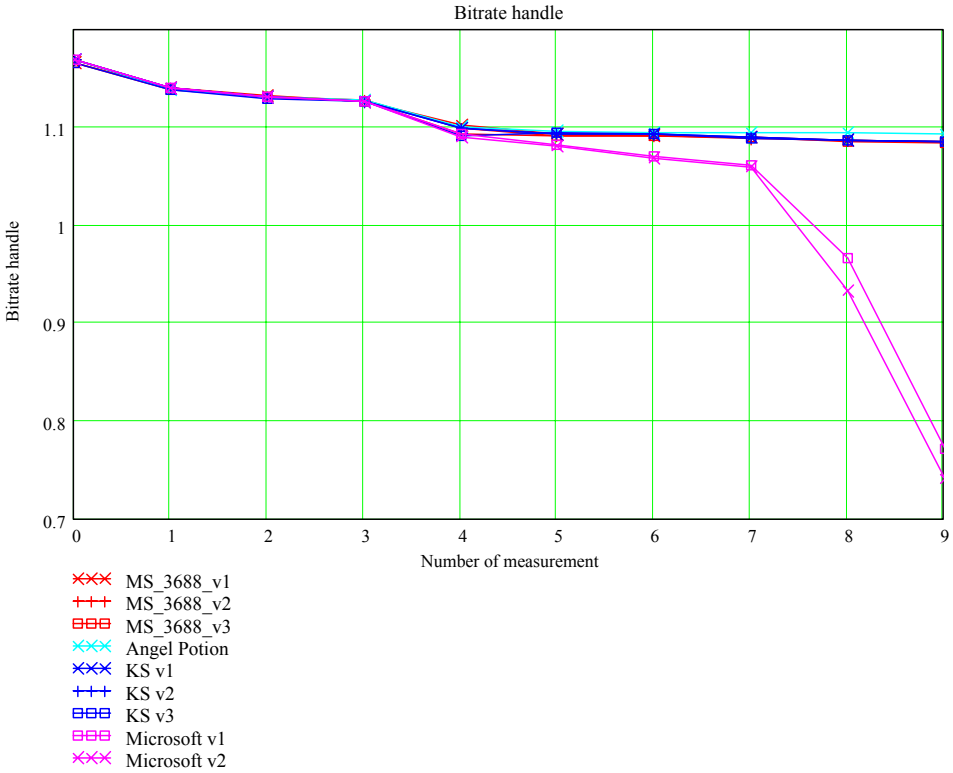

Y-PSNR
45
40
35
30
25
20
15
Y-PSNR
0
2000
4000
6000
8000
1·10^4
1.2·10^4
1.4·10^4
Frame size
MS_3688_v1
MS_3688_v2
MS_3688_v3
Angel Potion
KS v1
KS v2
KS v3
Microsoft v1
Microsoft v2


U-PSNR
44
42
40
38
36
34
32
30
28
U-PSNR
0
2000
4000
6000
8000
1·10^4
1.2·10^4
1.4·10^4
Frame size
MS_3688_v1
MS_3688_v2
MS_3688_v3
Angel Potion
KS v1
KS v2
KS v3
Microsoft v1
Microsoft v2


Y-PSNR
Y-PSNR
45
40
35
30
25
20
15
0
2000
4000
6000
8000
1·10^4
1.2·10^4
1.4·10^4
Frame size
MS_3688_v1
MS_3688_v2
MS_3688_v3
Angel Potion
KS v1
KS v2
KS v3
Microsoft v1
Microsoft v2


Y-PSNR
Y-PSNR
45
40
35
30
25
20
15
2000
3000
4000
5000
6000
7000
8000
9000
1·10^4
1.1·10^4
1.2·10^4
1.3·10^4
1.4·10^4
Frame size (with drop frames)
MS_3688_v1
MS_3688_v2
MS_3688_v3
Angel Potion
KS v1
KS v2
KS v3
Microsoft v1
Microsoft v2





Conclusions:

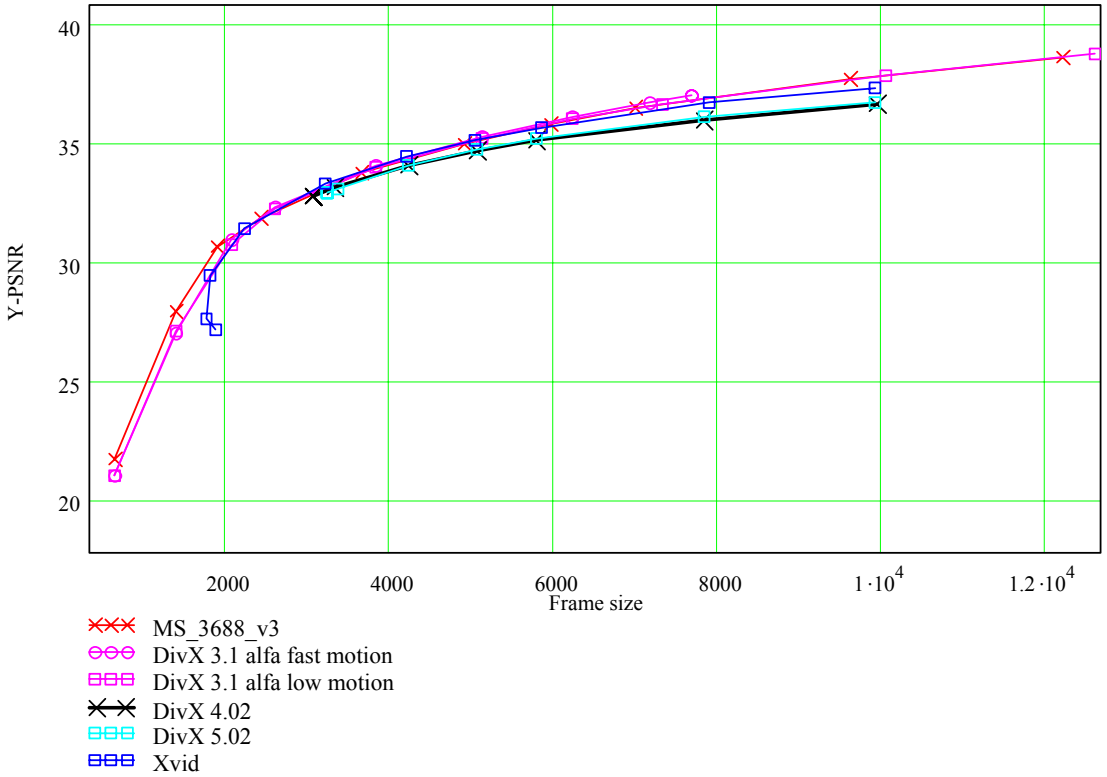
- Similar way of functioning is evident for this group.
- Small differences might be caused by the changes in the default settings and some small adjustments made to the original codec.
- Microsoft v3, KS v3 and Angel Potion (to a lesser degree) codecs proved to have some advantages before the other codecs. Among these advantages are the usage of drop frames and good Y-PSNR metric on low bitrate. Other codecs work almost identically.

Y-PSNR / Frame Size Diagrams

These diagrams are good for demonstrating the dependence of the quality of the compressed sequence on its size. Average values of metric and frame size are used as coordinates of the basic points of the diagrams. So each branch contains ten points, which relate to the different bitrate values.

MPEG4

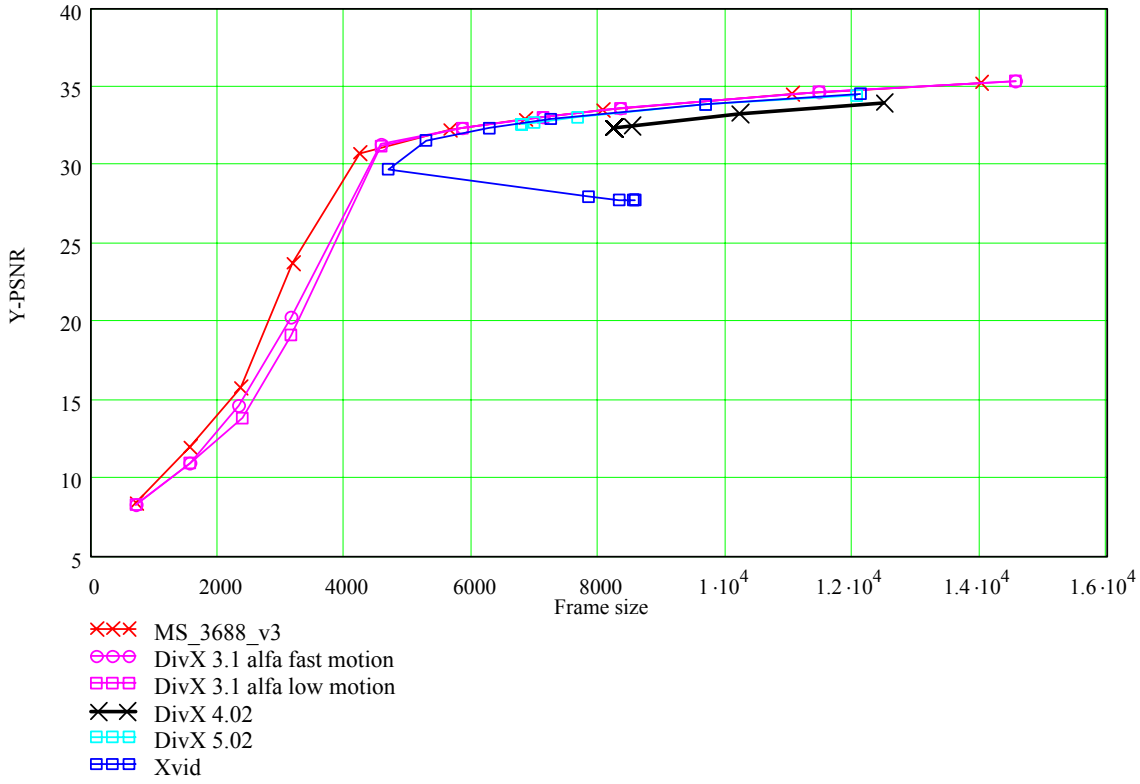
Microsoft 3688 v3, Divx 3.1, Divx 4.02, Divx 5.02 and Xvid 2.1



Picture 1. Sequence BANKOMATDdi

Conclusions:

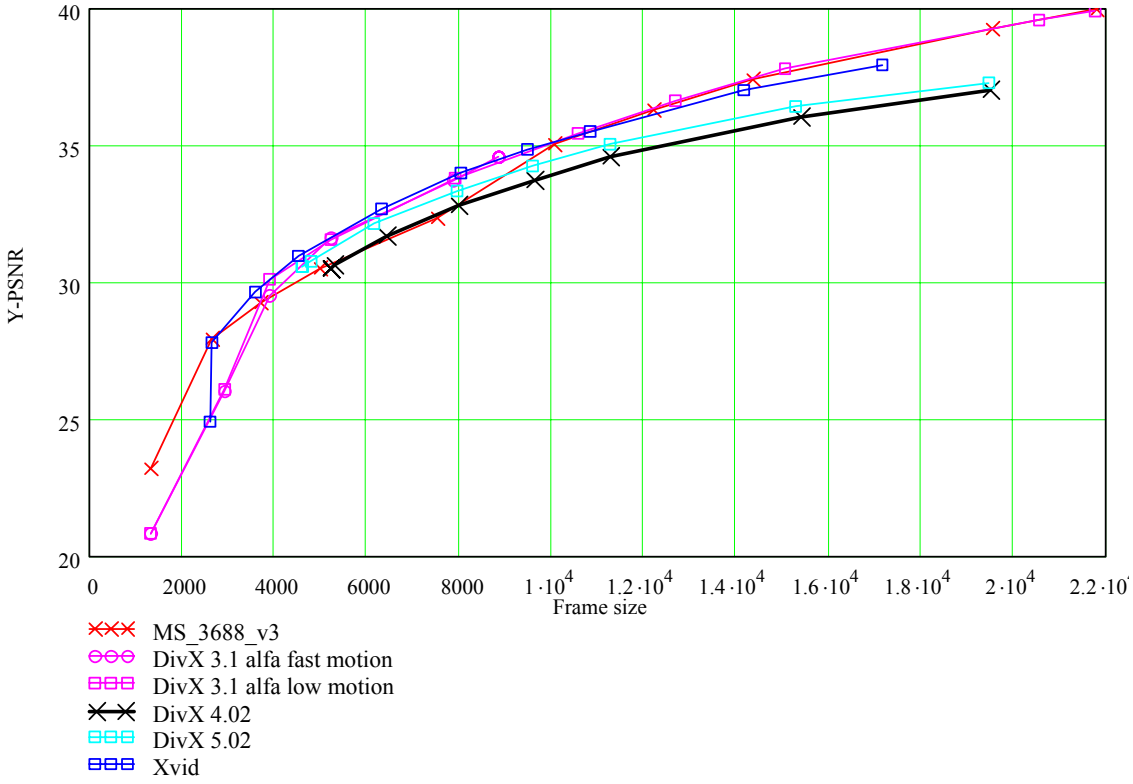
- Div 3.1 works a little bit worse than Microsoft on low bitrate.
- Codecs work almost identically if the frame size is around 2-4kb.
- Branches for Divx 4.02 and Divx 5.02 begin at the 3kb frame size. So this is the minimum bitrate which these codecs can compress with (having default settings).
- Low motion and fast motion versions of Divx 3.1 behave similarly on low bitrate and start to behave differently on the high one. Fast motion version, having a bit smaller PSNR, has a significantly smaller frame size. The battle, helicopterdi and nddp7di sequences showed the same result.



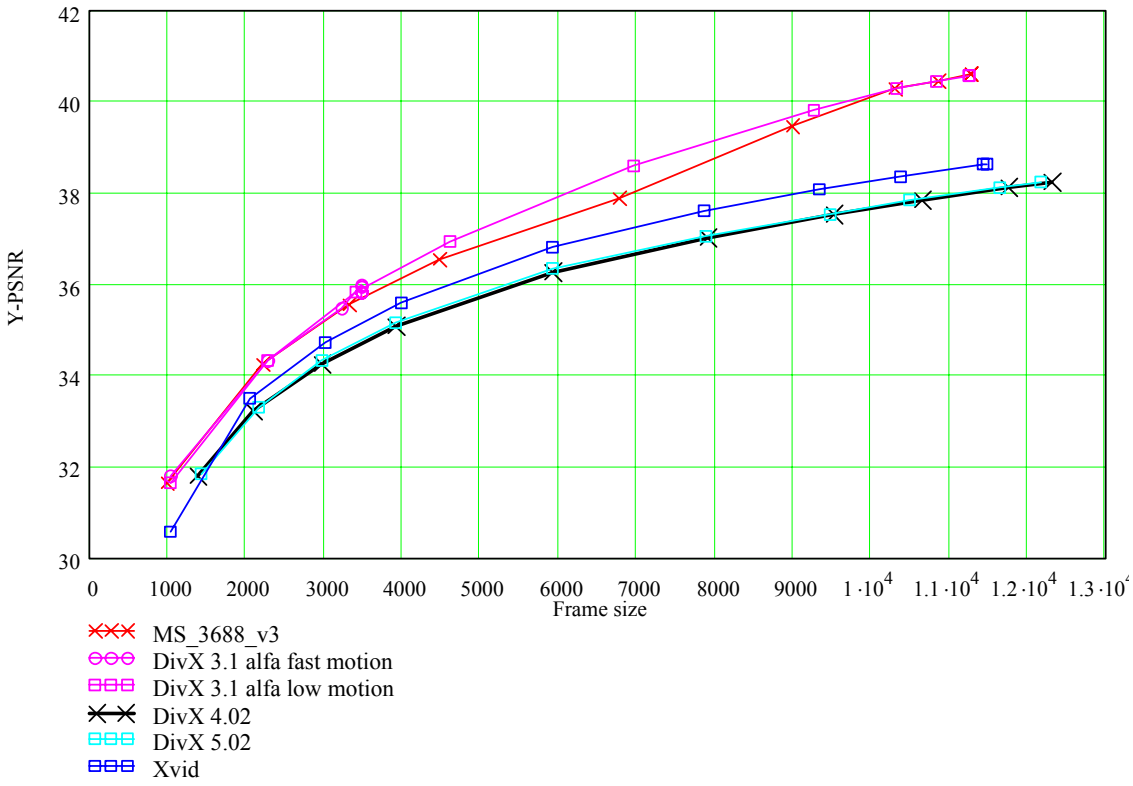
Picture 2. Sequence BBC3di

Conclusion:

- Beginning from the 4 kb frame size branches for low motion and fast motion are identical.
- Divx 5.02 works a little better than Divx 4.02 on this sequence.
- Bending of the Xvid 2.1 branch is caused by decreasing of the frame size on low bitrate. Frame size is decreasing beginning from bitrate value of 100 kbps and is increasing beginning from bitrate value of 938 kbps.

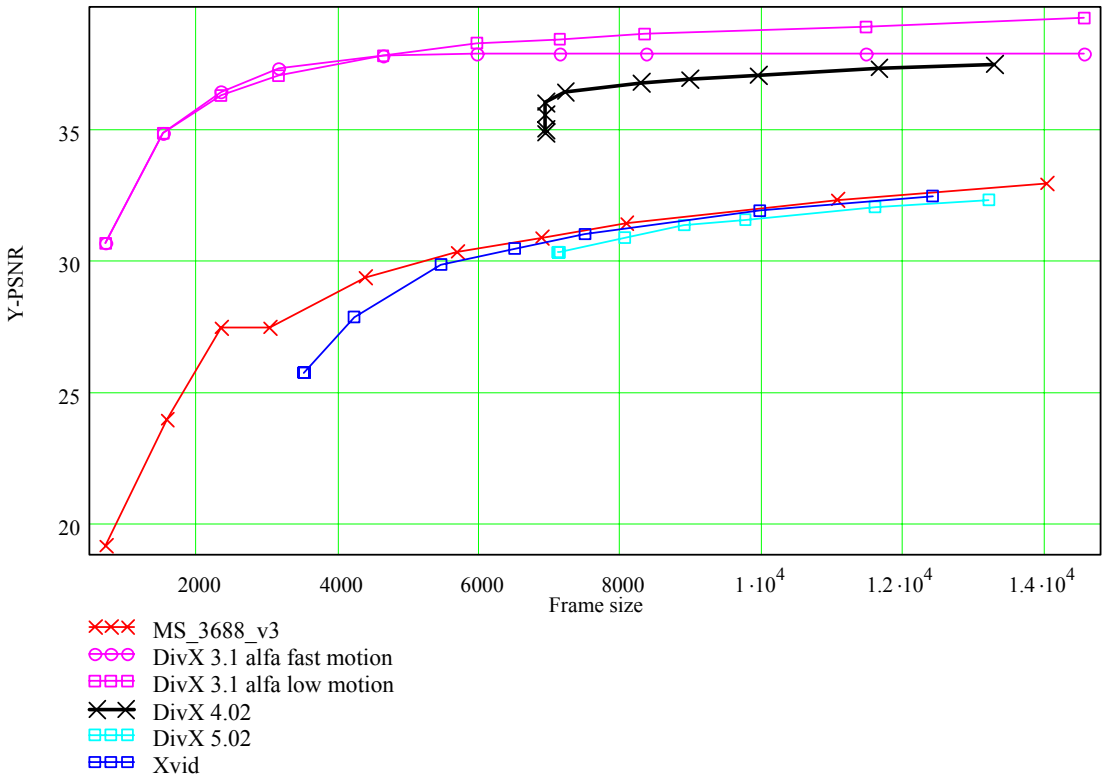


Picture 3. Sequence BUS

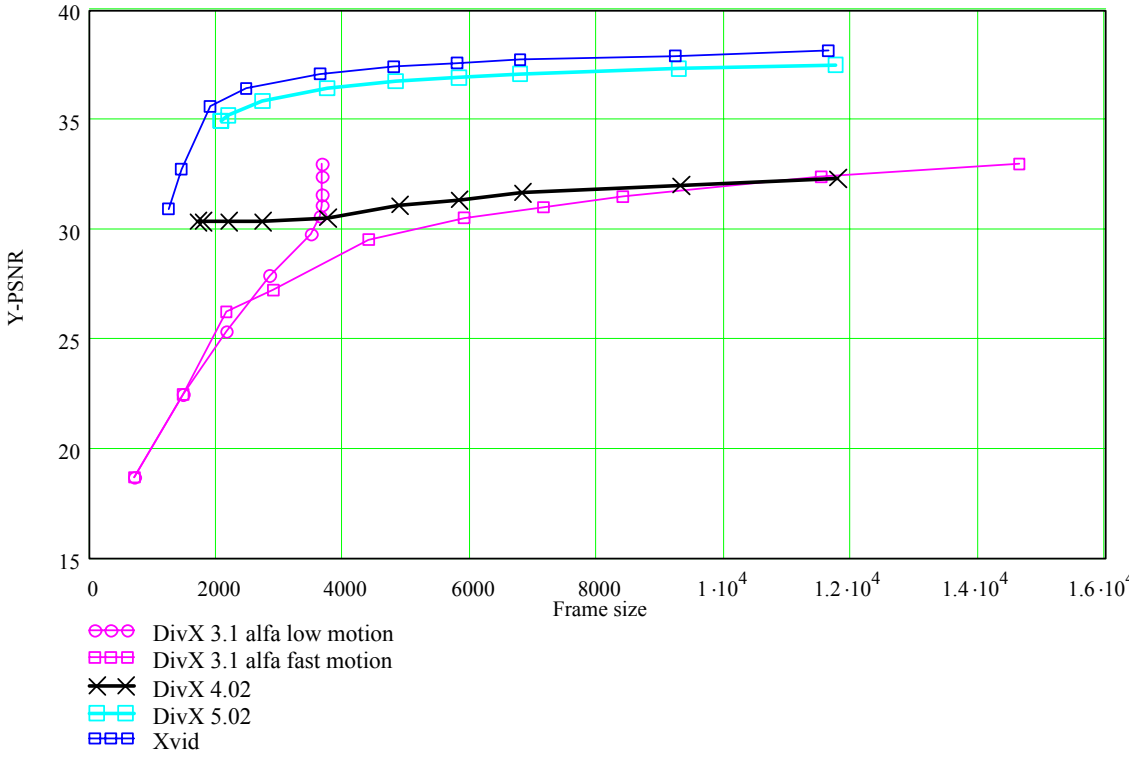


Picture 4. Sequence FOREMAN

Fast motion works worse than low motion on both foreman and bus sequences.



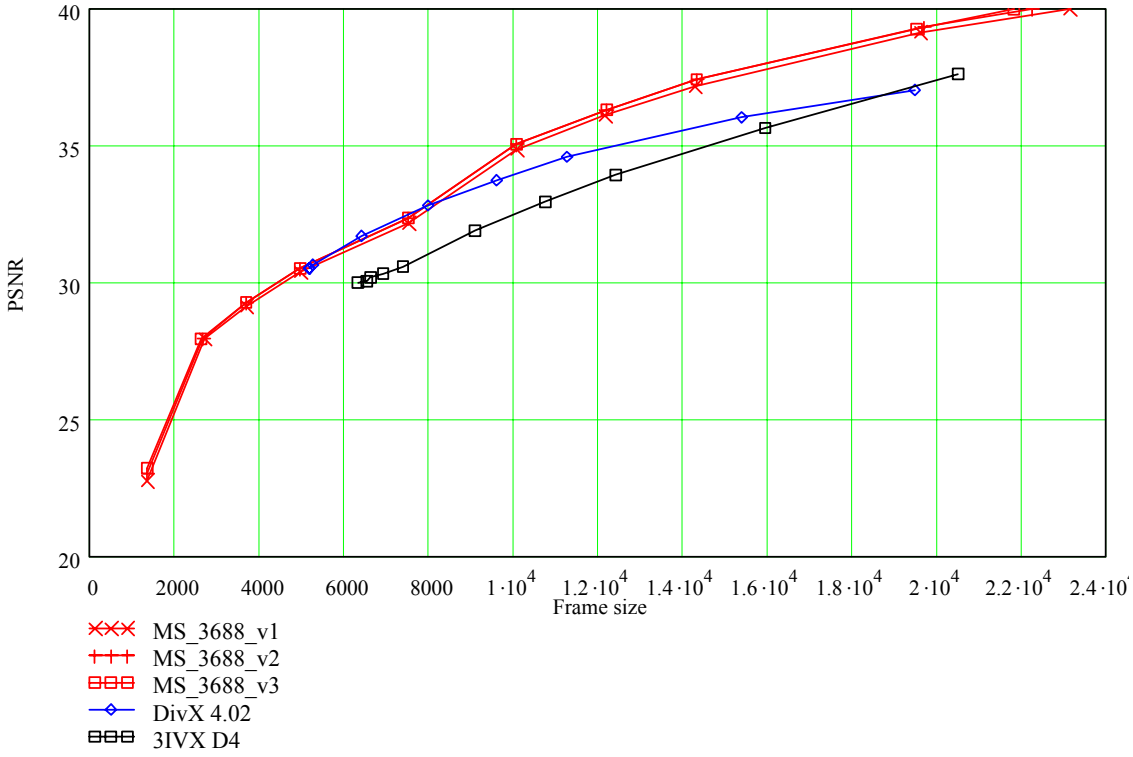
Picture 5. Sequence TENSdi



Picture 6. Sequence SUSIdi

Fast motion works much better than low motion on this clip. Having almost the same metric, frame after fast motion has the size, which is four times as small as the size of the frame after low motion.

Microsoft v1 & v2 & v3, Divx 4.02, 3IVX D4

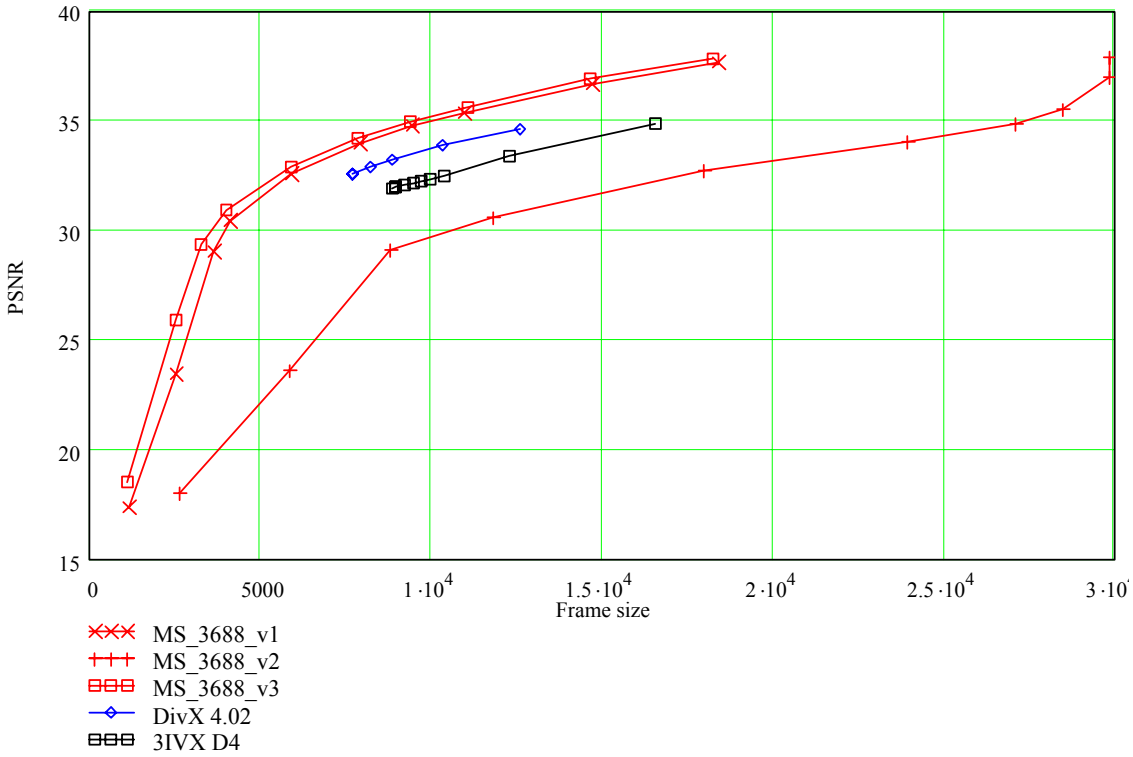


Picture 7. Sequence BUS

Conclusions:

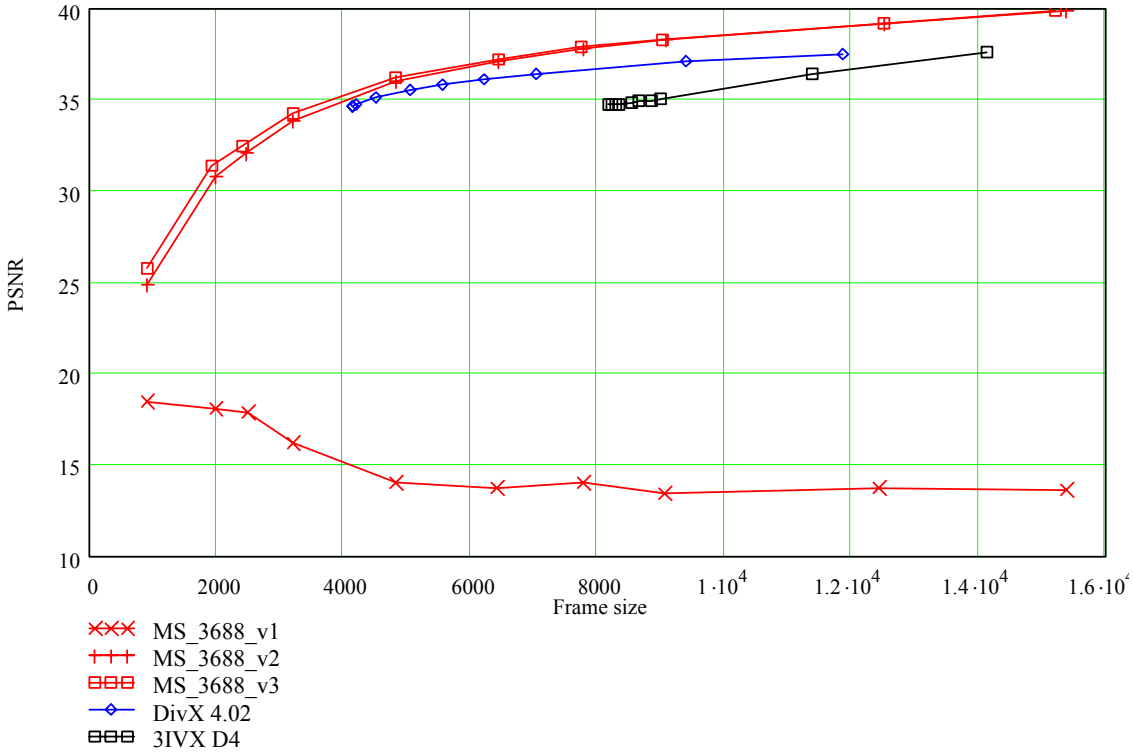
- Microsoft v1, v2, v3 work almost identically.
- Microsoft keeps low bitrate.
- The sequence, compressed by Microsoft, has a better quality than sequences compressed by the other codecs from this group.
- Divx 4.02 does not keep low bitrate, so several points in the beginning turn into one.
- Quality of the sequence, compressed by Divx 4.02, is almost identical with the one, compressed by Microsoft, on low bitrate and with the one, compressed by 3IVX D4, on high bitrate.
- 3IVX D4 changes bitrate a bit when it is set to a low value.

All these features are also true for all the diagrams, which were omitted.

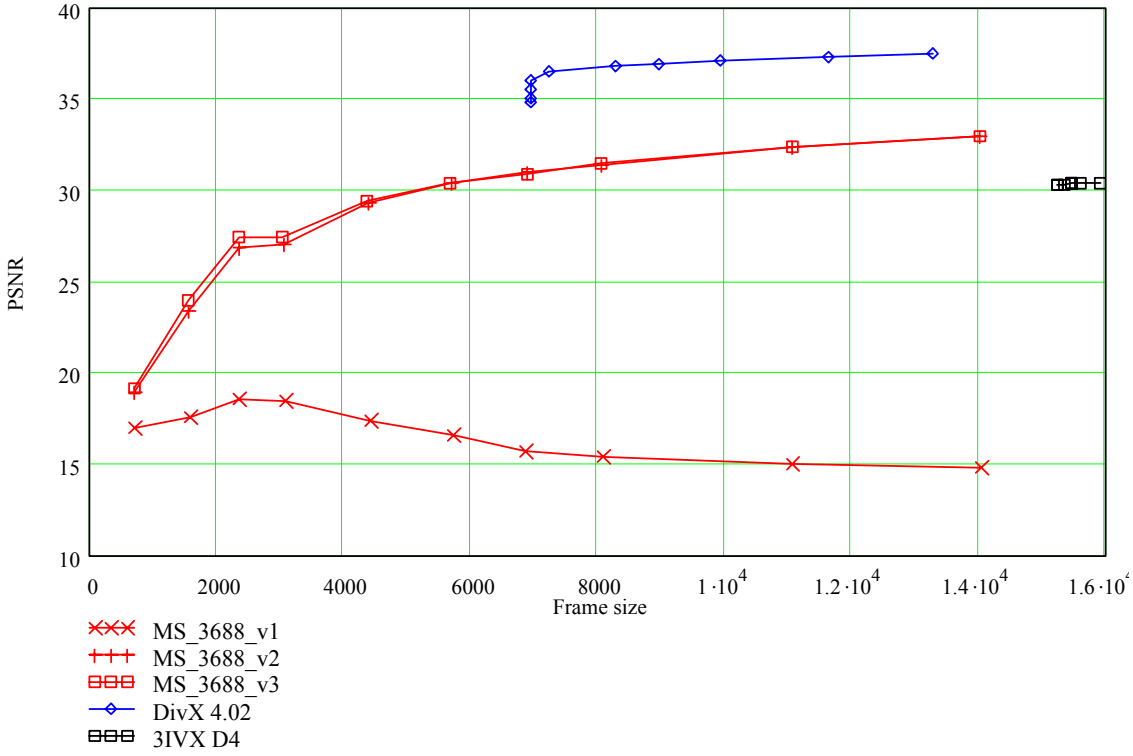


Picture 8. Sequence HELICOPTERdi

Here quality of the sequence compressed by Microsoft v2 is worse than quality of the sequences compressed by Microsoft v1 and v3.



Picture 9. Sequence NDDP7di



Picture 10. Sequence TENSdi

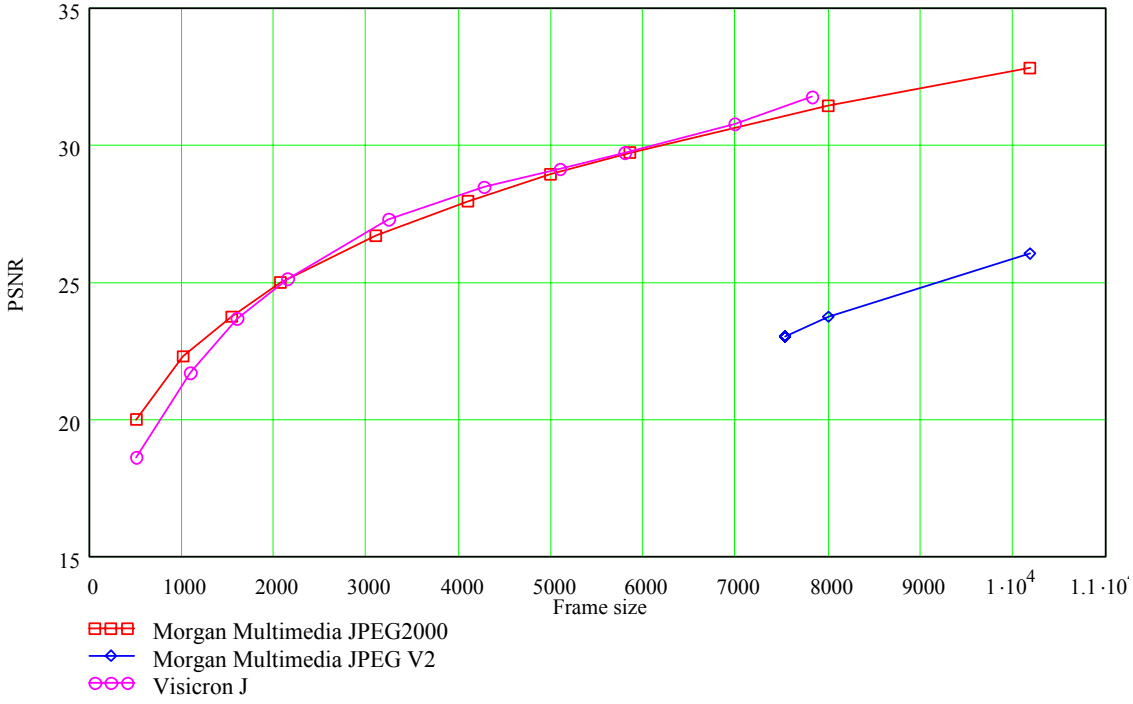
Conclusions:

- Low position of the branches related to Microsoft v1 (see pictures 9, 10) is caused by some error that occurred during compression/decompression of these sequences. The same error occurred with the bbc3di sequence; a

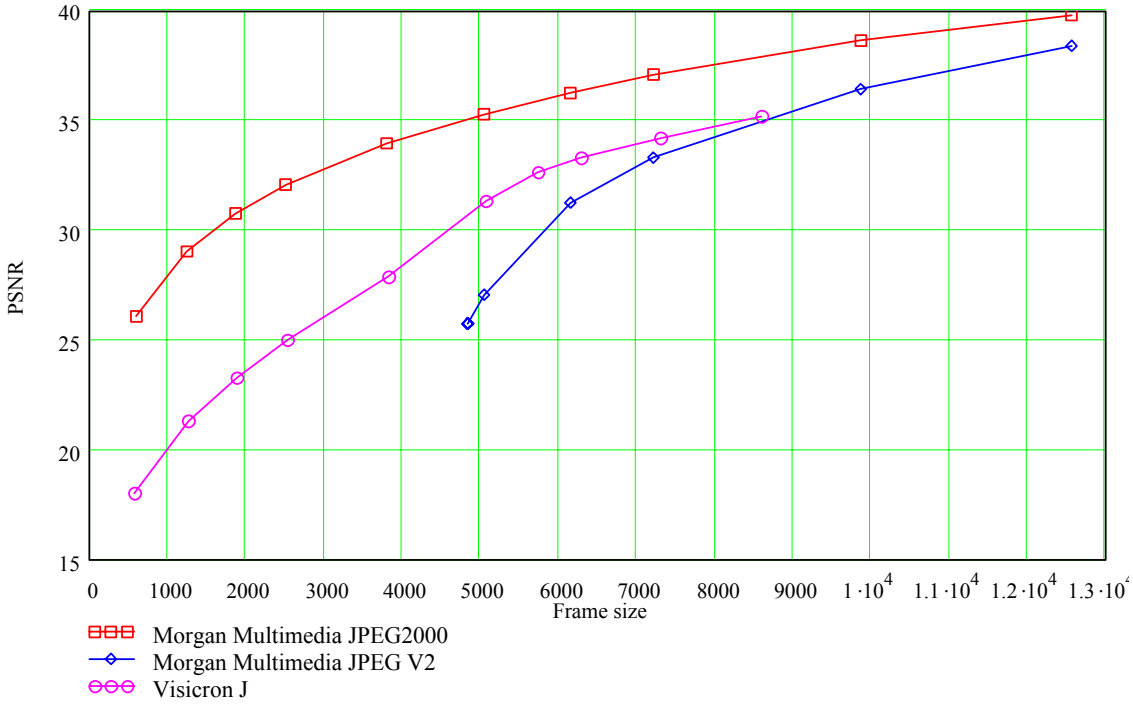
frame from this sequence is given in the description of the Microsoft codec (see “Methodology” section).

- Picture 10 demonstrates that that the quality of the sequence compressed by Divx 4.02 is better than the others.
- Picture10 also demonstrates that 3IVX D4 significantly exceeds the bitrate on the tesndi sequence.

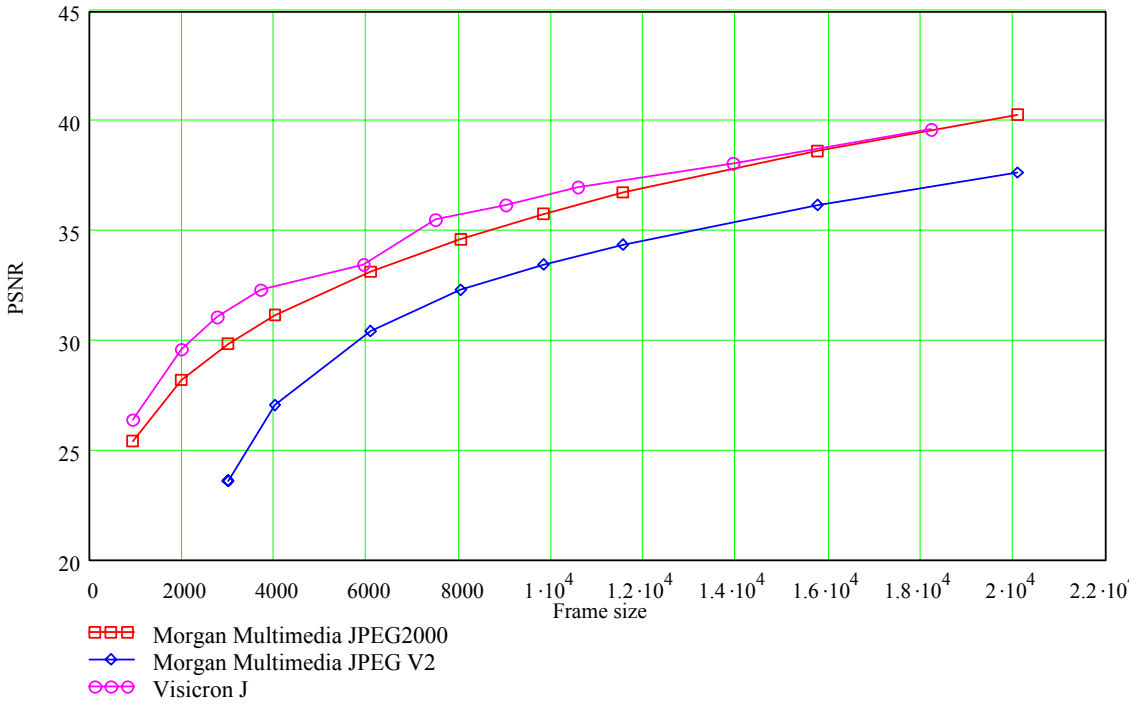
JPEG



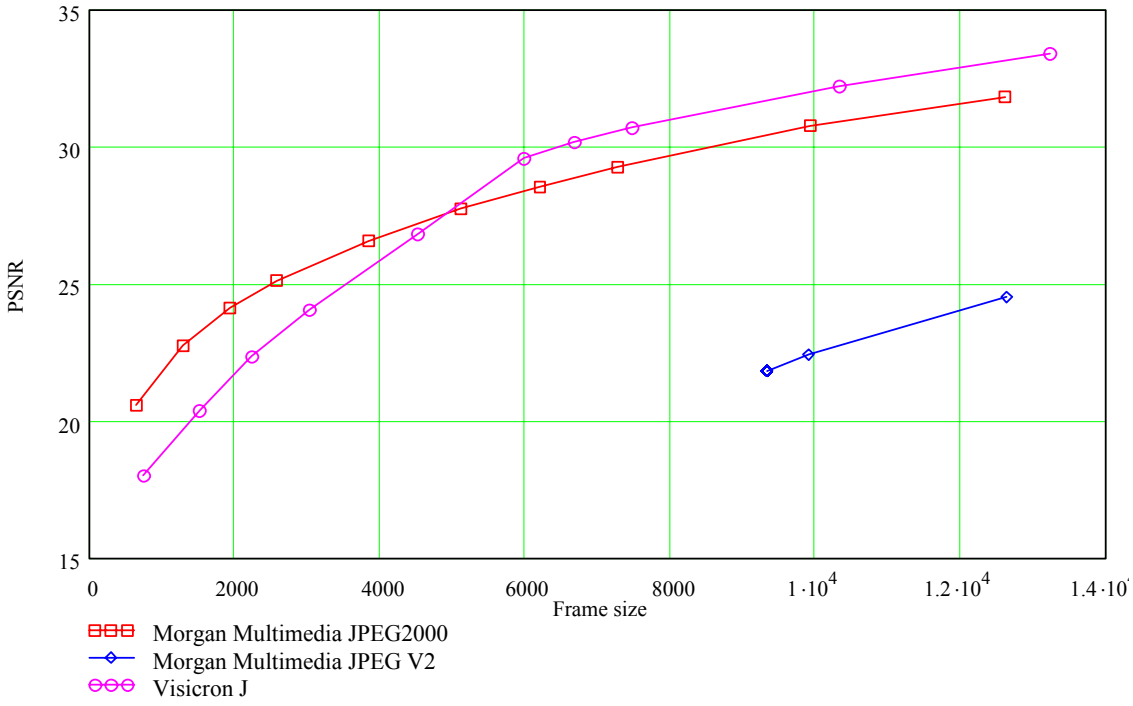
Picture 11. Sequence BANKOMATDdi



Picture 12. Sequence BATTLE



Picture 13. Sequence FOREMAN

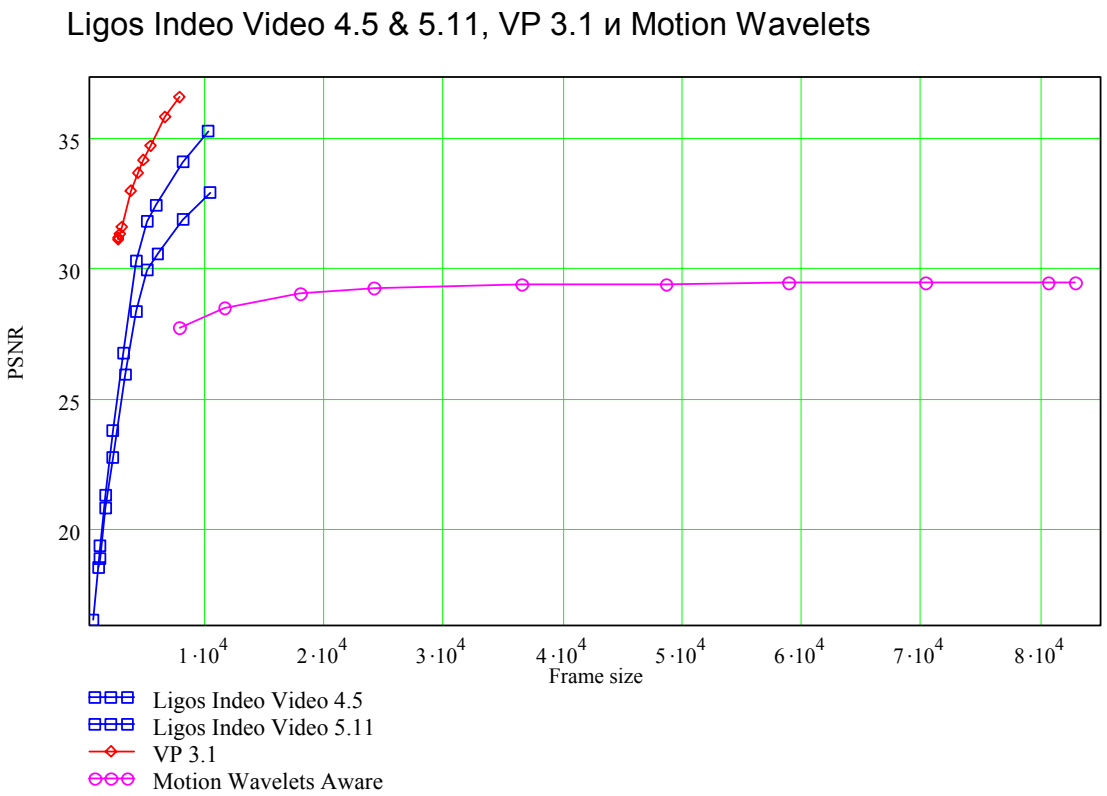


Picture 14. Sequence HELICOPTERdi

Conclusions:

- MM JPEG v2 has the worst quality in this group.
- MM JPEG v2 does not keep low bitrate. For some sequences its branches turned into one point, which means that this codec used one bitrate value with all the 10 different bitrate settings.
- Visicron J has a better quality than MM JPEG2000 on the tensdi sequence. Perhaps that's because MM JPEG2000 is oriented on video conferences and tensdi has some characteristic for such a video stream features.

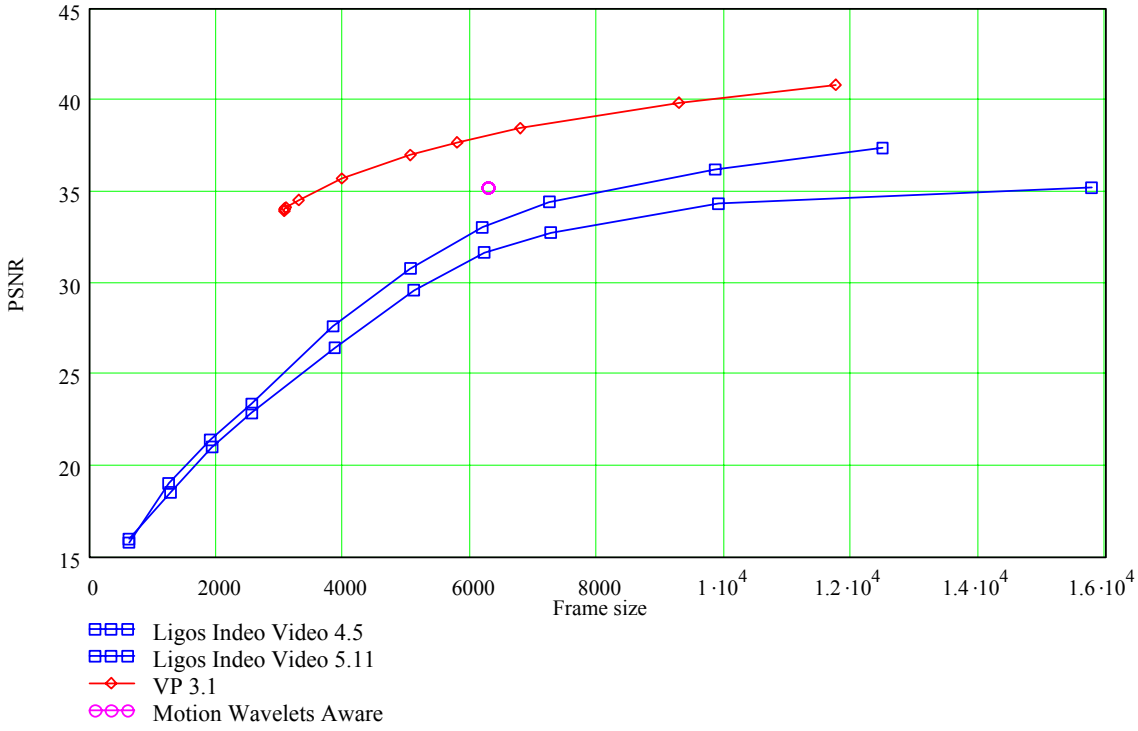
NON-STANDART



Picture 15. Sequence BANKOMATDdi

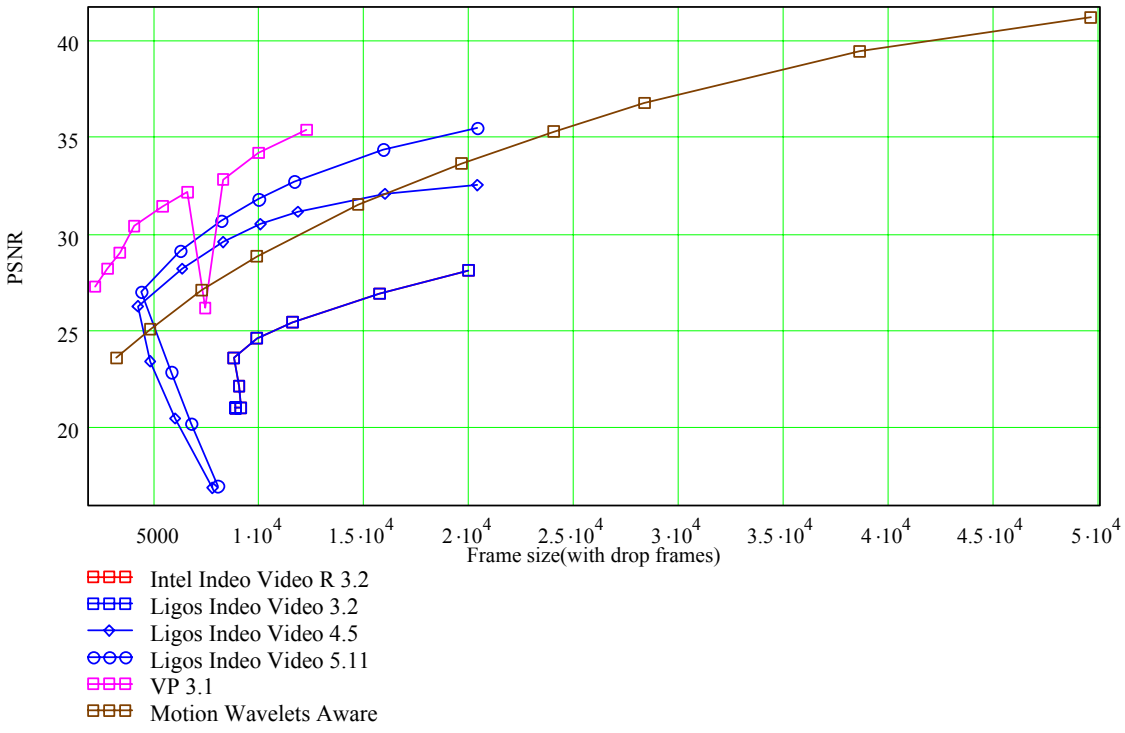
Conclusions:

- Length of the branch for Motion Wavelets indicates that this codec does not keep the bitrate and generates sequences with very high bitrate. This is also true for all other sequences.
- Ligos 4.5 works a little bit worse than Ligos 5.11. This tendency can be observed on all the tested sequences.
- VP 3.1 is the best in this group.



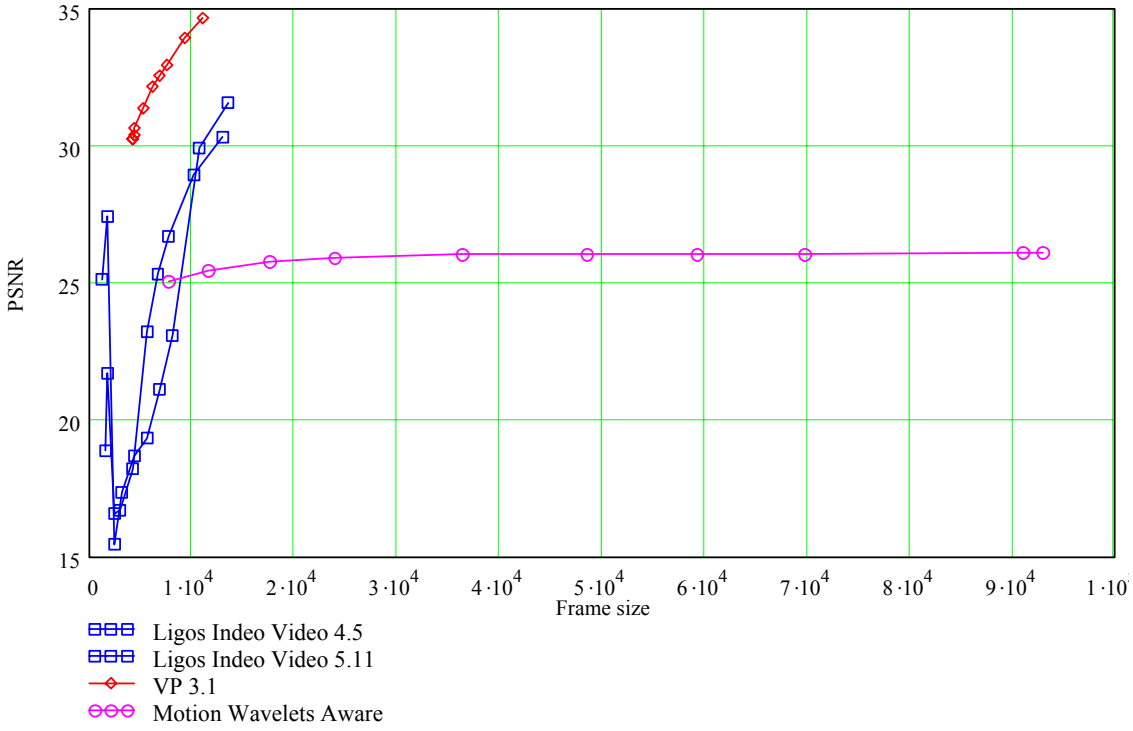
Picture 16. Sequence BATTLE

Here the branch for Motion Wavelets turns into the point. It means that this codec compresses the sequence with the same bitrate for all the bitrate settings.



Picture 17. Sequence BUS

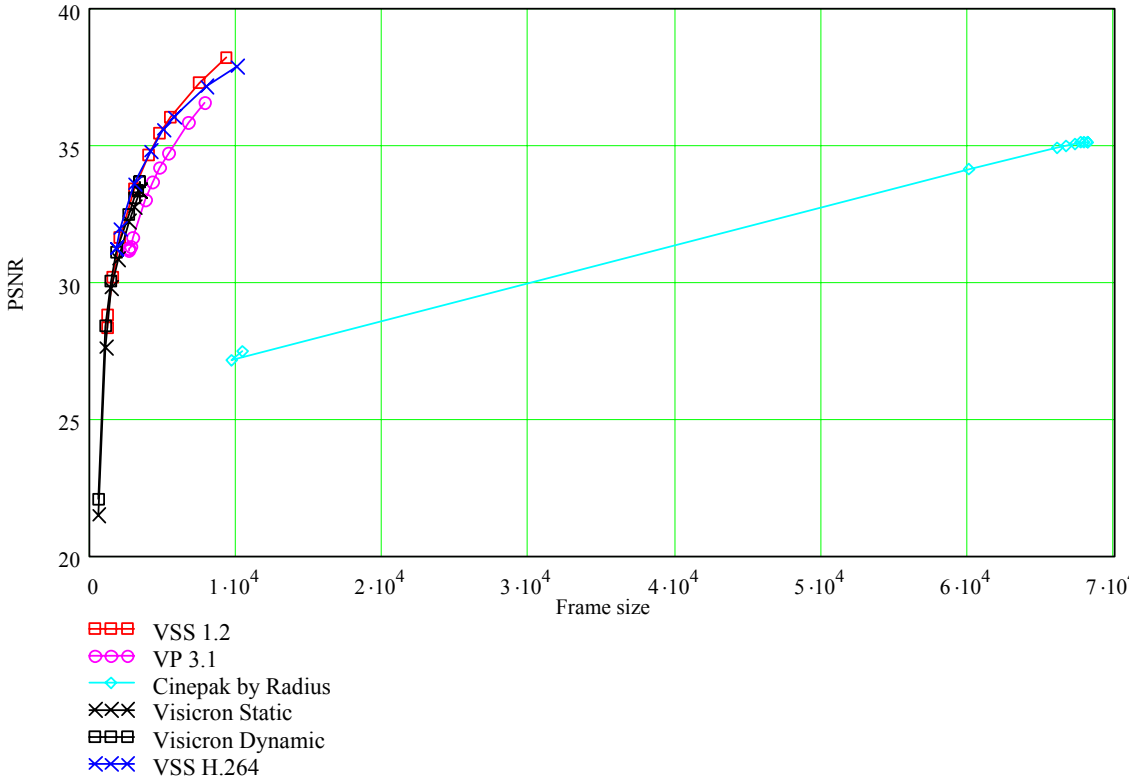
Here Ligos 3.2 works much worse than its later versions.



Picture 18. Sequence HELICOPTERdi

Abrupt changes of metric on low bitrate indicate instability of the Ligos 4.5 & 5.11 codecs' work.

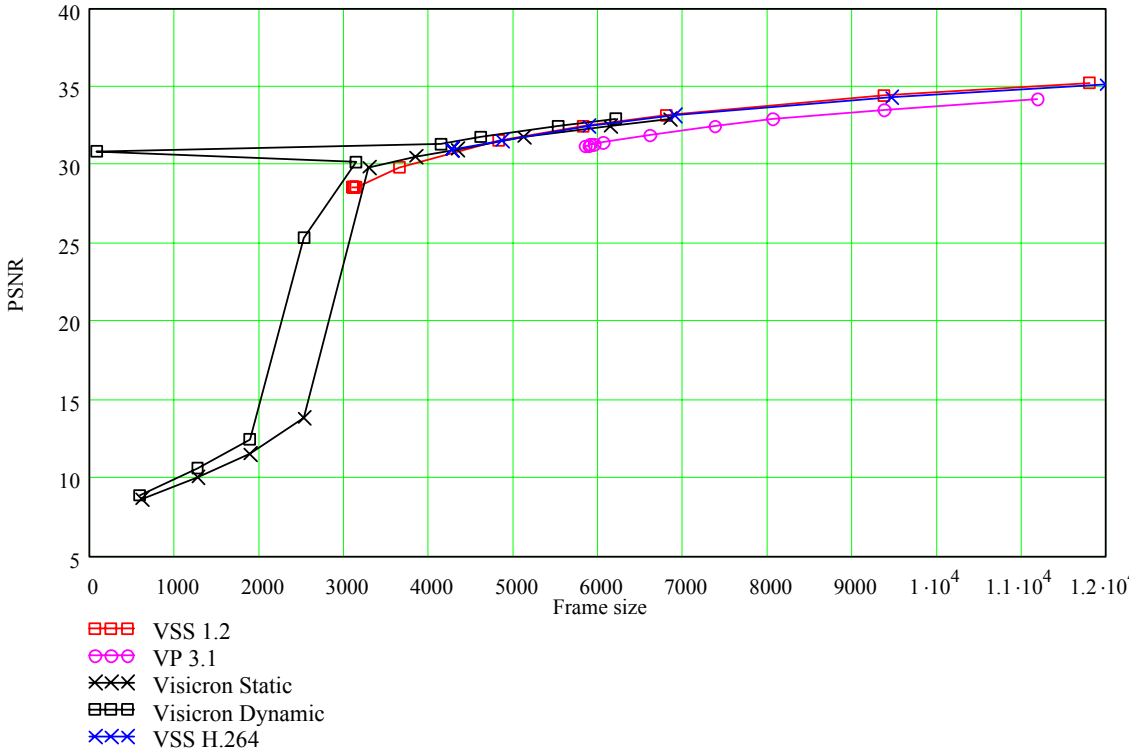
VSS H.264, VSS 1.2, Intel I.263, VP 3.1, Cinepak by Radius, Visicron Static & Dynamic



Picture 19. Sequence BANKOMATDdi

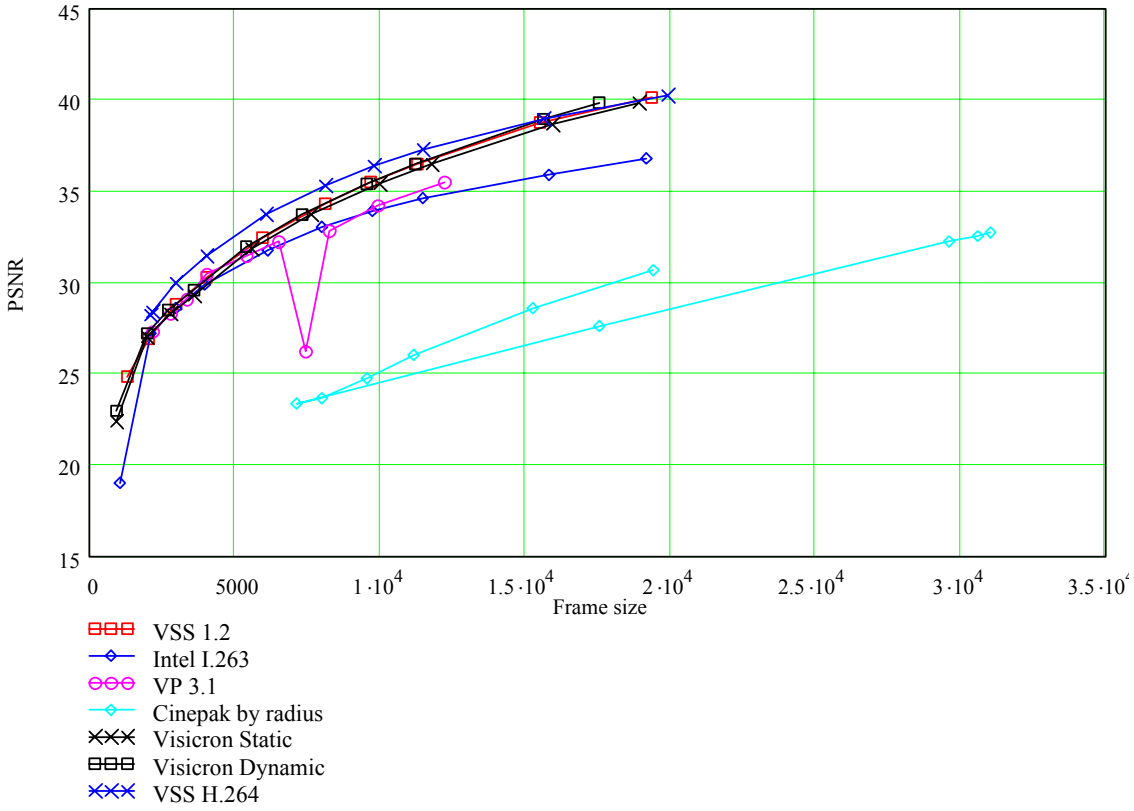
Conclusions:

- Cinepak by Radius greatly increases the bitrate and its branch badly affects the clarity of the diagram. That's why the branch for this codec is further mostly omitted.
- Visicron works almost in the same way in the Static and Dynamic modes; the corresponding branches are very close to each other.

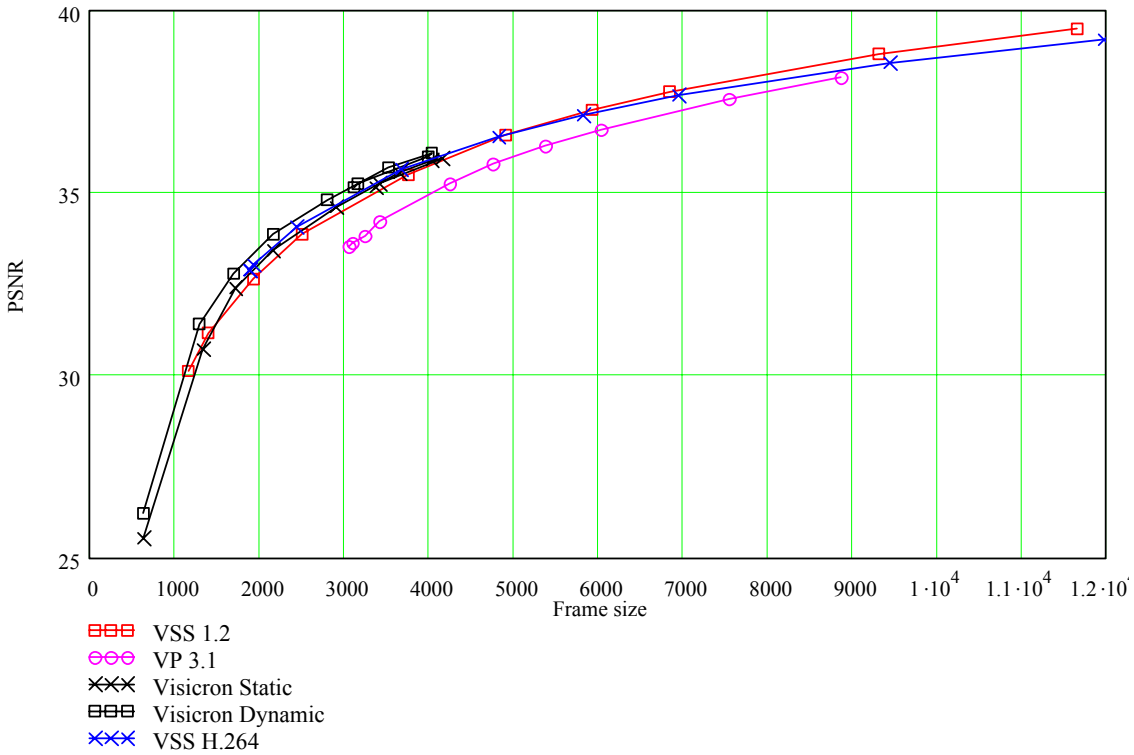


Picture 20. Sequence BBC3di

Failure of the branch for Visicron Dynamic is caused by the error which occurred during the compression (for description of this error see the “Methodology” section).



Picture 21. Sequence BUS



Picture 22. Sequence NDDP7di

Conclusions:

- Cinepak by Radius does not increase bitrate a lot on the sequences with low resolution. But the quality is still rather bad.
- Intel I.263, which works only on the bus and foreman sequences, achieves rather good results. Although Visicron and VP 3.1 still have a better quality.
- Quality of VP 3.1 is close to the quality of VSS 1.2, but the branch for VP 3.1 is stably located lower than the branch for VSS 1.2.
- Visicron has the same quality as VSS 1.2 on the same bitrate. But since Visicron keeps the bitrate better, the branch for VSS 1.2 is located a little bit more on the right and VSS 1.2 reaches a better quality on high bitrate.

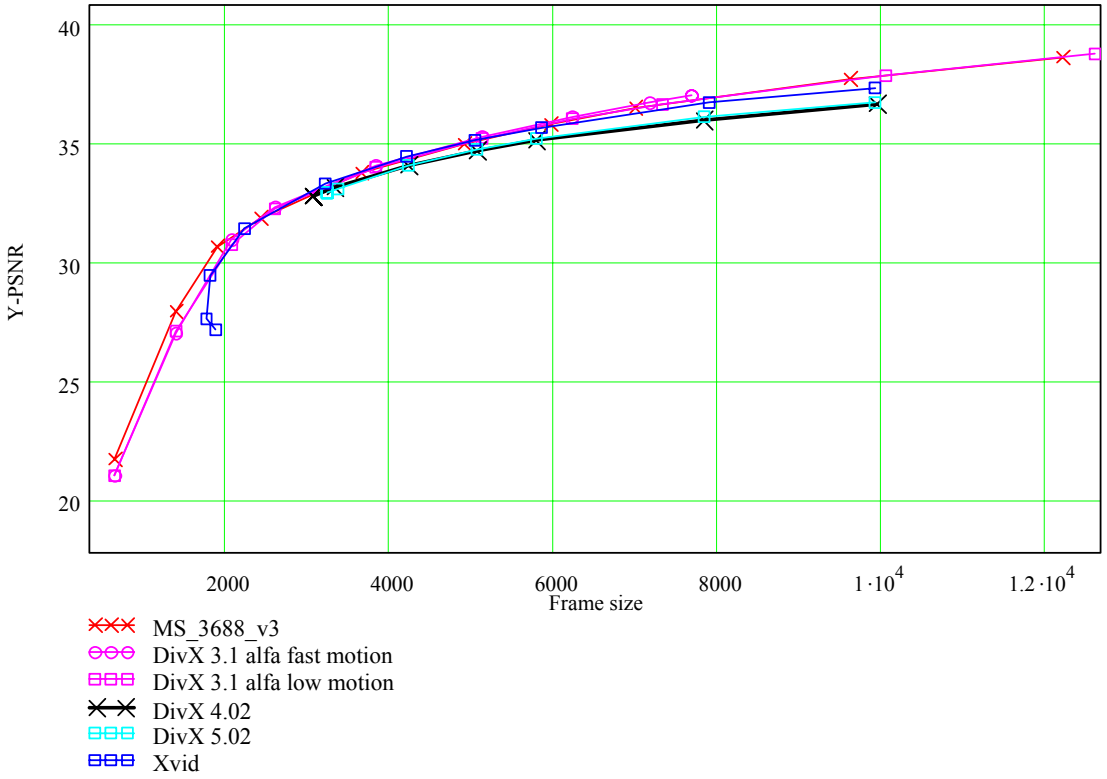
Strategy of Drop Frames

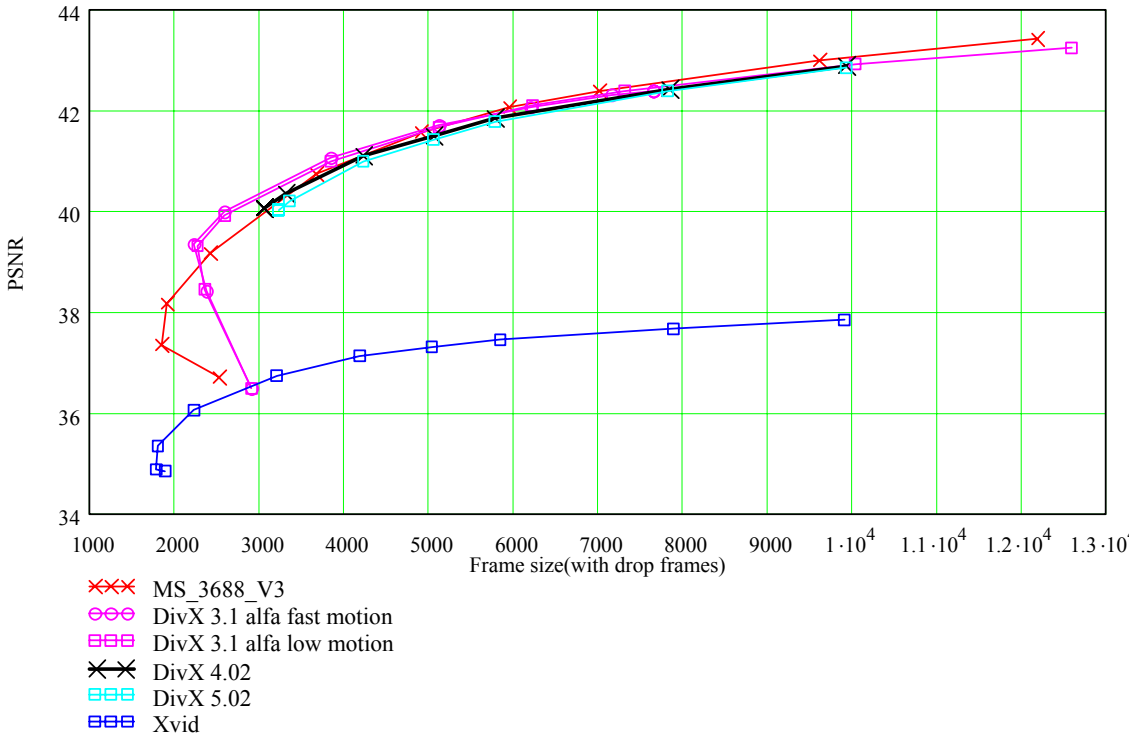
Drop frame is a frame that is not compressed by codec. Instead of compressing it codec replaces this frame with the last compressed frame. Unlike the previously shown diagram type, PSNR/Frame Size (with drop frames) diagrams show dependence of Y-YUV PSNR metric on real average frame size – that is the result of dividing the size of the sequence on the number of non-drop frames. Codec generates drop frames on order to keep the bitrate specified in its options (in other words to reduce the size of the compressed sequence). Frequently codecs generate several drop frames one after another, what affects the film rather unpleasantly: a static picture appears instead of the dynamic scene (slide show effect). On the PSNR/Frame Size (with drop frames) diagram one can easily see the bitrate, beginning from which codec stops generating drop frames. This bitrate relates to the point, beginning from which curves on the with/without drop frames diagrams concur with each other. But this bitrate actually can't be a criterion of codec's quality estimation, because some codecs generate drop frames correctly and make their presence in the sequence. These diagrams do not show positions of the drop frames in the video sequence, and therefore it is impossible to estimate how correctly drop frames were used.

When comparing video codecs in this section one should pay attention to how close to the Y-axis branches of the diagram with drop frames are located. The more on the left the branch is the less average frame size the video sequence has and therefore the greater fps there is at the output. So those codecs, whose branches are located more on the left, provide better fps at the output with the same quality.

MPEG4

Microsoft 3688 v3, Divx 3.1, Divx 4.02, Divx 5.02 and Xvid 2.1

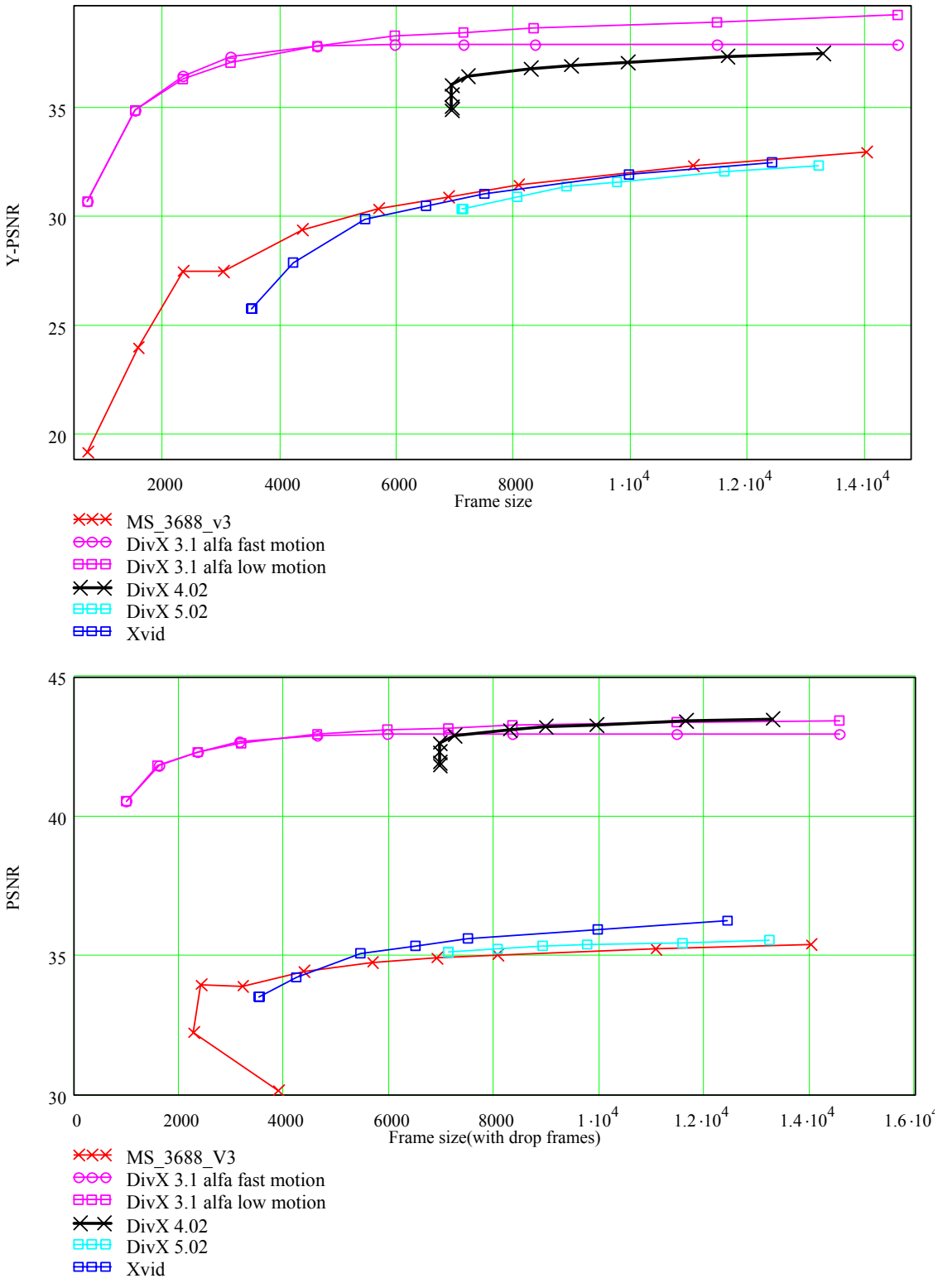




Picture 23. Sequence BANKOMATdi

Conclusions:

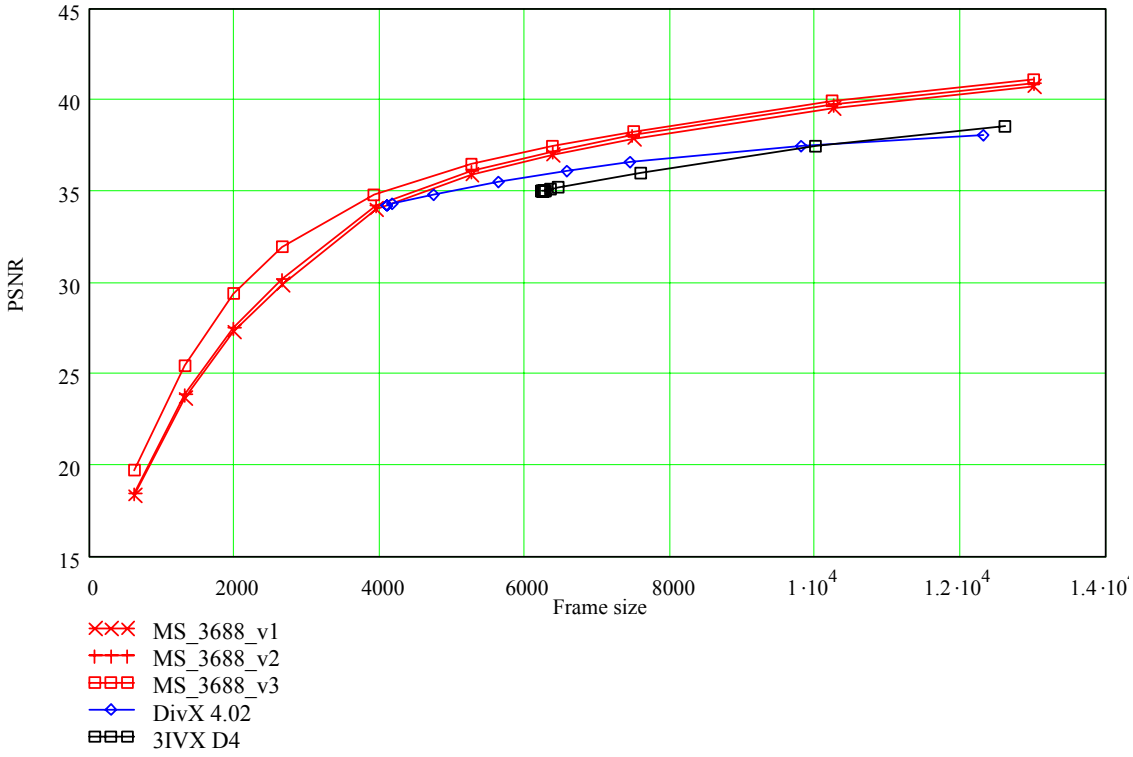
- Only Microsoft v3 and Divx 3.1 generate drop frames.
- The branch for Microsoft v3 is more on the left on high and low bitrate; having the same quality Microsoft v3 has a greater FPS at the output.
- The branch for Divx 3.1 is more on the left on average bitrate and thus Divx 3.1 has a greater FPS.
- The bend of the branch for Xvid 2.1 is caused not by the drop frames` usage but by some specific change of the average frame size.
- Divx 4.02 and Divx 5.02 do not generate drop frames and thus increase low bitrate.

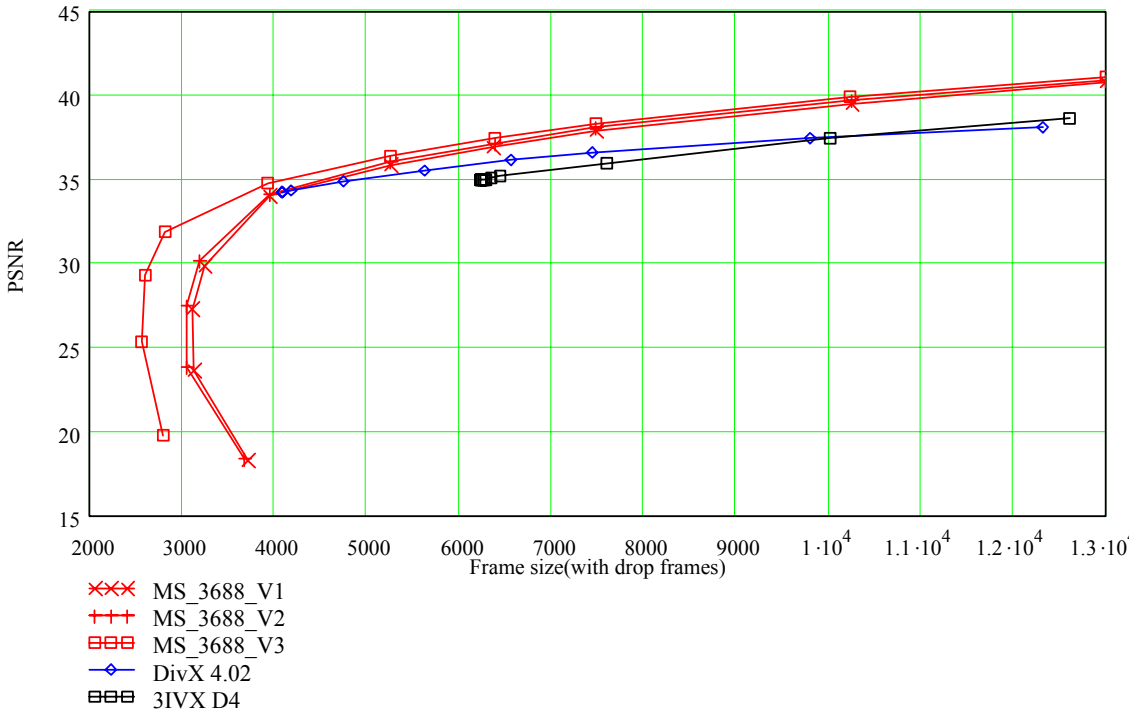


Picture 24. Sequence TENSdi

Divx 3.1 did not generate any drop frames in this sequence and this is the only sequences in which it happened.

Microsoft v1 & v2 & v3, Divx 4.02, 3IVX D4

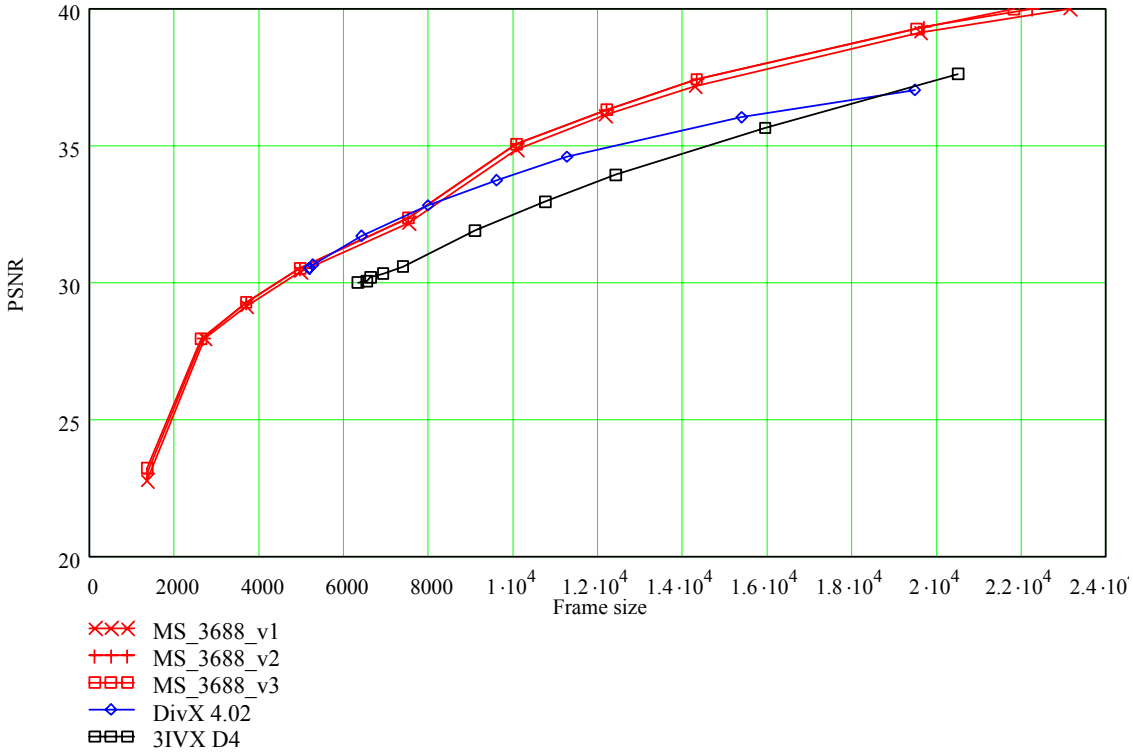


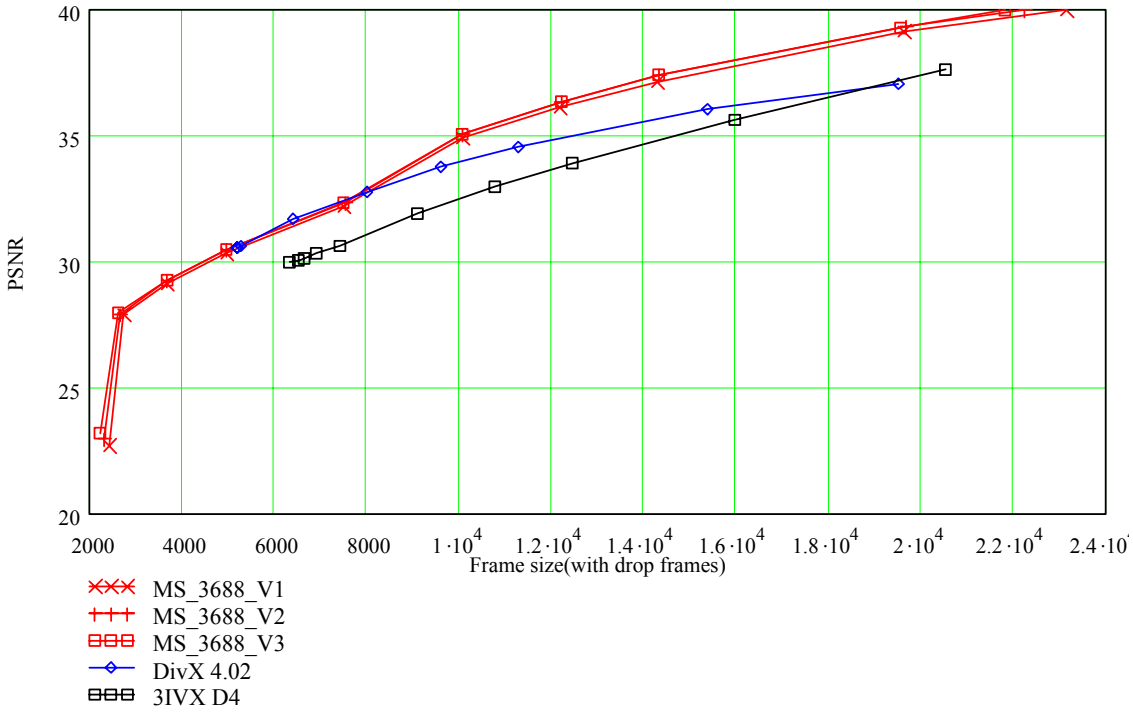


Picture 25. Sequence BATTLE

Conclusions:

- Only Microsoft codecs use drop frames in this group.
- Superiority of Microsoft v3 is evident for this group.



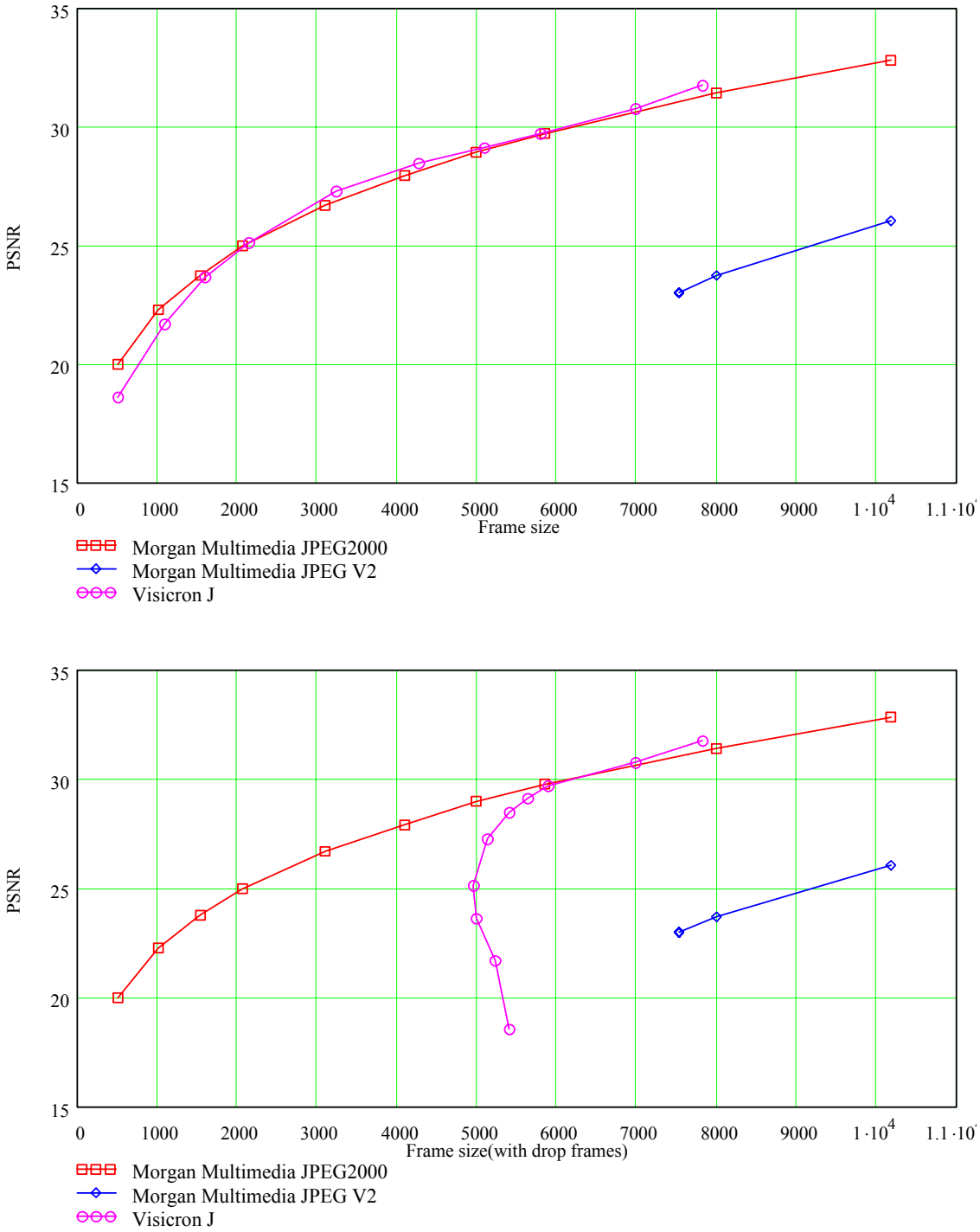


Picture 26. Sequence BUS

Conclusions:

- Microsoft codecs do not use drop frames on the sequences with low resolution like bus and foreman. Since the size of the frame is rather small it is possible to keep bitrate without generating drop frames.

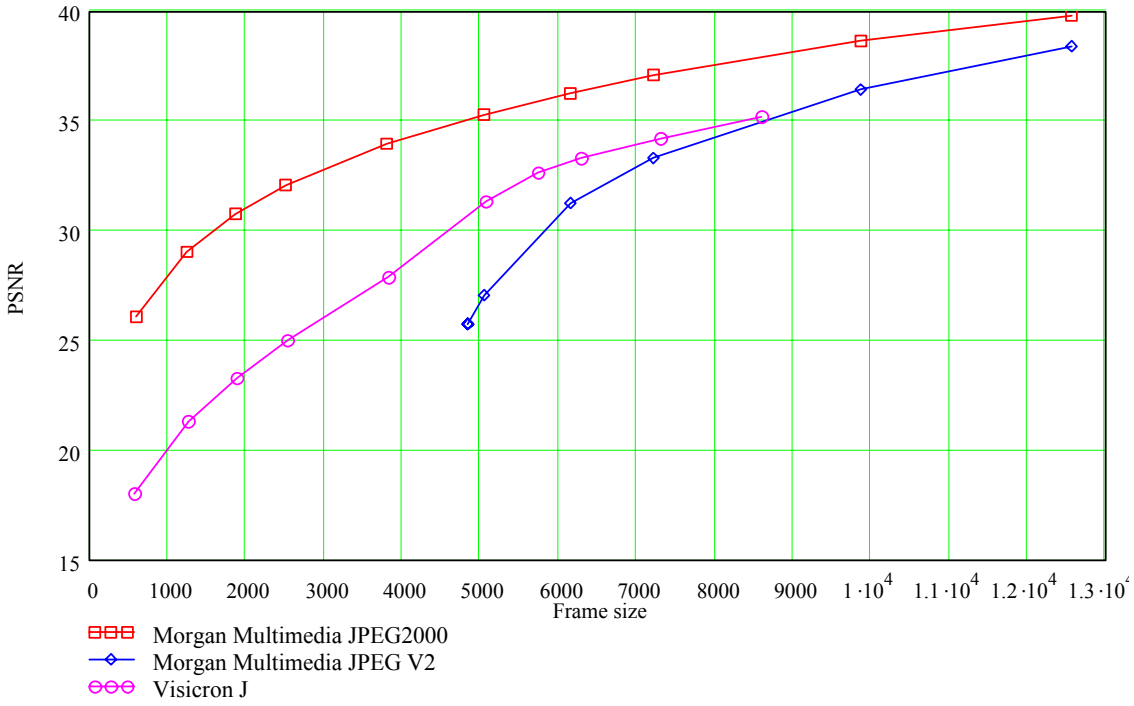
JPEG

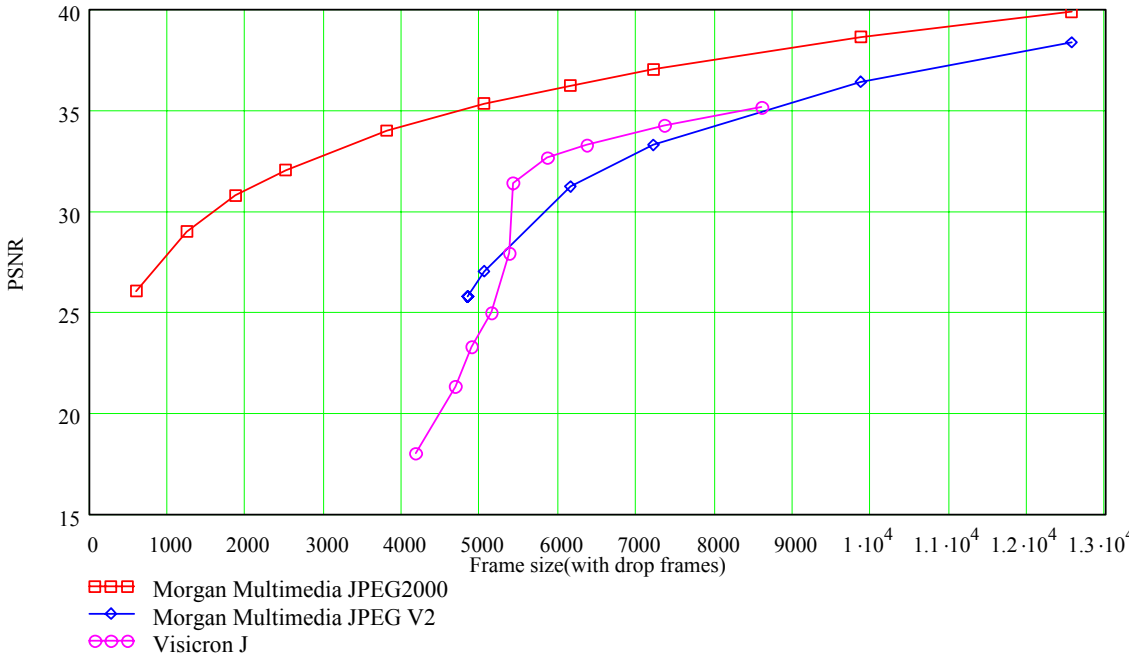


Picture 27. Sequence BANKOMATDdi

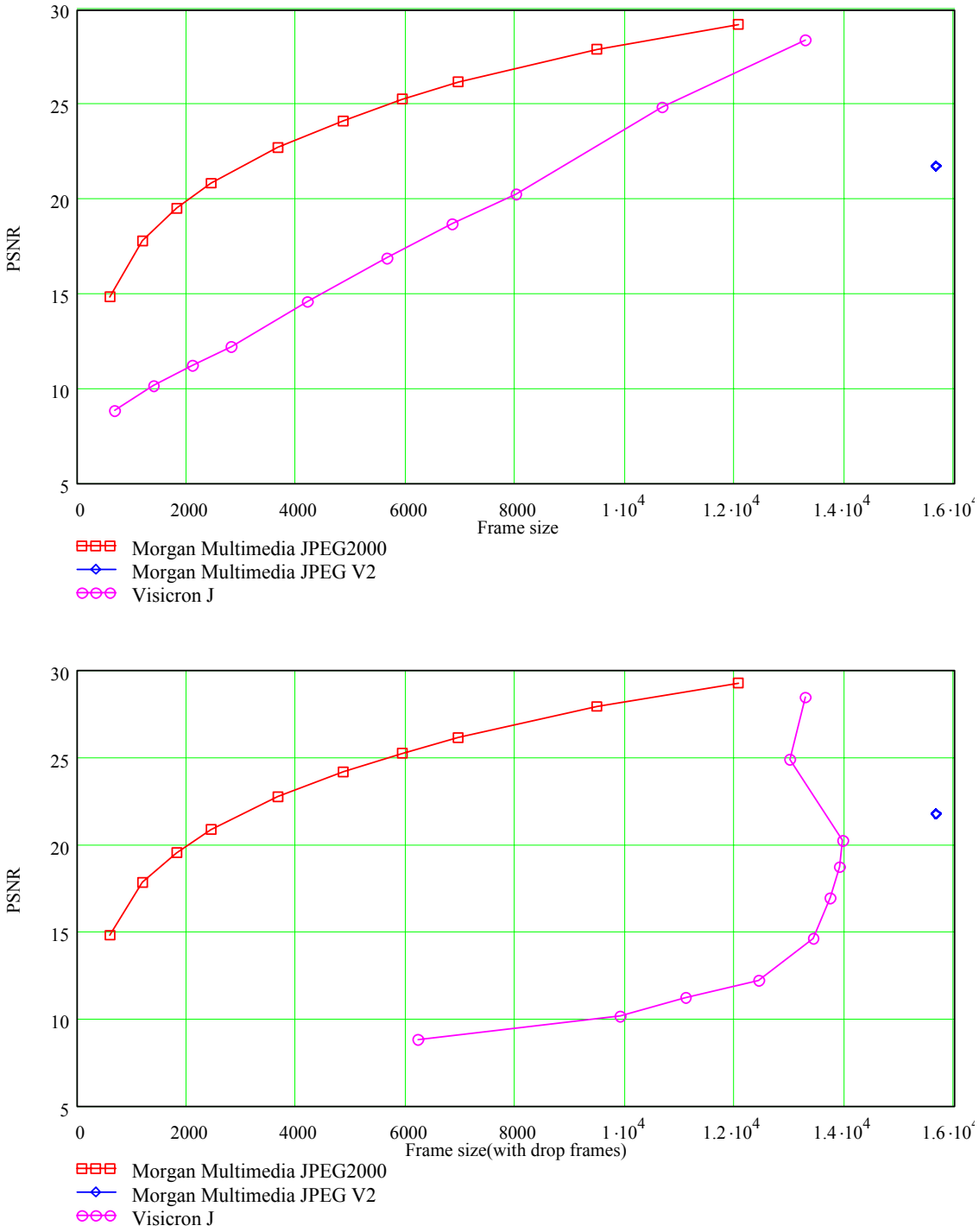
[SV1]Conclusions:

- Only Visicron J uses drop frames in this group. So it can't be compared with the other codecs.

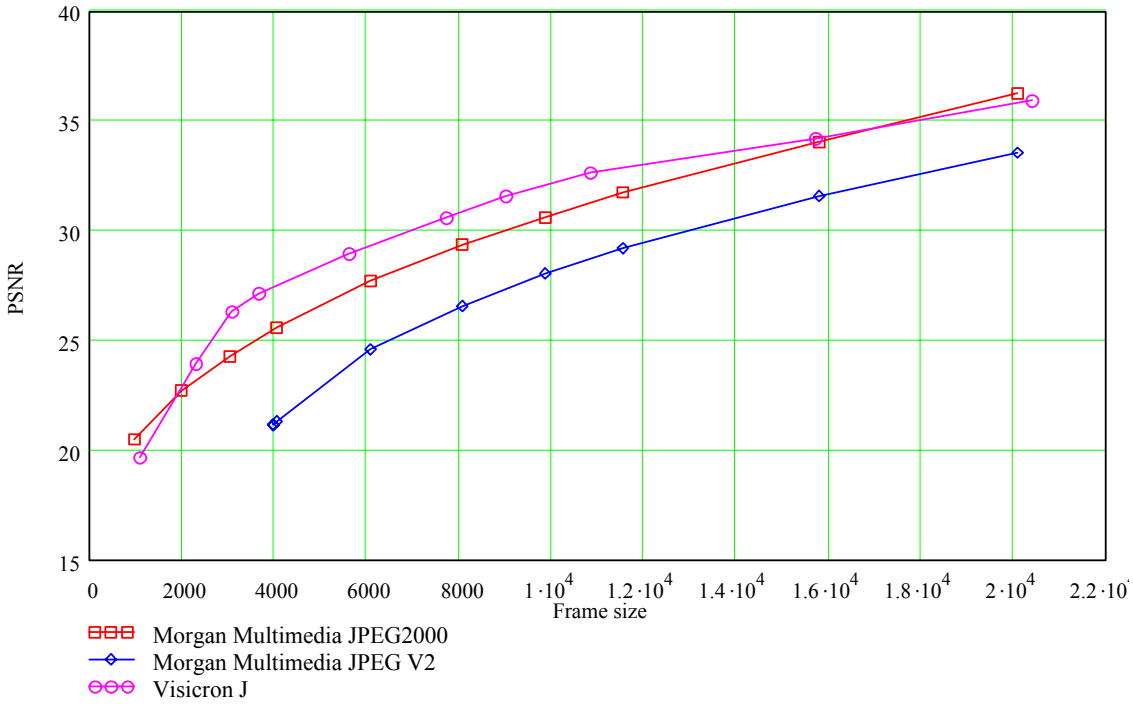


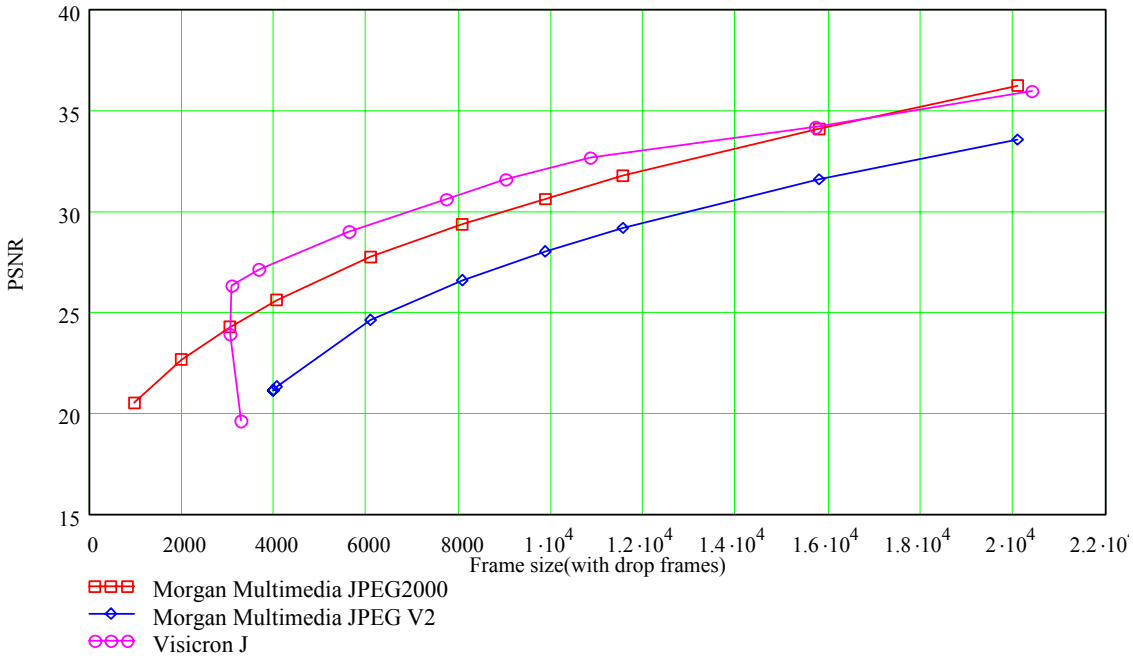


Picture 28. Sequence BATTLE

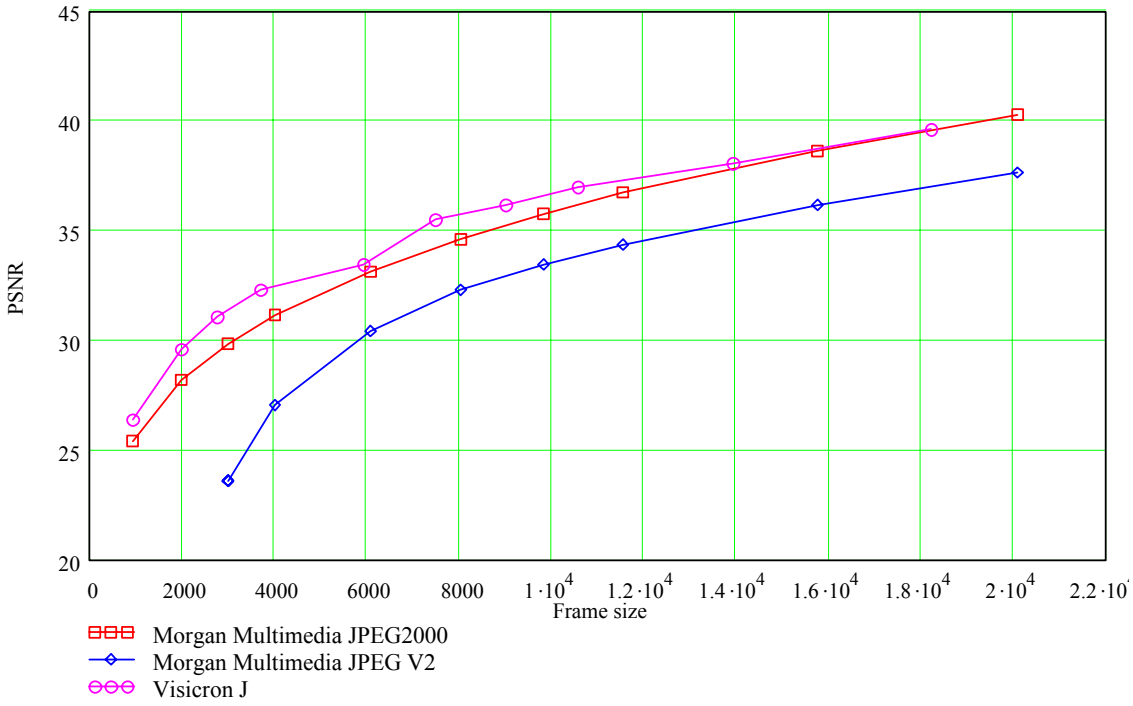


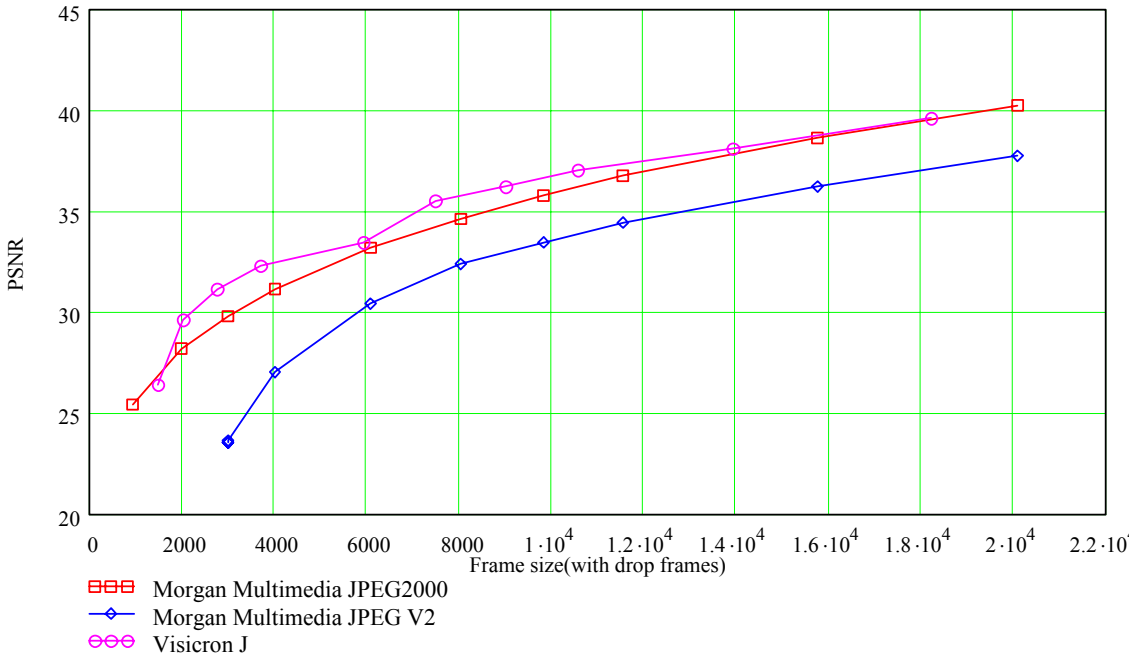
Picture 29. Sequence BBC3di



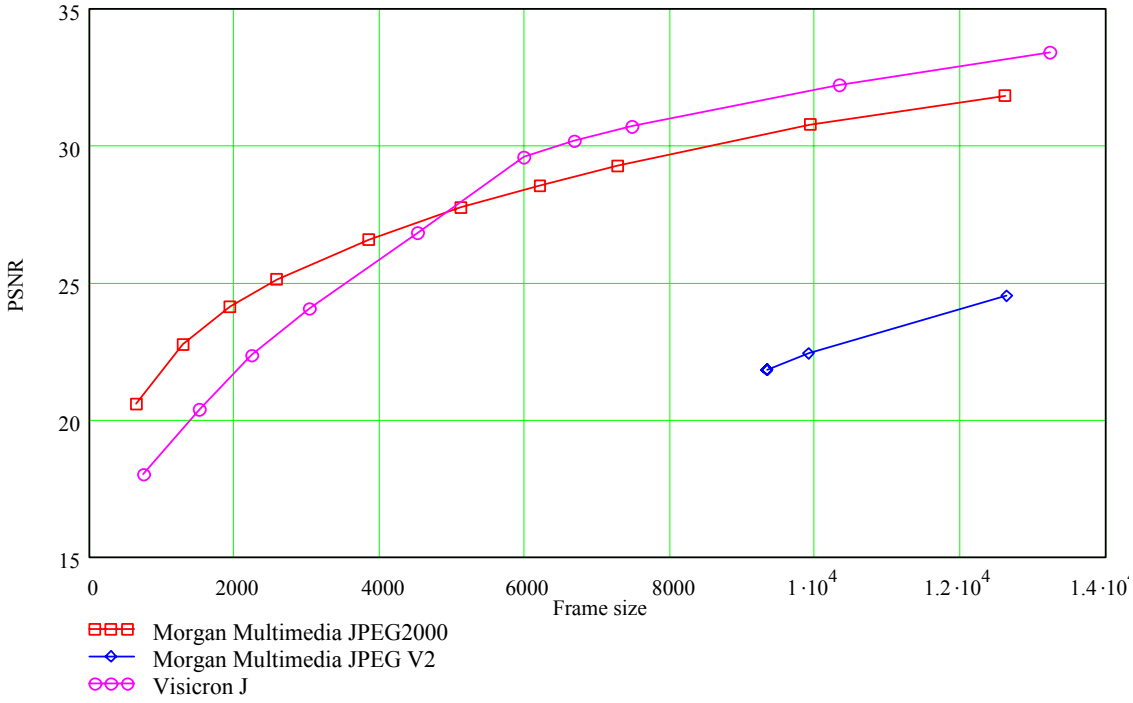


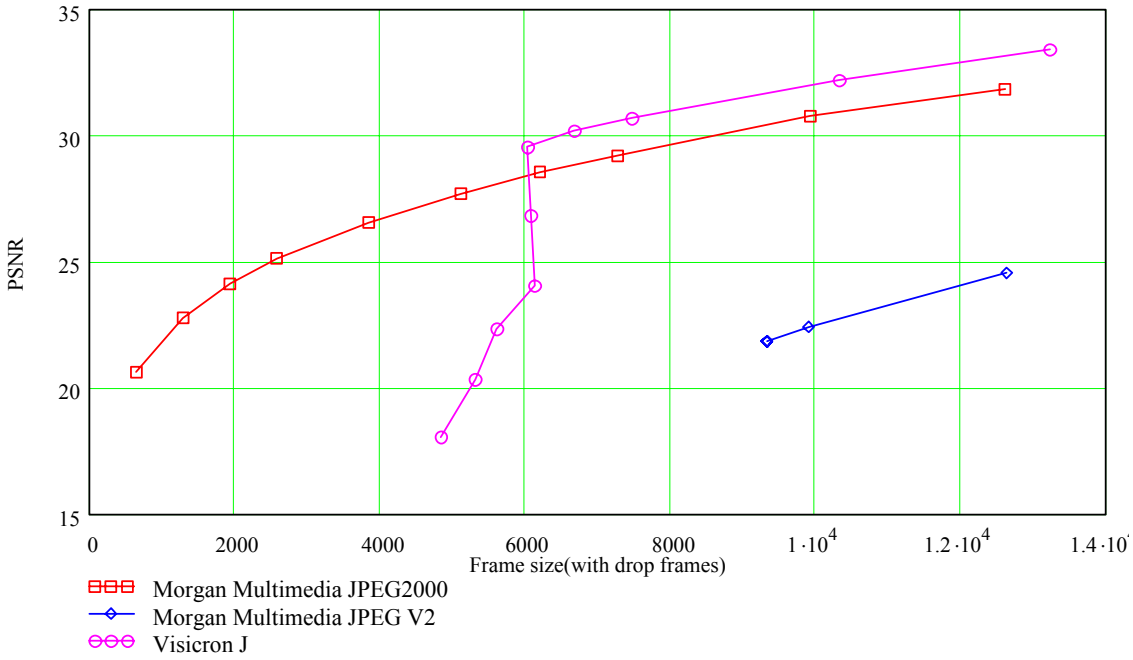
Picture 30. Sequence BUS



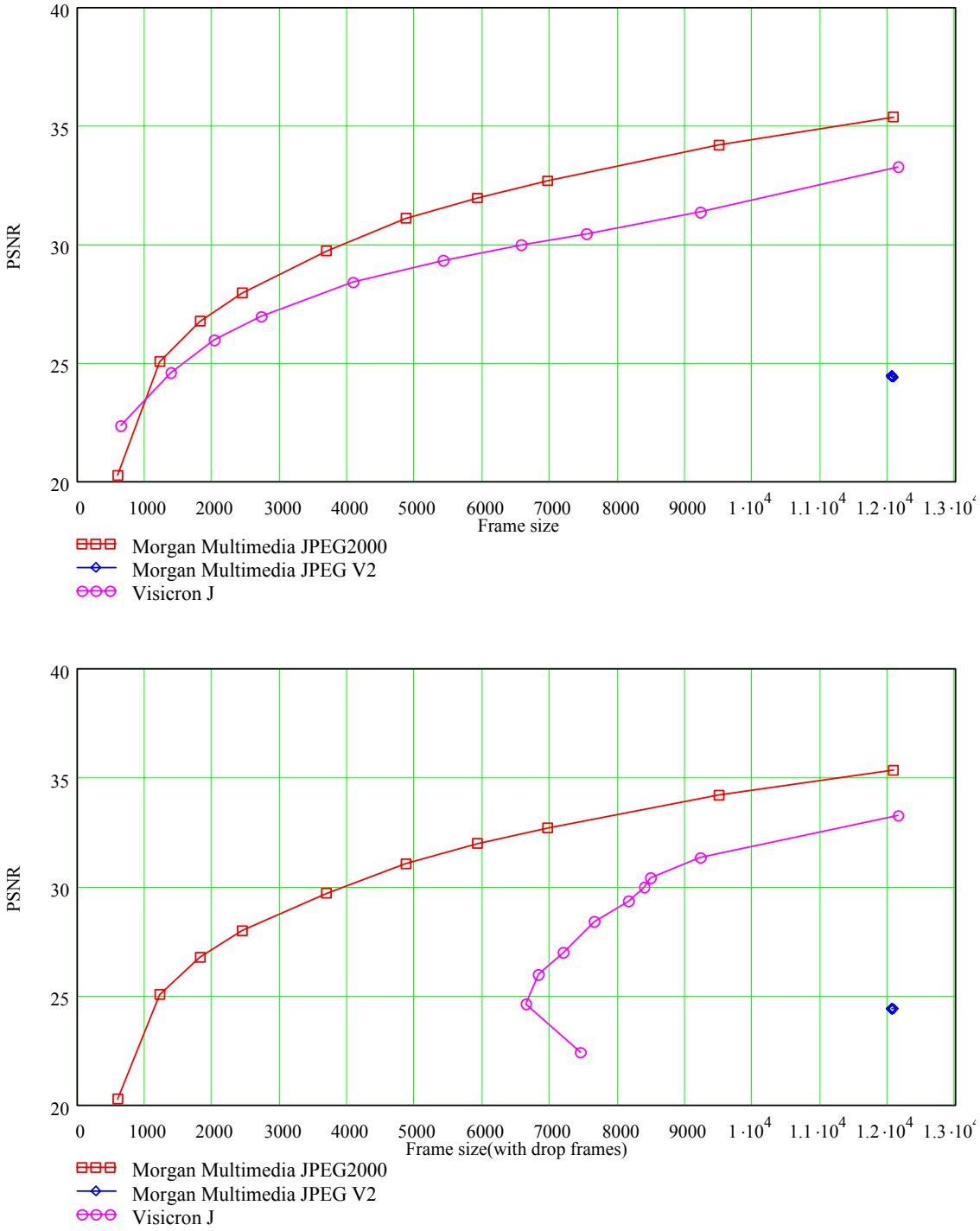


Picture 31. Sequence FOREMAN

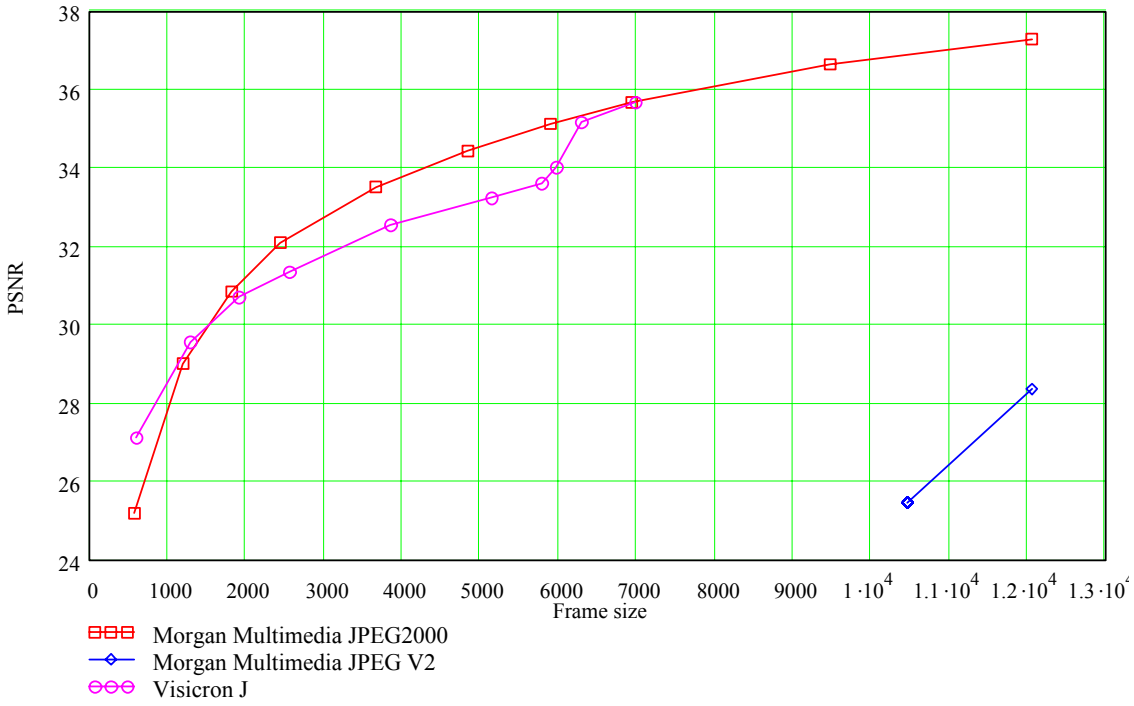


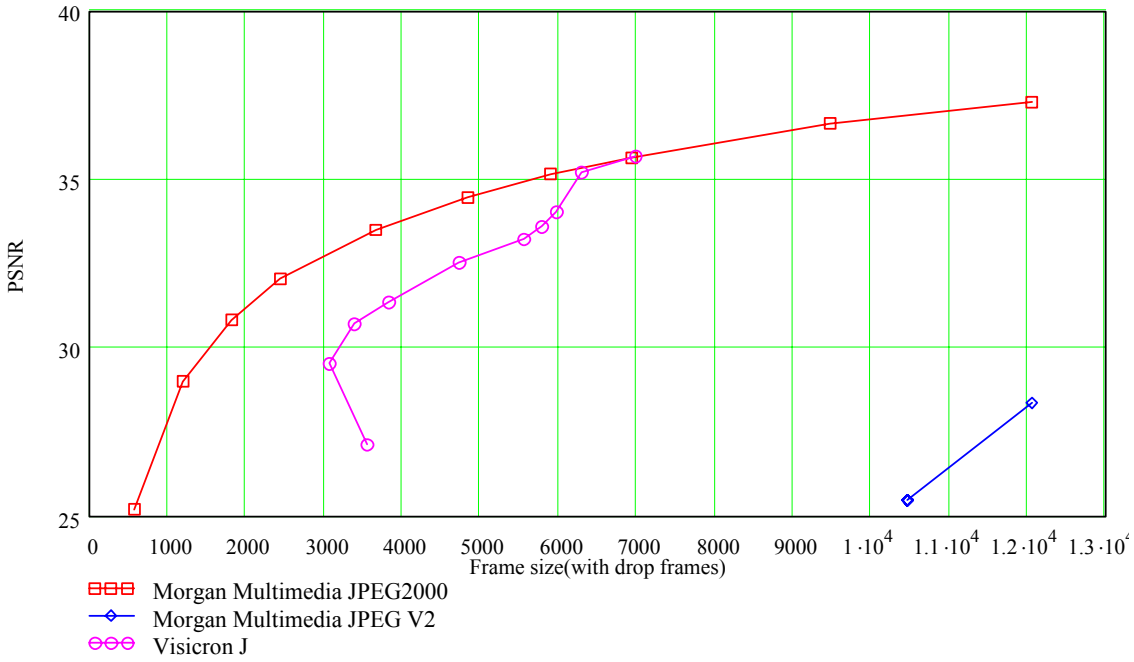


Picture 32. Sequence HELICOPTERdi

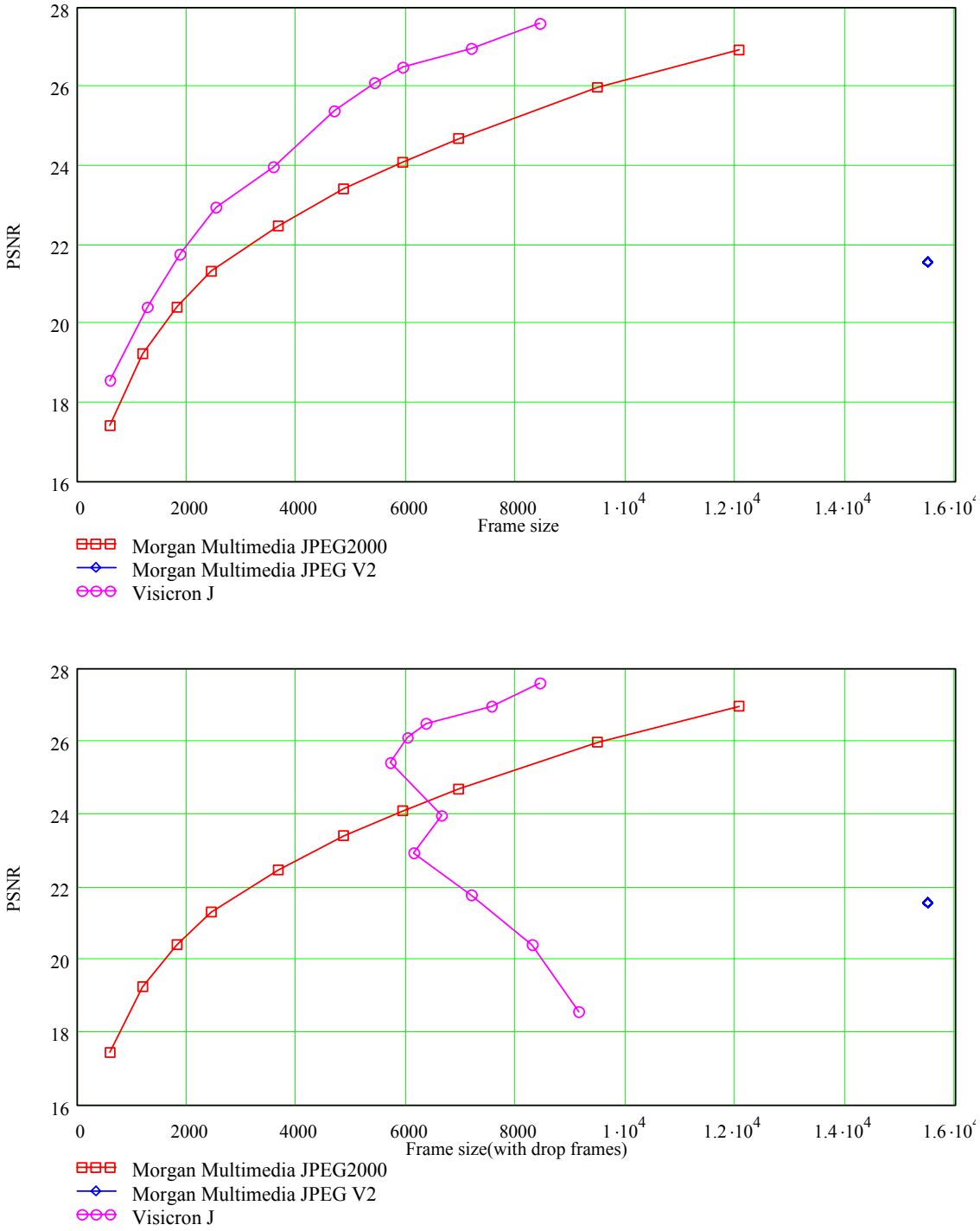


Picture 33. Sequence NDDP7di



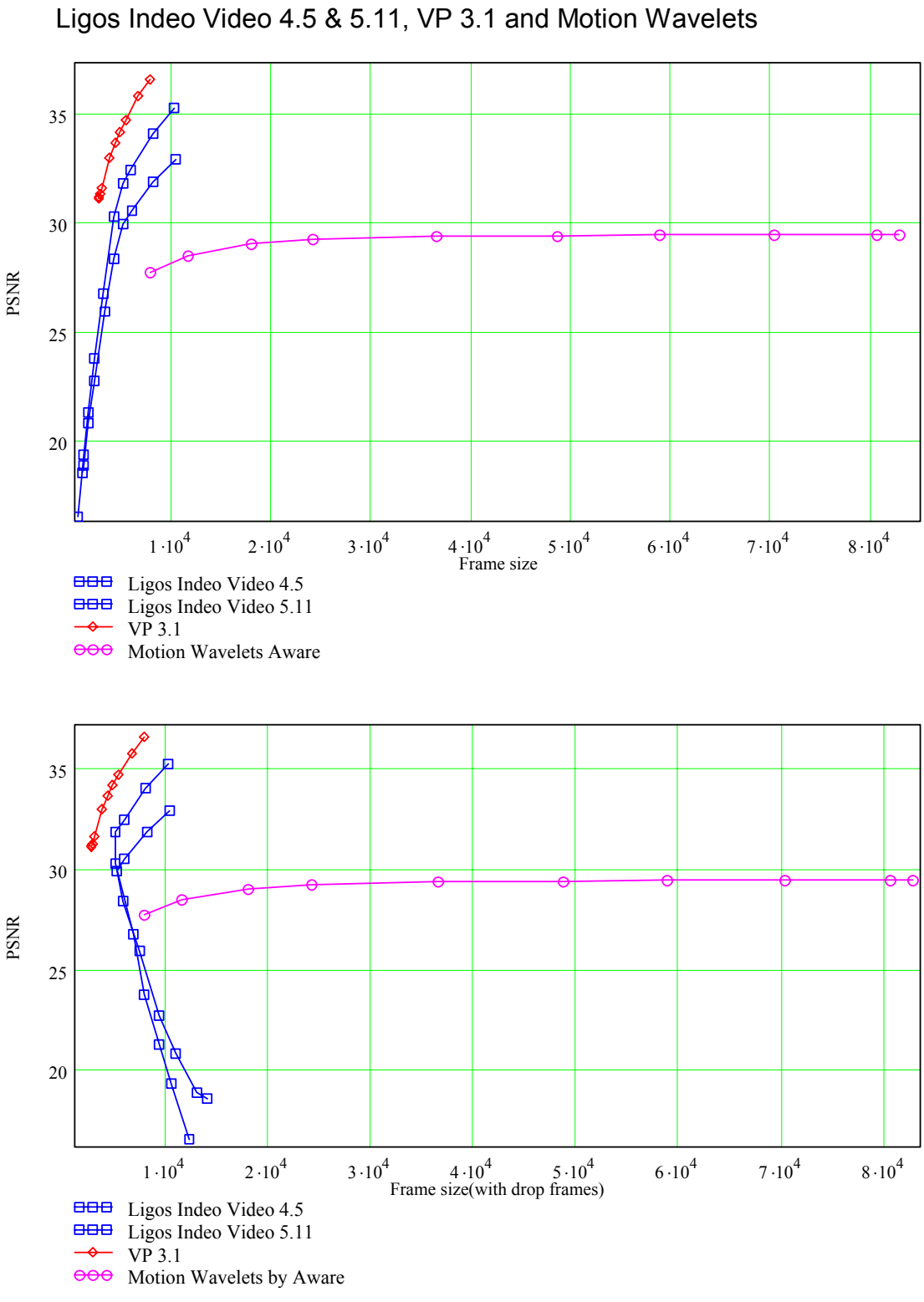


Picture 34. Sequence SUSIdi



Picture 35. Sequence TENSdi

NON-STANDART

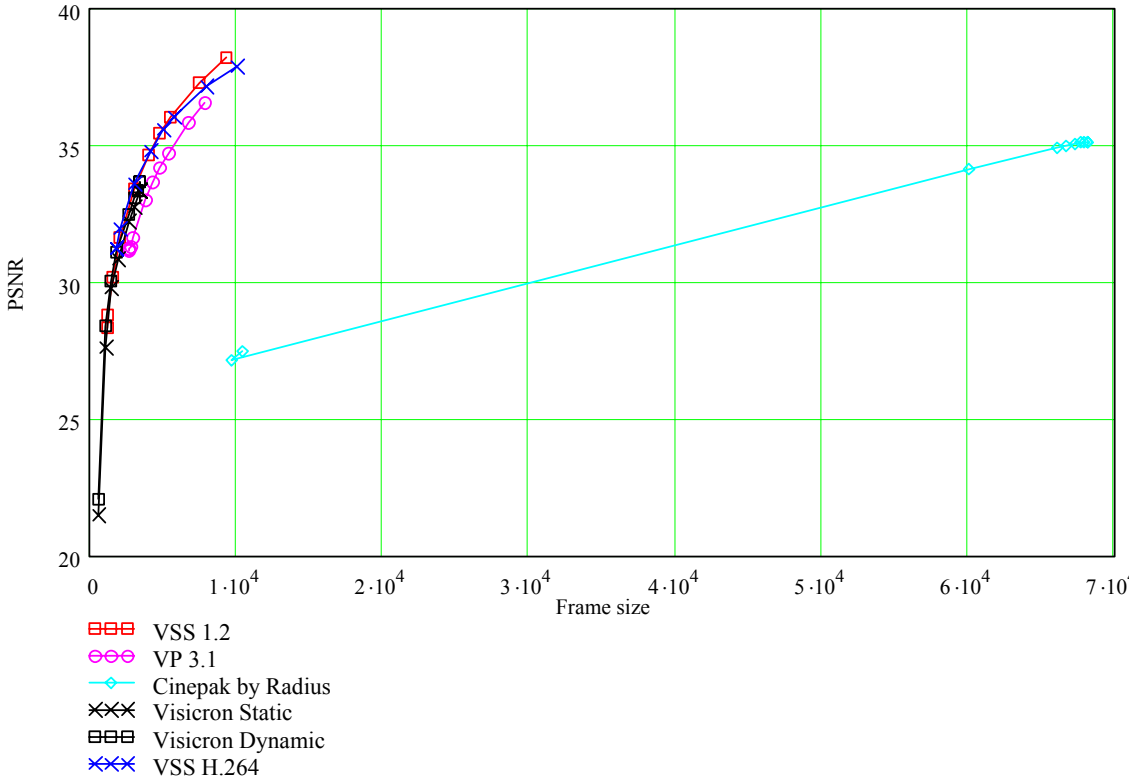


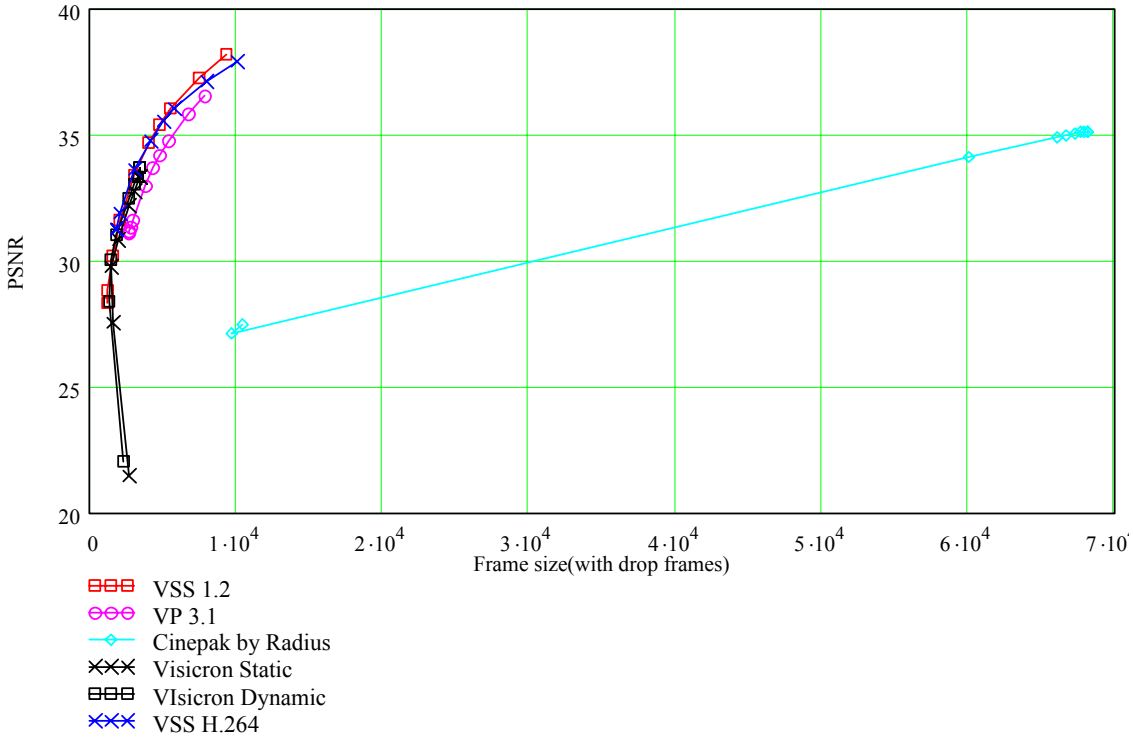
Picture 36. Sequence BANKOMATDdi

Conclusions:

- VP 3.1 and Motion Wavelets do not generate drop frames.
- Ligos 5.11 has the superiority; its branch is located more on the left.

VSS H.264, VSS 1.2, Intel I.263, VP 3.1, Cinepak by Radius, Visicron Static & Dynamic

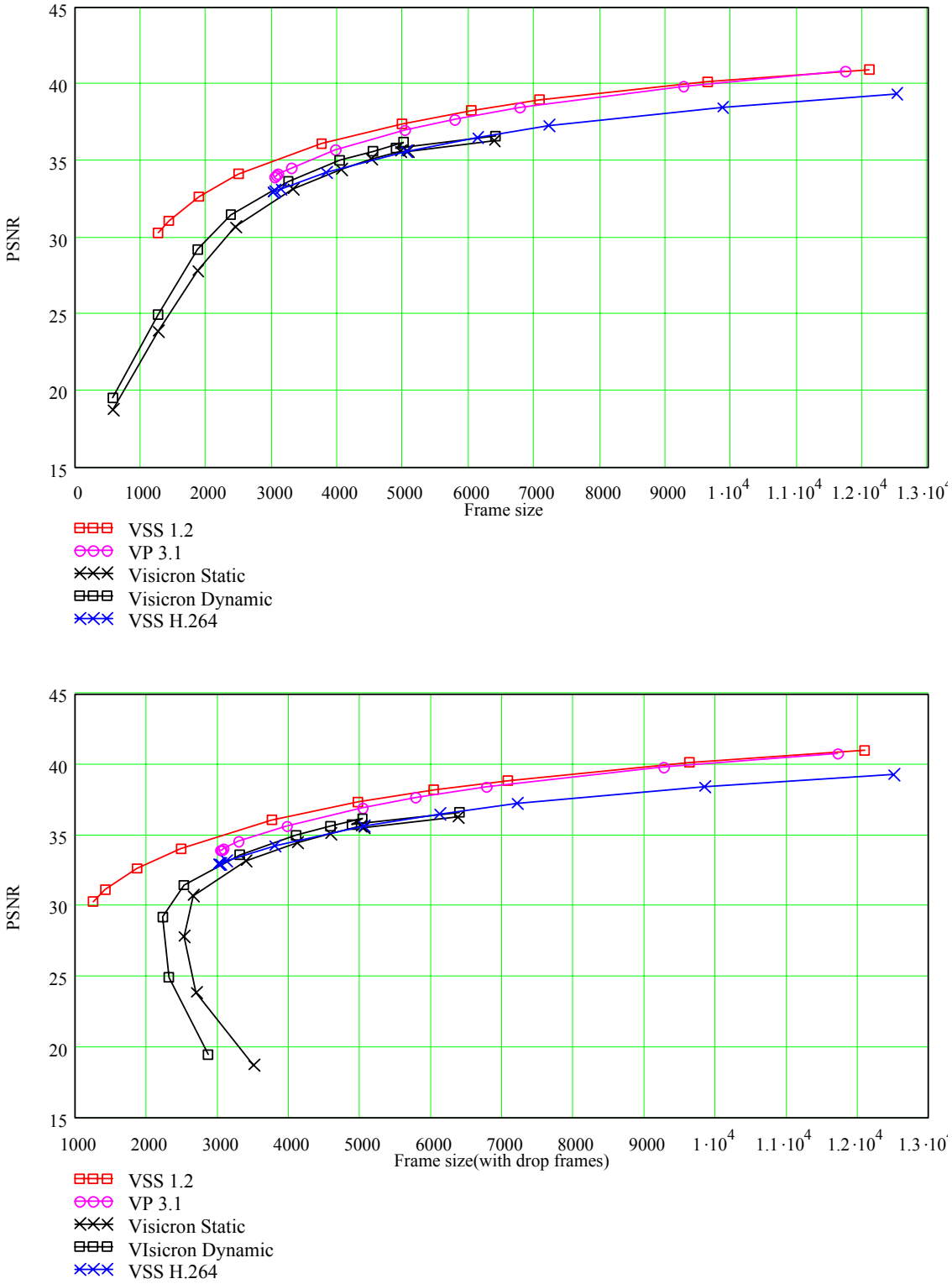




Picture 37. Sequence BANKOMATDdi

Conclusions:

- Cinepak by Radius doesn't use drop frames. But it doesn't need this, considering the bitrate it compresses with.



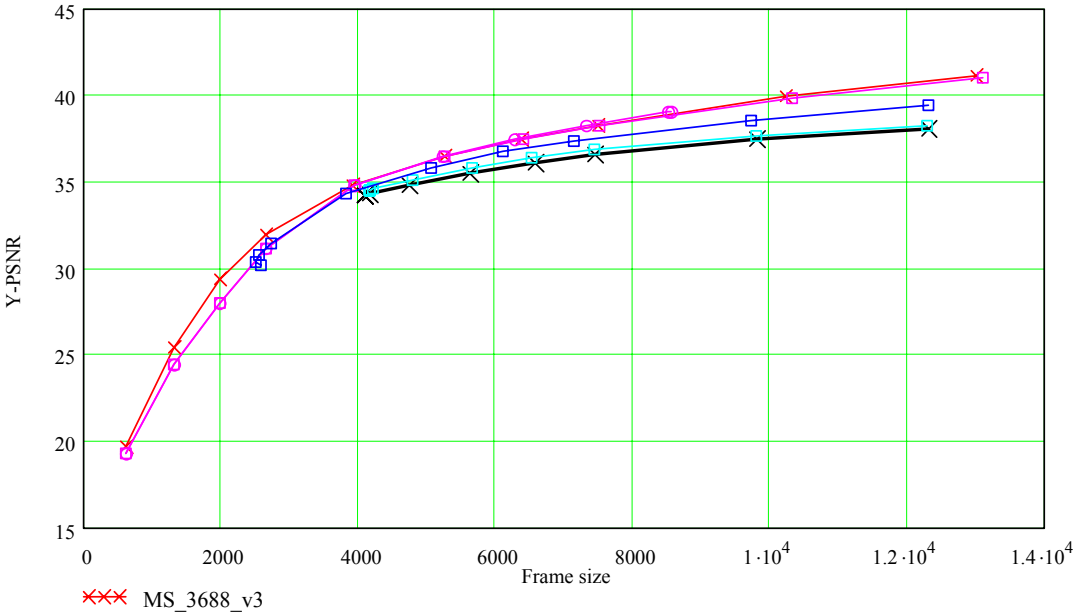
Picture 38. Sequence BATTLE

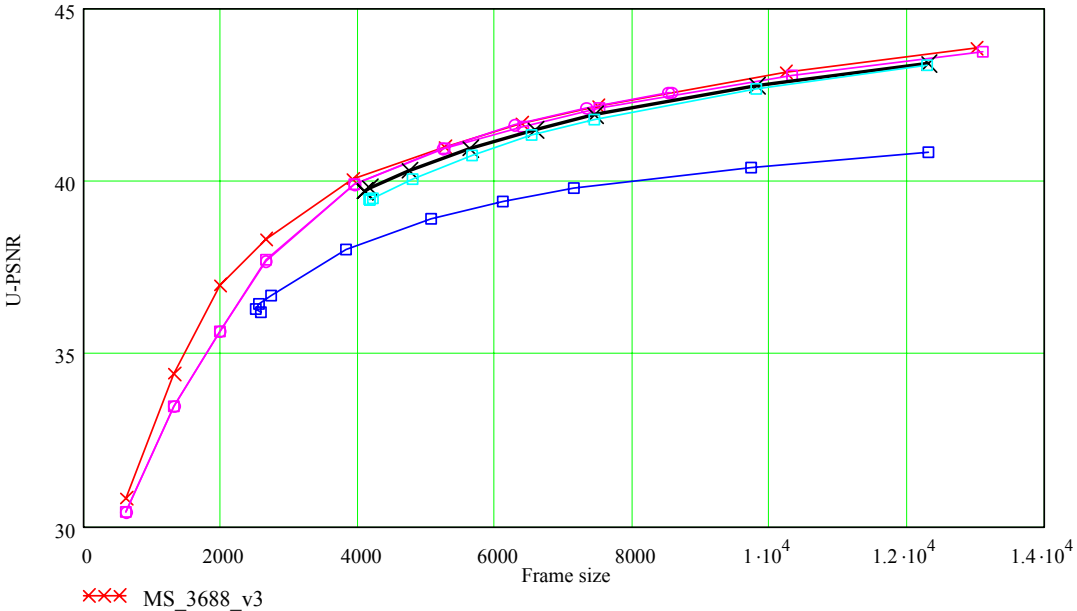
Conclusions:

- Only Visicron codecs use drop frames.
- Visicron Dynamic has a smaller average frame size and therefore a greater FPS at the output.
- These statements are true for all the other sequences as well.

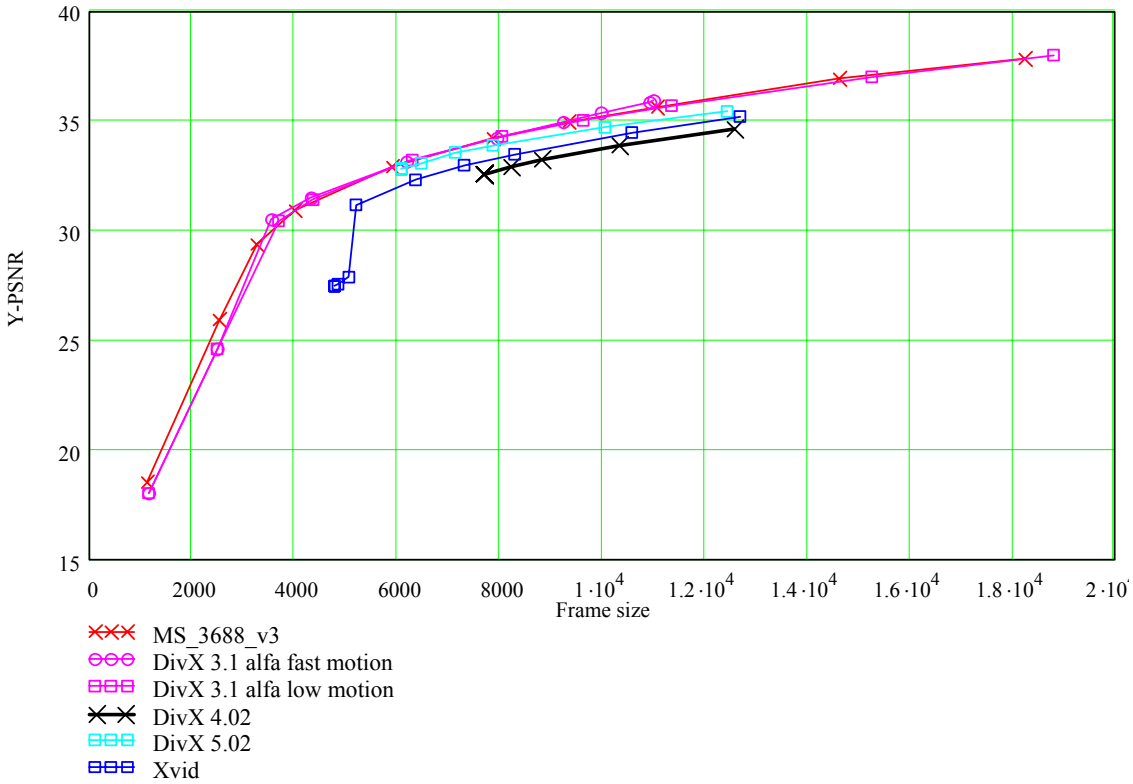
U-PSNR Diagrams

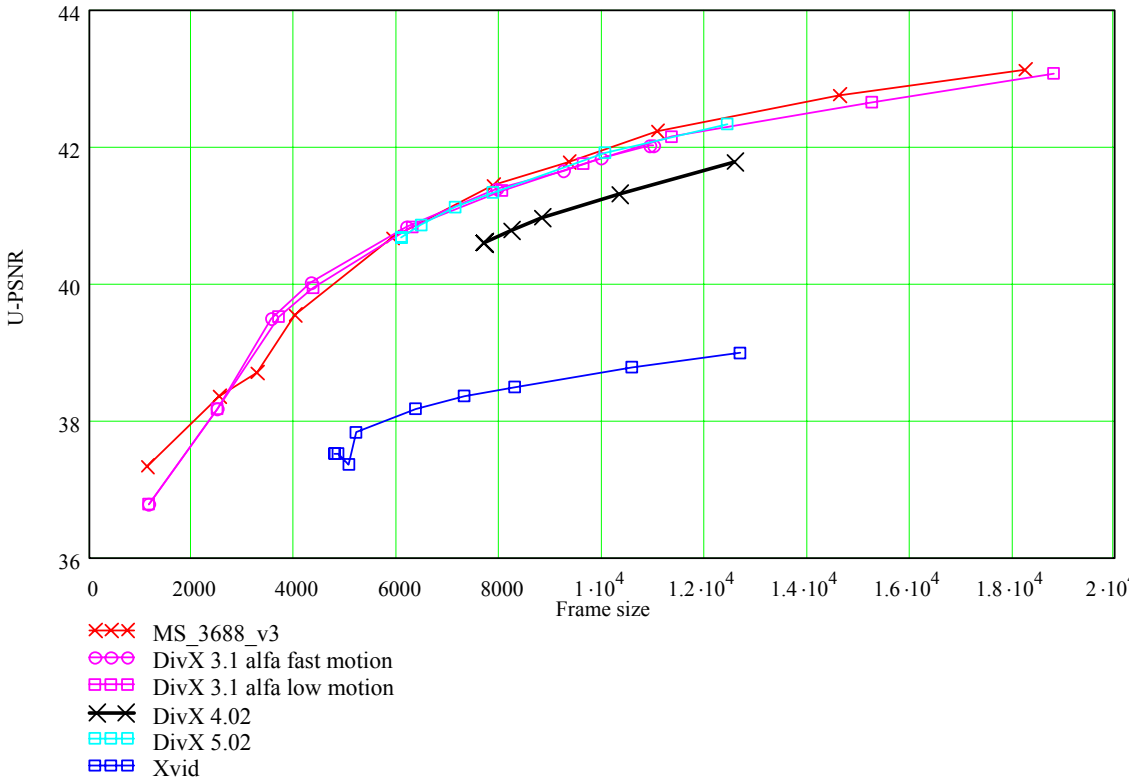
MPEG4 Microsoft 3688 v3, Divx 3.1, Divx 4.02, Divx 5.02 and Xvid 2.1



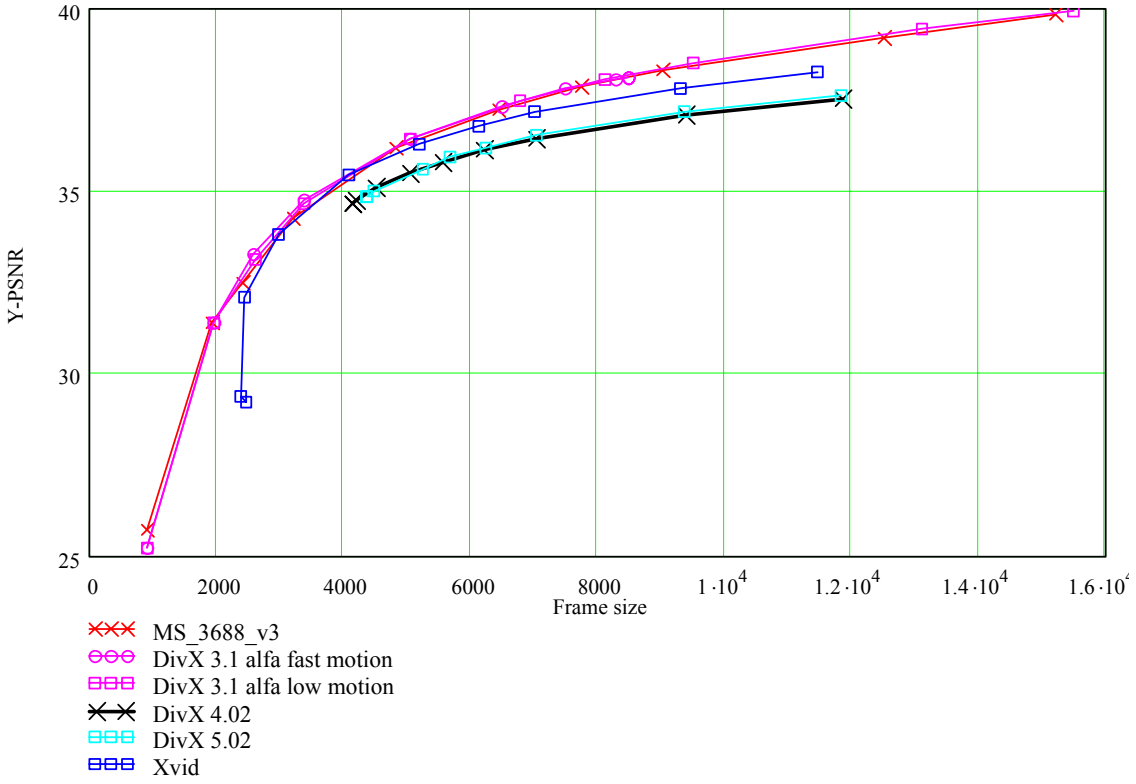


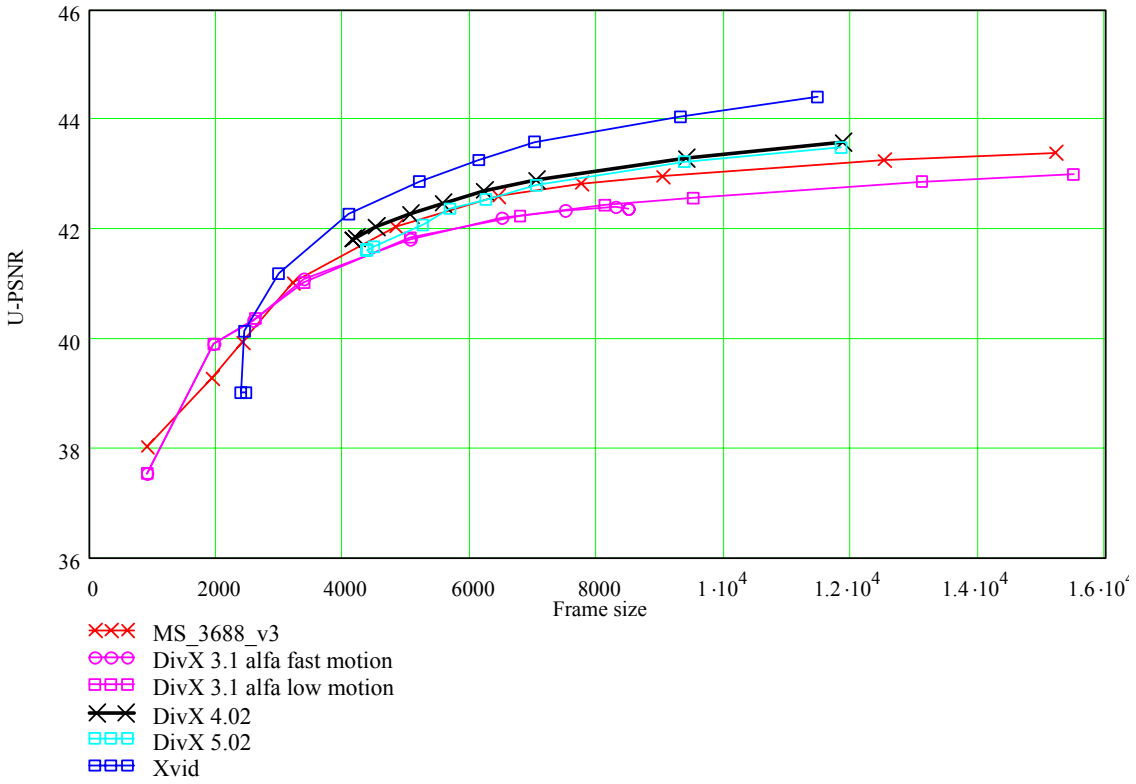
Picture 39. Sequence BATTLE



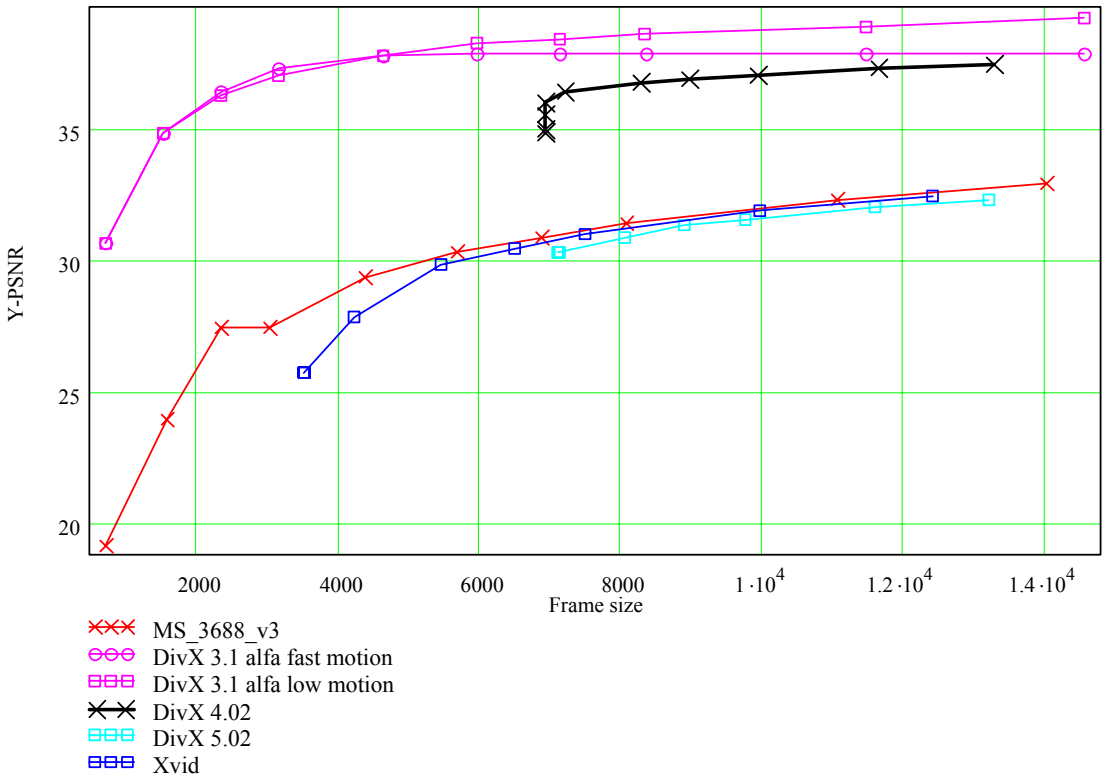


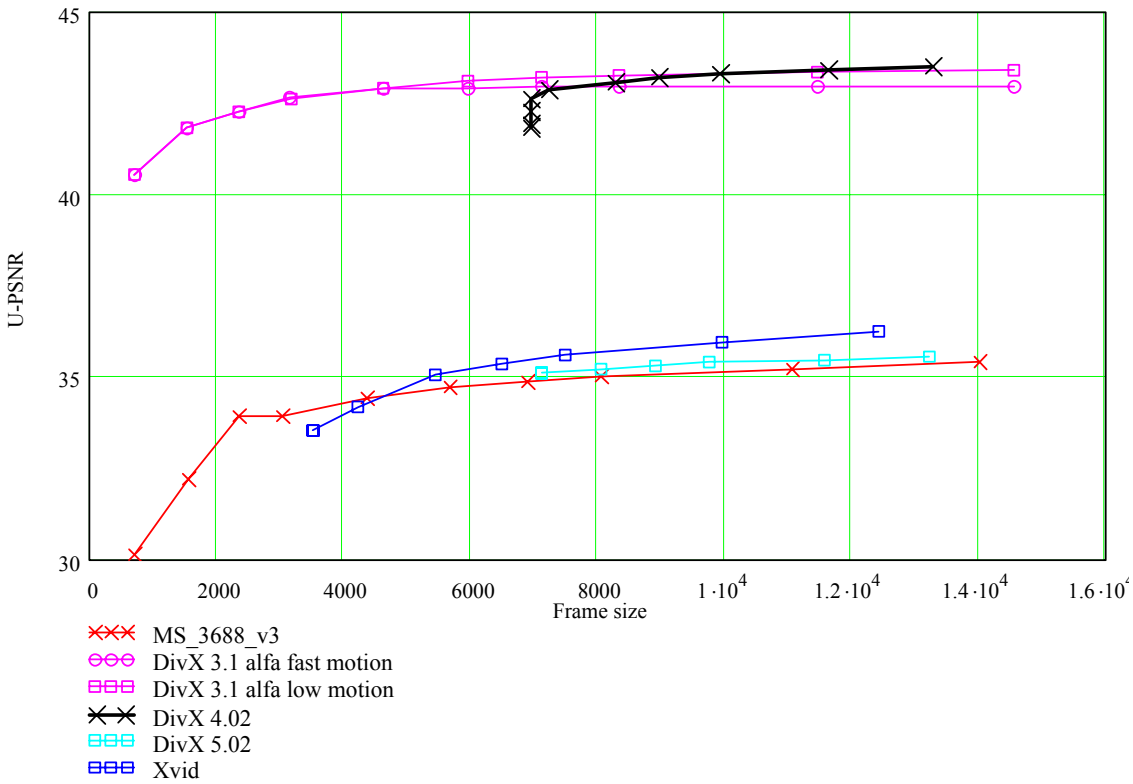
Picture 40. Sequence HELICOPTERdi



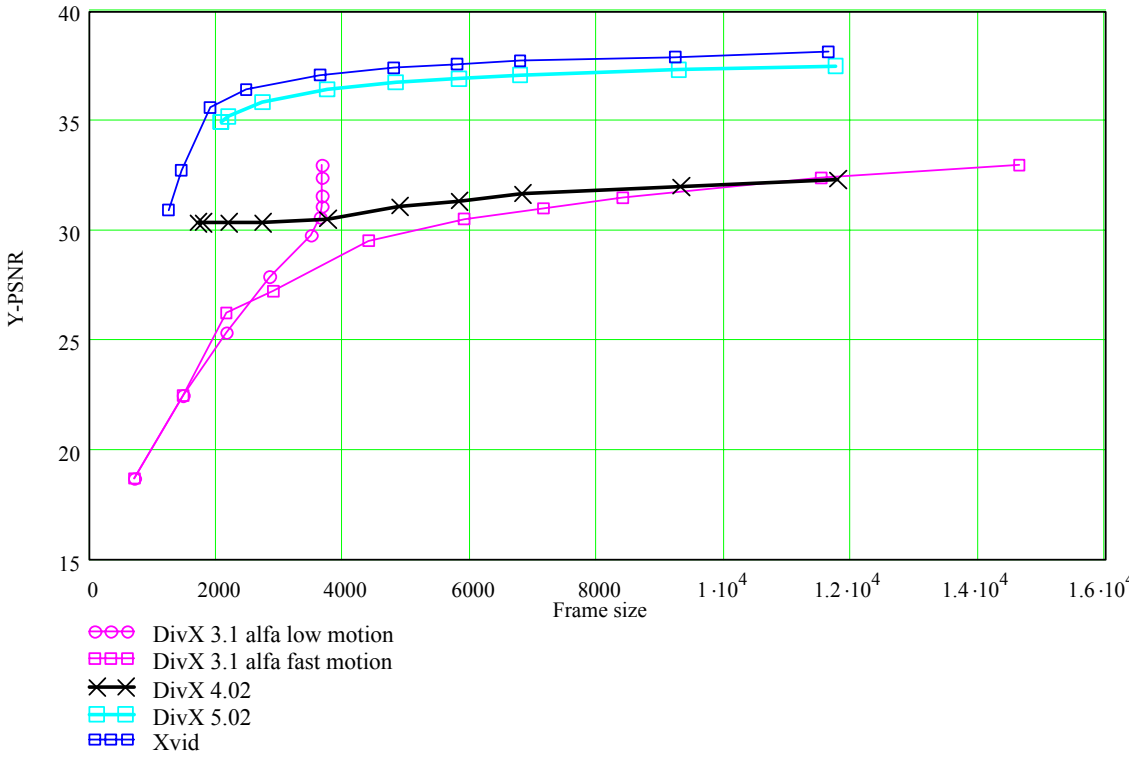


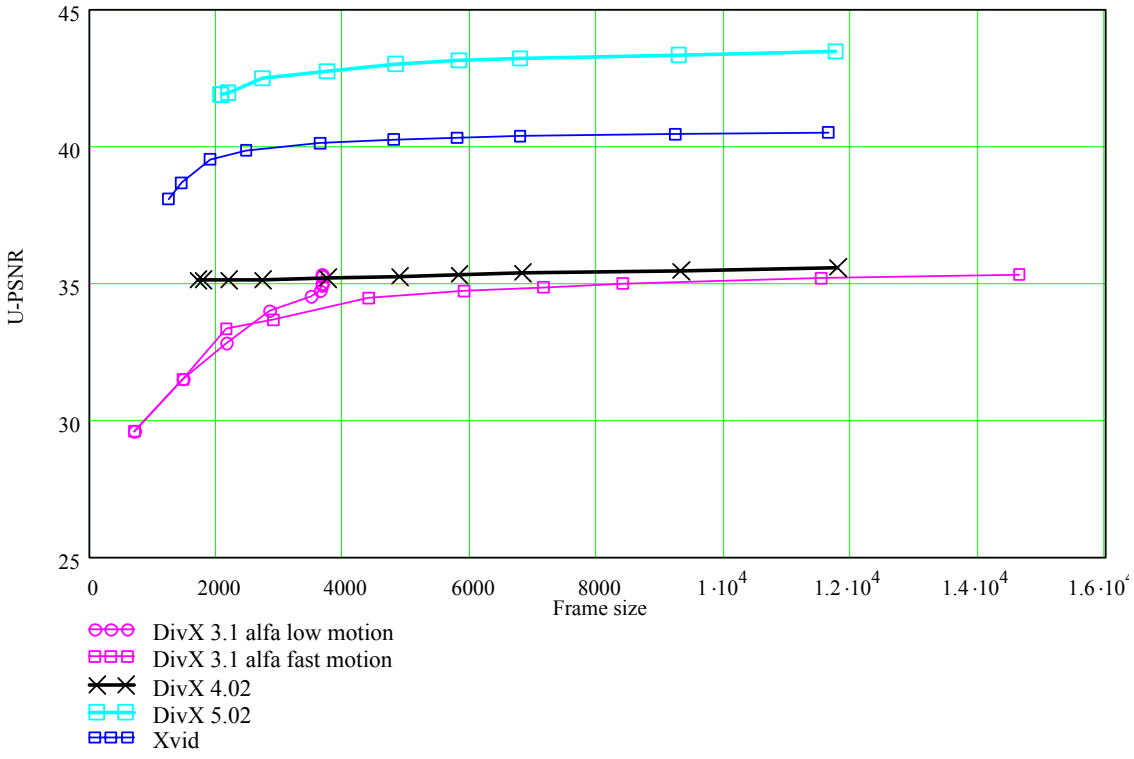
Picture 41. Sequence NDDP7di





Picture 42. Sequence TENSdi



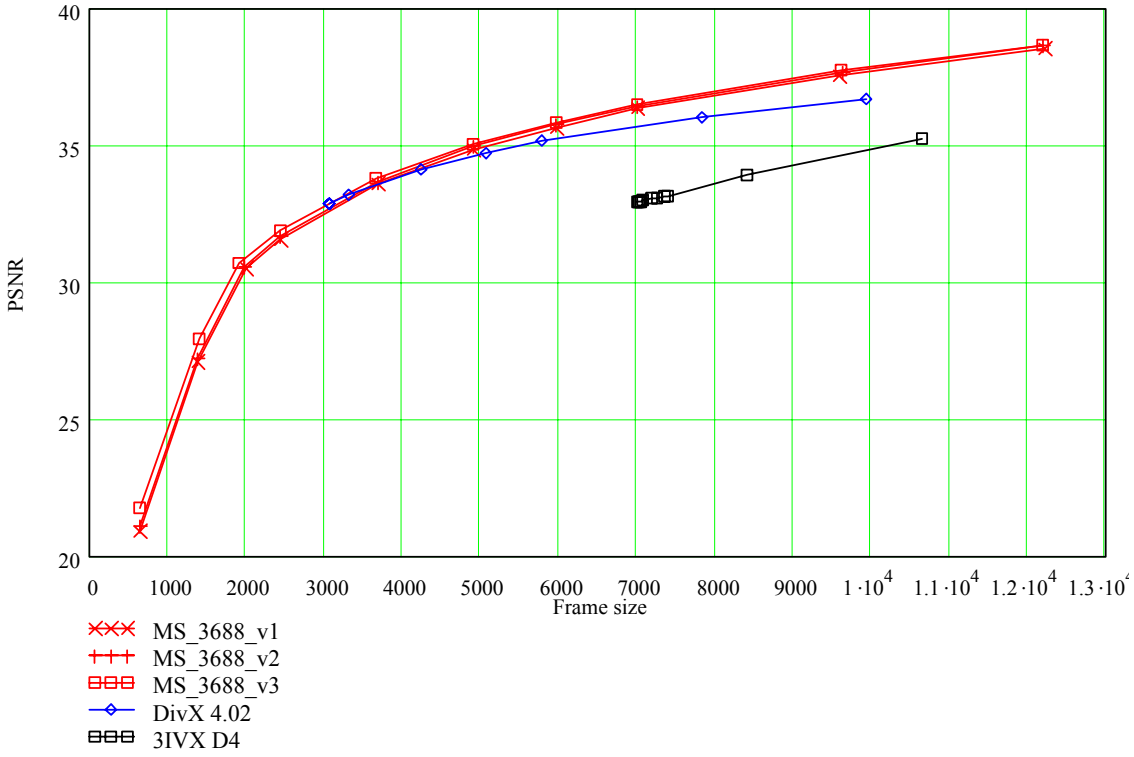


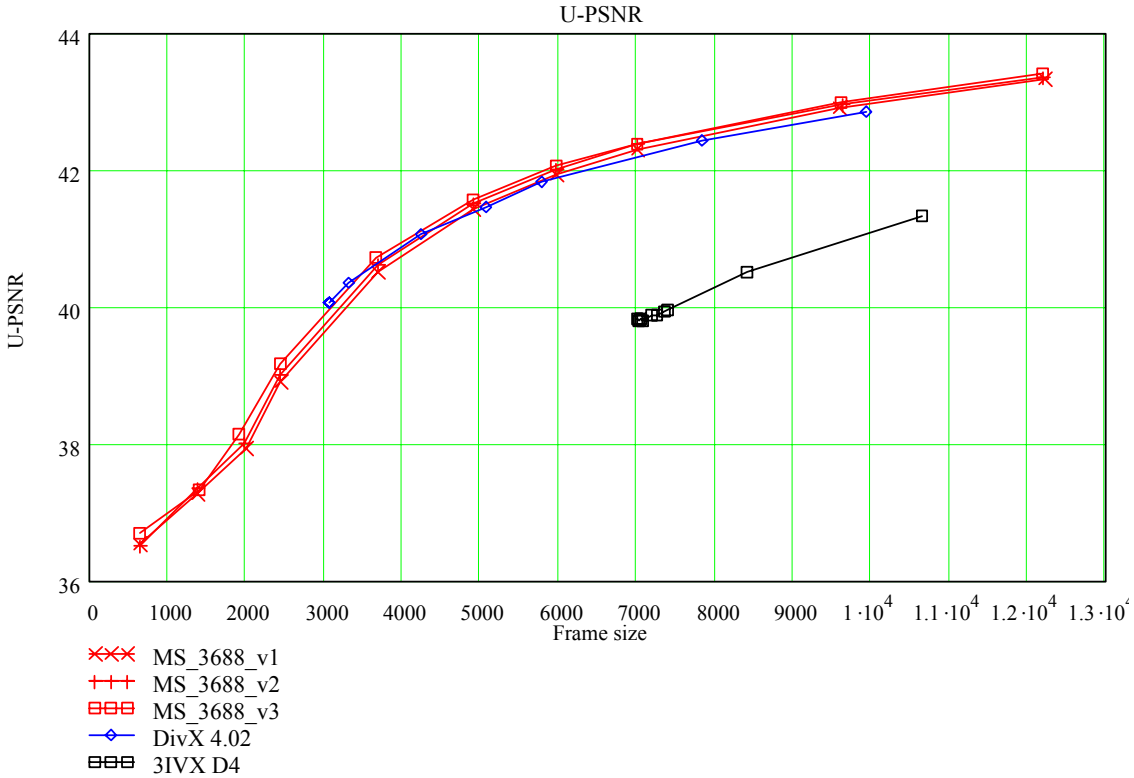
Picture 43. Sequence SUSIdi

Conclusions:

- Divx 3.1, 5.02 & 4.02 and Microsoft v3 stably keep quality of the color components. This is true for all the sequences.
- Xvid 2.1 keeps color components rather well on the sequences with noise like susidi, tensdi, nddp7di, and works worse than other codecs on the different sequences.

Microsoft v1 & v2 & v3, Divx 4.02, 3IVX D4



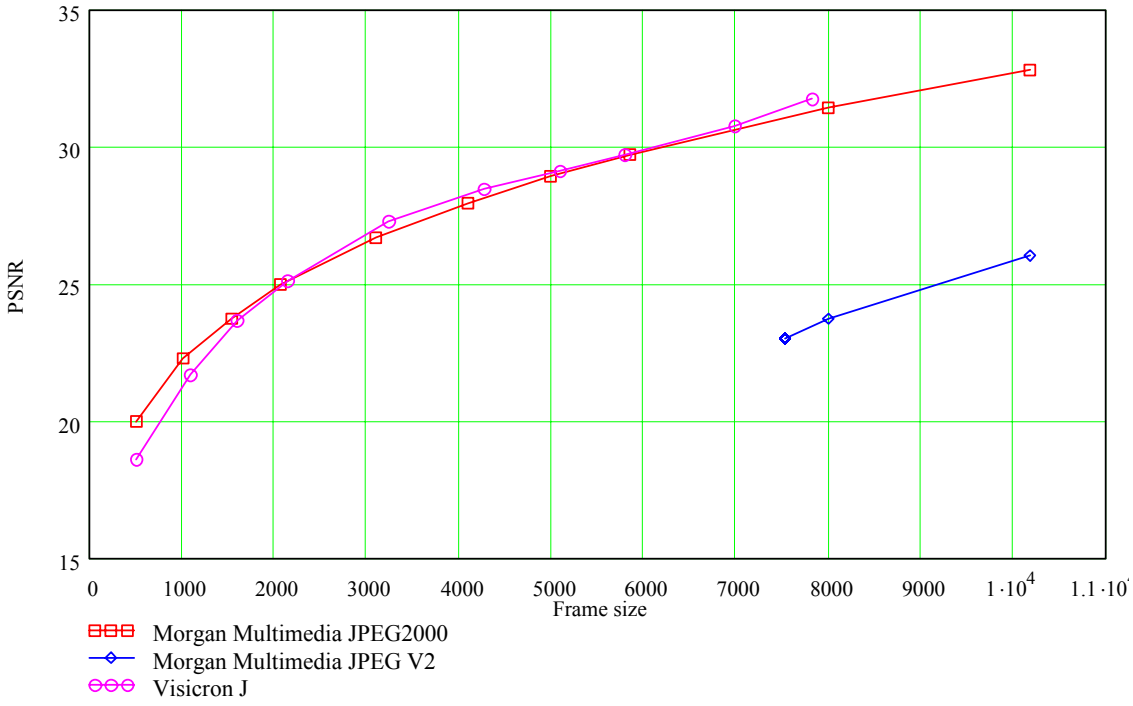


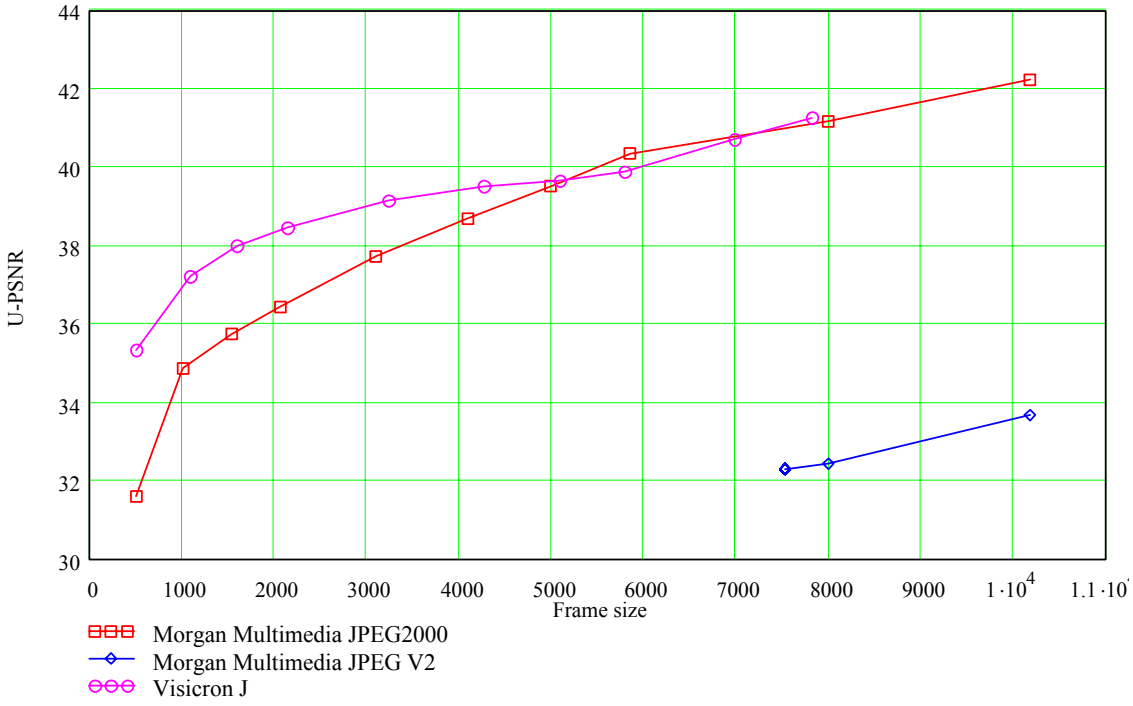
Picture 44. Sequence BANKOMATDdi

Conclusions:

- Microsoft codecs keep the U-component 5dB better than the Y-component on high bitrate and 15-20 dB better on low bitrate.
- All the codecs keep color components better than the Y-component. Divx 4.02 and 3IVX D4 keep U-component 4-5 dB better than the Y-component.
- These statements are true for all the other sequences as well.

JPEG

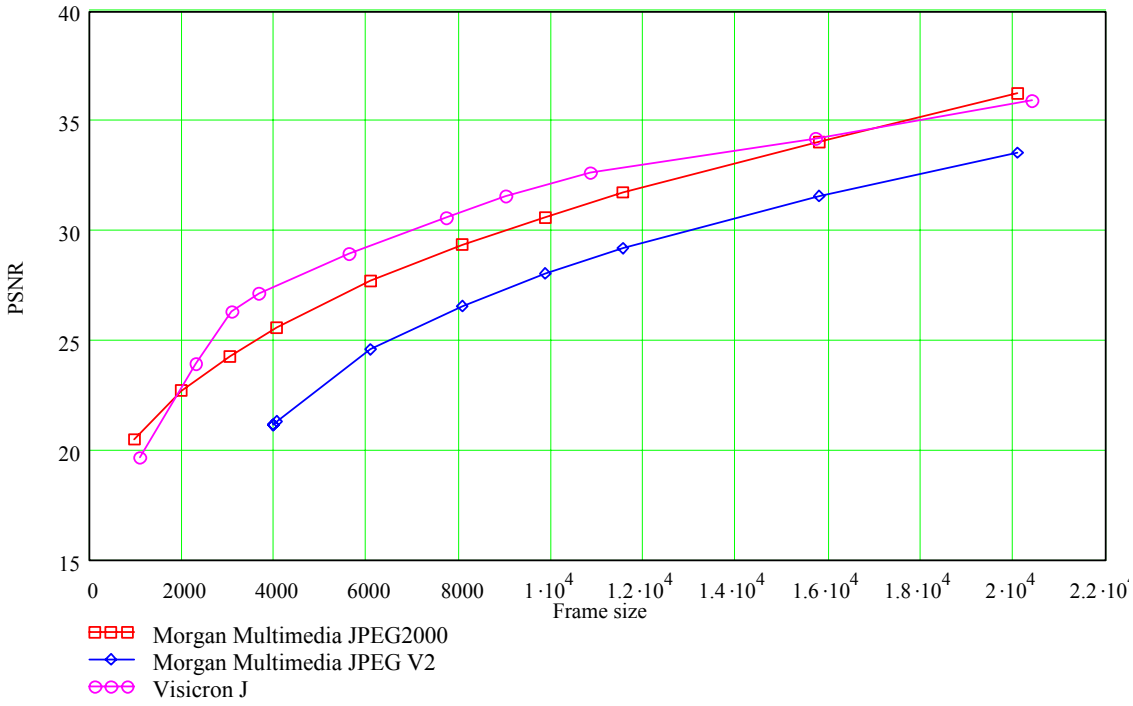


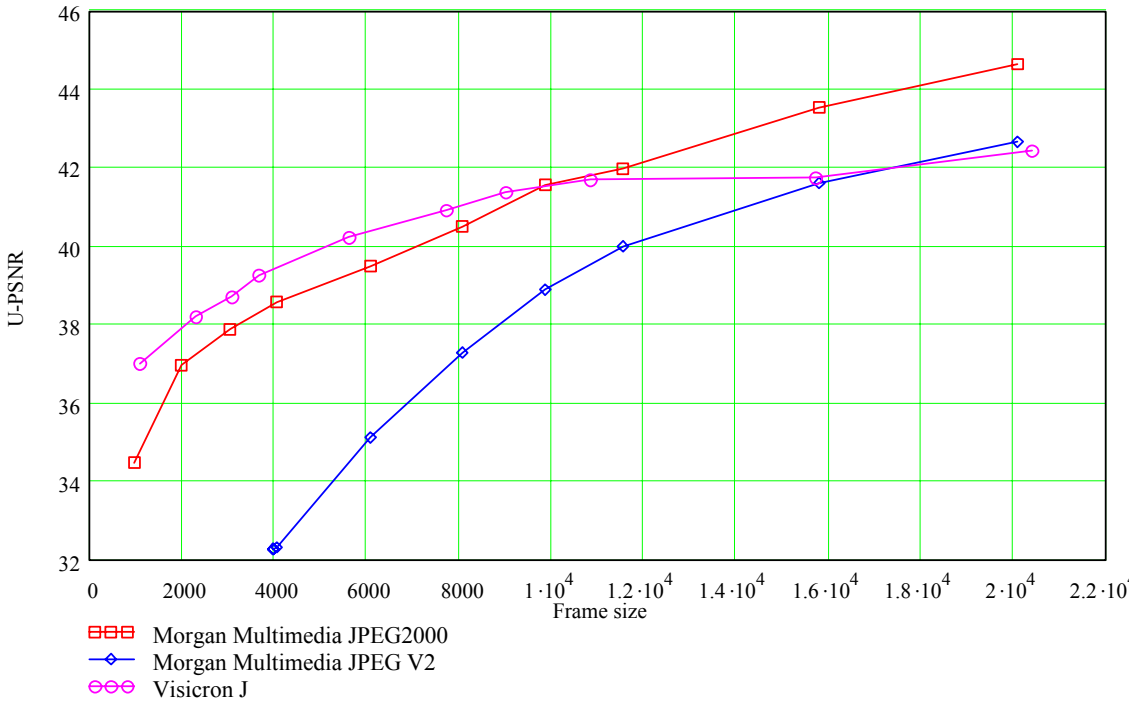


Picture 45. Sequence BANKOMATDdi

Conclusions:

- MM JPEGv2 keeps the U-component 5-15dB better than the Y-component.
- Visicron and MM JPEG2000 keep the U-component 5-7dB better than the Y-component on high bitrate and 10-15dB better on low bitrate.



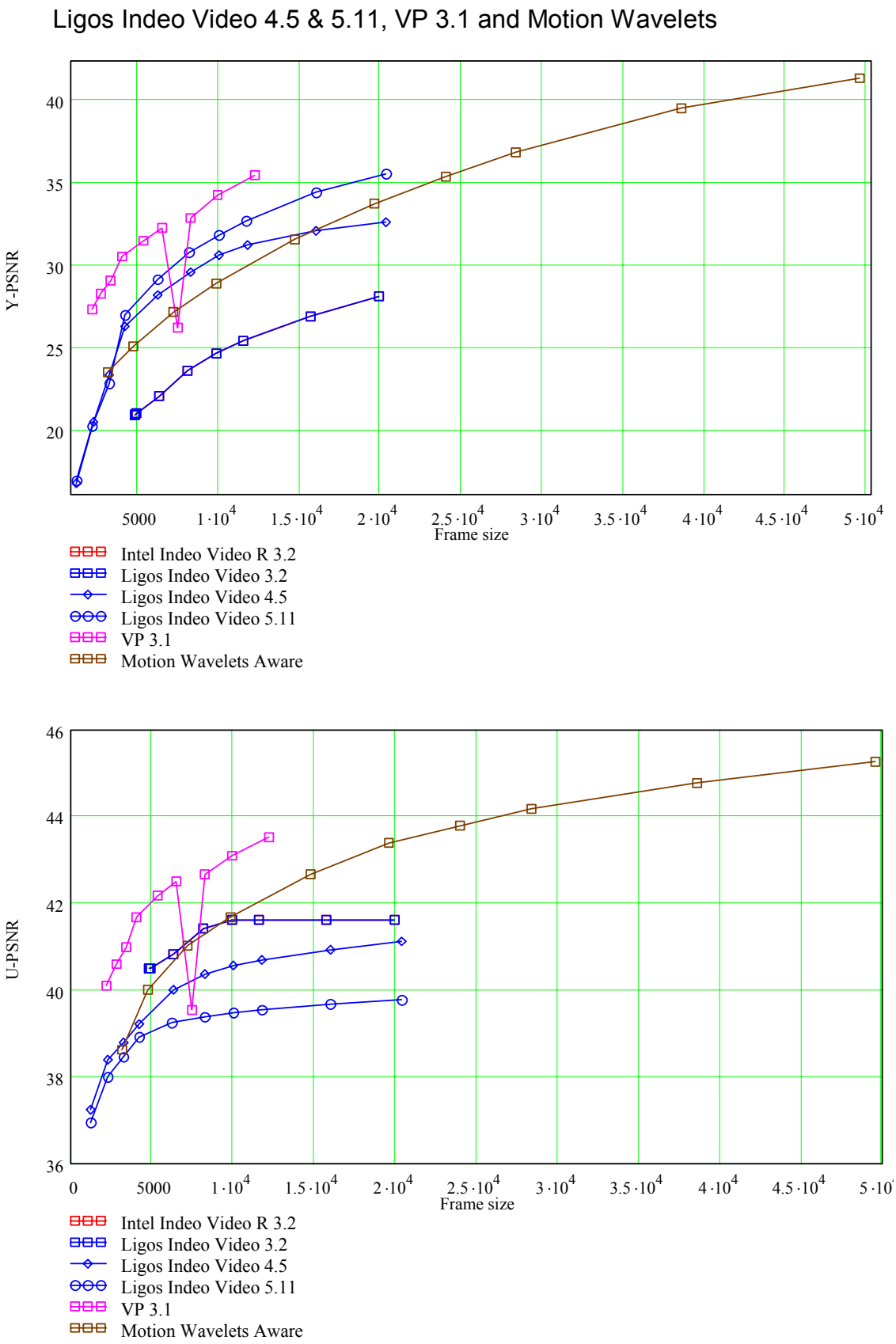


Picture 46. Sequence BUS

Conclusion:

- Visicron J has a better U-PSNR on low bitrate, while MM JPEG2000 has a better U-PSNR on high bitrate.
- All the codecs from this group keep the U-component better than the Y-component.

NON-STANDART

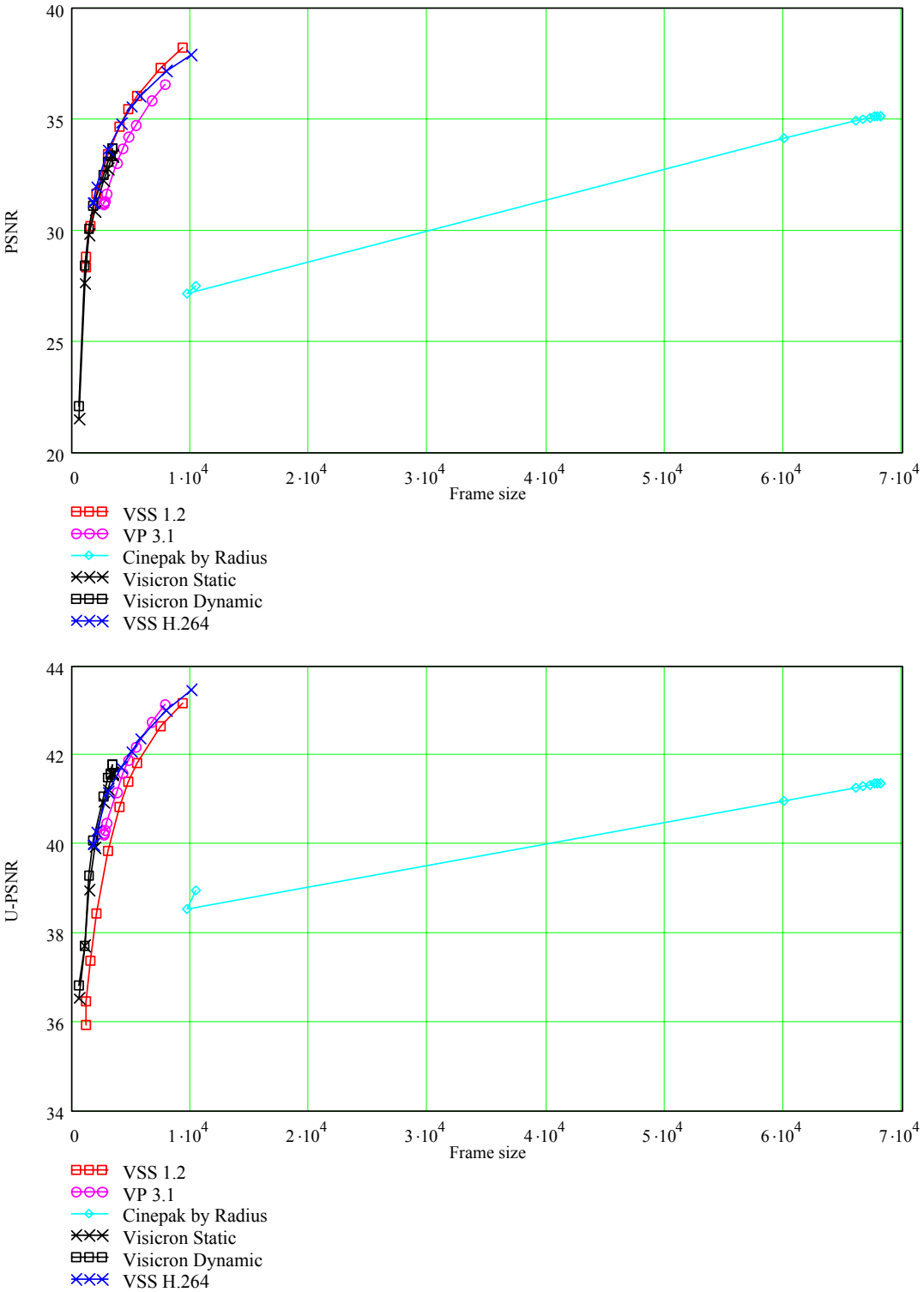


Picture 47. Sequence BUS

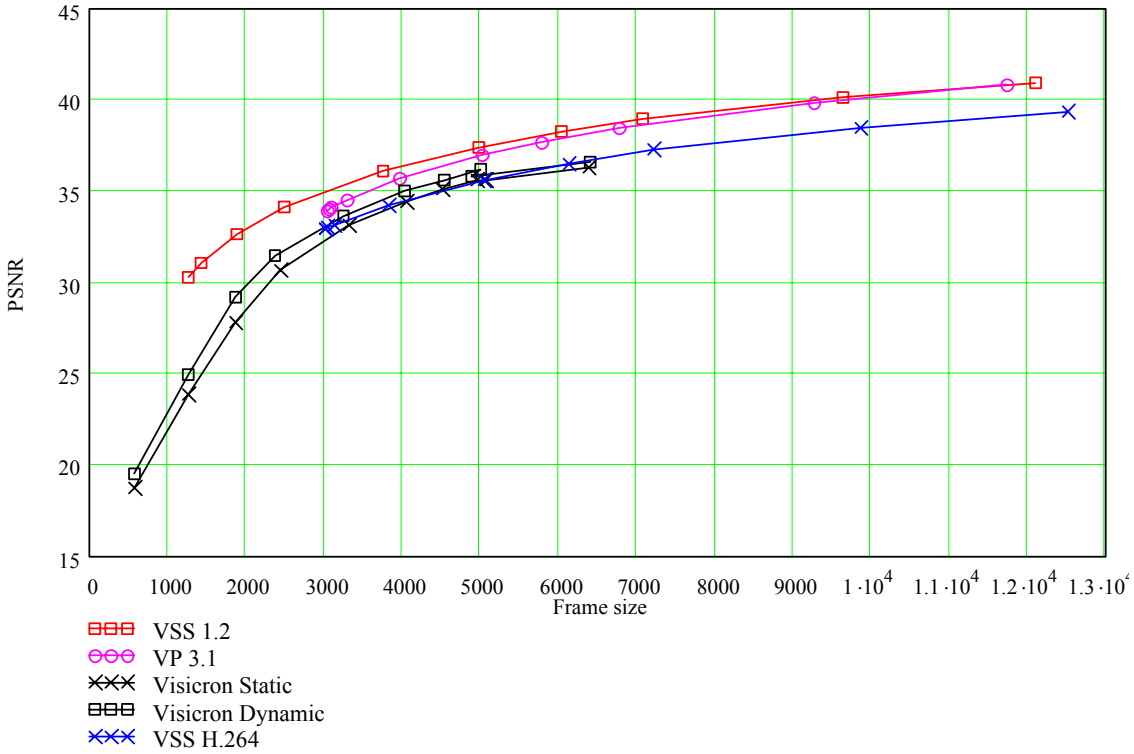
Conclusions:

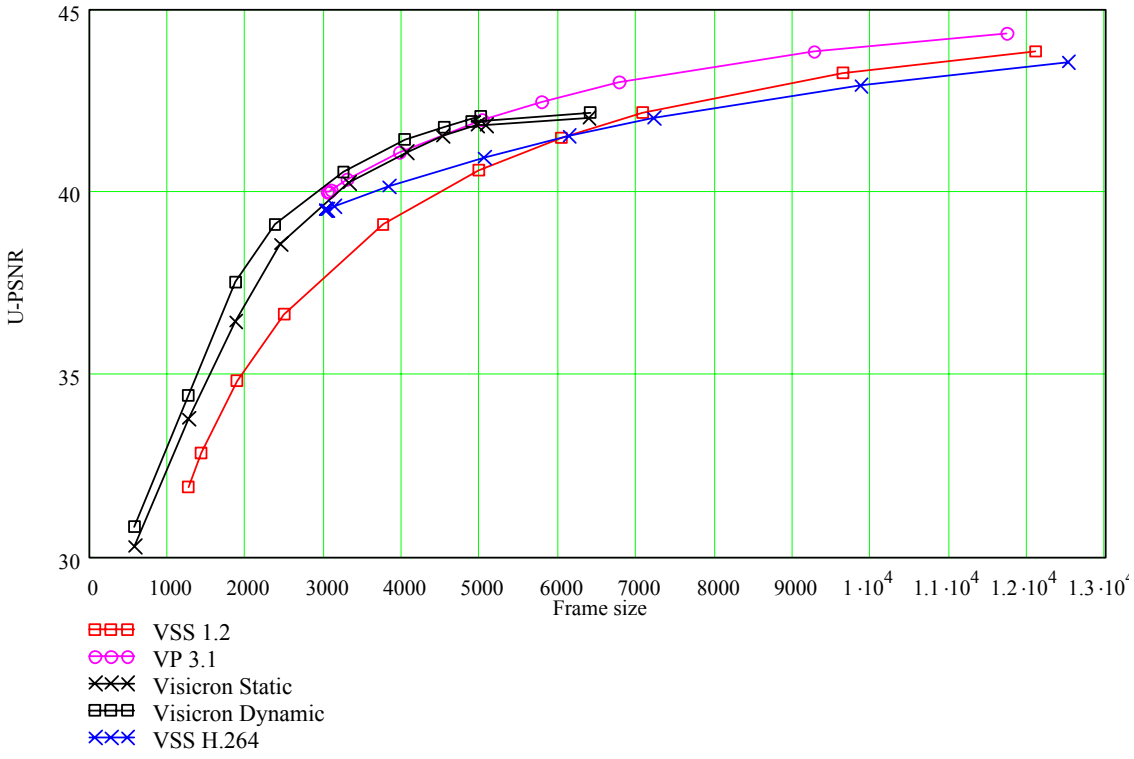
- Ligos 3.2 & 4.5 and VP 3.1 keep the U-component better than the Y-component. As it has been already said, this is usual for video codecs and is caused by the fact that human eye is more sensitive to the changes in color that to the changes in brightness.
- Motion Wavelets and Ligos 5.11 keep both components similarly.
- These codecs behave almost in the same way on the other sequences, so all the rest diagrams were omitted.

VSS H.264, VSS 1.2, Intel I.263, VP 3.1, Cinepak by Radius, Visicron Static & Dynamic



Picture 48. Sequence BANKOMATDdi

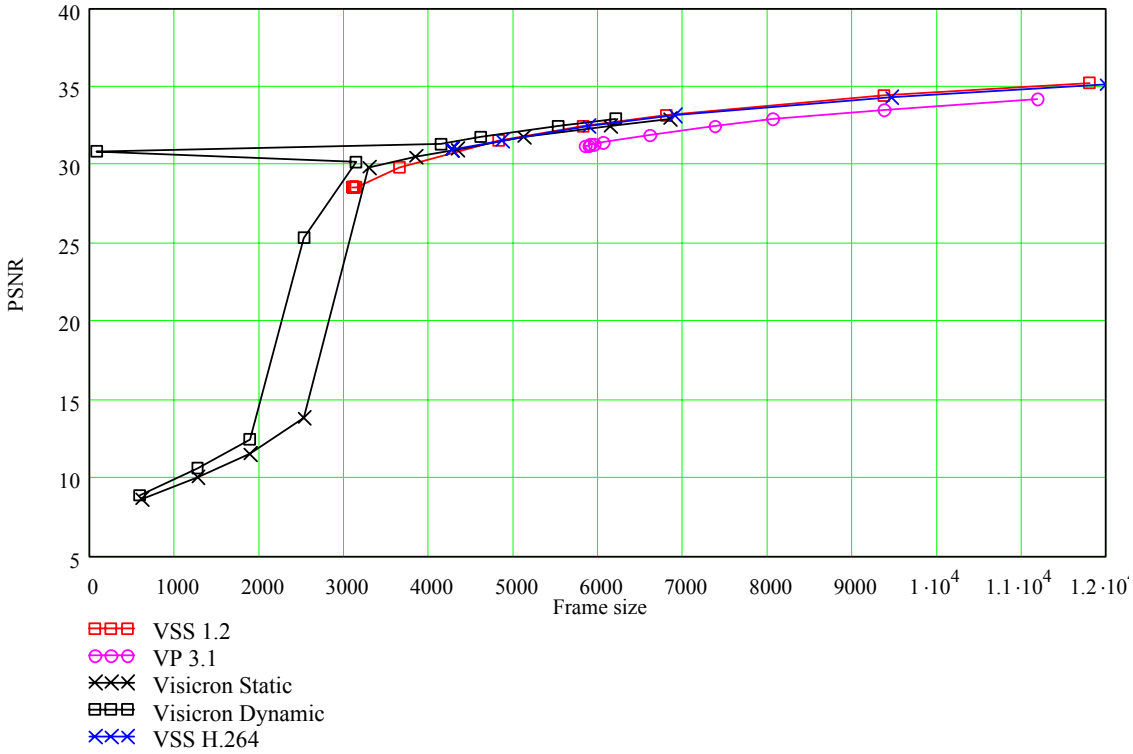


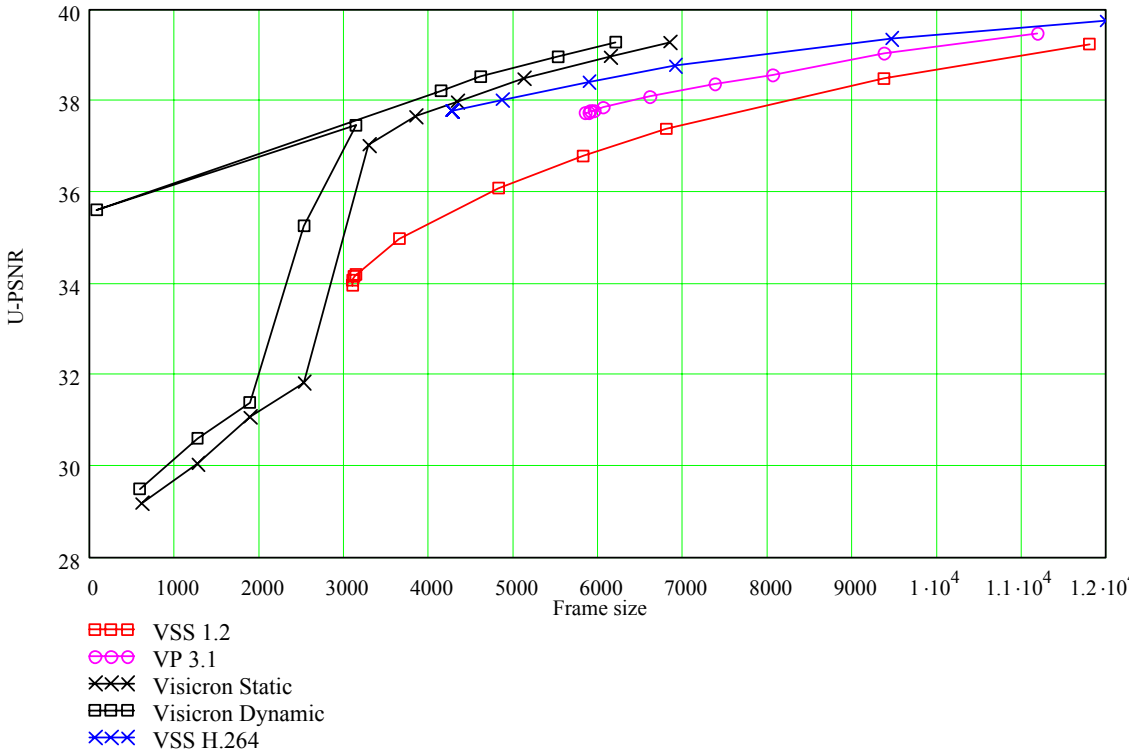


Picture 49. Sequence BATTLE

Conclusions:

- The branch for VSS 1.2 is located lower (and therefore VSS 1.2 has a worse U-PSNR) than the branches for VP 3.1 and Visicron on most sequences.

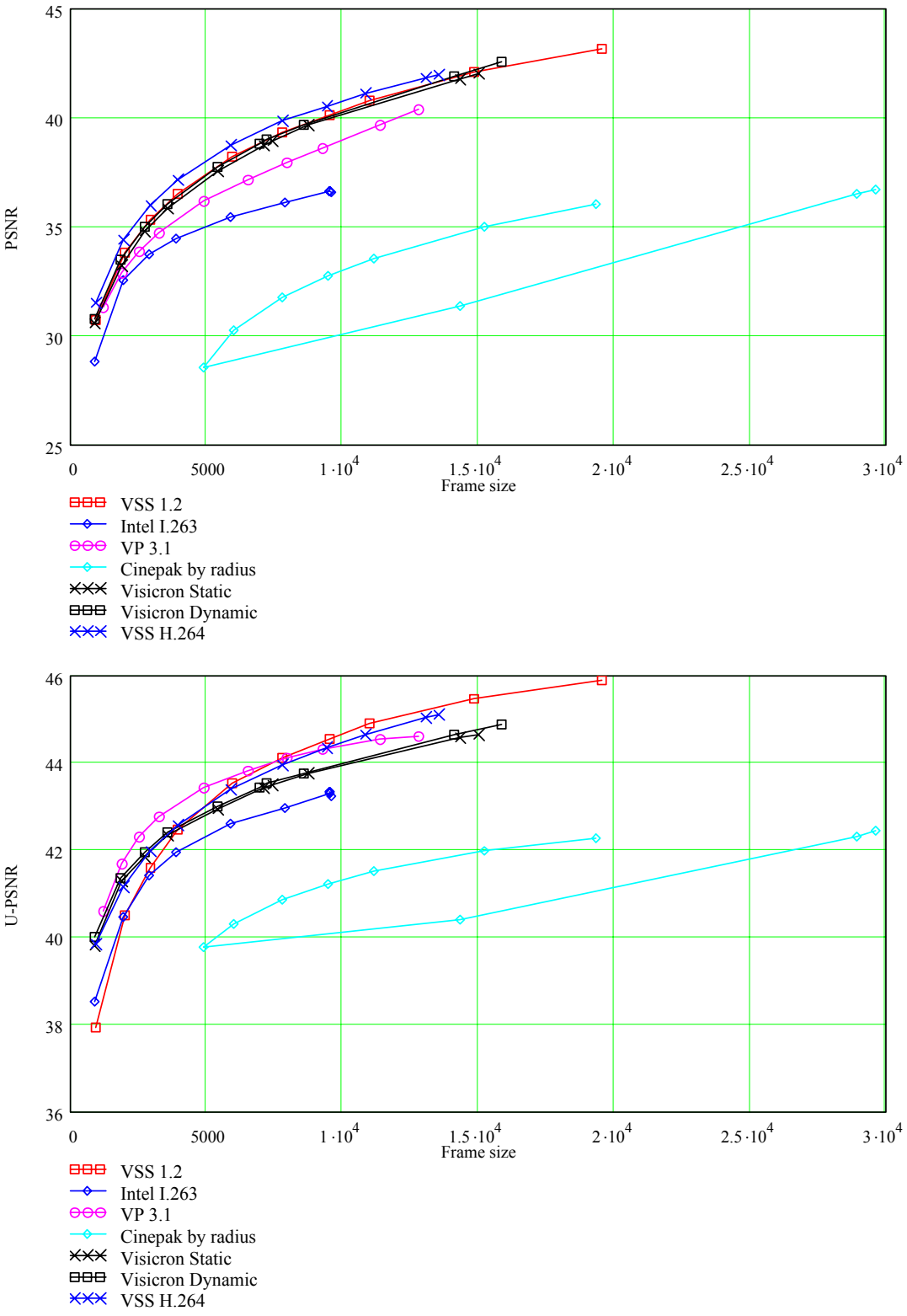




Picture 50. Последоваетльность BBC3di

Conclusions:

- Visicron is the best to keep the U-component on low bitrate; VP 3.1 is the best to keep it on high bitrate.



Picture 51. Sequence FOREMAN

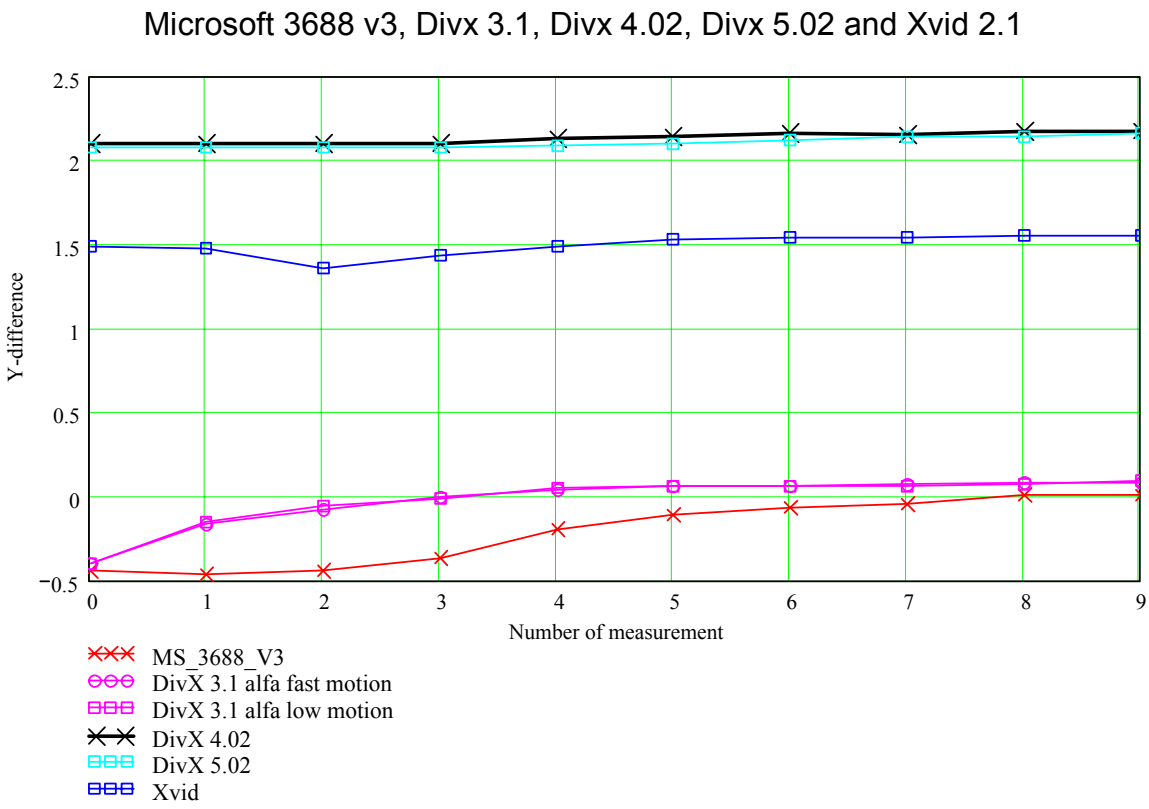
Conclusions:

- VSS 1.2 is the best in this group to keep the U-component in this sequence.

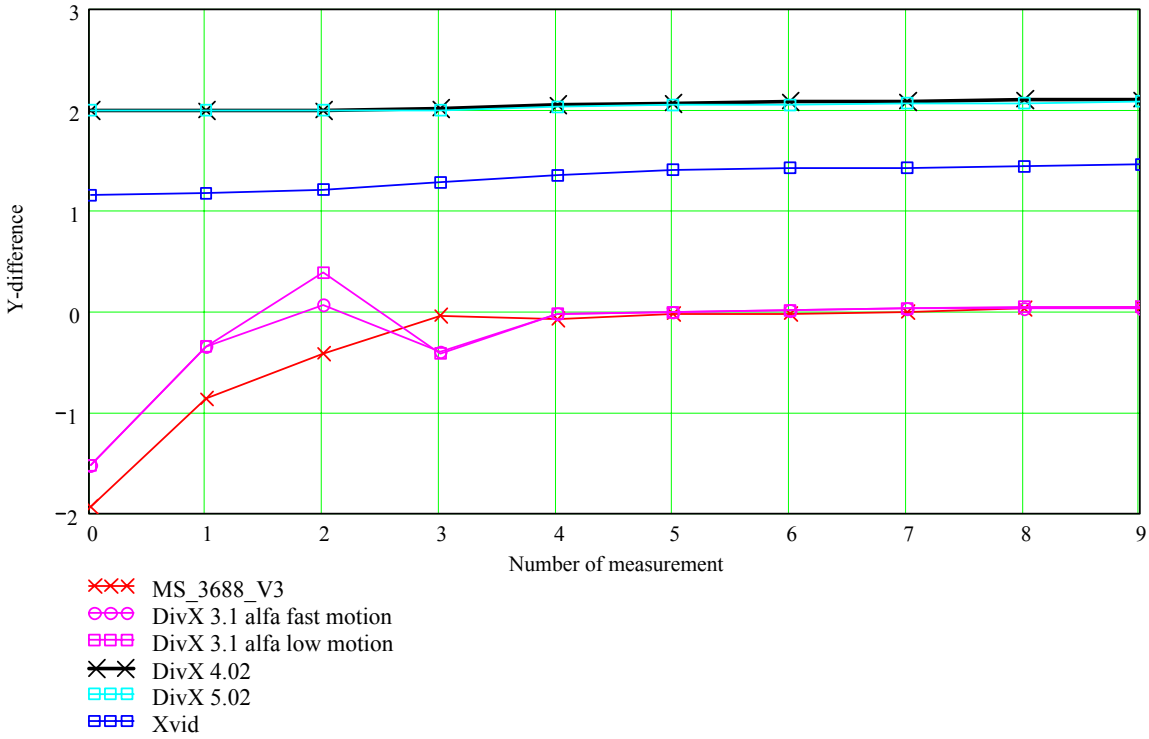
Y-Difference Diagrams

This type of diagrams reflects dynamics of the change of brightness in the sequence depending on the bitrate. Y-axis represents the difference between average brightness of the compressed and source sequences. X-axis represents the number of the measurement (bitrate). So a positive ordinate of the point means increase of brightness after compression and a negative one means decrease (darkening).

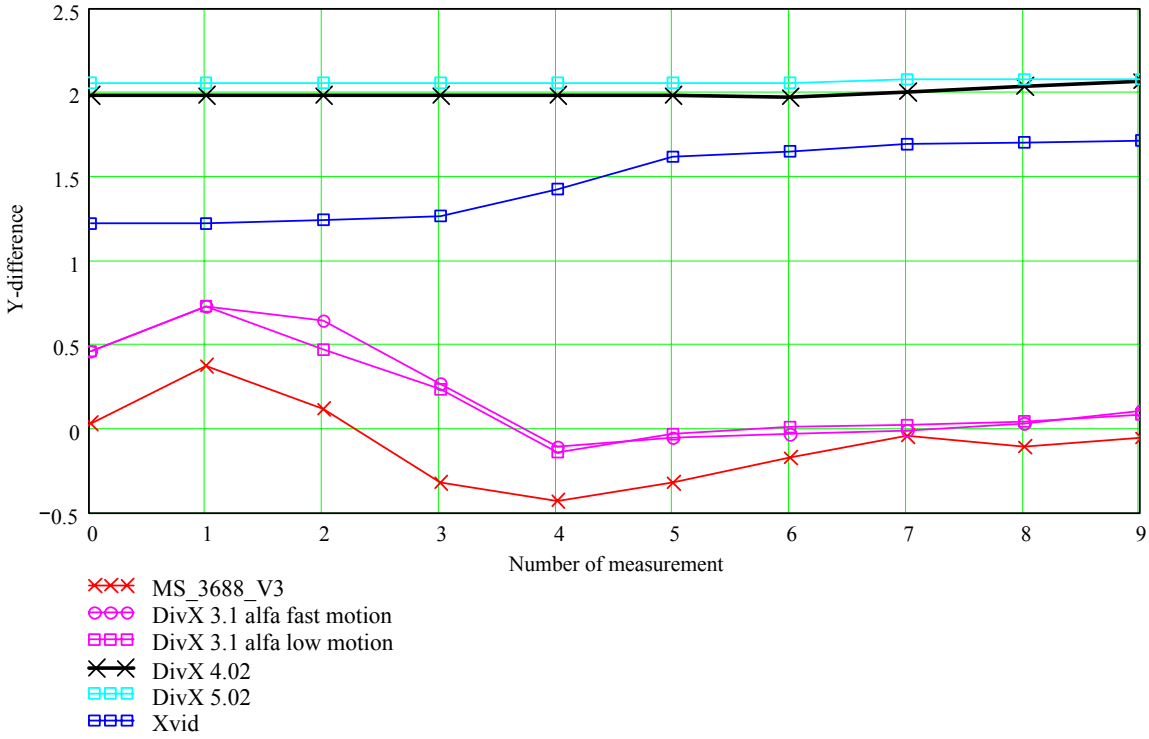
MPEG4



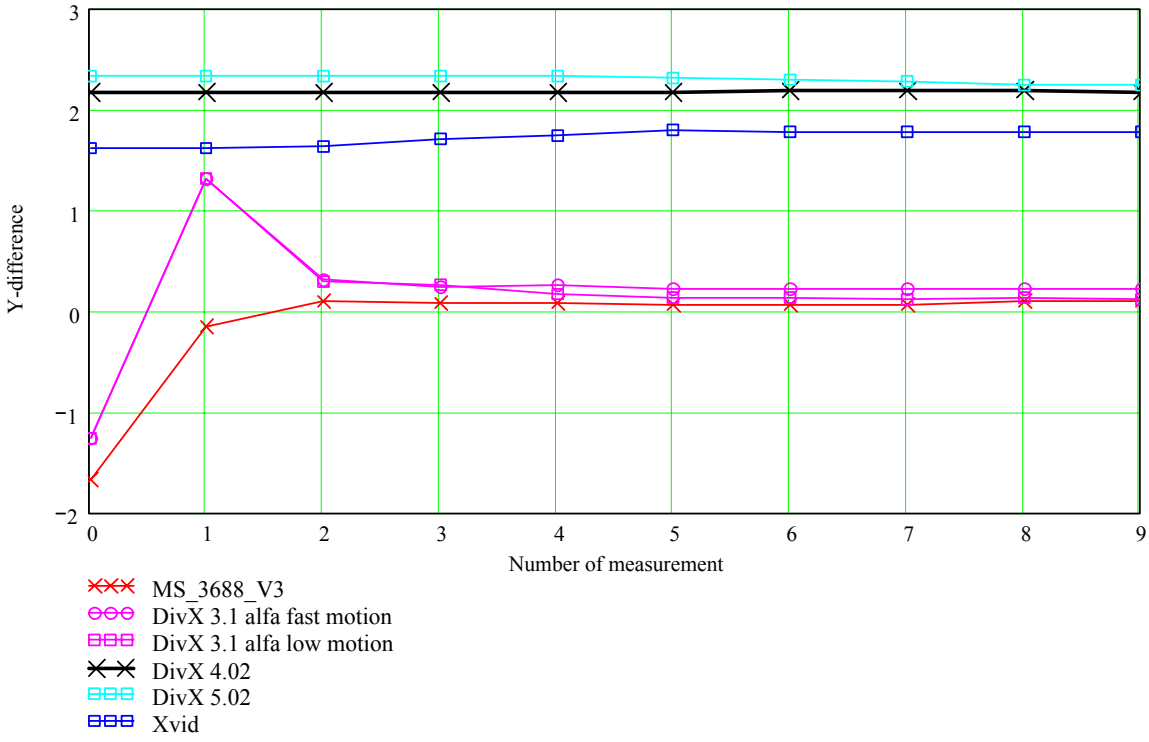
Picture 52. Sequence BANKOMATDdi



Picture 53. Sequence BATTLE



Picture 54. Sequence BBC3di

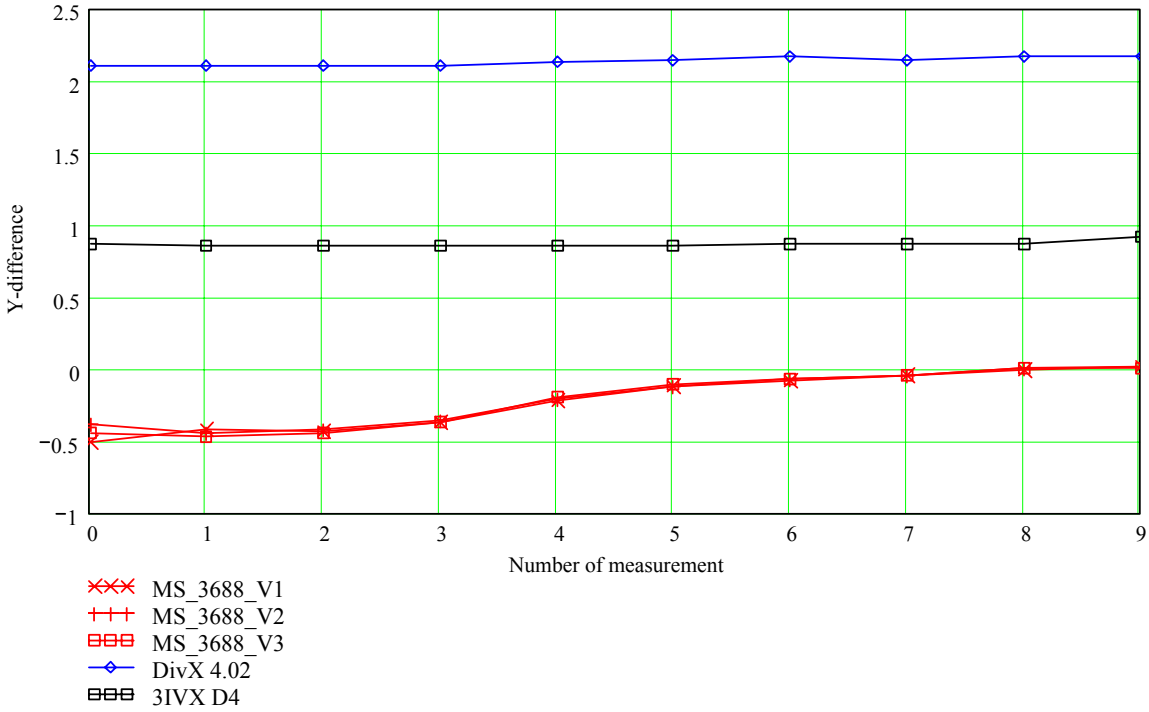


Picture 55. Sequence HELICOPTERdi

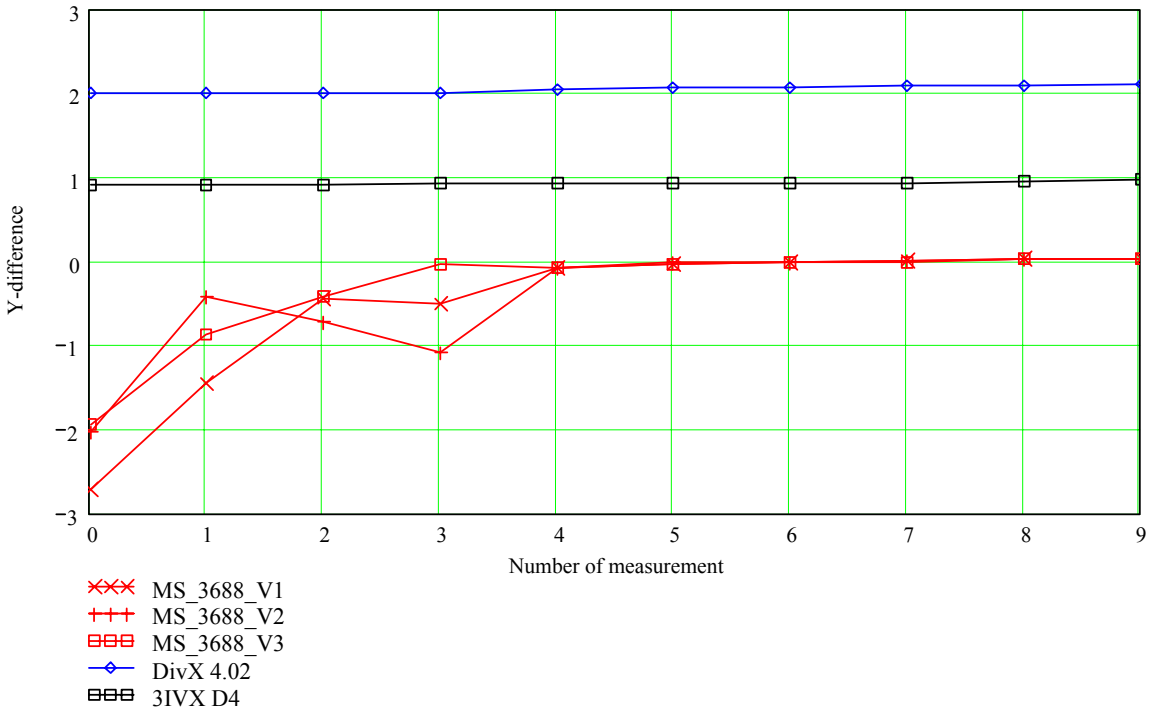
Conclusions:

- Divx 4.02 & 5.02 stably increase brightness by 2-2.5 dB.
- Xvid 2.1 increases brightness by 1-2 dB.
- Divx 3.1 and Microsoft v3 change (in both directions) brightness by 1.5-2 dB on low bitrate and keep it almost unchanged on high one.

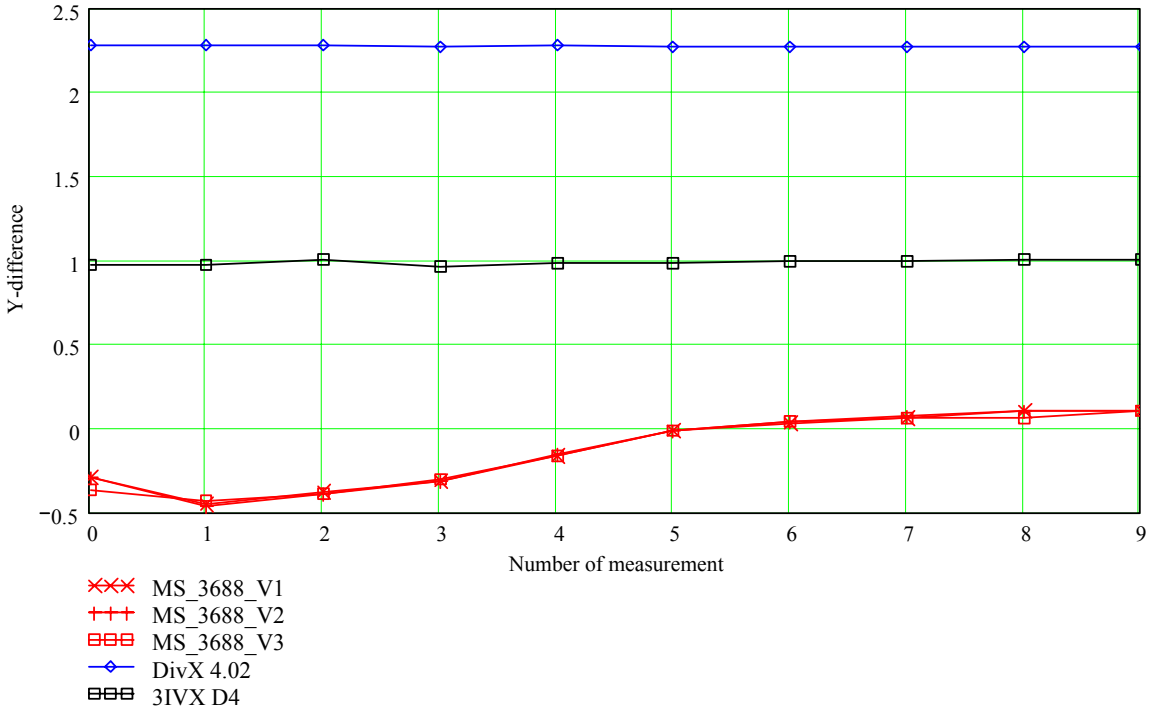
Microsoft v1 & v2 & v3, Divx 4.02, 3IVX D4



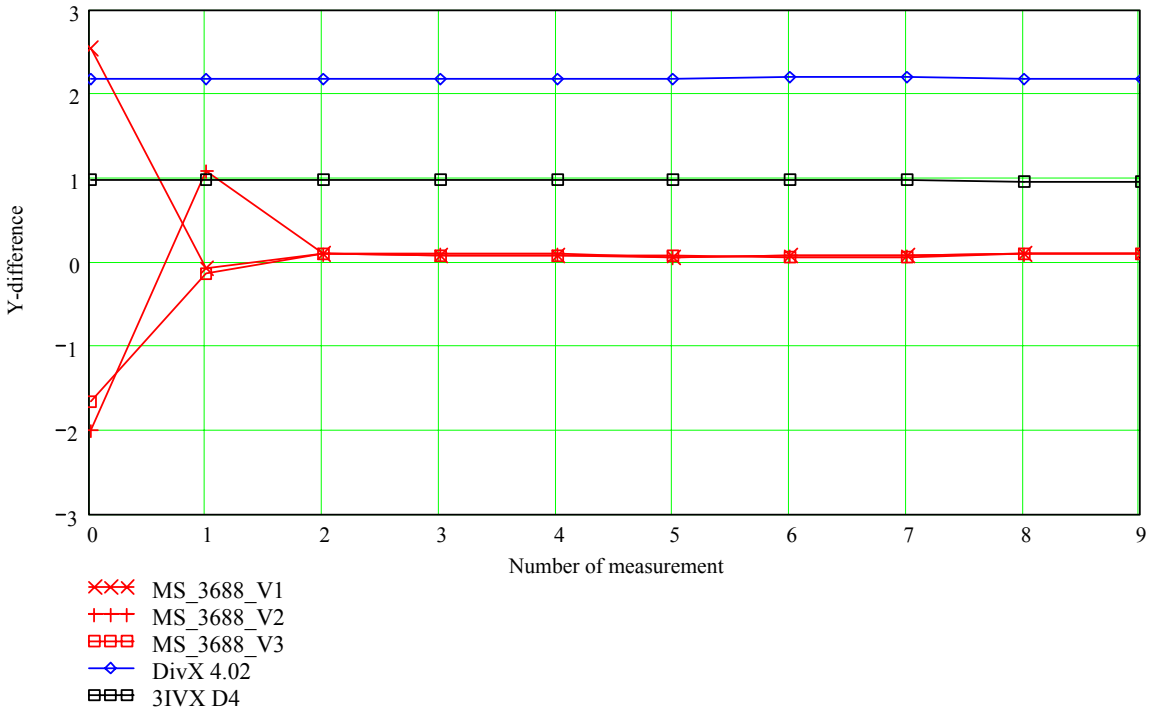
Picture 56. Sequence BANKOMATDdi



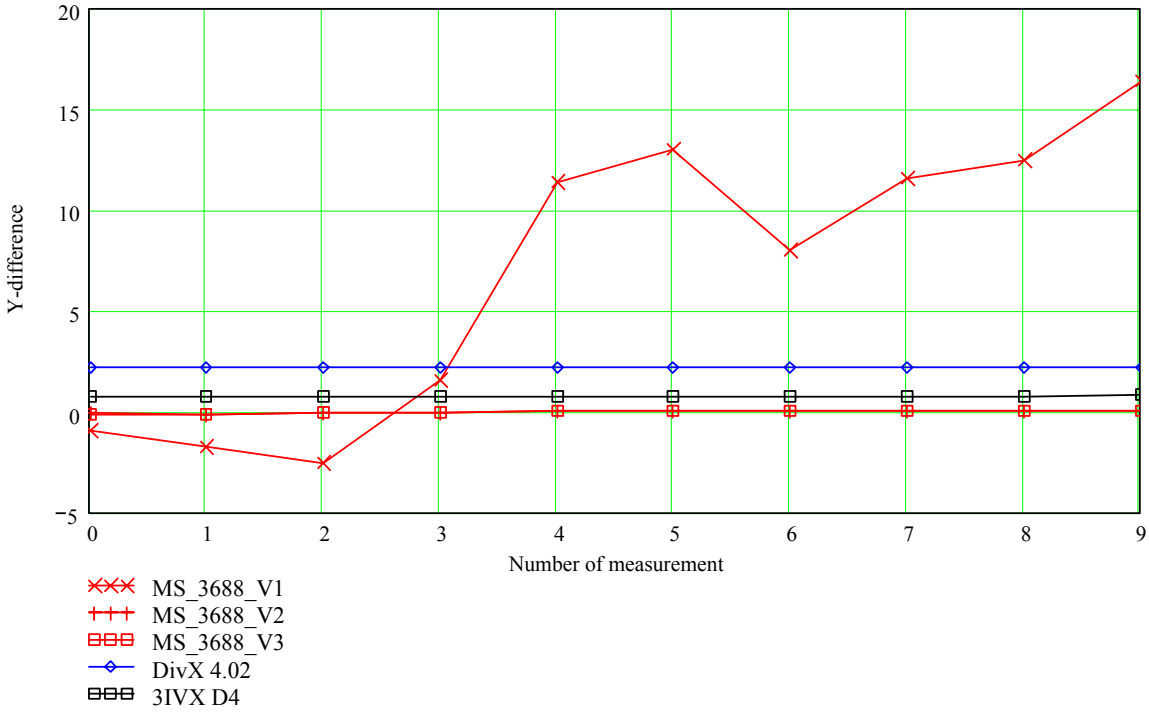
Picture 57. Sequence BATTLE



Picture 58. Sequence BUS



Picture 59. Sequence HELICOPTERdi

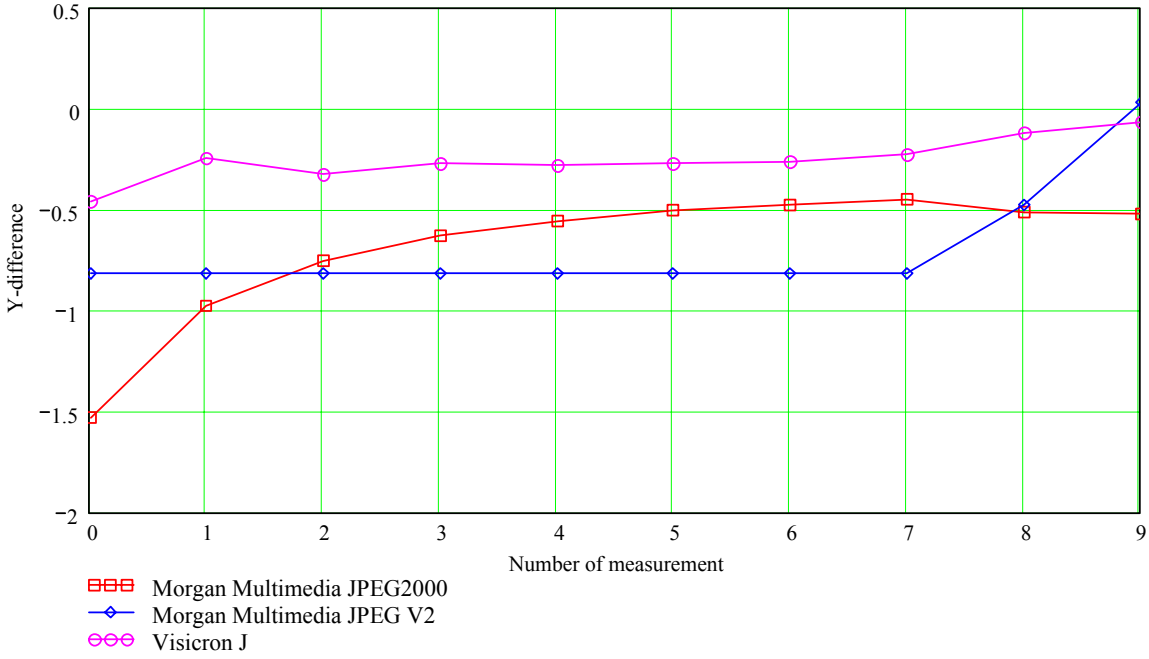


Picture 60. Sequence NDDP7di

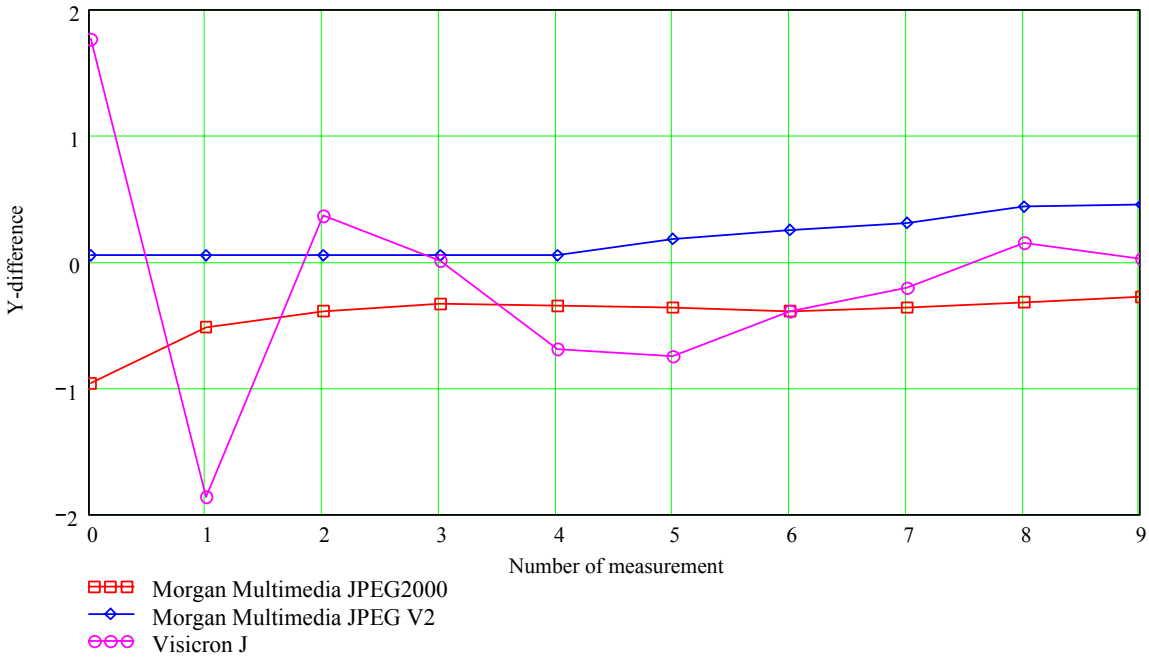
Conclusions:

- Divx 4.02 stably increases brightness by 2-2.5 dB; 3IVX D4 – by 1 dB.
- Microsoft codecs change brightness in some sequences on low bitrate and do not change it on high one.
- Differences of brightness on the diagram for Microsoft v1 (see the diagram for nddp7di) are caused by an error which occurred during the compression.

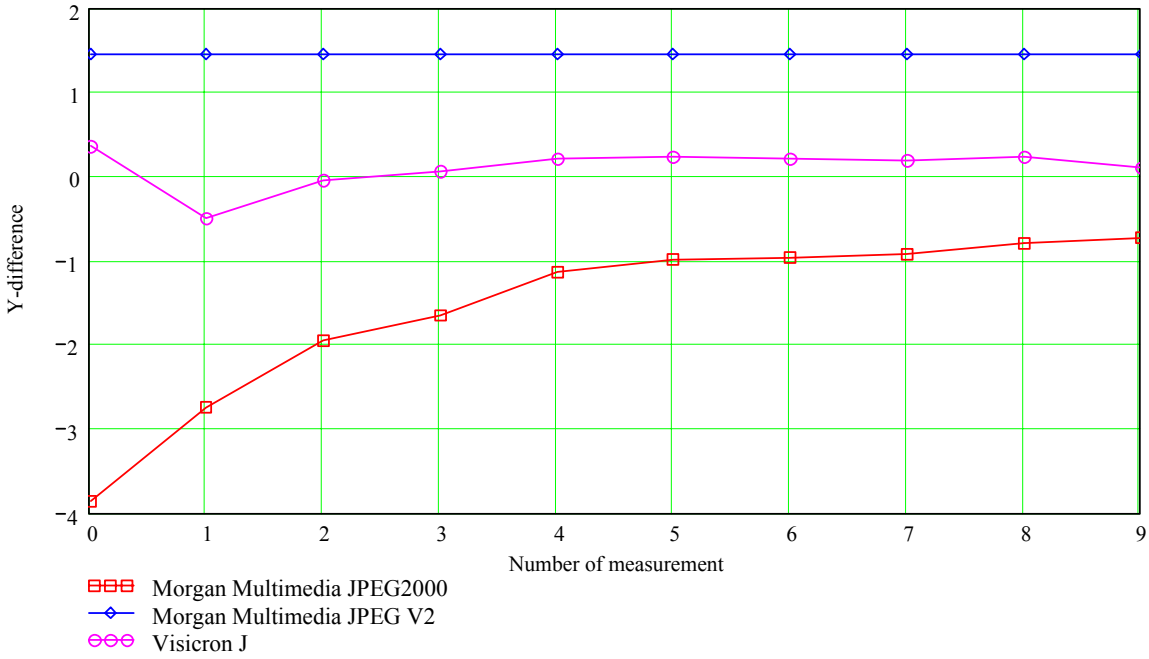
JPEG



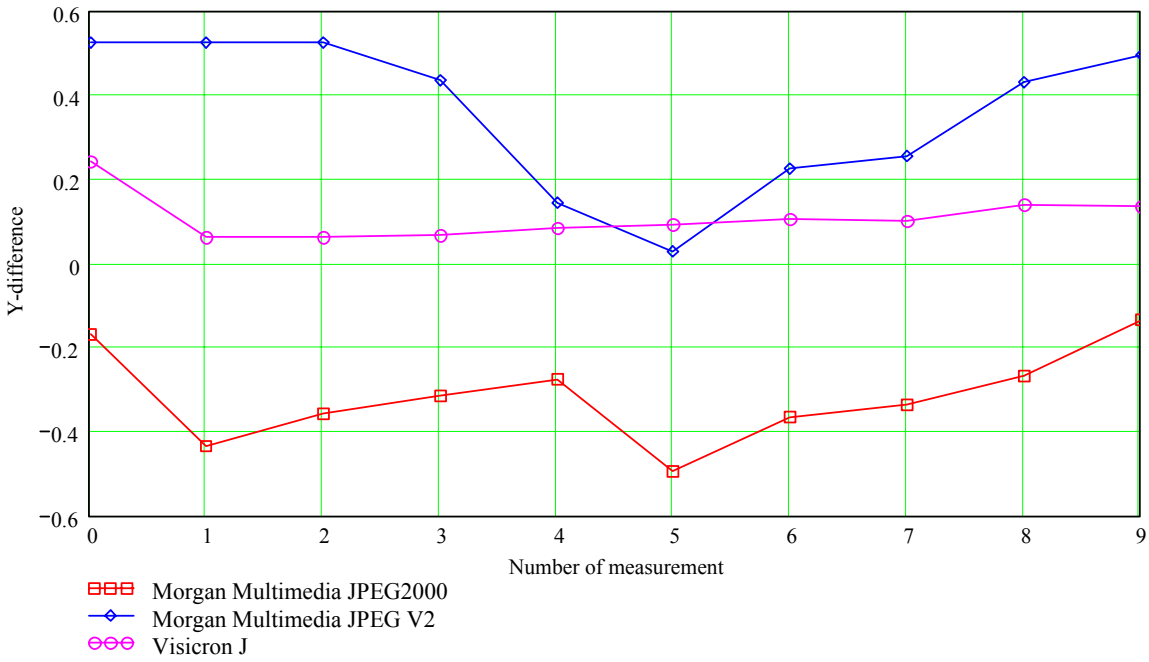
Picture 61. Sequence BANKOMATDdi



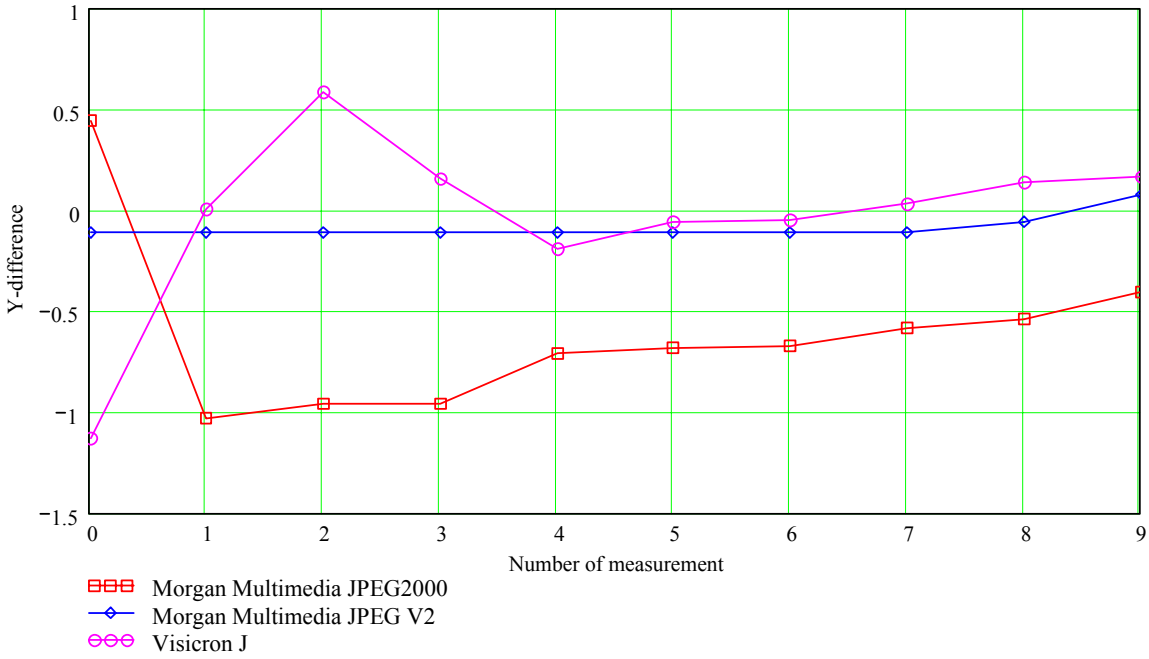
Picture 62. Sequence BATTLE



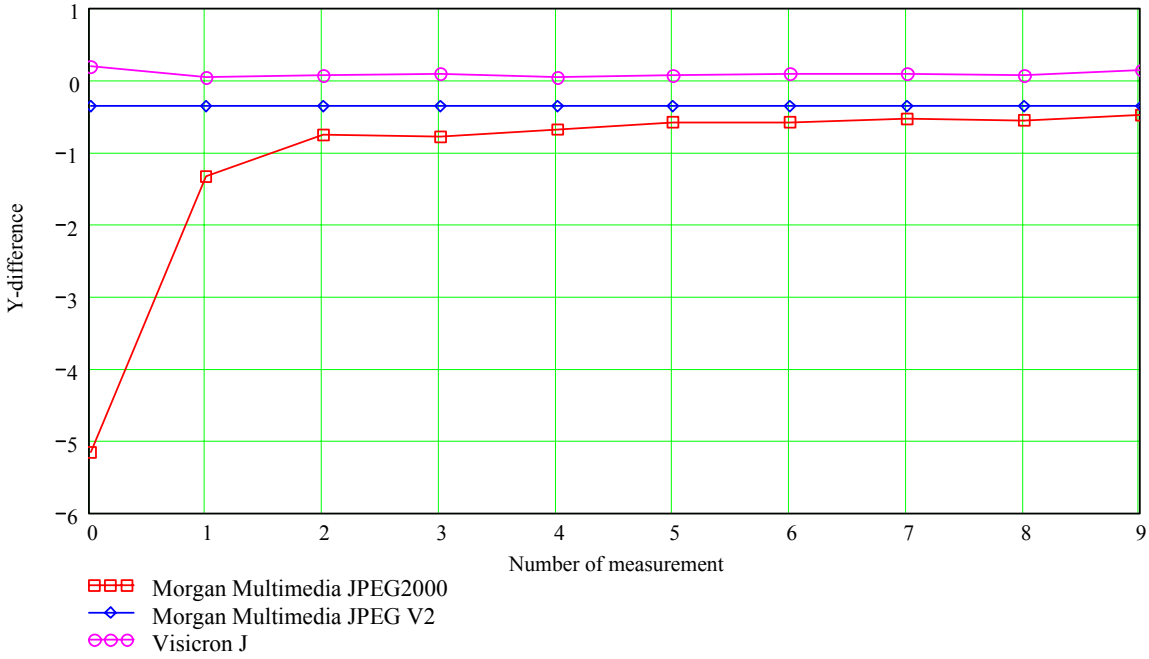
Picture 63. Sequence BBC3di



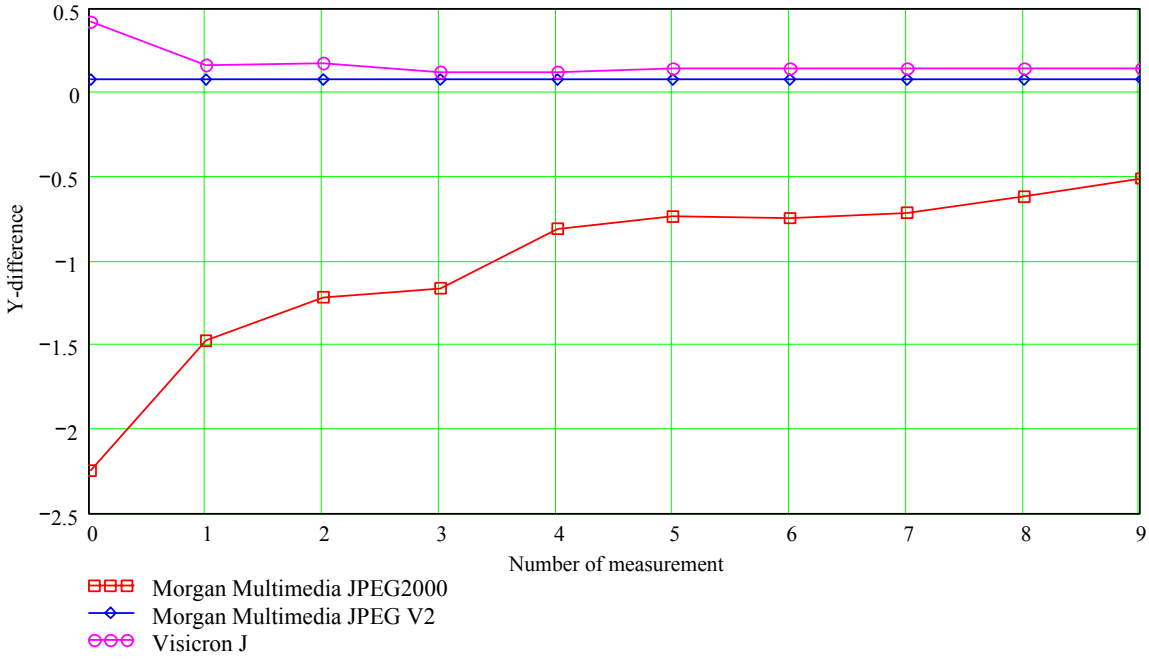
Picture 64. Sequence BUS



Picture 65. Sequence HELICOPTERdi



Picture 66. Sequence NDDP7di

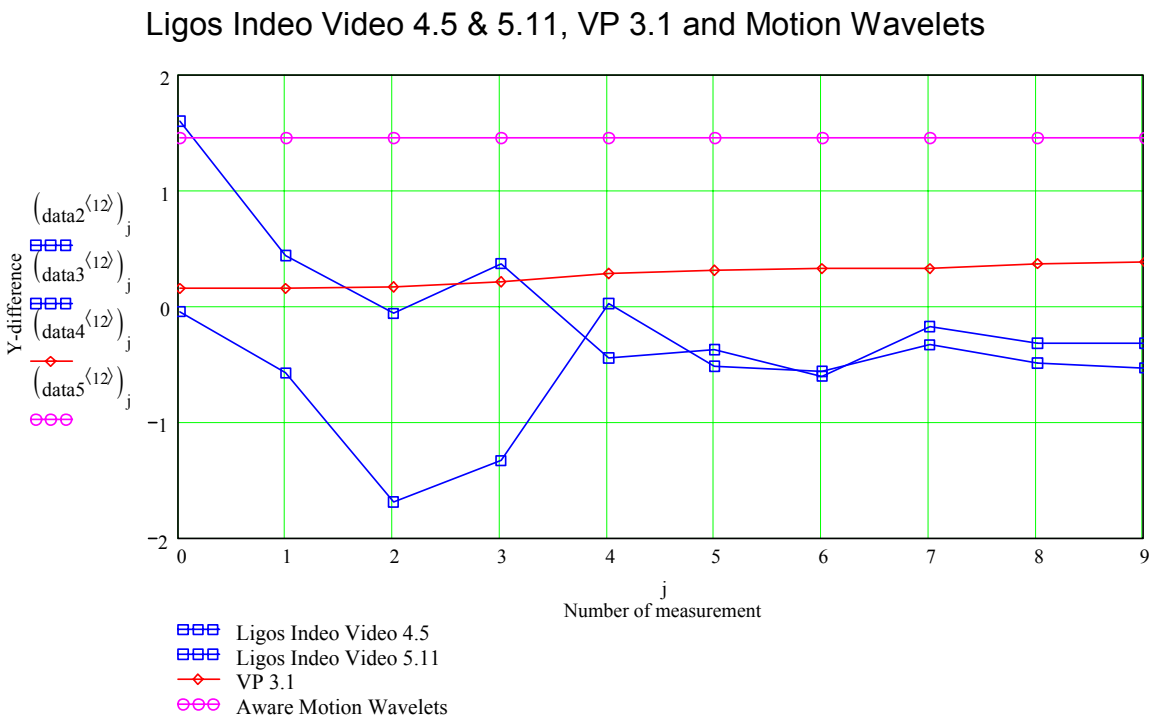


Picture 67. Sequence TENSdi

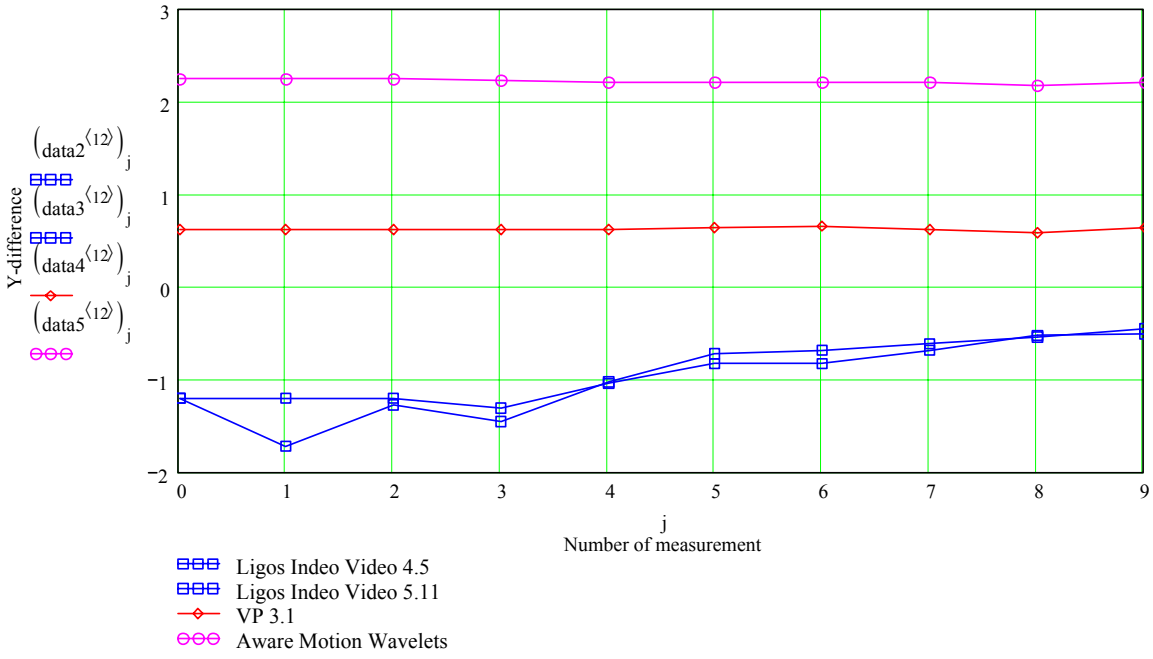
Conclusions:

- MM JPEG2000 changes brightness by 4-5 dB in some sequences on low bitrate and changes it very slightly on high bitrate.
- Visicron J changes brightness not more than by 1 dB. Only in the battle sequence brightness is changed by 2 dB on low bitrate.
- MM JPEG v2 changes brightness less than by 1 dB on any bitrate, except for the bbc3di sequence, where it changed brightness by 1.5 dB.

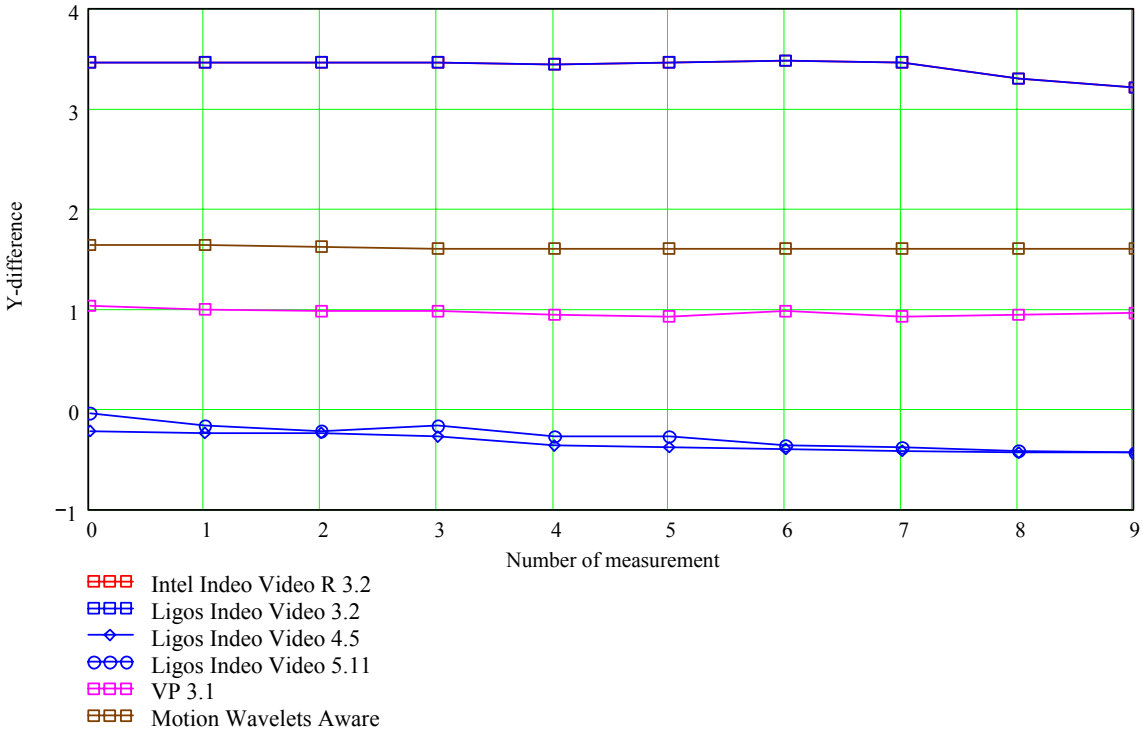
NON-STANDART



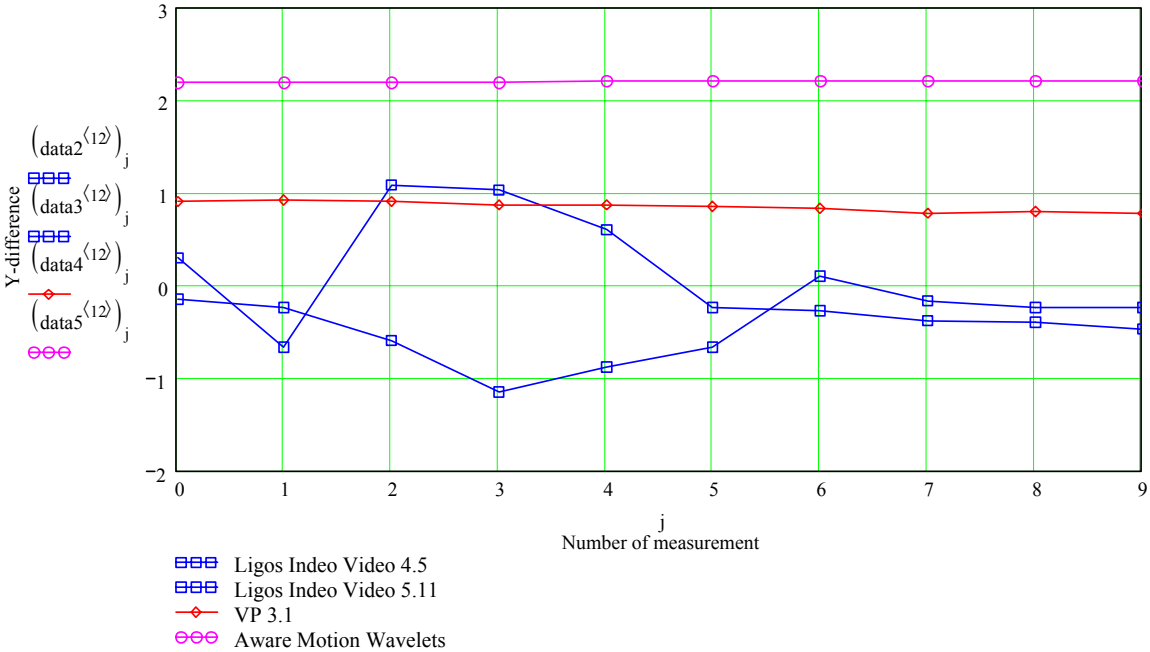
Picture 68. Sequence BATTLE



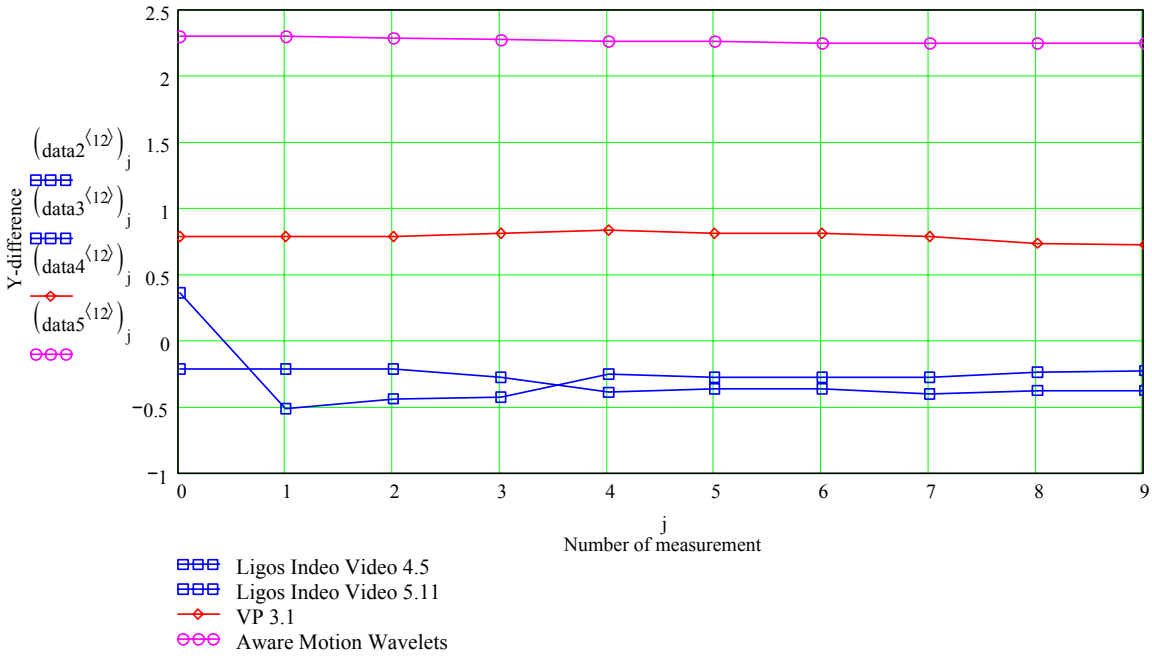
Picture 69. Sequence BBC3di



Picture 70. Sequence BUS



Picture 71. Sequence HELICOPTERdi

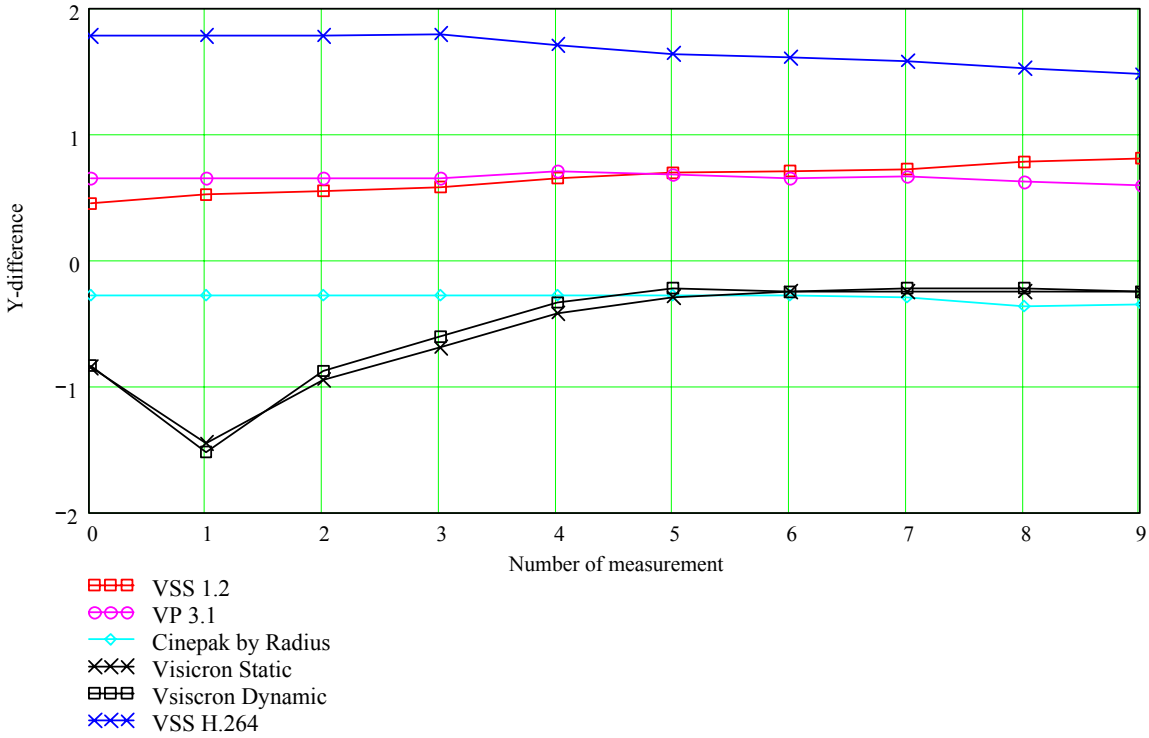


Picture 72. Sequence TENSdi

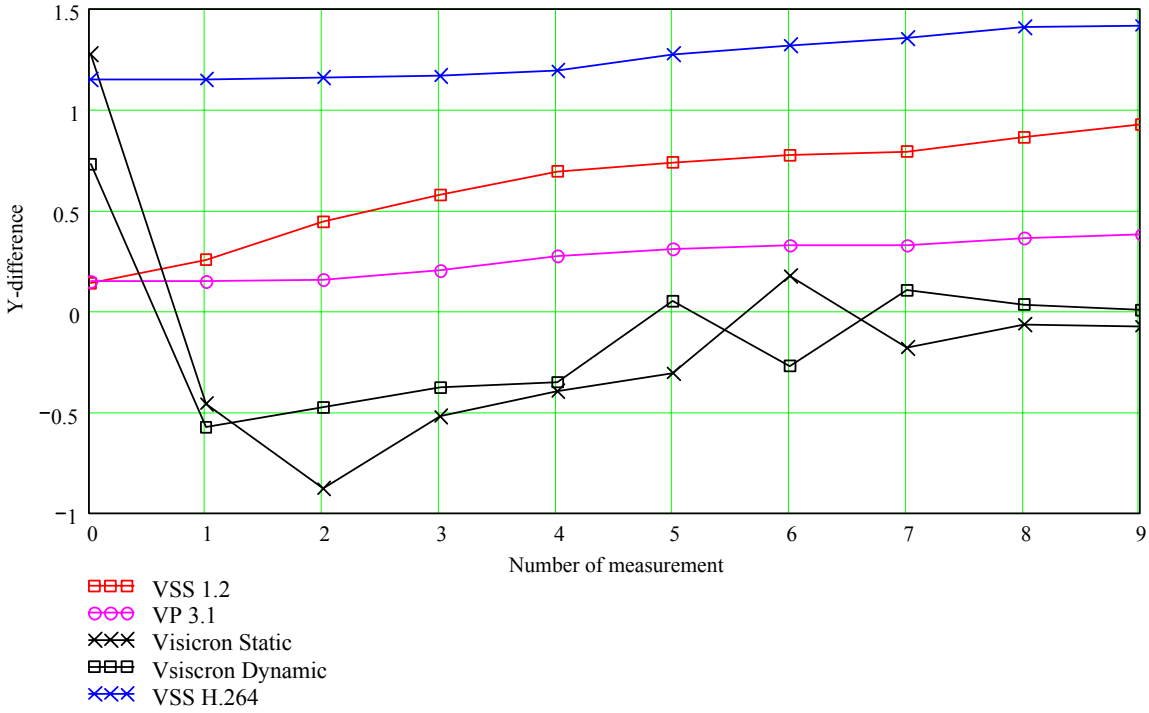
Conclusions:

- Motion Wavelets and VP 3.1 increase brightness stably; Motion Wavelets increase it by 2- 2.5 dB, VP 3.10.5 – by 0.5-1.0dB.
- Ligos codecs change brightness in both directions on low bitrate. These oscillations can be rather significant, for example on the helicopterdi and battle sequences. But change of brightness becomes stable on high bitrate; here it is decreased less than by 0.5 dB.

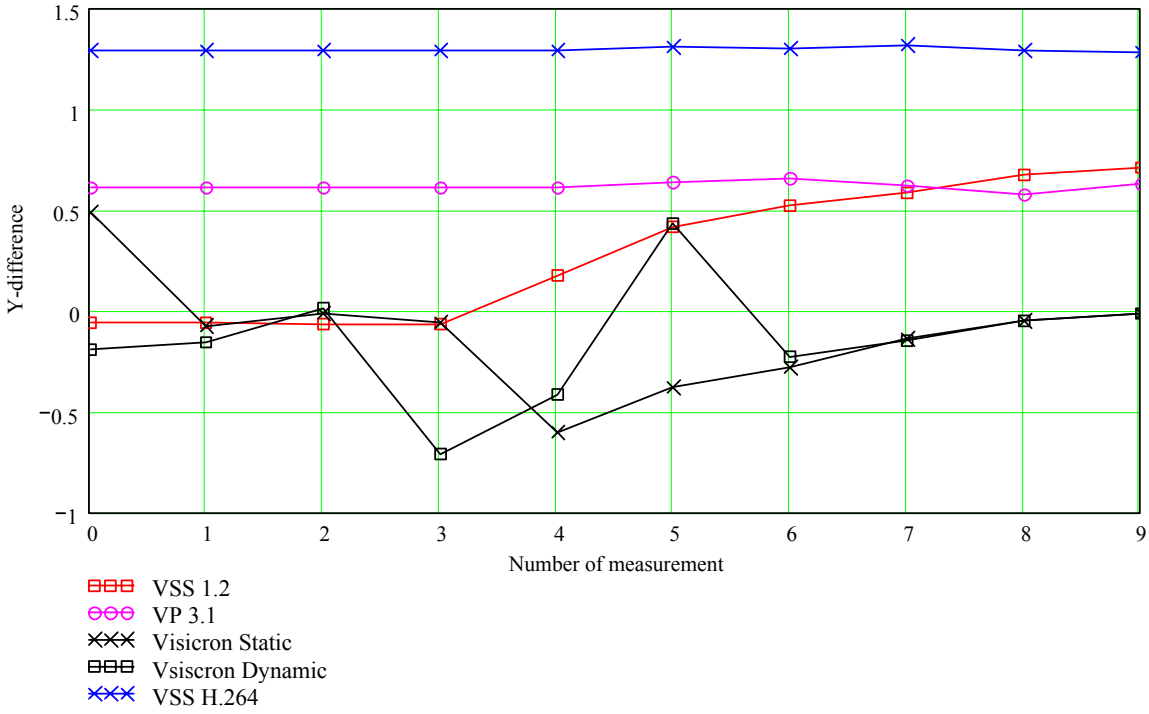
VSS H.264, VSS 1.2, Intel I.263, VP 3.1, Cinepak by Radius, Visicron Static & Dynamic



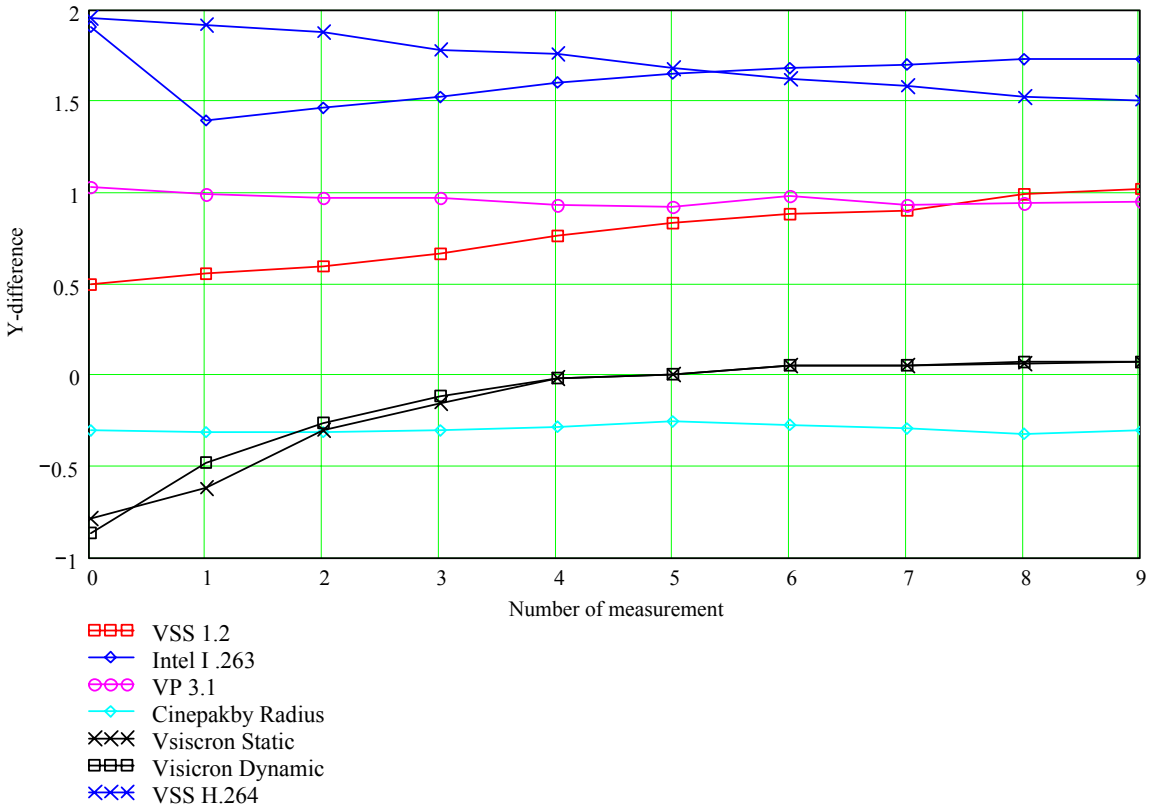
Picture 73. Sequence BANKOMATDdi



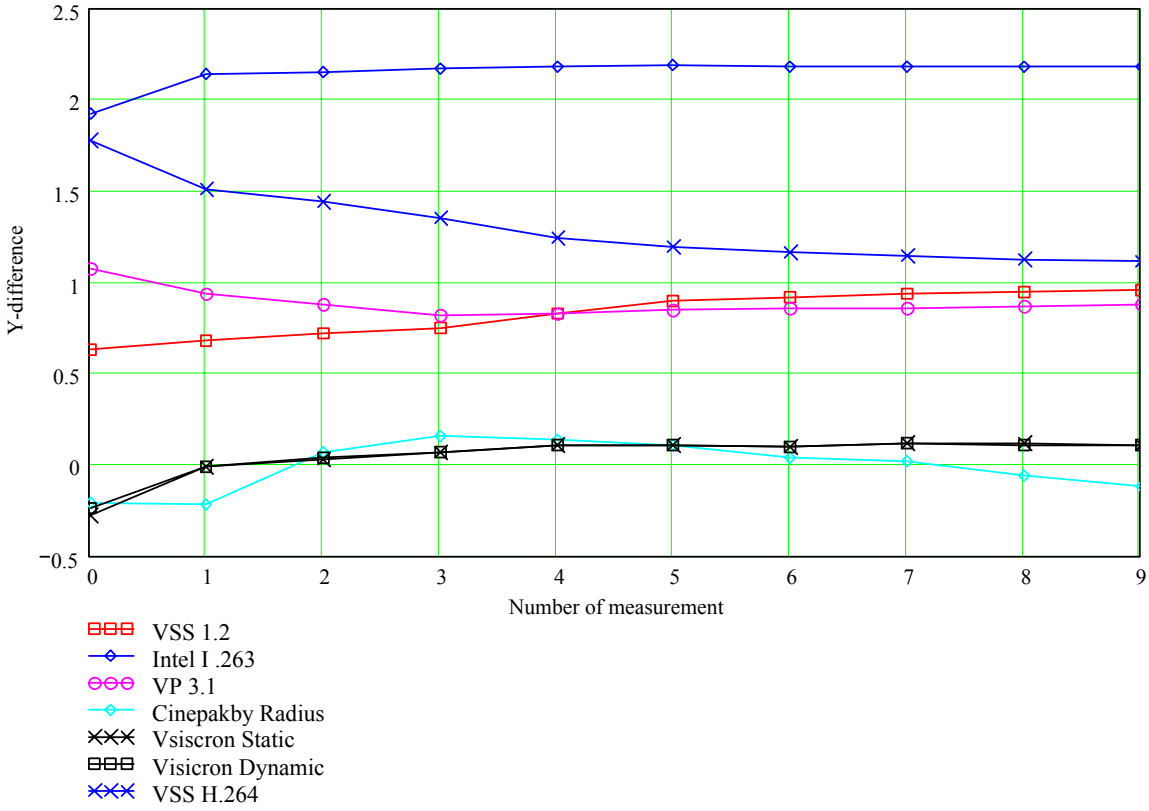
Picture 74. Sequence BATTLE



Picture 75. Sequence BBC3di



Picture 76. Sequence BUS



Picture 77. Sequence FOREMAN

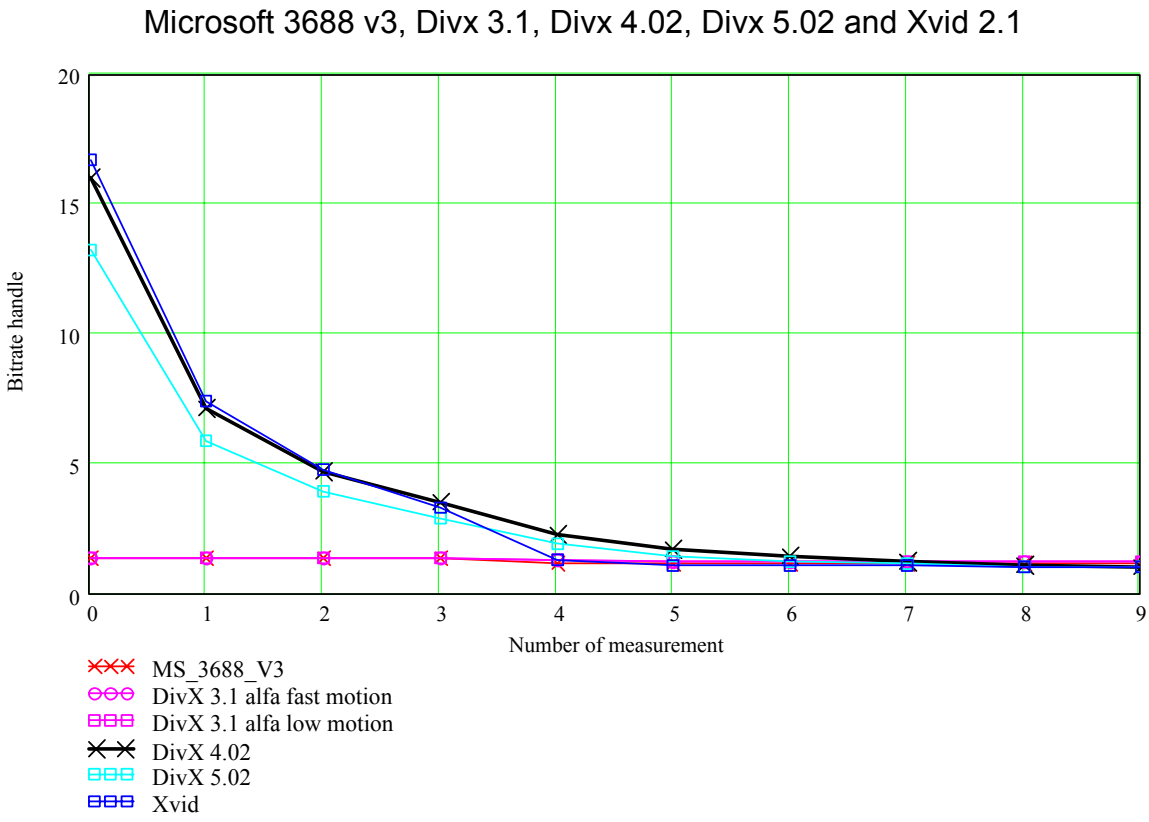
Conclusions:

- Cinepak by Radius keeps brightness almost unchanged.
- VSS 1.2 and VP 3.1 also change brightness insignificantly.
- Visicron codecs change brightness not more than by 1.5 dB. Changing of brightness often does not stabilize with the growth of bitrate.
- H.264 stably increases brightness by 1-2 dB.

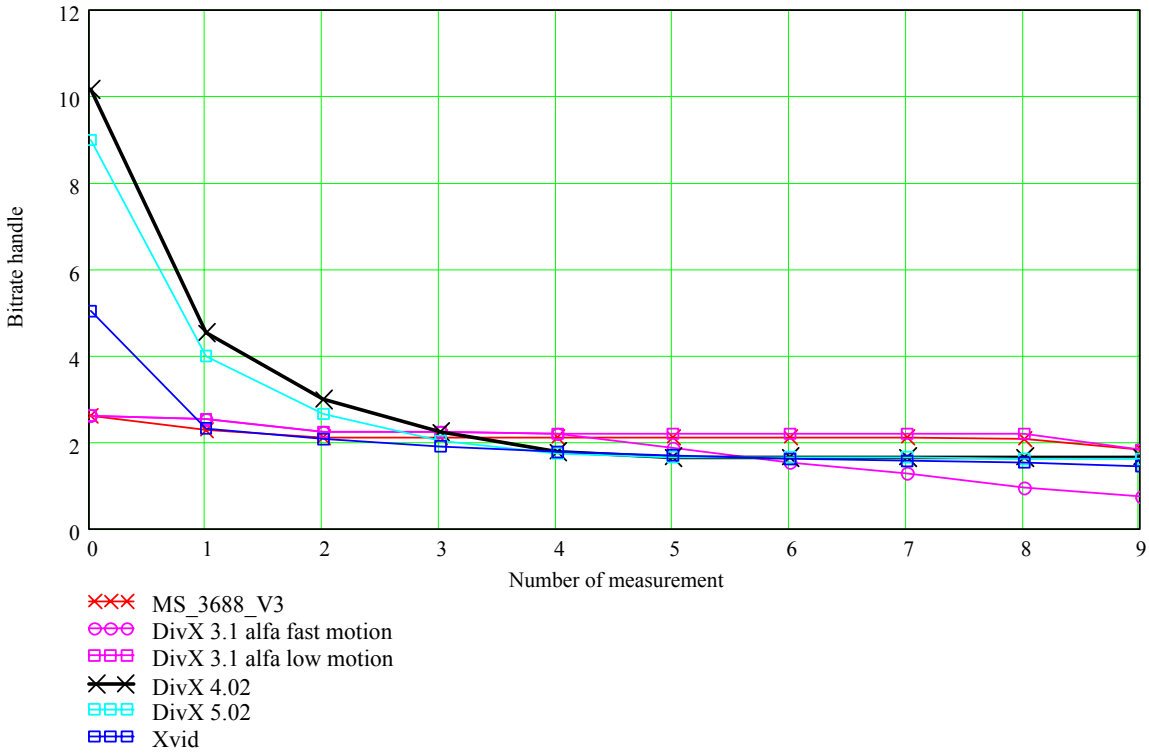
Bitrate Handle Diagrams

Y-axis represents bitrate of the compressed sequence divided by bitrate that was specified before the compression in the codec's options. X-axis represents the number of the measurement (each measurement is done with different bitrate settings; the first measurement relates to the lowest bitrate). So this type of diagrams shows, how many times real bitrate is as big (Bitrate Handle > 1) or small (Bitrate Handle < 1) as bitrate that was specified by a user in the codec's options.

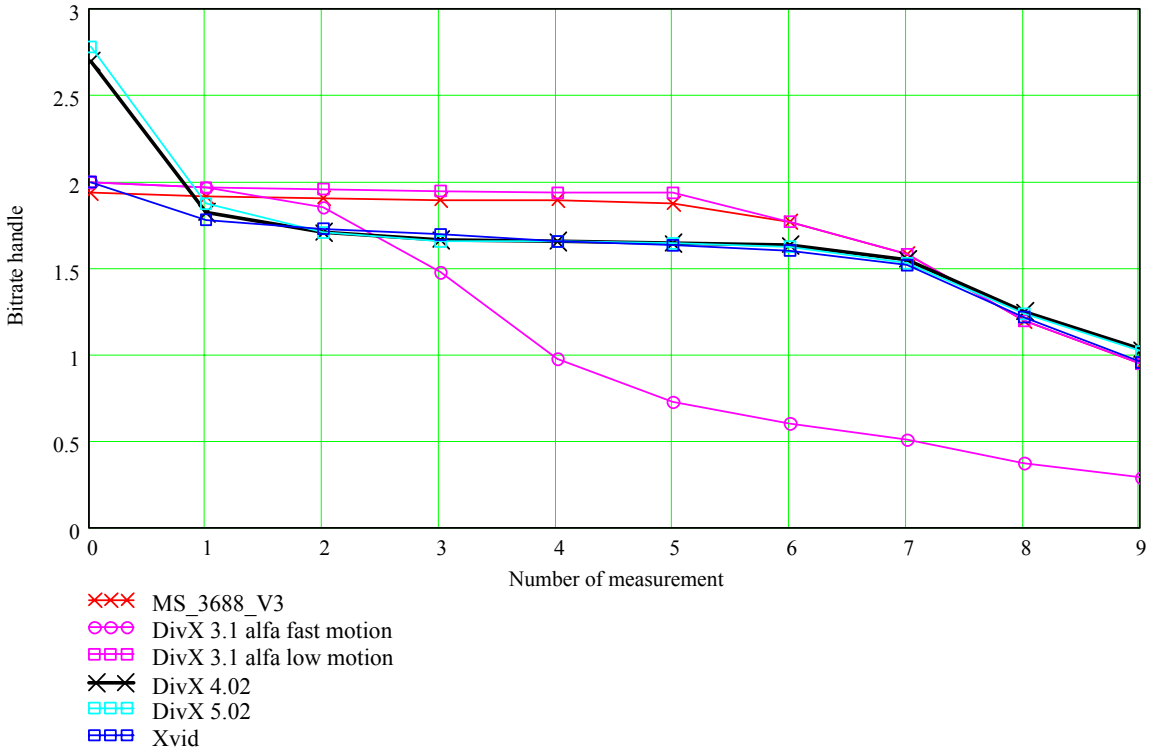
MPEG4



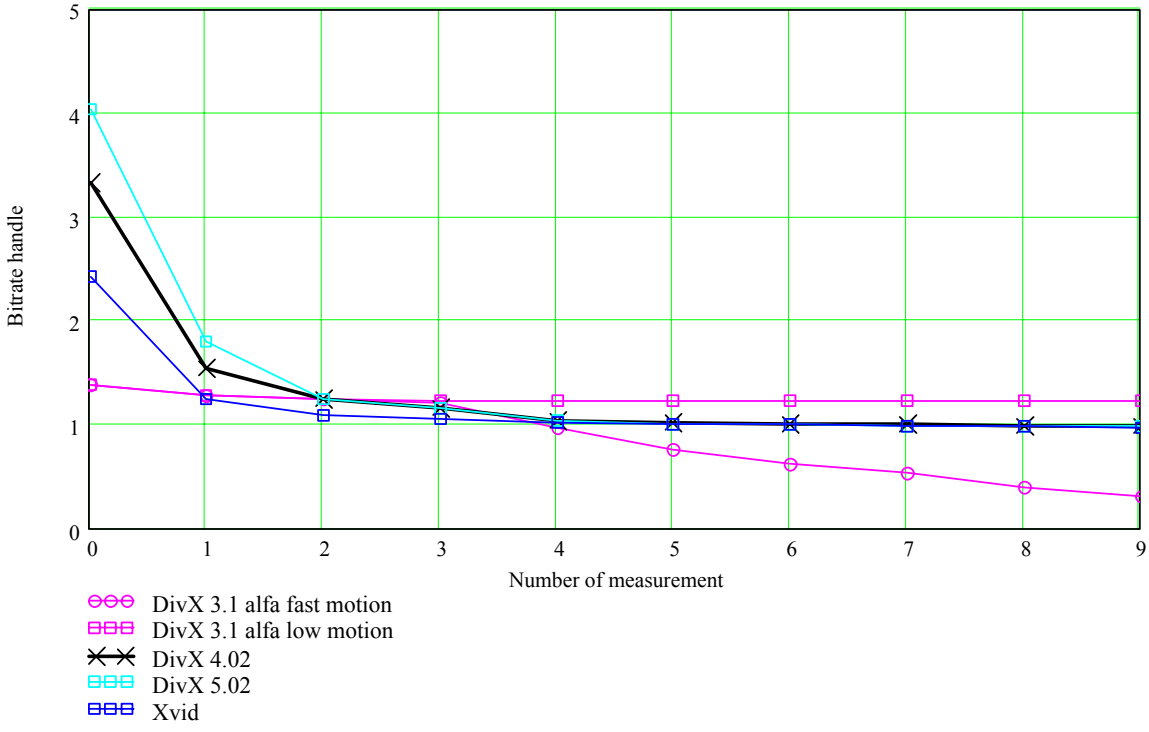
Picture 78. Sequence BBC3di



Picture 79. Sequence BUS



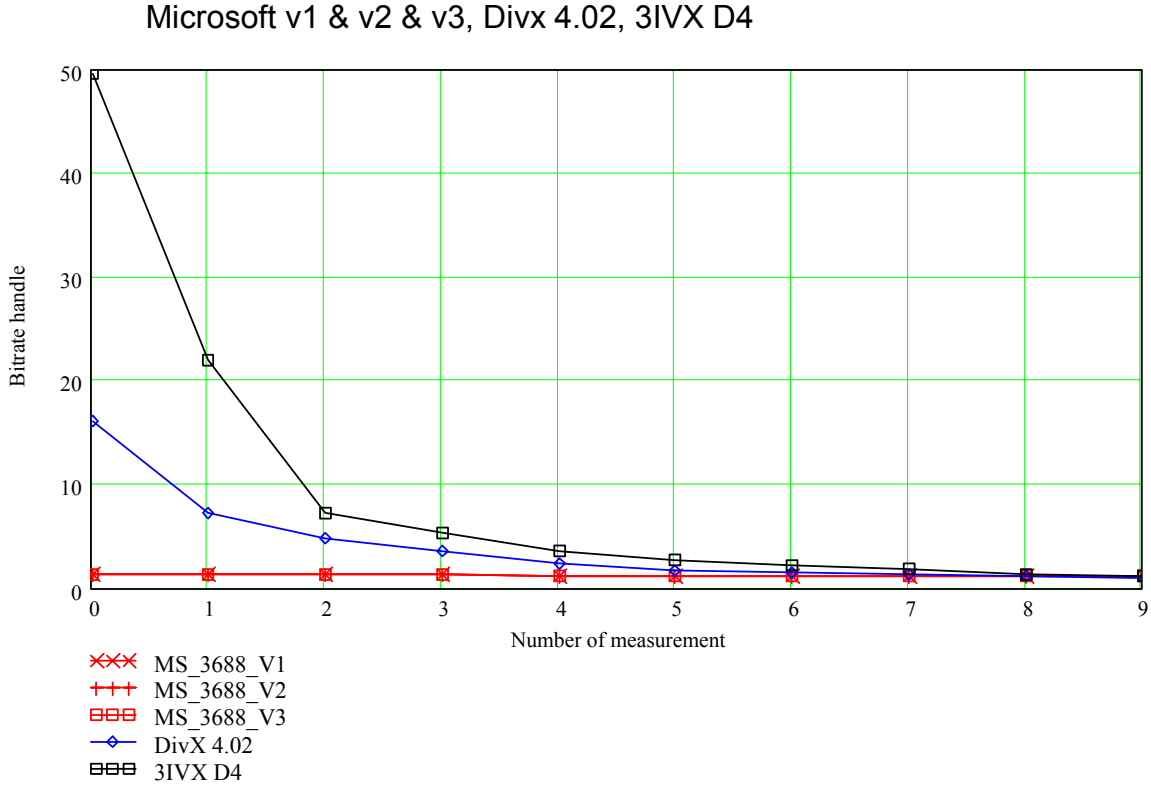
Picture 80. Sequence FOREMAN



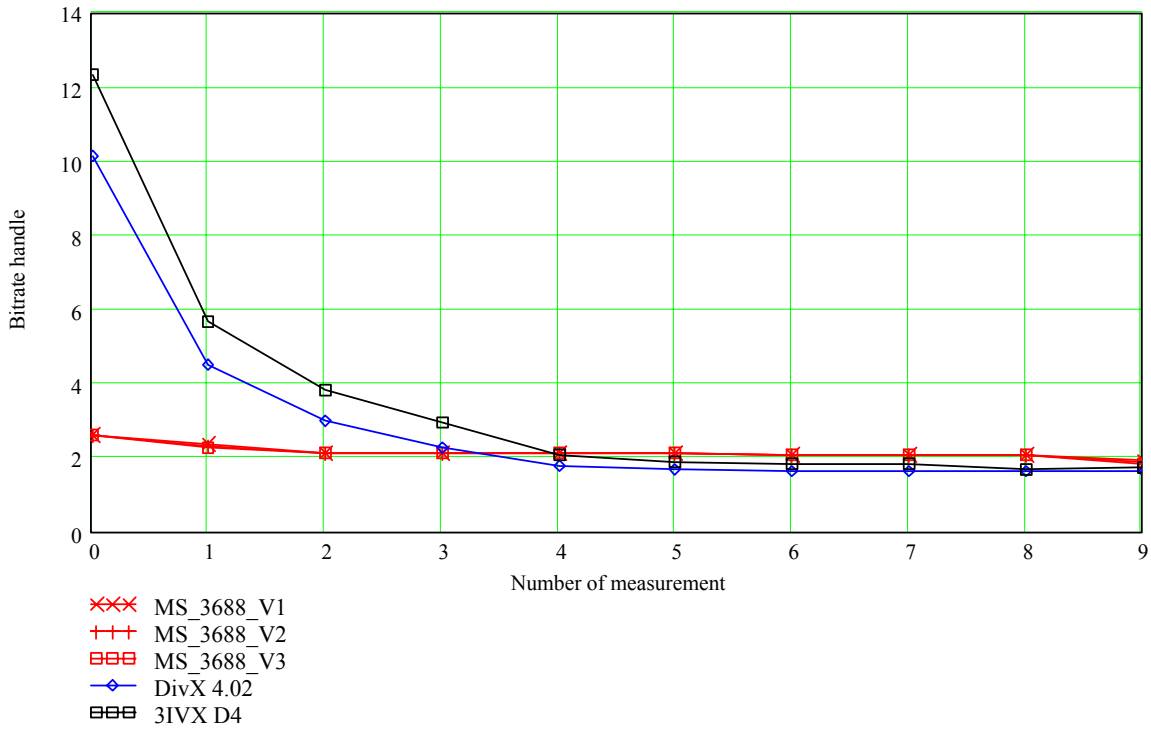
Picture 81. Sequence SUSIdi

Conclusions:

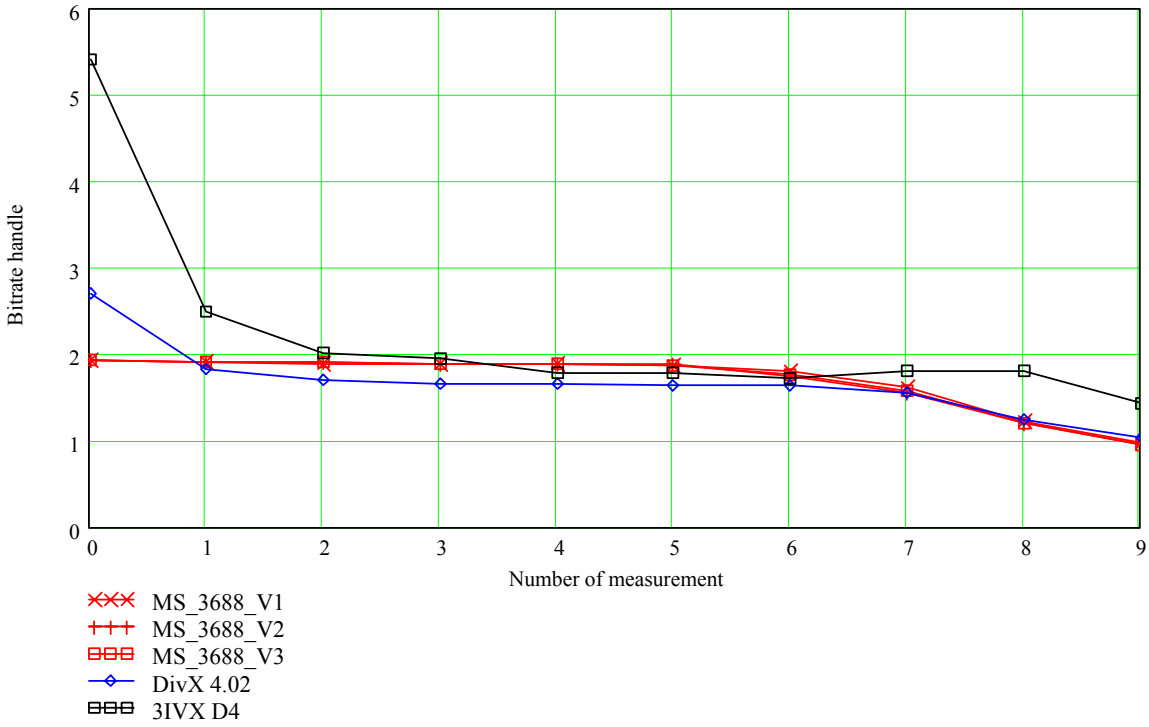
- Divx 3.1 and Microsoft v3 keep bitrate much better than the other codecs in this group but they achieve it only by using drop frames (see “Strategy of drop frames” section).
- Fast motion works on some sequences better than low on high bitrate.
- Xvid 2.1 works not bad; it keeps bitrate almost as well as Divx 3.1 and Microsoft v3 without using drop frames. But still there are sequences like bbc3di where it handles low bitrate much worse than these two codecs.
- Divx 4.02 & 5.02 behave almost in the same way; in some cases version 4.02 works better, in some - the other. According to the diagrams given here and in the “Strategy of drop frames” section, Divx 4.02 and its later versions do not generate drop frames. That is why they do not keep low bitrate and thus improve the quality of the compressed sequence.



Picture 82. Sequence BBC3di



Picture 83. Sequence BUS

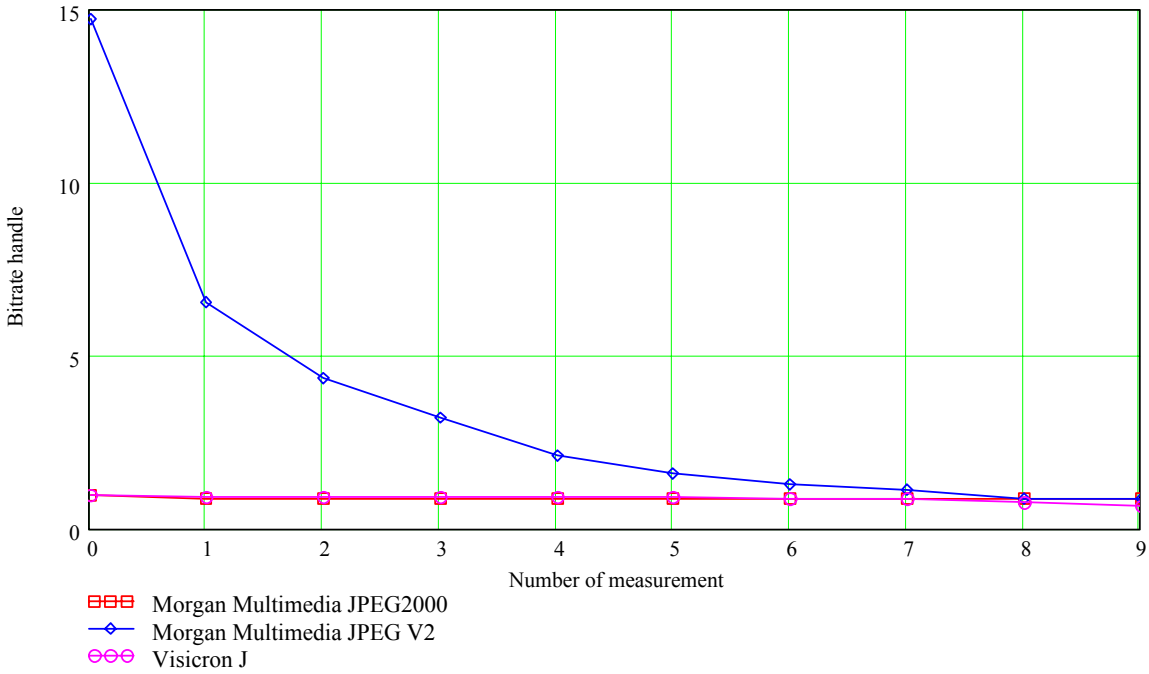


Picture 84. Sequence FOREMAN

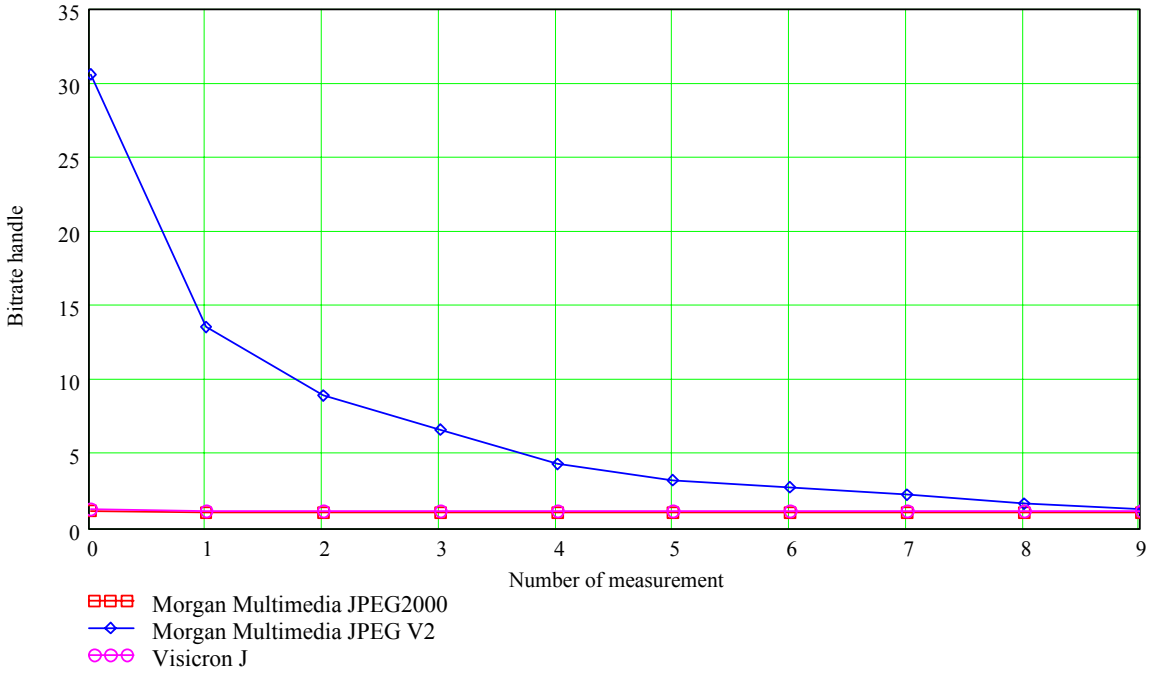
Conclusions:

- Microsoft codecs increase bitrate by 1.5-3 times and use drop frames on low bitrate.
- 3IVX D4 increases low bitrate by 10-50 times and high bitrate by 1.5-2 times depending on the sequence. It does not use drop frames.
- Divx 4.02 increases low bitrate by 10-20 times and high bitrate by 1.5-2 times depending on the sequence.

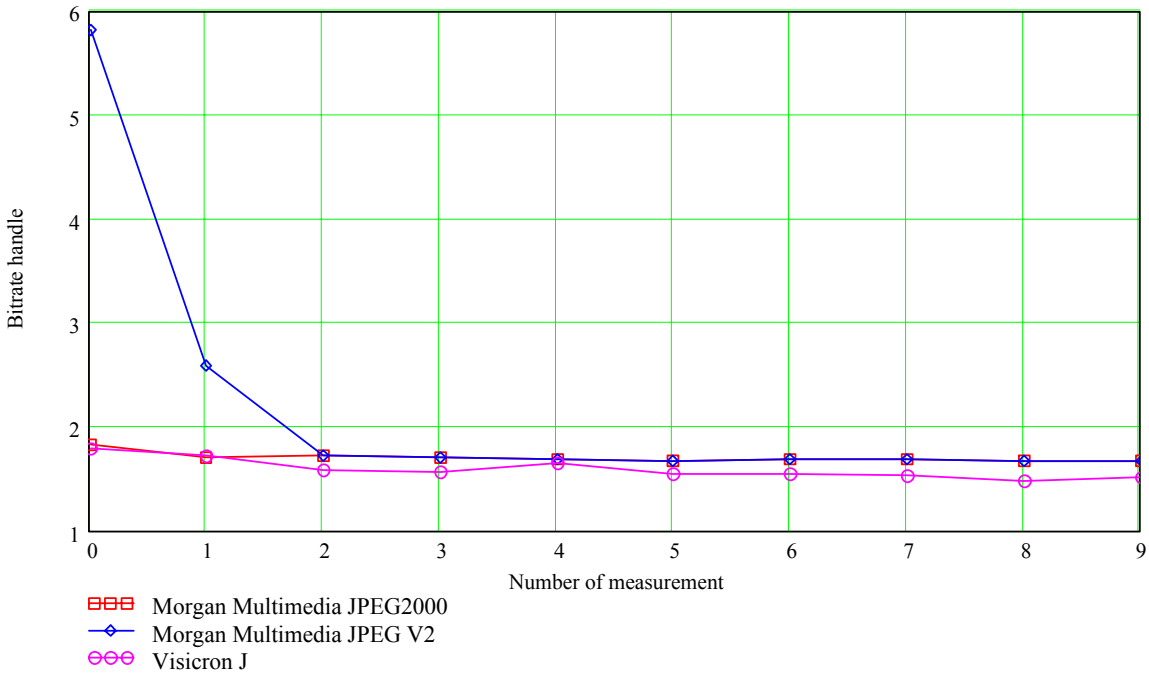
JPEG



Picture 85. Sequence BANKOMATDdi



Picture 86. Sequence BBC3di

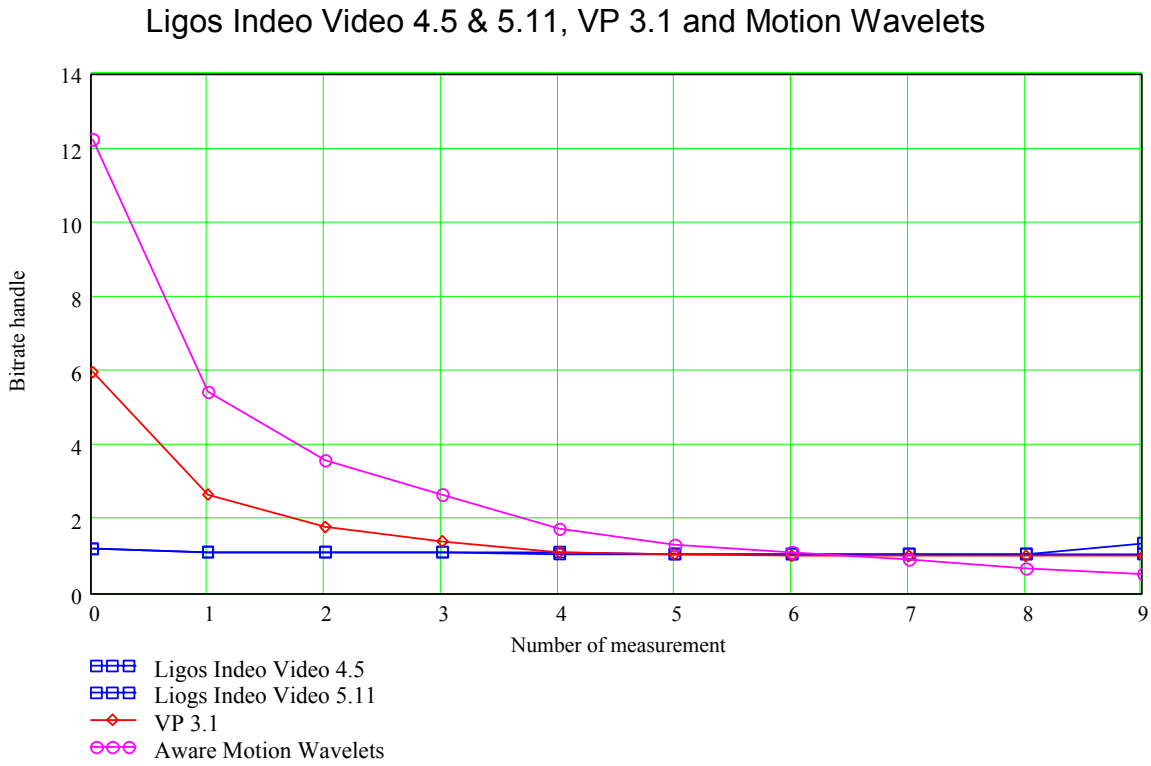


Picture 87. Sequence FOREMAN

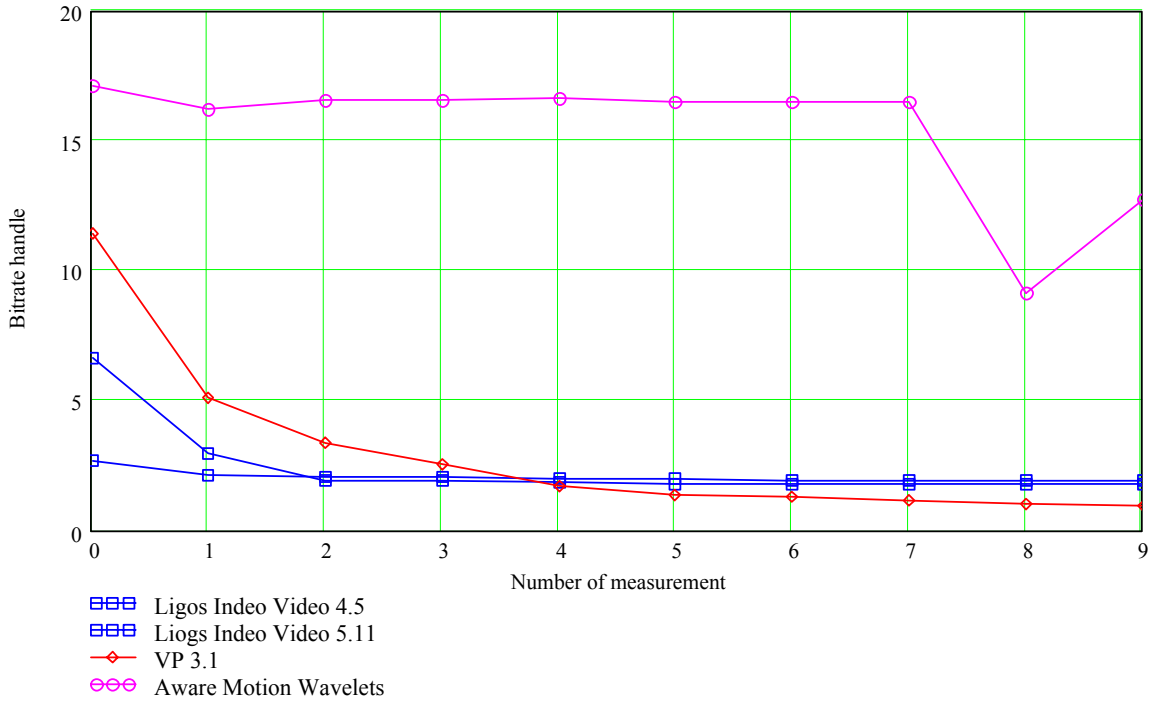
Conclusions:

- MM JPEG v2 increases low bitrate by 6-30 times depending on the video sequence. It keeps only the bitrate of 2340 kbps on all the sequences, except for bus and foreman.
- Visicron J and MM JPEG2000 keep bitrate, increasing it not more than twice.

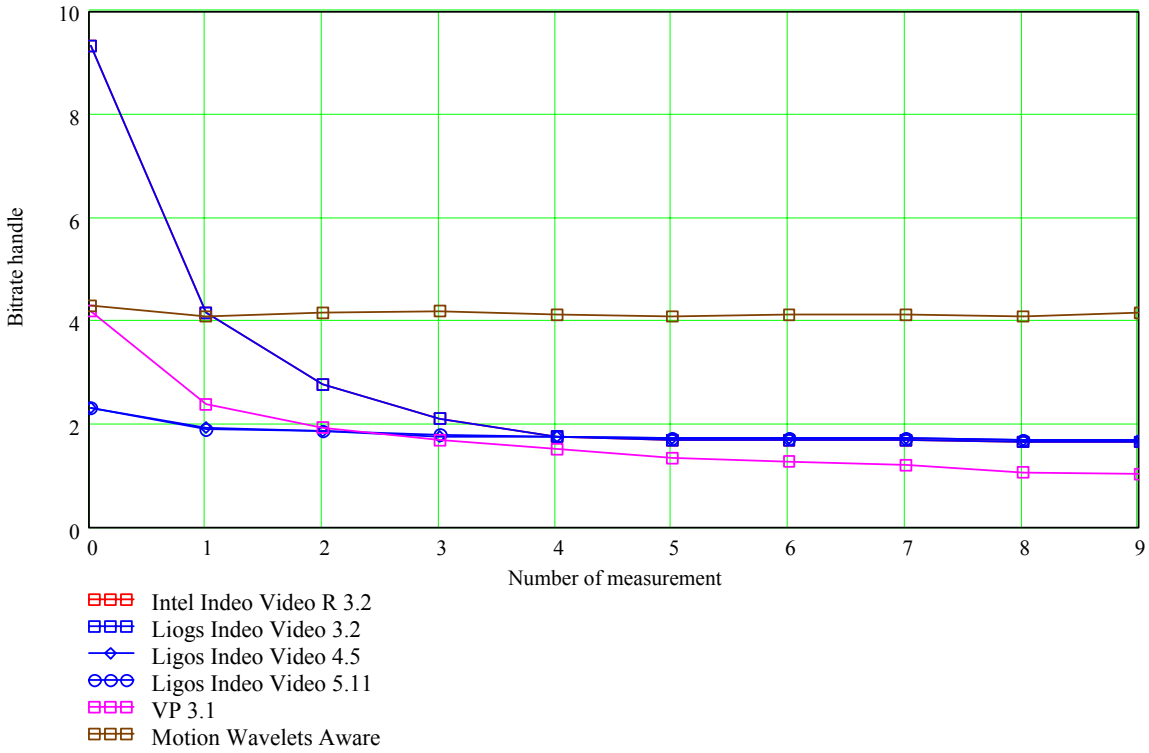
NON-STANDART



Picture 88. Sequence BATTLE



Picture 89. Sequence BBC3di

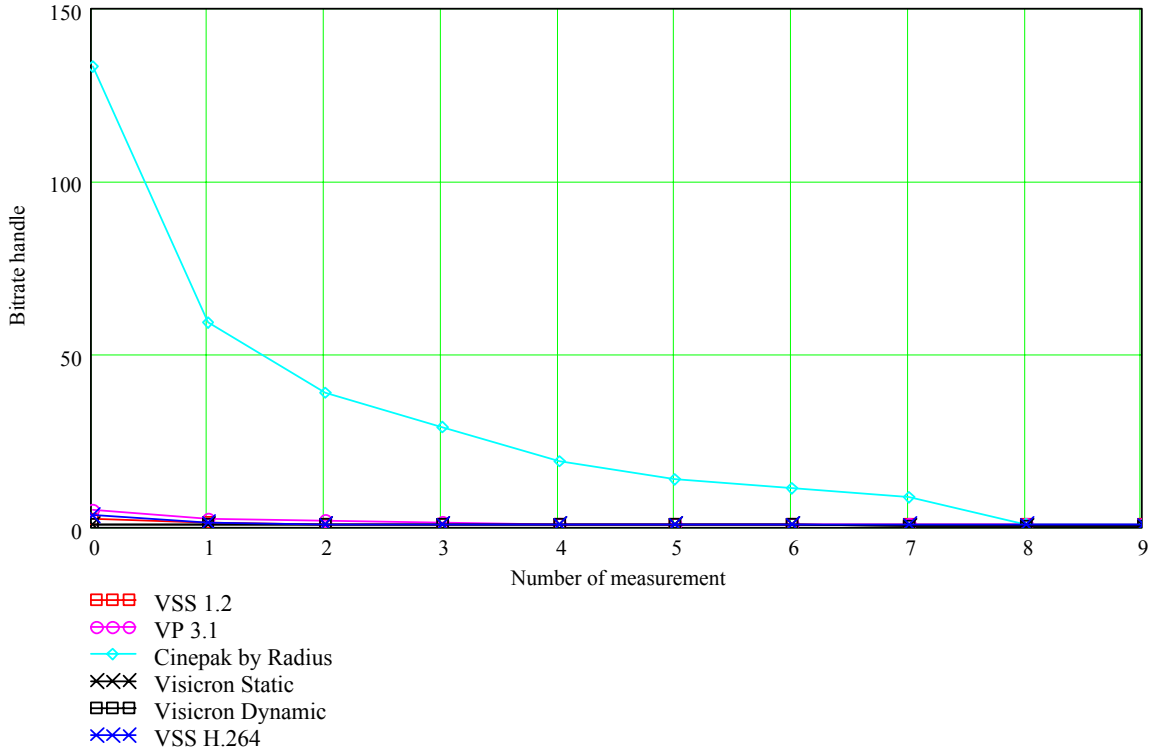


Picture 90. Sequence BUS

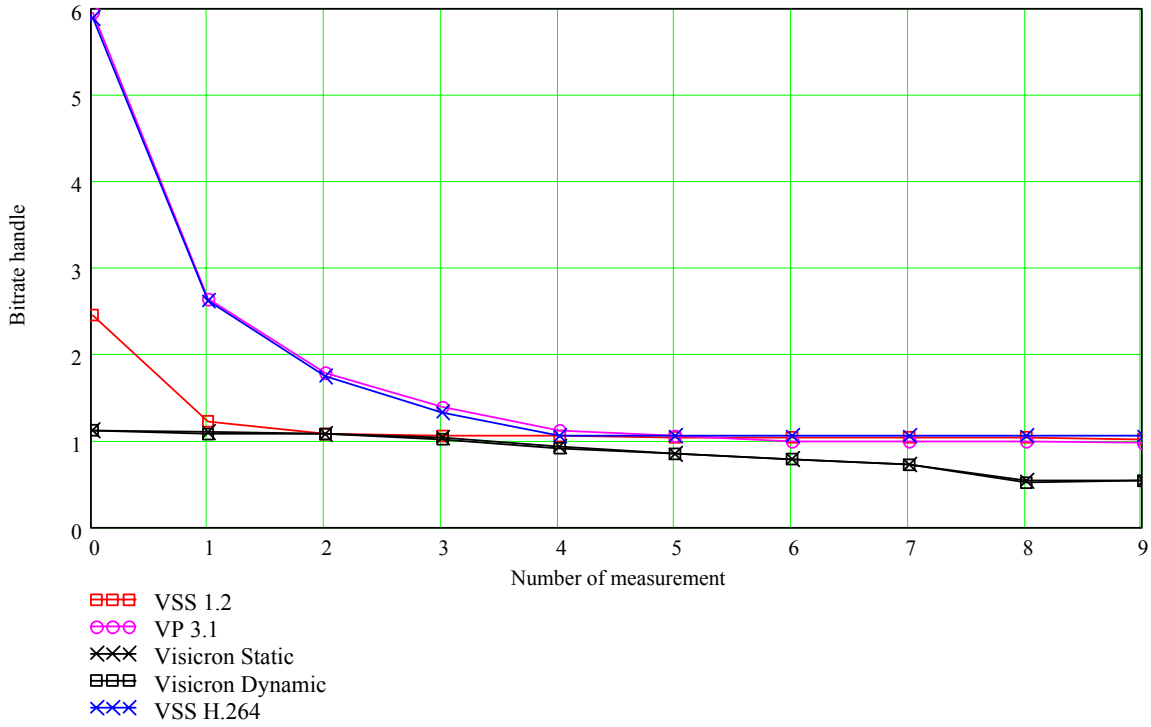
Conclusions:

- Motion Wavelets does not even keep high bitrate. Battle is the only sequence where its diagram comes close to the value of 1 on the Y-axis as bitrate increases.
- VP 3.1 does not keep low bitrate. That is not surprising because this codec does not use drop frames. However on high bitrate it works not bad and mostly better than the Ligos codecs.
- Ligos 4.5 & 5.11 mostly keep low bitrate by means of drop frames but yet can double low or high bitrate on some sequences.
- Ligos 3.2 does not keep low bitrate and works in the same way on high bitrate as its versions 4.5 and 5.11.

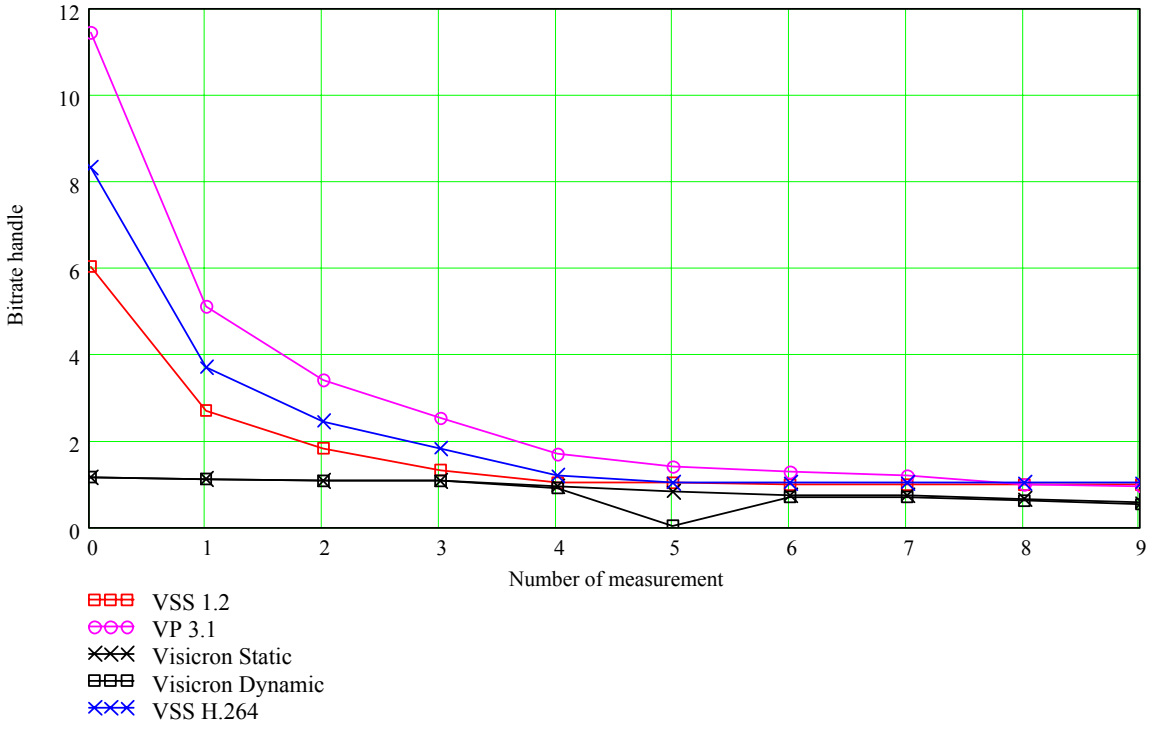
VSS H.264, VSS 1.2, Intel I.263, VP 3.1, Cinepak by Radius, Visicron Static & Dynamic



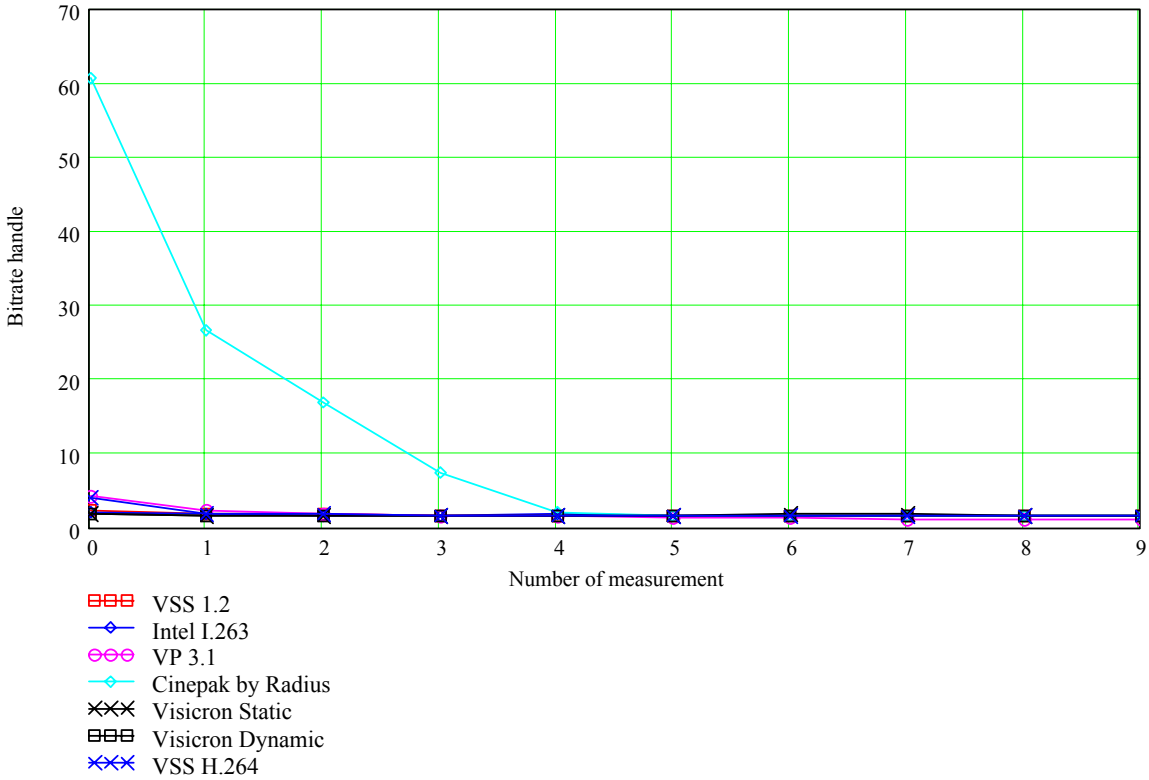
Picture 91. Sequence BANKOMATDdi



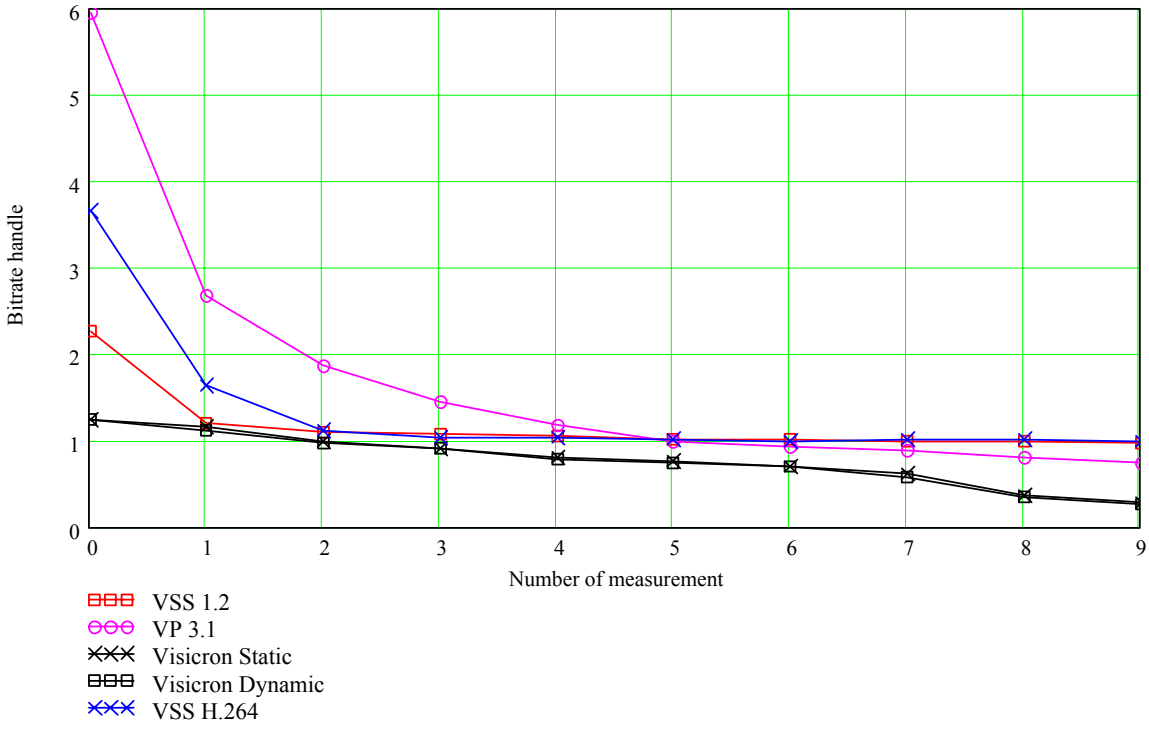
Picture 92. Sequence BATTLE



Picture 93. Sequence BBC3di



Picture 94. Sequence BUS



Picture 95. Sequence NDDP7di

Conclusions:

- Cinepak by Radius greatly increases the bitrate; it is more than 100 times greater on some sequences.
- VP 3.1 does not keep low bitrate. Also it does not use drop frames.
- VSS 1.2 does not keep low bitrate as well, but does not make it more than 5 times greater.
- Intel I.263 does not keep the bitrate and uses drop frames on low bitrate.
- Visicron codecs do not increase bitrate. They even lower high bitrate which is probably done for transferring video information through the network.
- H.264 keeps the bitrate worse than VSS 1.2; both codecs do not use drop frames.

Outline

Video Codecs Comparison consists of the following sections:

- Part 1: Methodology
- **Part 2: PSNR Diagrams For All Video Codecs – *this document***
- Part 3: Frame-accurate Comparison
- Part 4: Visual Comparison

NOTE: These files contain only a VERY SMALL PART of the processed and measured data.

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