



**MTS4CC
Elementary Stream Compliance Checker
Tutorials**

001-1415-01

This document applies to software version 1.0 and above.

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Getting Started

This set of seven tutorials helps you learn more about operating the Tektronix MTS4CC Elementary Stream Compliance Checker. Perform tutorials 1–7 in the order they are presented, regardless of the video standard of interest. Tutorial 6 relates only to MPEG-2 and interlaced video.

The tutorials will help you answer the following questions:

- How do you know that your video compression complies with the standards?
- If your codec doesn't work well with other vendors' codecs, where is the problem — is it with your codec or theirs?
- Codec optimization:
 - Are you making the best use of available bandwidth?
 - Which frames and movement types use the most bits and why?
 - What changes to your codec software give the best reductions in bits used for the least reduction in visual quality?
 - What types of video content does your codec work poorly with and why?

Table 1 includes a description for each tutorial.













Table 1: Tutorial descriptions

Tutorial	Name	Standard	Areas Covered
1	H.263 Compliance and Motion Vectors	H.263 Baseline	Errors and error log; motion vectors.
2	MPEG-4 Compliance	MPEG-4 Simple Profile	Common errors; searching for areas of codec optimization.
3	MP4 Compliance Basics	MP4/ Simple Profile/ L1(2)	Extract and examine container files; level conformance error.
4	MP4 Optimization	MP4/ Simple Profile/ L1(2)	Using MB type overlays and searching for areas of optimization.
5	MPEG-4 and H.264/AVC Buffer Analysis	MPEG-4 ASP and H.264/AVC	Buffer analysis in MPEG-4 and H.264/AVC; fixing problems.
6	MPEG-2 Compliance	MPEG-2 Main Profile / Main Level	Syntax errors; MPEG structure analysis; interlace.
7	Fidelity Analysis	MPEG-4, MPEG-2, and H.264	Fidelity analysis; visual difference.

Basic Functions

To complete the tutorial procedures, you must be familiar with the basic functions shown in Table 2. To perform the desired function, click on the associated icon or type the appropriate keyboard shortcut.

Table 2: Basic functions

Function	Forward		Backward	
	Icon	Keyboard shortcut	Icon	Keyboard shortcut
Play video		Ctrl + P		Ctrl + Shift + P
Stop video		Ctrl + S		Ctrl + S
Pause/step one frame		Ctrl + A		Ctrl + Shift + A
Fast forward/backward		Ctrl + F		Ctrl + Shift + F
Pause on frame				
Skip to next frame type/number/time		Ctrl + K		Ctrl + Shift + K

How to Begin a Tutorial

1. After starting MTS4CC, click anywhere to remove the splash screen. If you do nothing, the splash screen will disappear after 4 seconds.
2. Load the desired tutorial stream. Note that the demo version of the MTS4CC will only play the provided example video files.

Tutorial 1: H.263 Compliance and Motion Vectors

This tutorial covers the standards and compliance issues in H.263, and also demonstrates the proper functioning of the motion vectors.

Procedure

1. To load the H.263 tutorial, click **File > Example files > H.263 stream > Rally (250K)**. The window title changes to **MTS4CC-H.263 Example - Rally (250k)**, and a warning message appears, as shown in Figure 1.

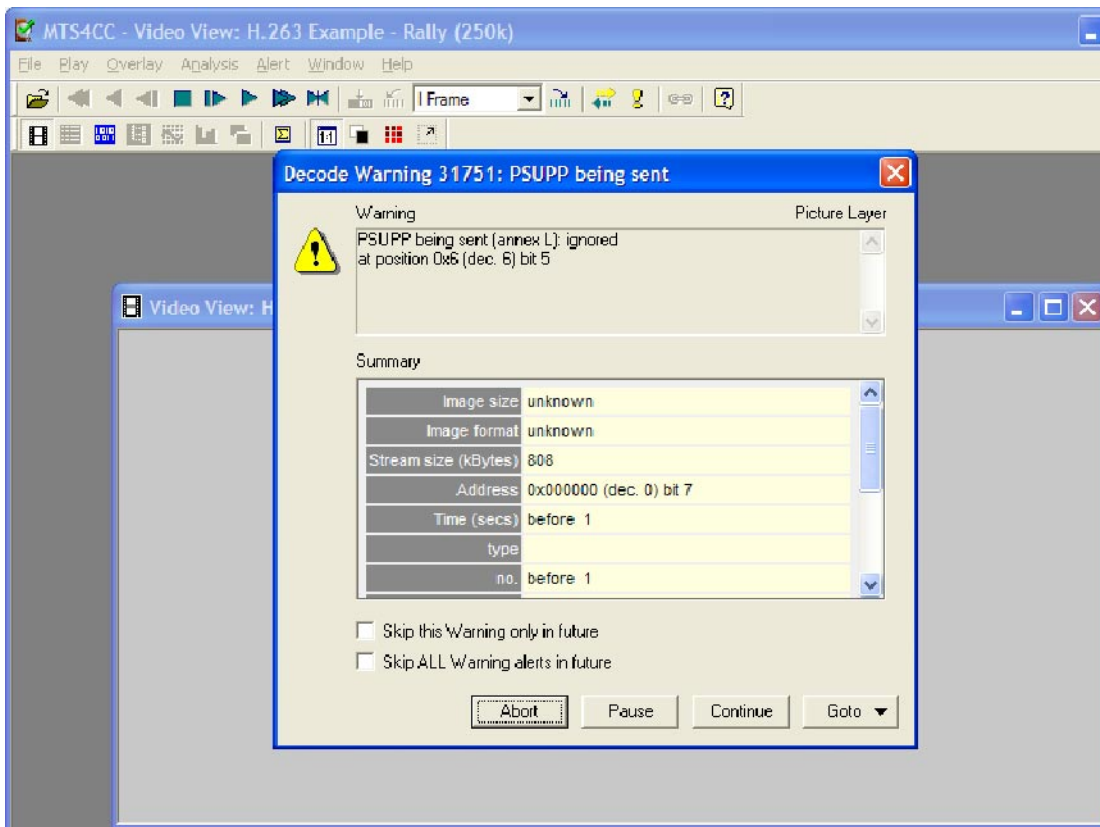



Figure 1: Initial warning message

2. View the warning message elements:
 - **Warning** - Indicates that the PSUPP field is being sent and ignored.
 - **Summary** - Gives summary information about the stream.
 - **Skip this Warning only in the future** - elects to skip this particular warning in the future (recommended).
 - **Skip ALL Warning alerts in the future** - elects to skip this alert and all other alerts in the future.
3. Select **Skip this Warning only in the future**, and then click **Continue**.
4. Click the  toolbar icon or type **CTRL + P** to resume playing the video. The error message shown in Figure 2 appears.
5. View the error information provided, which indicates a more serious error that occurs at bitstream byte address 0x0c9cfa, bit 3, after frame 326.

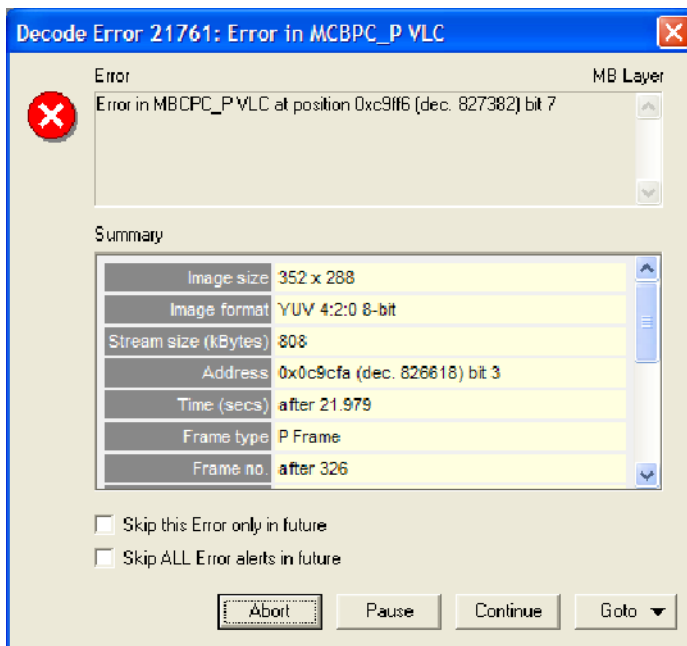


Figure 2: Initial error message

6. Click **Continue**. An error message appears, as shown in Figure 3.
7. Note that it was an MBCPC error that resulted in the Out of Sync alert message shown in Figure 3. This often occurs when one syntax error triggers a series of alerts.

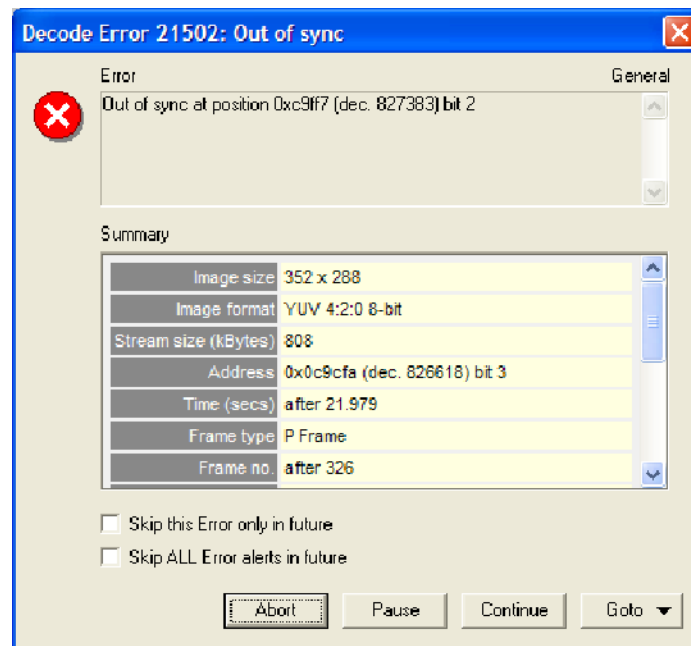



Figure 3: Out of sync error message

8. Select the **Skip ALL Error alerts in the future** check box, and then click **Continue**.
9. To open the Alert Log, click the Alert Log icon . The Alert log window appears, as shown in Figure 4.
10. Note the active filter button in the toolbar. Because **Skip ALL error alerts in the future** was selected, the alert log view is filtered and the filter button is active. The status bar indicates that 23 of 24 alerts are hidden.
11. Click the **Filter** icon to deactivate the filter and view all alerts, as shown in Figure 5.

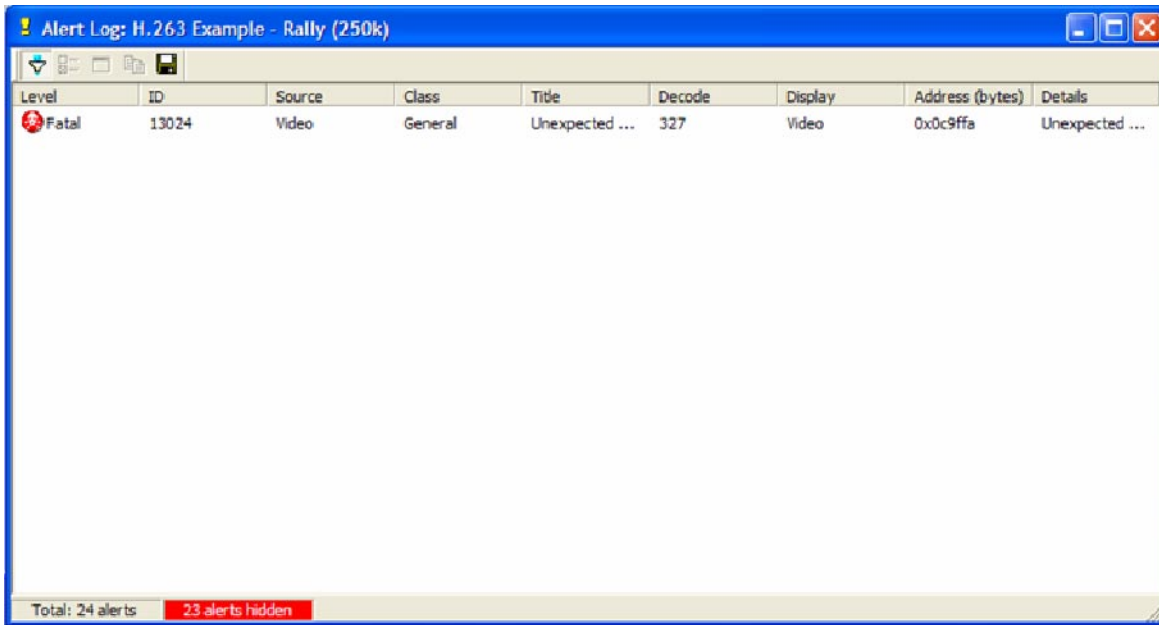


Figure 4: Alert Log window, filtered

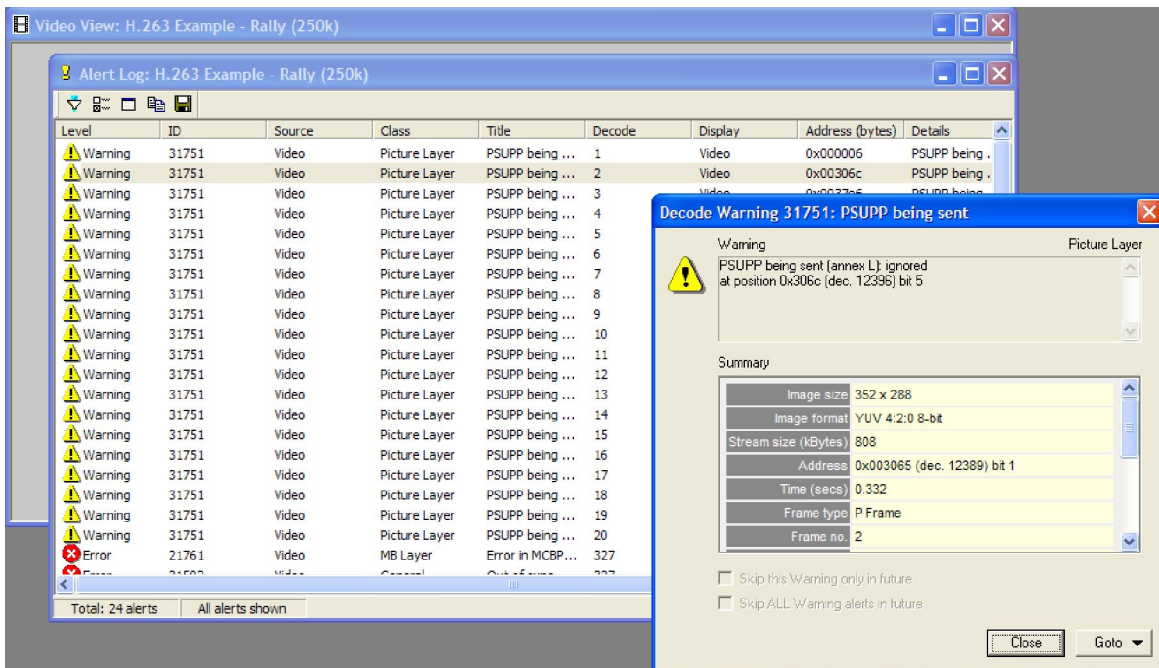


Figure 5: Alert Log and Alert Details

12. Double-click an alert to view the alert details, as shown in Figure 5, and then click **Close**. View the columns that appear in the alert log, which are shown in Figure 6, and note the column descriptions that follow.

- **Level** - the severity level for the alert. Levels include **Info**, **Warning**, **Error**, and **Fatal**.
- **ID** - MTS4CC unique alert ID number.
- **Class** - Syntax area where the alert occurs.
- **Title** - Alert title.
- **Decode and Display** - Frame numbers where the alert is decoded and displayed (can vary).
- **Address** - The address of the alert in the bitstream.
- **Details** - Alert details.
















Level	ID	Source	Class	Title	Decode	Display	Address (bytes)	Details
 Warning	31751	Video	Picture Layer	PSUPP being ...	1	Video	0x000006	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	2	Video	0x00306c	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	3	Video	0x0037e6	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	4	Video	0x004074	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	5	Video	0x004718	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	6	Video	0x005024	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	7	Video	0x005713	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	8	Video	0x005d62	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	9	Video	0x0063a8	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	10	Video	0x0068d3	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	11	Video	0x006d97	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	12	Video	0x0072c3	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	13	Video	0x007831	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	14	Video	0x007d3d	PSUPP being ...
 Warning	31751	Video	Picture Layer	PSUPP being ...	15	Video	0x0081e9	PSUPP being ...

Figure 6: Alert Log, unfiltered




13. Close the **Alert log** and return to the main page of the application.
14. Click the  icon to play the video again with the Motion Vectors (MVs) visible. An image of the video is shown in Figure 7.
15. Note the following about the image:
 - The white dots are at the center of each MacroBlock.
 - The white lines indicate motion vectors. The arrows for each MV point to the position in the previous frame that contains the data for the current MacroBlock.
16. Click the color transfer icon  to change the overlay from white to black.
17. To play the video again, click the  icon or type **CTRL + A**. Note that the motion vectors are clear and accurate.



Figure 7: Video image

Conclusion


This tutorial demonstrated where there is a standards-compliance issue in the H.263 bitstream, but also showed that other aspects of the H.263 bitstream, such as the motion vectors, are implemented properly.

Tutorial 2: MPEG-4 Compliance

This tutorial covers the following:

- Basic functions
- Alerts for syntax errors
- Video summary tooltip
- MacroBlock overlay MB types
- Optimization
- Frequency of intra-coding

Procedure

1. To load the H.263 tutorial, click **File > Example files > MPEG-4 Elementary Streams > Space**. An error message appears, as shown in Figure 8.
2. View the error details:
 - The error occurs at bitstream byte address 0x11, bit 3, before VOP 1.
 - The error is present in the header, and MTS4CC does an initial check of the file header when it loads the file.
 - The error indicates that method 1 quantization is in use, which is not allowed because the stream is Simple Profile.
3. Click **Continue**. MTS4CC loads the stream, and the window title changes to **MTS4CC-MPEG4 Example-Space**.
4. Click the  icon or type **CTRL + P** to resume playing the stream. The error message shown in Figure 8 appears again.
5. Click **Continue**. A warning message appears, as shown in Figure 9.

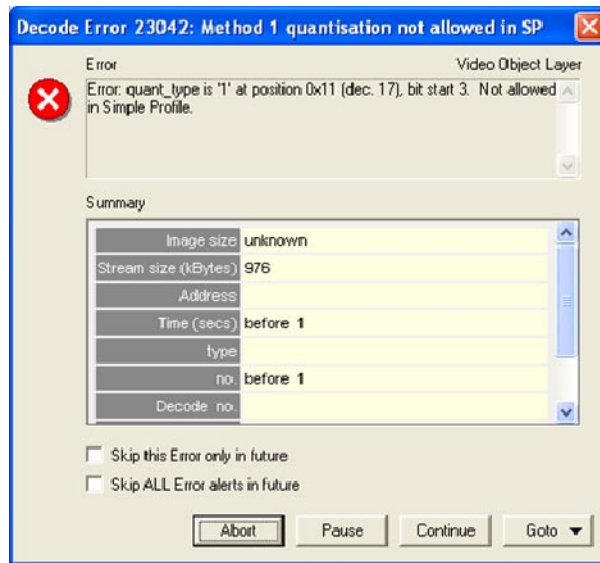


Figure 8: Initial error message

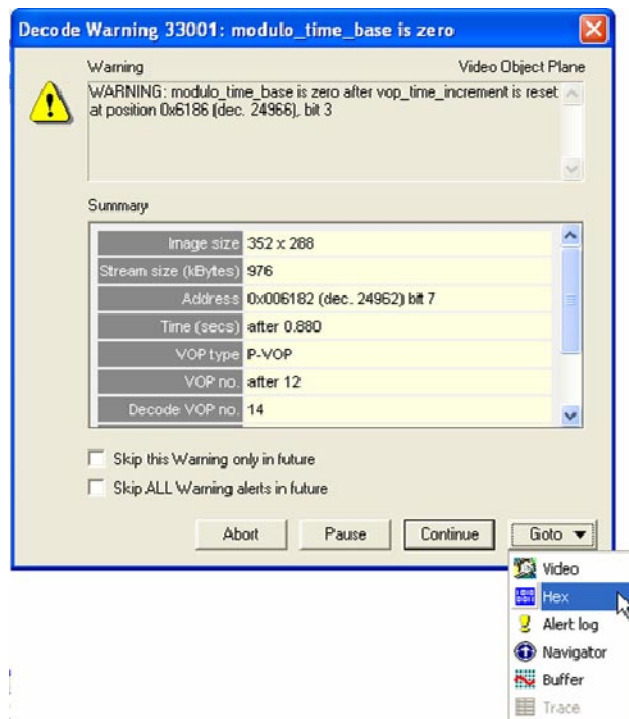

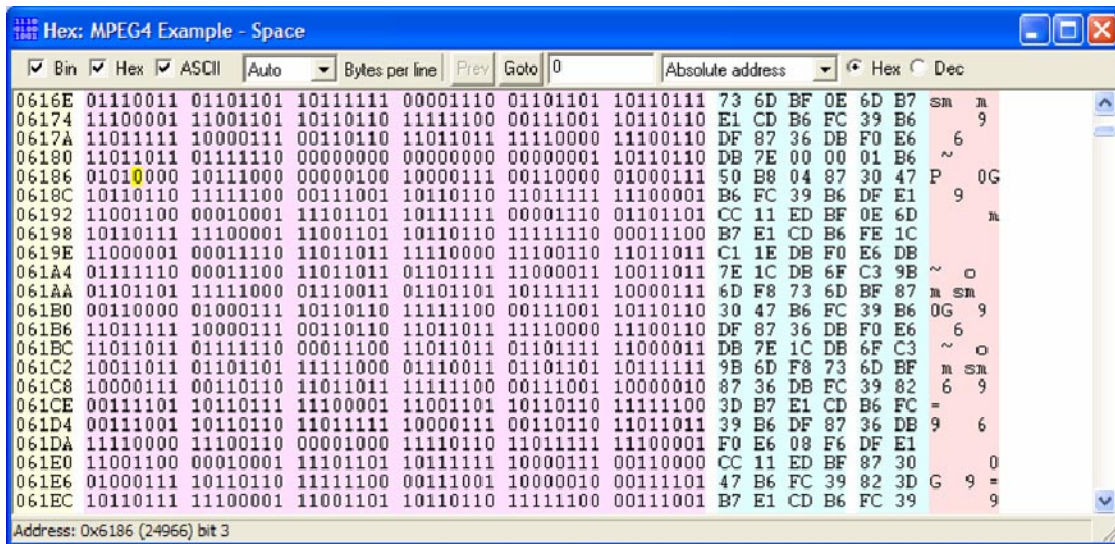


Figure 9: Initial warning message

6. Click **Goto**, and then click **Hex**, as shown in Figure 9. The Hex view appears with the error location highlighted, as shown in Figure 10.
7. Close the Hex view, and again view the error shown in Figure 9. The error occurs because `modulo_time_base` was set to 1 after a whole second elapsed since the `modulo_time_base` was last 1 (at which time `vop_time_increment` should be reset, although not necessarily to zero).
8. Click the  icon or type **CTRL + P** to resume playing the stream. The alert shown in Figure 9 appears again.
9. In the alert dialog box, select **Skip this Warning only in the future**, and then click **Continue**.
10. Complete the video and observe whether it works properly.



```

Hex: MPEG4 Example - Space
Bin Hex ASCII Auto Bytes per line Prev Goto 0 Absolute address Hex Dec
0616E 01110011 01101101 10111111 00001110 01101101 10110111 73 6D BF 0E 6D E7 sm n
06174 11100001 11001101 10110110 11111100 00111001 10110110 E1 CD B6 FC 39 B6 9
0617A 11011111 10000111 00110110 11011011 11110000 11100110 DF 87 36 DB F0 E6 6
06180 11011011 01111110 00000000 00000000 00000001 10110110 DB 7E 00 00 01 B6 ~
06186 01010000 10111000 00000100 10000111 00110000 01000111 50 B8 04 87 30 47 P 0G
0618C 10110110 11111100 00111001 10110110 11011111 11100001 B6 FC 39 B6 DF E1 9
06192 11001100 00010001 11101101 10111111 00001110 01101101 CC 11 ED BF 0E 6D n
06198 10110111 11100001 11001101 10110110 11111110 00011100 B7 E1 CD B6 FE 1C
0619E 11000001 00011110 11011011 11110000 11100110 11011011 C1 1E DB F0 E6 DB
061A4 01111110 00011100 11011011 01101111 11000011 10011011 7E 1C DB 6F C3 9E ~
061AA 01101101 11111000 01110011 01101101 10111111 10000111 6D F8 73 6D BF 87 n sm
061B0 00110000 01000111 10110110 11111100 00111001 10110110 30 47 B6 FC 39 B6 0G 9
061B6 11011111 10000111 00110110 11011011 11110000 11100110 DF 87 36 DB F0 E6 6
061BC 11011011 01111110 00011100 11011011 01101111 11000011 DB 7E 1C DB 6F C3 ~
061C2 10011011 01101101 11111000 01110011 01101101 10111111 9B 6D F8 73 6D BF n sm
061C8 10000111 00110110 11011011 11111100 00111001 10000010 87 36 DB FC 39 82 6 9
061CE 00111101 10110111 11100001 11001101 10110110 11111100 3D B7 E1 CD B6 FC =
061D4 00111001 10110110 11011111 10000111 00110110 11011011 39 B6 DF 87 36 DB 9 6
061DA 11110000 11100110 00001000 11110110 11011111 11100001 F0 E6 08 F6 DF E1
061E0 11001100 00010001 11101101 10111111 10000111 00110000 CC 11 ED BF 87 30 0
061E6 01000111 10110110 11111100 00111001 10000010 00111101 47 B6 FC 39 82 3D G 9 =
061EC 10110111 11100001 11001101 10110110 11111100 00111001 B7 E1 CD B6 FC 39 9
Address: 0x6186 (24966) bit 3

```

Figure 10: Hex view with error location

11. From the **Overlay** menu, click **Video summary tooltip** to enable the Video Summary tooltip.
12. View the **Final Video Summary Tooltip**, shown in Figure 11, and note these field descriptions.
 - Image size: 352 pixels high x 288 pixels wide (CIF).
 - Stream size: 976 kBytes.
 - Total frames: 175.
 - Total play time of the sequence: 13.920 seconds.
 - Total bits: 7,998,576.
 - Bandwidth required to transmit this: 574 kbits/second.
 - Frame play rate: 12.50 frames per second (Hz).
 - Clip is MPEG-4 Simple Profile with Resync markers & Method 1 quantification.
13. Observe how the sequence looks, and then close the **Final Video Summary** window.

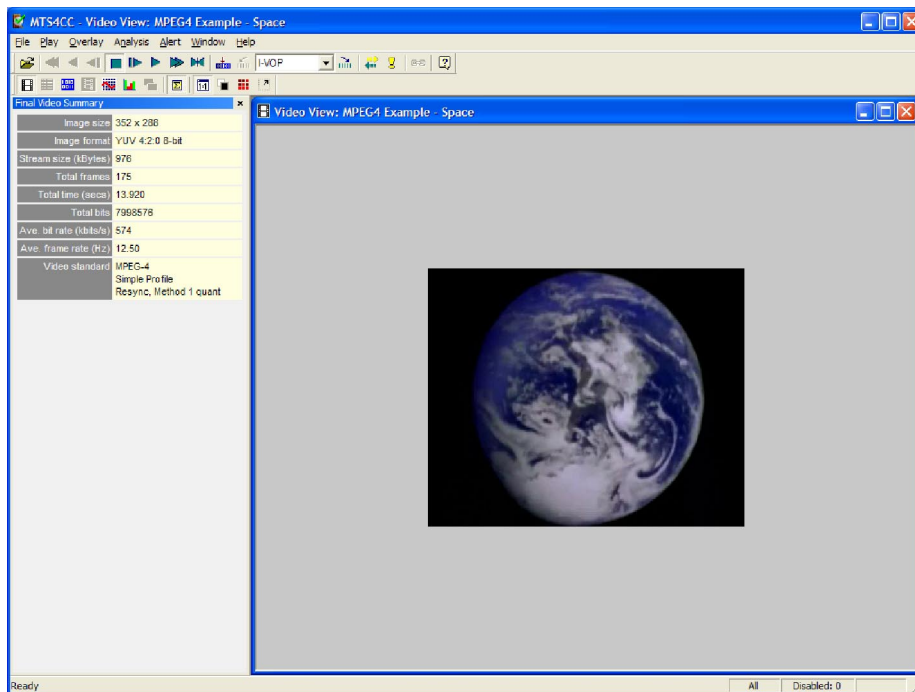


Figure 11: Final video summary tooltip

14. To see if the codec makes the best use of the MPEG-4 standard, open the **Overlay** menu, and then click **MB Types** (you can also type **CTRL+ Y**). The **MB Types key** appears.
15. Move forward 3 frames. The MB types are color-coded as shown in Figure 12.

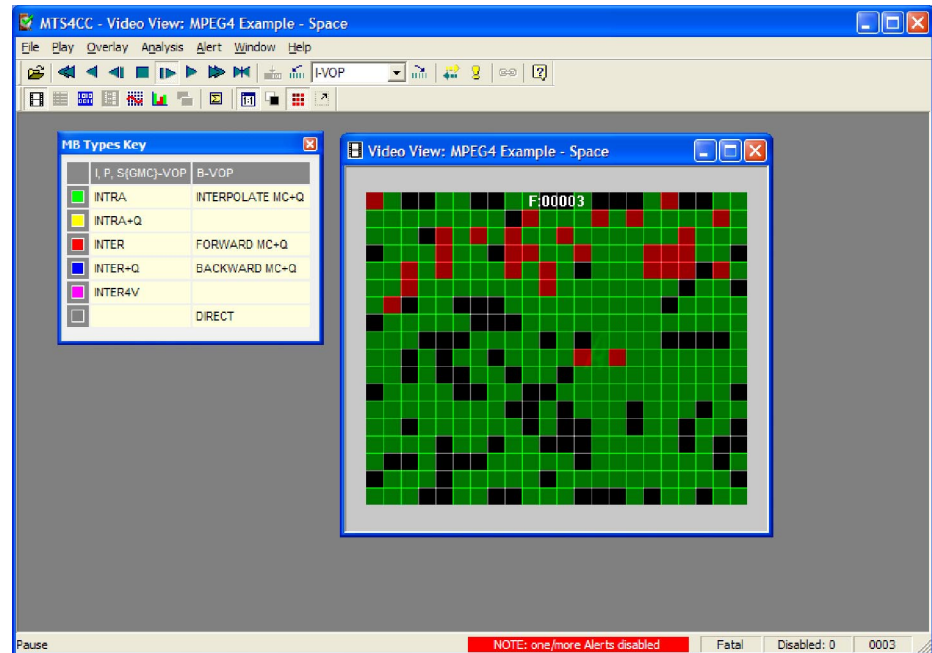


Figure 12: MB Types color key

16. Move forward to frame 34. As shown in Figure 13, note that there are several green (intra) coded MacroBlocks in the static black background (intra coded MBs generally use the most bits).
17. View frames 35, 36 and 37, as shown in Figure 14. Observe that the MacroBlocks disappear.
18. Go back to frame 34.
19. From the **Overlay** menu, click **MB Statistics**, and then click **Bits**. In Figure 15, note that the black background uses a high number of bits.
20. View frames 35, 36 and 37, as shown in Figure 16. Observe that the background uses progressively fewer bits.
21. Compare frame 34 with frame 37. Observe that the black background in frame 34 is coded and uses many bits, while the black background in frame 37 is not coded, and it uses no bits.

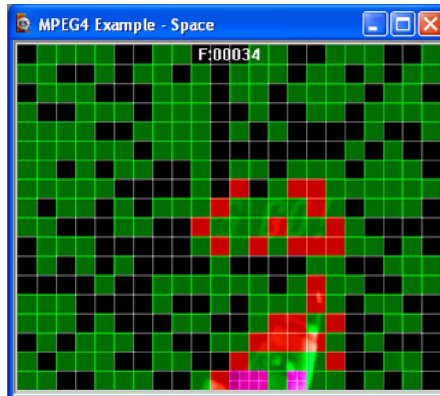


Figure 13: Frame 34, color key

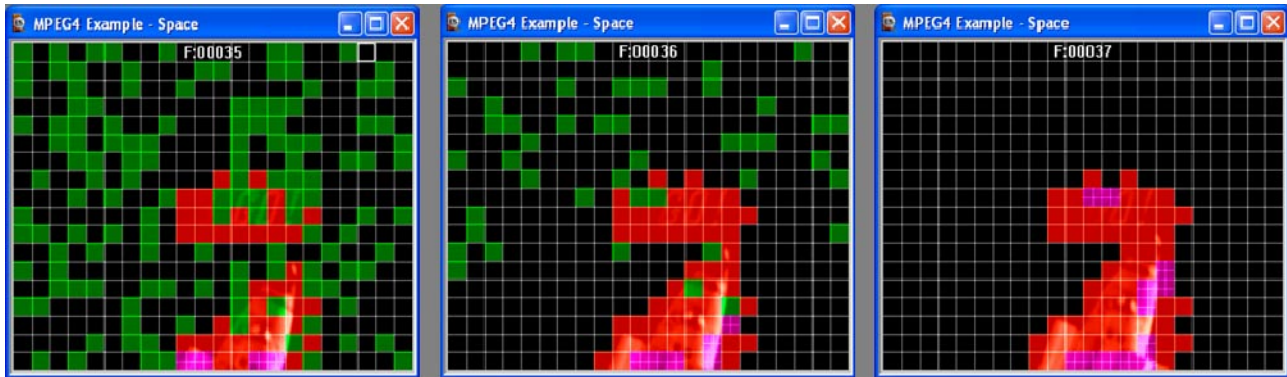


Figure 14: Frames 35, 36, and 37, color key

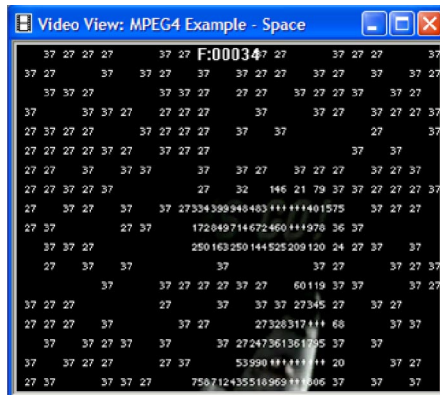


Figure 15: Frame 34

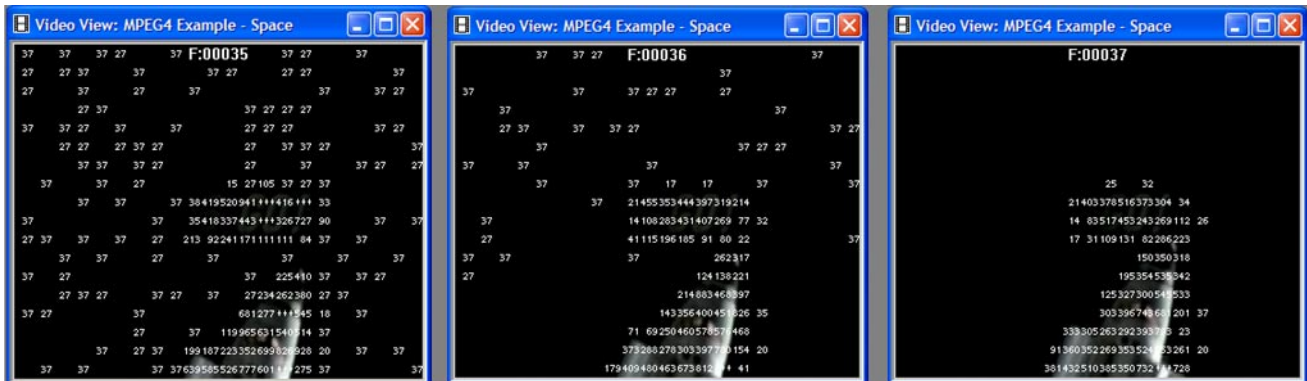


Figure 16: Frames 35, 36 and 37

Conclusions

This tutorial demonstrated how to:

- Use and interpret the alert pop-up messages.
- Use the Video summary tooltip and understand the information provided.
- Use the MacroBlock overlays: MB types and motion vectors.
- Use the hexview bitstream viewer.

Additional Information Covered

It appears that the encoder chooses MB types less than optimally by using intra MBs for the background, which wastes many bits.

- Consider whether there are software bugs, such that the encoder is too sensitive to minor changes in the gray level.
- Check the encoder part of the codec that decides when to use Intra MBs and Inter MBs, and when to not code the MB.

Fixing this problem would save many wasted data bits.

NOTE. The MPEG-4 standard provides more data bits for intensity-gray level than for color information, so it is naturally more sensitive to changes in gray level (this mimics the human visual system). However, it appears that the sensitivity to gray in this example is too great.

Tutorial 3: MP4 Compliance Basics

This tutorial covers the following:

- Opening an MP4 file and viewing the tracks.
- Syntax error: not obeying Profile/Level restrictions.
- Extracting and saving the video track.
- Viewing MP4 file structure.

This tutorial requires that you have completed the previous tutorials and that you can perform the following tasks:

- Play, stop, step forward, and fast forward a video.
- Use and interpret the alert messages.
- Use the Video summary tooltip and understand the provided information.
- Use the MacroBlock overlays: MB types and motion vectors.
- Use the hexview bitstream viewer.

Procedure

1. To load the MP4 tutorial, click **File > Example files > MP4 Files > Packet Woman**. A list of tracks included in the MP4 appears in a dialog box, as shown in Figure 17.
2. View the track information included in the dialog box. The video track **ID**, for example, is 001. Although there can be multiple tracks, the first video track is selected automatically.
3. Click **OK**. The video track is analyzed, and an error message appears, as shown in Figure 18.
4. View the error message details as shown in Figure 18:
 - The VOP has more MacroBlocks (396) than allowed in MPEG-4 / Simple Profile / Level 1: the maximum number allowed is 99.
 - This is likely an error with the level. It is stated as Level 1 in the encoded file, but it is actually the size of a Level 2.

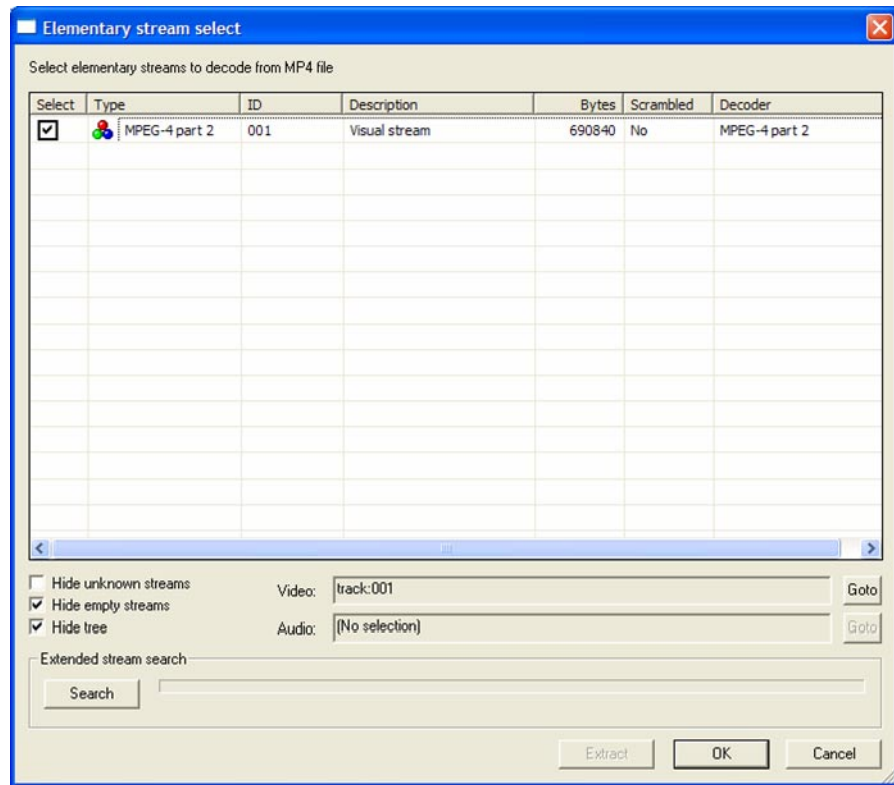


Figure 17: Track list

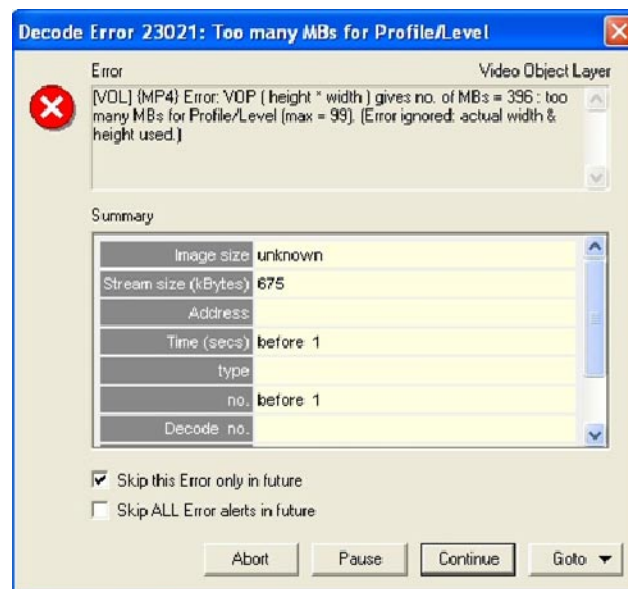


Figure 18: Initial error message

5. Select **Skip this Error only in the future**, and then click **Continue**. MTS4CC will continue, by using the actual size. A buffer conformance warning message appears, as shown in Figure 19.
6. View the warning message details as shown in Figure 19:
 - Overflow by 297 MB.
 - This error is to be expected, because the Level is incorrectly given as L1 (which has a limit of 99 MBs) whereas it should be L2 (which has a limit of 396 MBs).

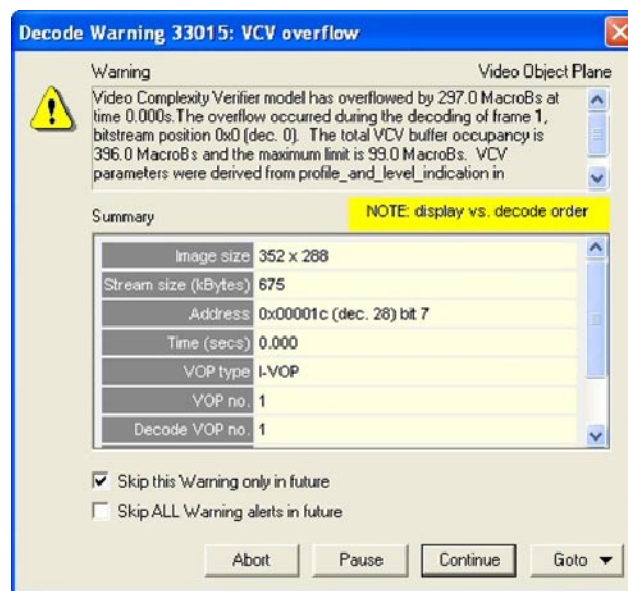


Figure 19: VCV overflow warning message

7. Select **Skip this Warning only in the future**, and then click **Continue**. Another buffer conformance warning message appears, as shown in Figure 20.
8. Select **Skip this Warning only in the future**, and then click **Continue**.
9. To ensure that the application window is active, click the Title bar.
10. From the analysis menu, select **View video stream structure**. The **Structure** window appears, as shown in Figure 21.
11. View the top-level atoms in the MP4 file. Click the + next to each atom to view the data for the atom.

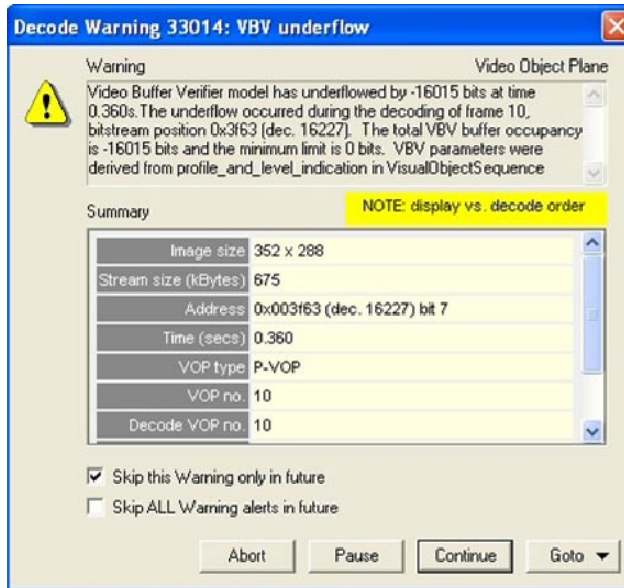


Figure 20: VBV underflow warning

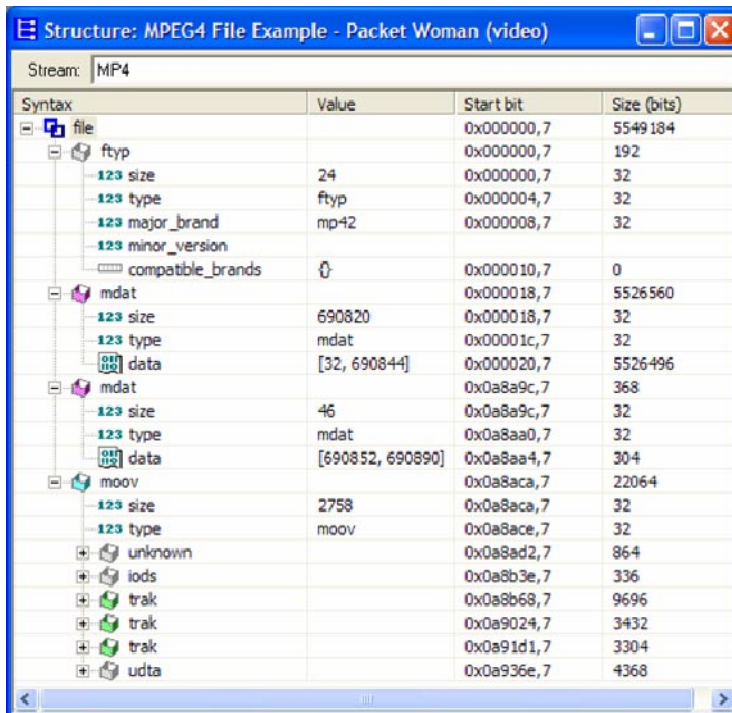


Figure 21: Structure window

12. From the **File** menu, click **Close stream**, and then reopen the stream.
13. When the track list appears, click **Extract**, as shown in Figure 22. The **Save stream file as** dialog box appears, as shown in Figure 23.

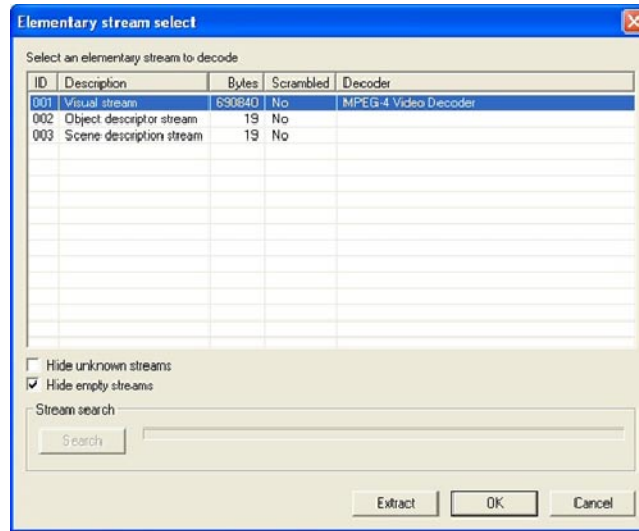


Figure 22: Track list

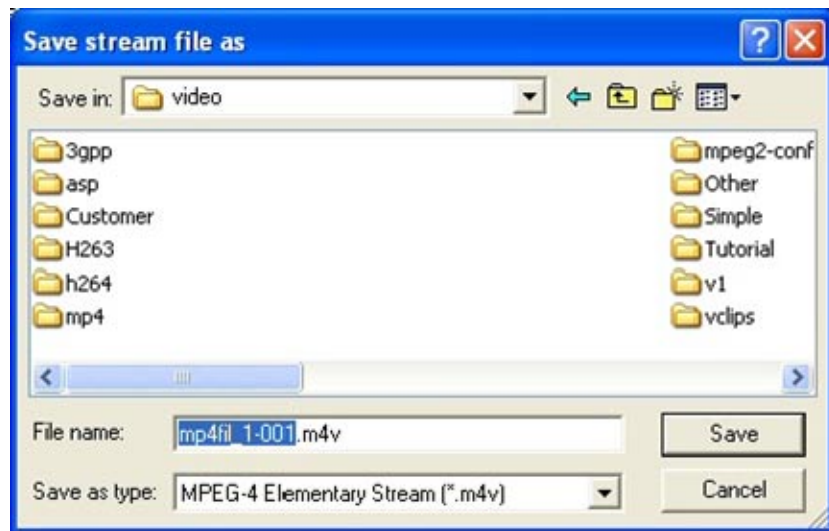


Figure 23: Save stream file as dialog box

- 14.** In the **Save stream file as** dialog box, type a different file name if required. The track ID and video file type has been automatically appended to the file name.

NOTE. *To open this dialog box in the future for a video track that was not extracted at the time the MP4 file was first opened, open the **File** menu and then click **Save stream file as**.*

Conclusion

This tutorial demonstrated how to:

- View the tracks in an MP4 file.
- Extract and play a video, while checking for errors.
- Identify and locate the Level conformance error.
- Identify two buffer conformance errors (see Tutorial 5 for details about buffer analysis).

Tutorial 4: MP4 Optimization




This tutorial covers the following:

- Opening an MP4 file and viewing the video track.
- Using the Video summary tooltip and the MB types overlay.
- Performing optimization checks that could reduce bit usage by 45% in this sequence.

This tutorial requires that you have completed the previous tutorials, and that you know how to:

- Play, stop, step forward, and fast forward the video.
- Use and interpret the pop-up alerts.
- Use the Video summary tooltip and understand the information provided.
- Use the MacroBlock overlays: MB types and motion vectors.
- Use the hexview bitstream viewer.
- Open MP4 files, view/extract the video, and view the MP4 file structure.

Procedure

1. To load the MP4 tutorial, click **File > Example files > MP4 Files > Picadilly Circus**. A list of tracks included in the MP4 appears in a dialog box, as shown in Figure 24.
2. View the track information included in the dialog box. The video track **ID**, for example, is 001. Although there can be multiple tracks, the first video track is selected automatically.
3. Click **OK**.
4. To view the Video Summary tooltip, click the  icon or type **CTRL + U**.
5. To view the MB types overlay, click the  icon or type **CTRL + M**.
6. Click the  icon. A VCV buffer conformance warning message appears, as shown in Figure 25.

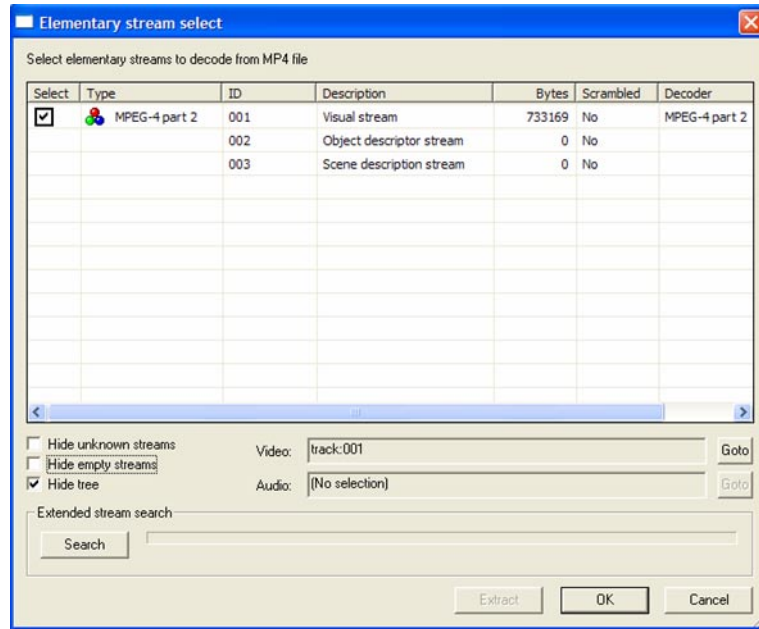


Figure 24: Track list

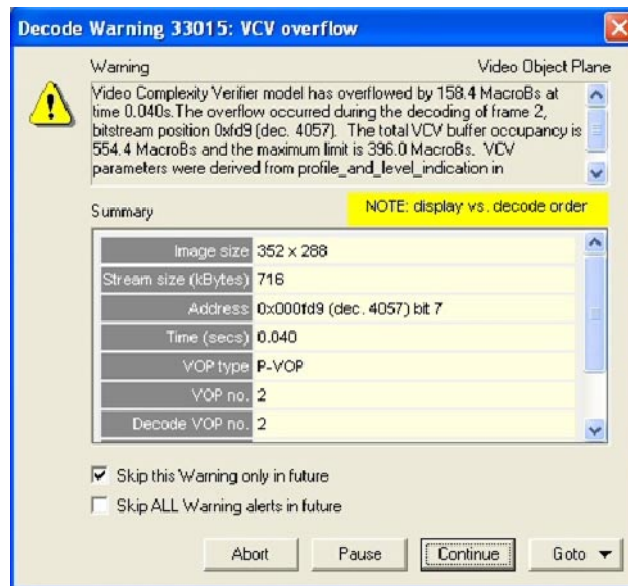


Figure 25: VCV buffer conformance warning message

7. Select **Skip this Warning only in the future**, and then click **Continue**.
8. View the progression of frames, and note that the first frame is green, as is every third frame (Intra MBs), as shown in Figure 26. Another buffer conformance warning message appears, as shown in Figure 27.

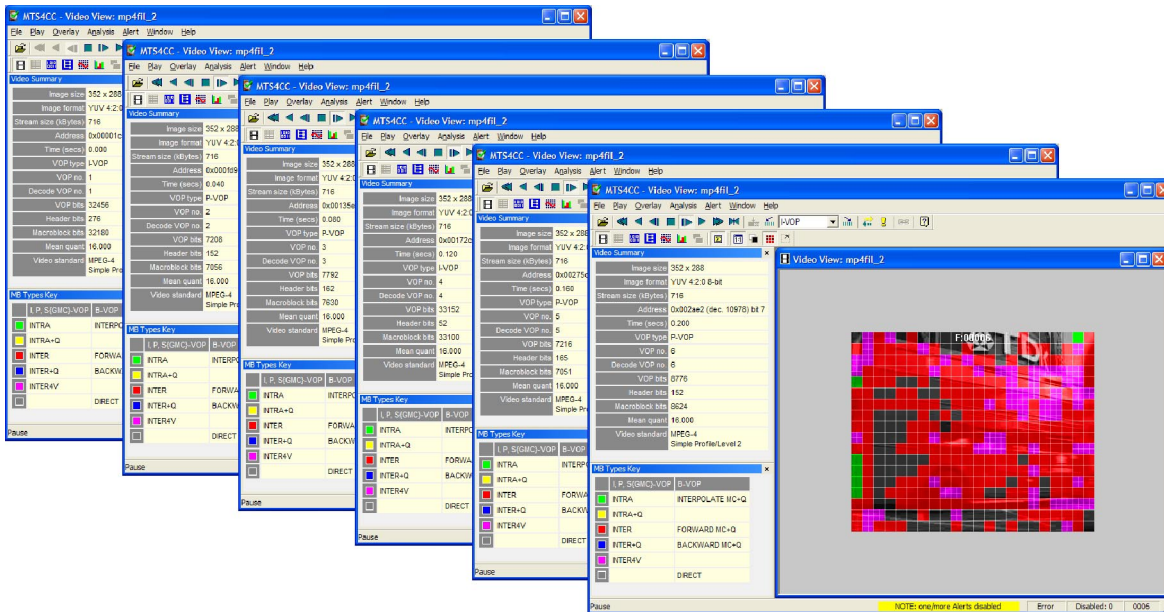


Figure 26: Progression of frames

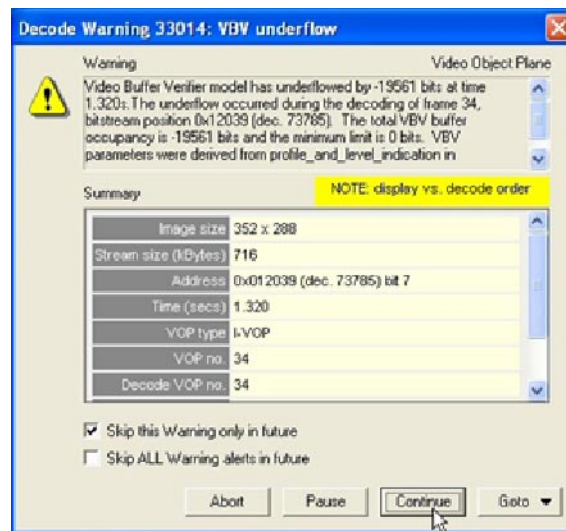


Figure 27: VBV underflow warning

9. Select **Skip this Warning only in the future**, and then click **Continue**.
10. To replay the video file, click **Pause, step forward**. Note that the first frame takes 32,456 bits, as shown in Figure 28.

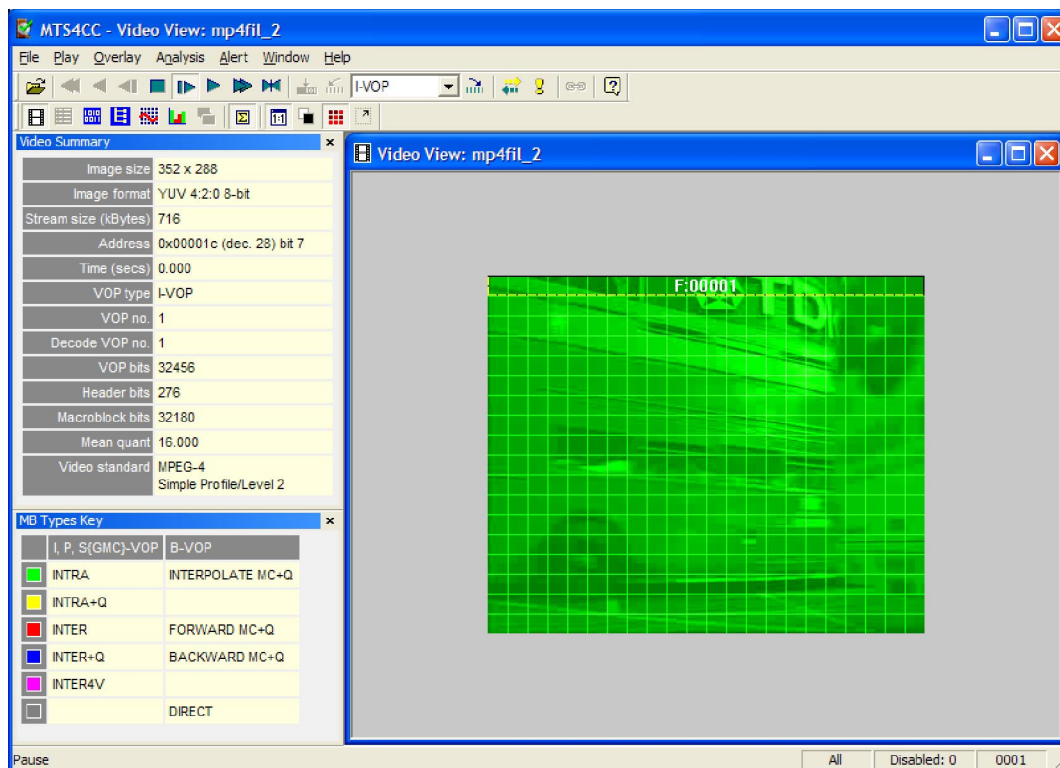



Figure 28: Frame 1

11. Click the red close button to remove the **MB Types Key** window.
12. Click the  icon twice to reopen the **MB Types Key** window.
13. To undock the **MB Types Key** window, hold the **CTRL** key, while dragging it with the mouse pointer.
14. View the next six frames, including Frame 2, which is shown in Figure 29.
15. For each frame, view the details, which are outlined in Table 3.

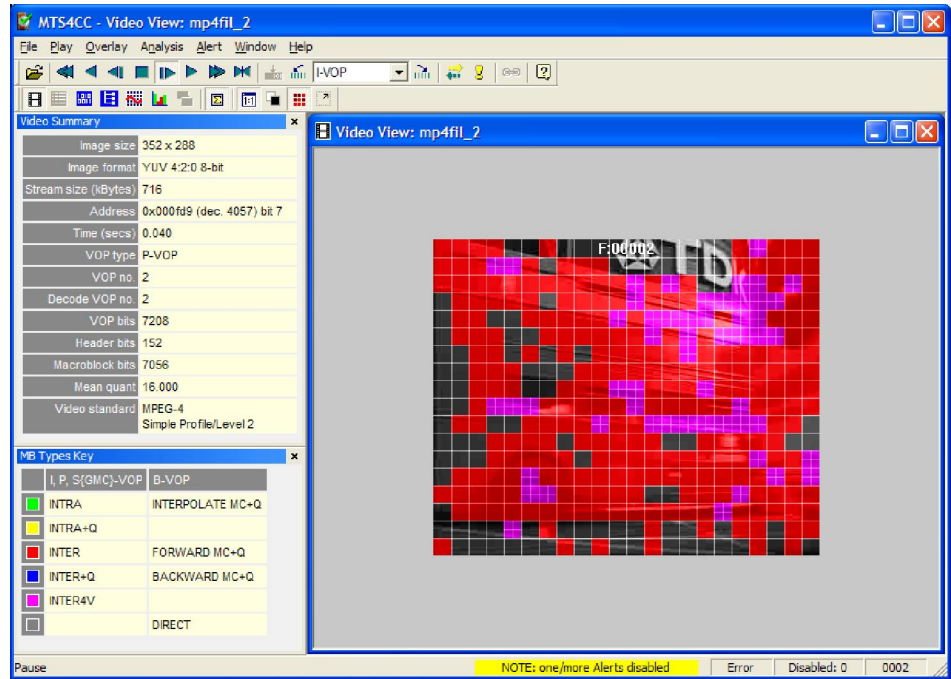


Figure 29: Frame 2

Table 3: Frame details

Frame	Frame type	Bits used
2	P-VOP	7,208
3	P-VOP	7,792
4	I-VOP	33,152
5	P-VOP	7,216
6	P-VOP	8,776
7	I-VOP	34,344

Conclusion

This tutorial demonstrated the following:

- The I-VOPs require about 4.5 times as many bits as the P-VOPs.
- There are I-VOPs every 3rd frame.
- There is no need to have I-VOPs so often. If the frequency of I-VOPs were reduced to 1 in 30, the bits used for the sequence would reduce by ~45%.
- You can reduce the number of bits used.

Tutorial 5: MPEG-4 and H.264/AVC Buffer Analysis

This tutorial covers the following:

- Buffer analysis in real-time (VBV, VCV, VMV of MPEG-4 ES).
 - Information provided - values, overflow/underflow indications.
 - Icon controls for navigation through the graphs.
- Buffer conformance errors/alerts.
 - Graphs.
 - Error dialog boxes.
- Achieving conformance.
 - Altering the buffer parameters and seeing the effect in the graph.
 - Adjusting values to prevent overflow.
- HRD buffer analysis in H.264/AVC.









This tutorial requires that you have completed the previous tutorials, and that you know how to:

- Play, stop, step forward, and fast forward a video.
- Use and interpret the alert messages.

This tutorial also requires that you already understand the principles of buffer analysis/conformance (VBV, VCV, VMV) in MPEG-4 and H.264/AVC (HRD).

Table 4 provides the functions of each Buffer Analysis toolbar icon.

Table 4: Buffer analysis icons

Icon	Function
	Zoom in (+) and zoom out (-) centered on the window; affected by the Lock X / Y icons.
	Fit all data into window.
	Go to origin (zero), which is the start of the video sequence.
	Lock X/Y zoom in/out and scrolling/panning. When the Lock Y button is pressed, zoom in and zoom out and scroll/pan only affect the X-direction. This allows you to keep a useful vertical scale, while still viewing the length of the video sequence.
	Autoscroll; fill the analysis data in real time as the video is being decoded and scroll the window to the right.
	Measure the data at the cursor. The data values are reported on the status line at the bottom of the analysis window. Offsets and angles/slopes of lines can also be measured by holding the mouse and dragging.
	Scroll/pan (the cursor changes to show the scroll/pan direction); this is affected by the Lock X-Y icons.
	Zoom in/zoom out centered on the location of this cursor; this is affected by the Lock X-Y icons. Press the <shift> key to zoom out.

Procedure

1. To load the tutorial, click **File > Example files > MPEG-4 Elementary Streams > Man Walking**. Ensure that the video is not playing.
2. From the **Analysis** menu, click **View buffer analysis**. The **Buffer Analysis** window appears, as shown in Figure 30.
3. View the graph example in Figure 30, as well as the descriptions in Table 5.

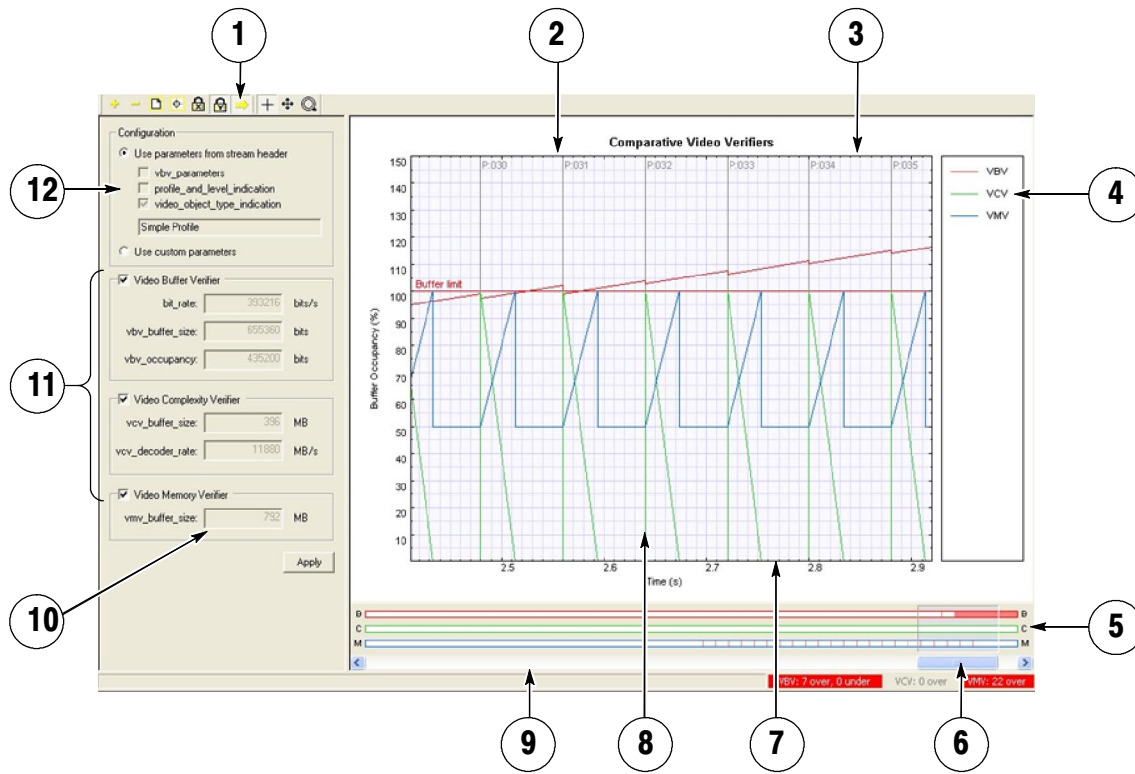


Figure 30: Buffer analysis window, example graph

Table 5: Buffer analysis descriptions

Area	Description
1	Graph window control toolbar.
2	Frame type, number.
3	Graph window.
4	List of analyses for VBW, VCV, and VMV.
5	Location of overflows and underflows in stream.
6	Scroll bar for sequence.
7	Time through sequence.
8	Vertical blue line at time=0; vertical gray lines at each VOP decode time.
9	Status lines.
10	Custom values.
11	Switch on/off VBW, VCV, VMV graphs
12	Source of buffer analysis values

4. Observe the VBV, VCV and VMV values that appear beside the graph and are shown in Figure 31. These parameters are specified in the stream, or from the implied values from the Profile/Level, as given in the standard, or the implied values from the Object Type (Simple or Advanced Simple), at the highest level for each. You can enter them manually by selecting **Use custom parameters**.

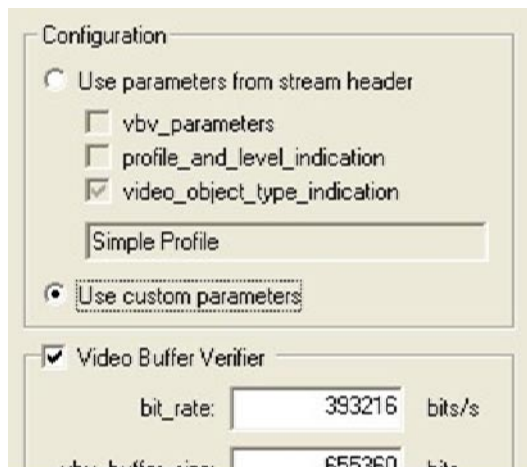






Figure 31: VBV, VCV and VMV values

5. Click the **Pause/ Step Forward** icon  three times. Nothing appears in the window because the Man Walking sequence contains B-VOPs, and the buffer analysis cannot start until there is sufficient data for the calculations (this will not occur until frame 4).
6. Click the **Pause/ Step Forward** icon  one more time. The graph appears.
7. Click the **Fit to Window** icon  for a more detailed view of the graph, as shown in Figure 32.
8. Click the **Fast forward** icon . A warning message occurs, as shown in Figure 33.
9. Note that the VBV overflow occurred while decoding frame 55 (the display frame number is 54).

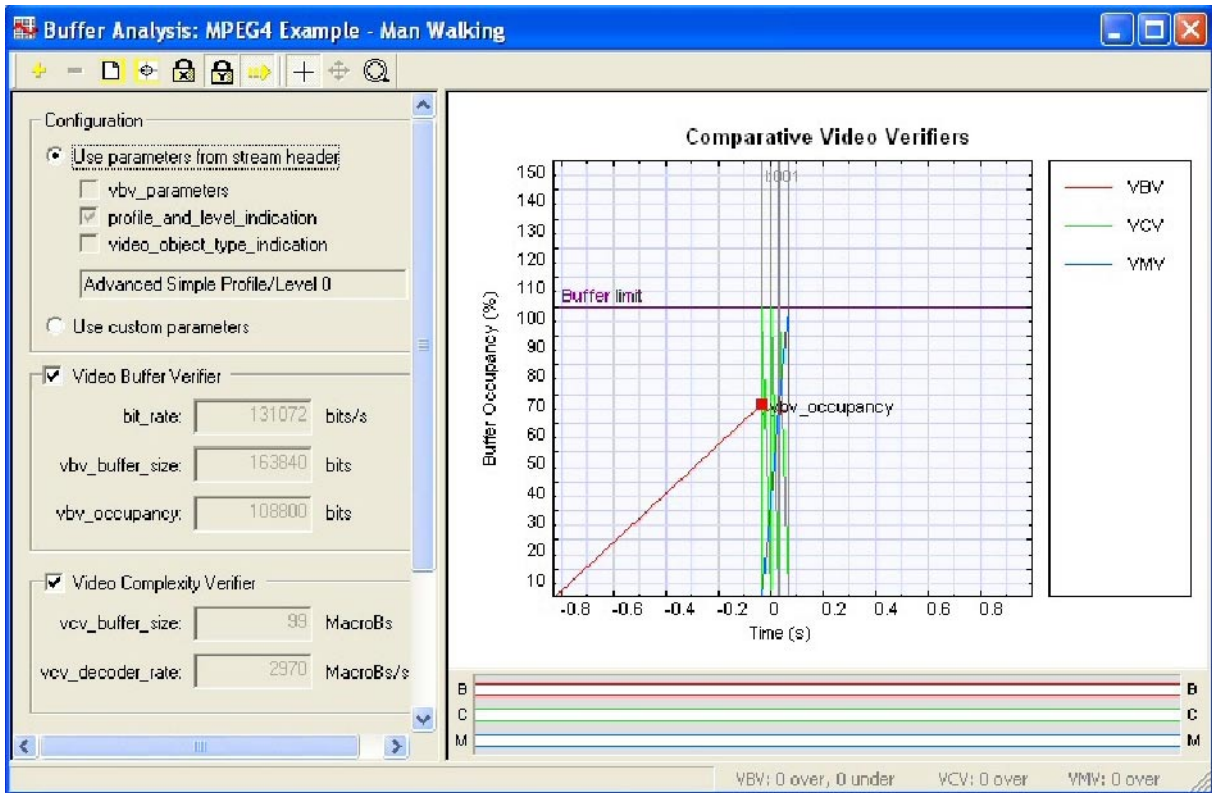


Figure 32: Buffer analysis graph, detailed view

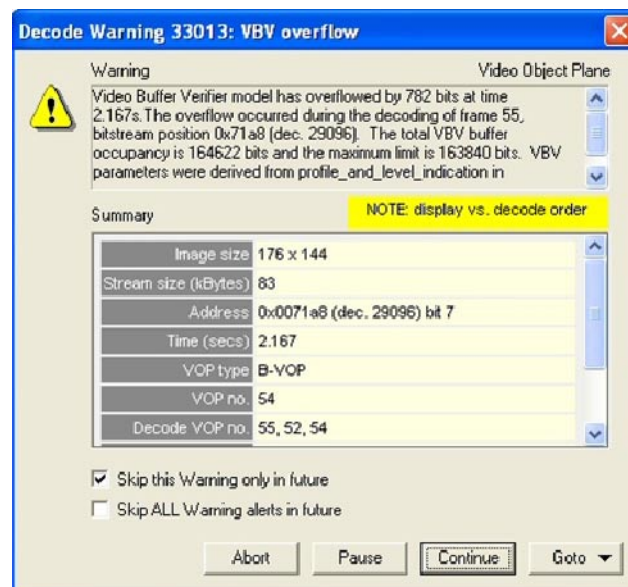


Figure 33: VBV overflow warning

10. Select **Skip this Warning only in the future**, and then click **Continue**.
11. Observe that the red VBV line goes above the **Buffer limit** line, as shown in Figure 34.
12. Observe that when the decoding stops, the graph looks like the section that appears between 75% and 105% buffer occupancy. Note also that the number of frames with VBV overflow appears at the bottom of the screen. In this case, the number of frames with VBV overflow is 106.

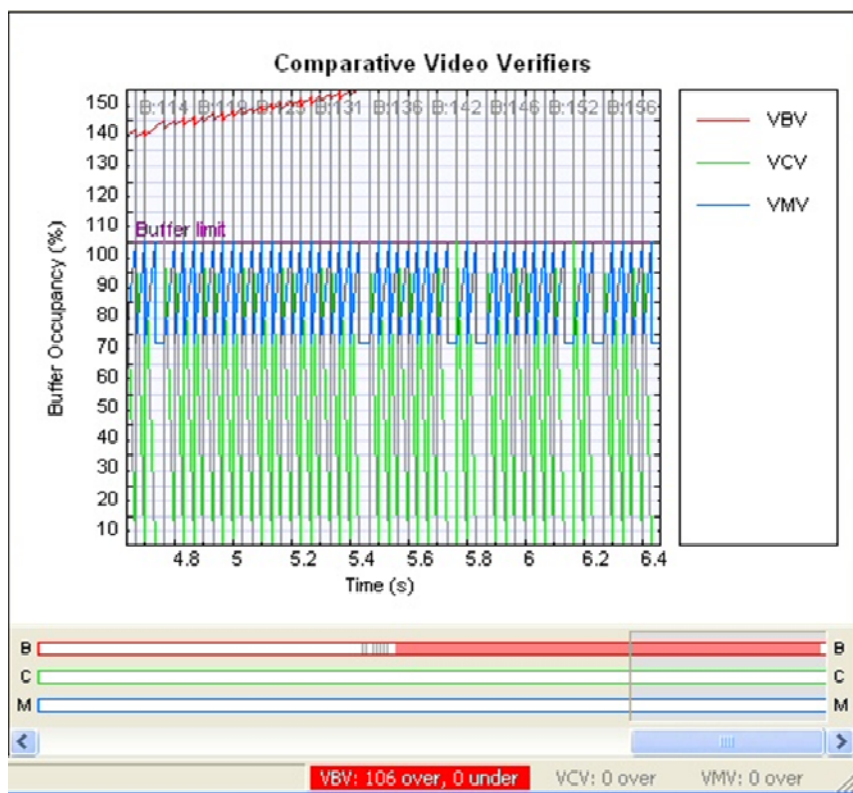



Figure 34: Buffer limit graph

13. To fit the graph to the window, click the  icon on the **Buffer Analysis** toolbar. The red line displays the VBV overflow, as shown in Figure 35.

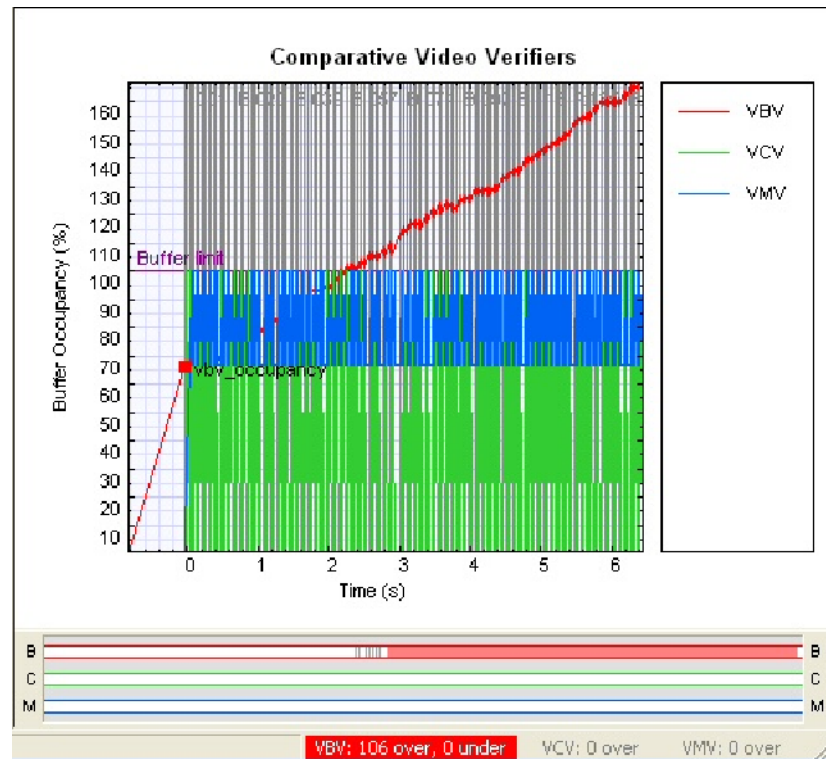




Figure 35: Comparative video verifier graph

14. Consider the information presented by the graph. The standard values used for a frame result in a VBW overflow, which means that the decoding rate cannot keep up with the input data rate, and frames will drop, beginning with frame 54.

Solutions include:

- Increase the vbw_buffer_size so that it does not overflow.
- Decrease the bit-rate, which is the rate at which the encoder sends the data to the decoder.
- Increase the displayed frame rate, so that the decoder removes bits more quickly.
- Increase the number of bits per frame by changing the quantizer or increasing the frame size.
- Change the Profile/Level indication, so that it stays within the set limits (for example, change to ASP at Level 2).
- Use custom values in the vbw_parameters in the sequence header.

15. Clear the check boxes for VCV and VMV so that only the VBV check box is selected. Note that the vertical scale is now measured in bits, not %, as shown in Figure 36.
16. Observe that the VBV line has disappeared because it is beyond the scale set for the VBV.
17. Click the  icon on the **Buffer Analysis** toolbar, and then click the  icon three times for a detailed view of the graph, as shown in Figure 37.

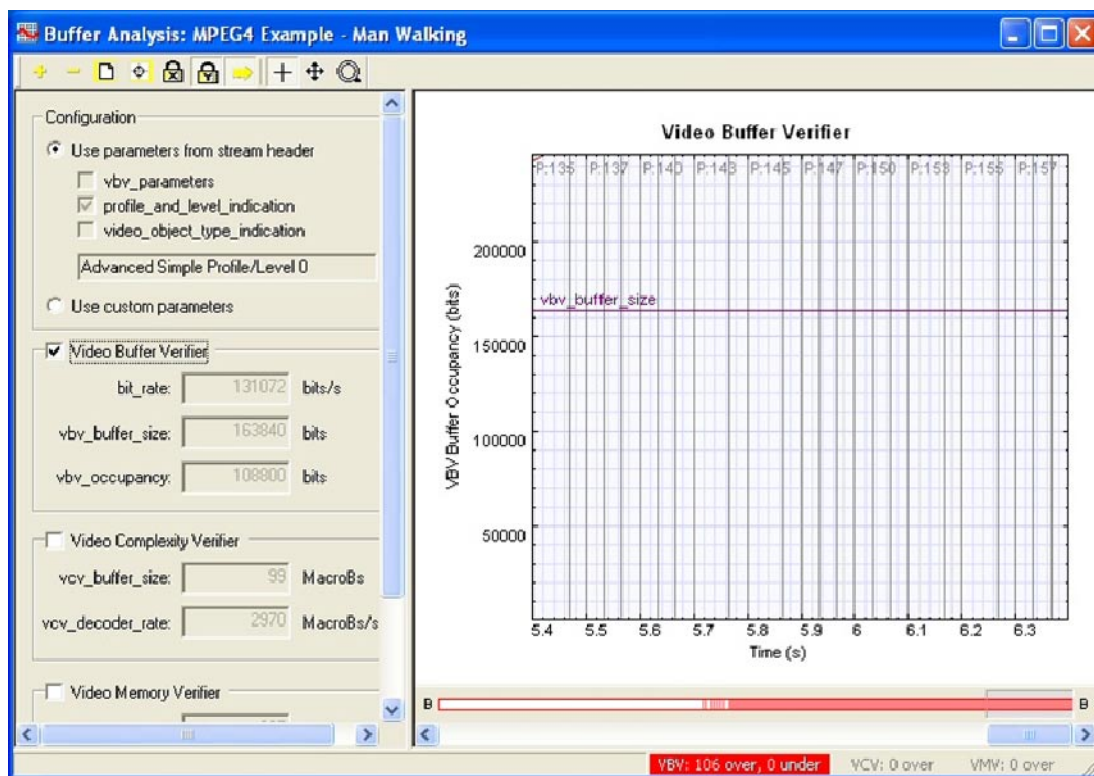


Figure 36: Frame 2

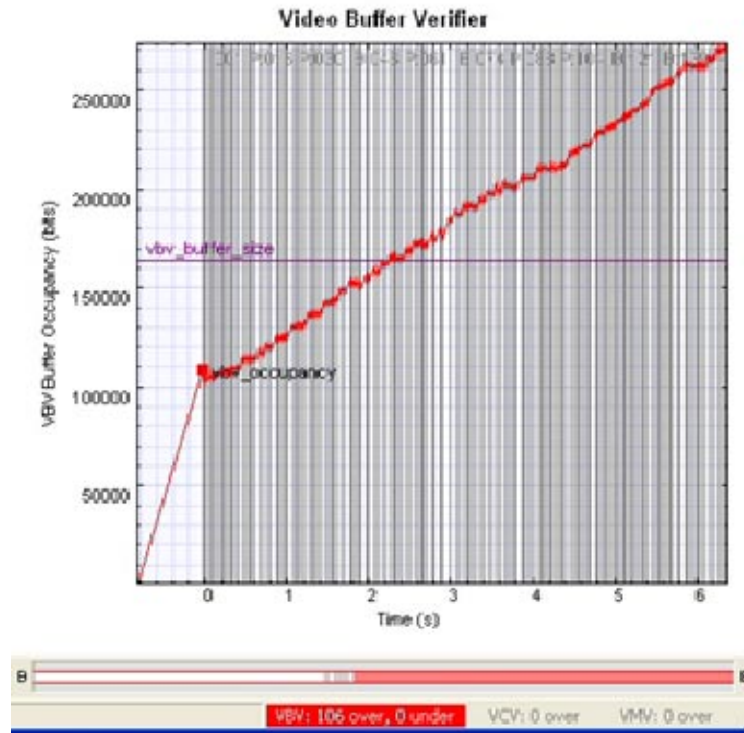



Figure 37: Graph details

18. Note the following details about the graph:

- The Y scale of the graph is locked, which keeps the graph at a useful zoom level.
- The VBV graph is higher at the end of every frame than at the start, which shows that the VBV buffer is filling faster than the decoder can empty it.

19. Click the  icon to zoom out.

20. Select the **Use custom parameters** option button, as shown in Figure 38. The word **BUF** appears in a yellow box in the main MTS4CC status bar, indicating that custom buffer parameters are in use, as shown in Figure 39.

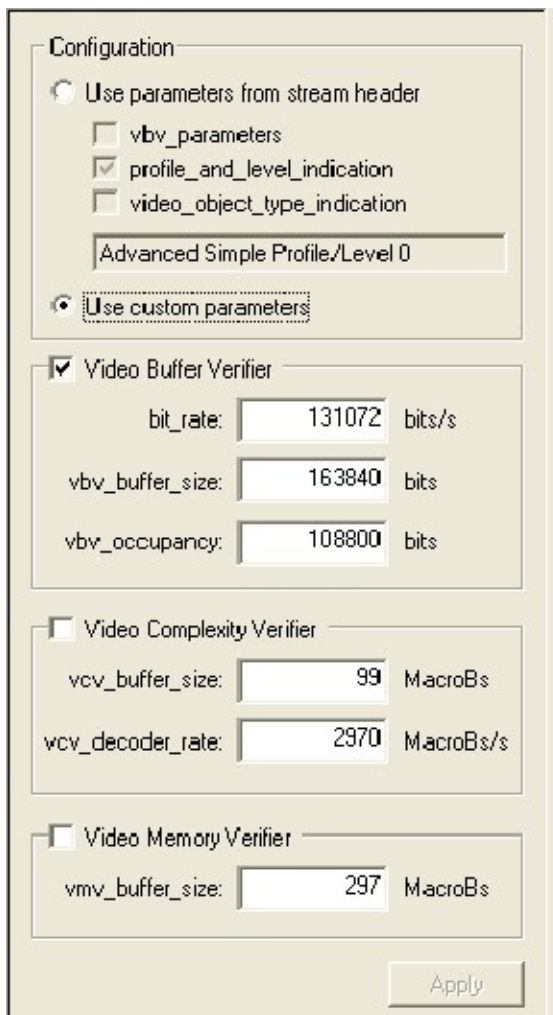



Figure 38: Buffer analysis configurations



Figure 39: Buffer parameter indicator

21. View the video buffer verifier, as shown in Figure 40. The default `vbv_buffer_size` for ASP L0 is 163,840 bits = 20,480 bytes, which is not very large.
22. Enter 655,360 bits = 80 kbytes, click **Apply**, and then click the **Fit to window** icon . Observe that the graph stays below the limit and there are no overflows or underflows.
23. Consider the following:
 - What if your mobile device cannot spare 80 KBs of memory, and can only spare 20 KBs, as specified by the standard?
 - By how much does the input data rate need to be reduced?
 - Does this comply with the specifications of the network on which your device will operate?

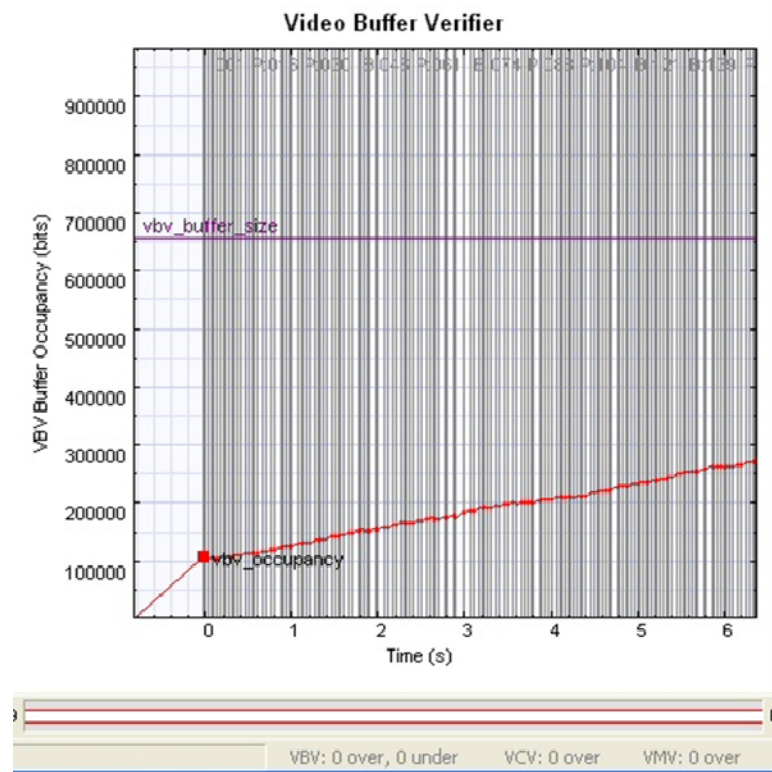


Figure 40: Video buffer verifier graph

24. Reset the parameters by clicking **Use parameters from stream header**, and then reselect the **Use custom parameters** check box. The VBV graph shows that the decoder is being supplied with data faster than it can decode.
25. Reduce the bit rate to 121072 bits, as shown in Figure 41, and then click **Apply**. The graph goes up slightly and there are fewer frames with overflow, as shown in Figure 42.

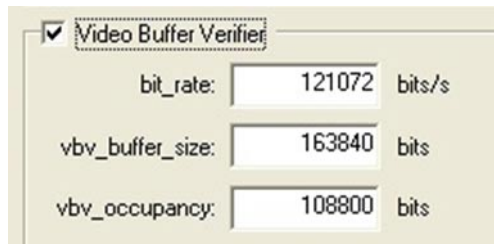


Figure 41: Bit rate configurations

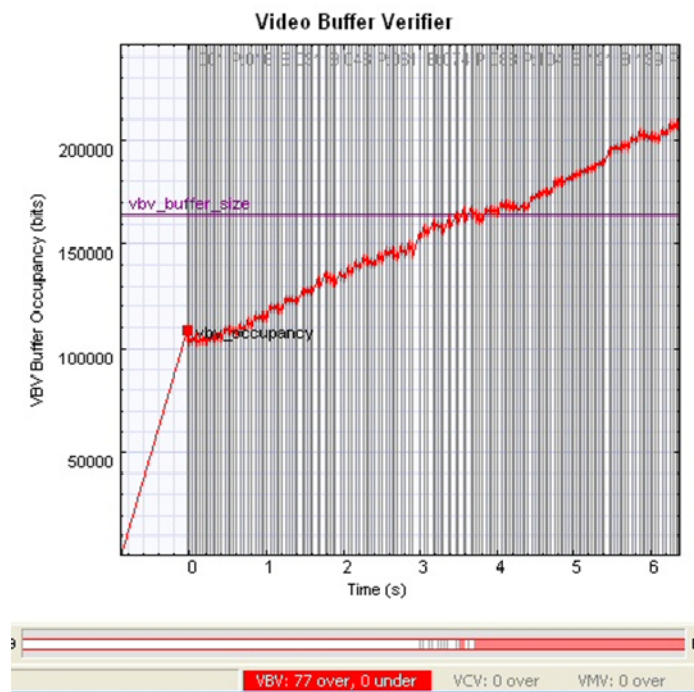


Figure 42: Video buffer verifier graph

26. Reduce the bit rate to 111072 bits, as shown in Figure 43, and then click **Apply**.
27. Observe that the graph line now stays below the buffer limit, as shown in Figure 44.
28. Consider whether the maximum rate of 111,072 bits meets your network's specifications.

Video Buffer Verifier

bit_rate:	111072	bits/s
vbv_buffer_size:	163840	bits
vbv_occupancy:	108800	bits

Figure 43: Video buffer verifier configurations

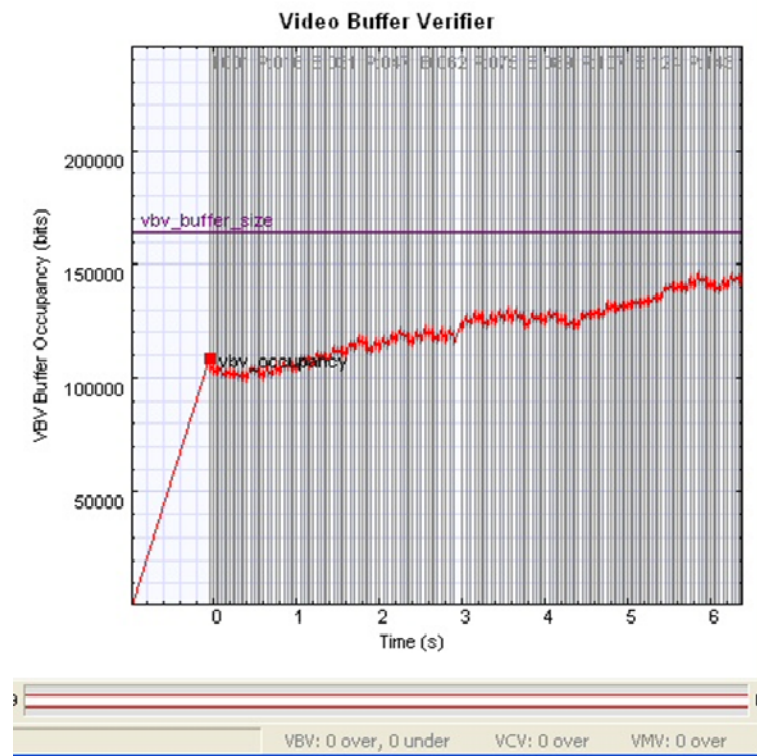


Figure 44: Video buffer verifier graph

Conclusion

This tutorial demonstrated that the buffer analysis of the MPEG-4 example, Man Walking, showed that the stream does not comply with the buffer constraints. The tutorial recommended ways to resolve this issue.

The tutorial also brought up the following considerations:

- How much memory needs to be allocated? Can your hardware allow this much memory usage?
- Is the input data rate limit appropriate for your network?

Tutorial 6: MPEG-2 Compliance

This tutorial covers the following:

- Opening an MPEG-2 program stream.
- Interpreting syntax errors:
 - Person track: invalid VLC for `dct_differential`.
 - Grenadier guards: `frame_rate_extension` denominator and numerator equal but not zero.
- Using the HexView:
 - Going from the alert pop-up to the HexView.
 - Examining the bitstream in the HexView.
- Looking at the MPEG-2 program stream structure.
- Looking at MacroBlock types in an interlaced video.

Procedure

1. To load this tutorial, click **File > Example files > MPEG-2 Program Streams > Person Track**. A list of tracks included in the MPEG-2 program stream appears in a dialog box, as shown in Figure 45.
2. View the track information included in the dialog box. The video track **ID**, for example, is 0xe0. Although there can be multiple tracks, the first video track is selected automatically.

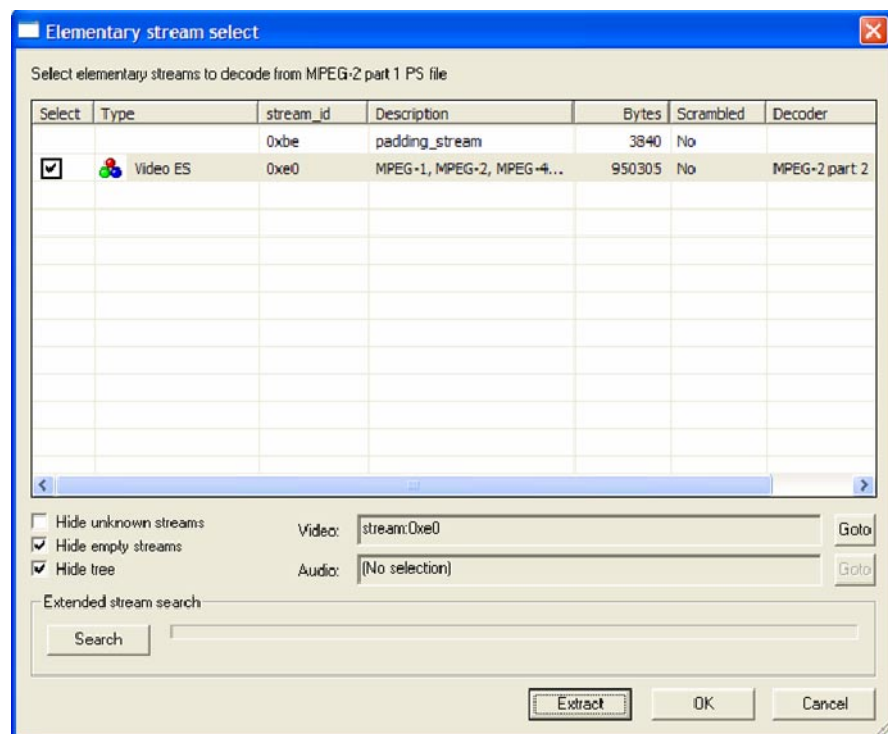


Figure 45: Track list

3. Click **OK**. The video track is analyzed and an error appears, as shown in Figure 46.
4. View the error message details, which provide a summary of the stream up to the point of the error.
5. Click **Continue**. Ensure that the **Skip this Error only in the future** check box is not selected. Another buffer conformance error message appears, as shown in Figure 47.

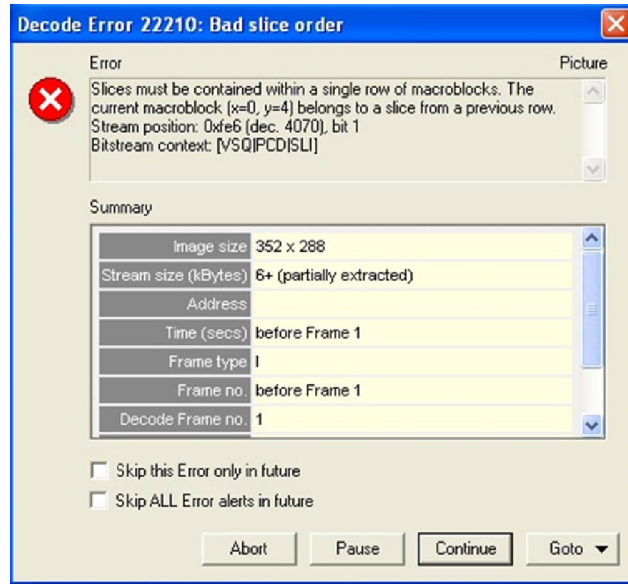


Figure 46: Initial error message

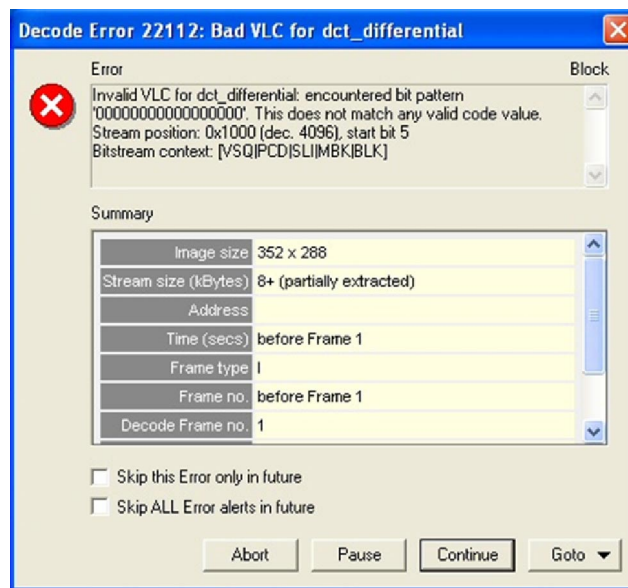



Figure 47: Invalid VLC error message

6. View the error message details. An invalid VLC has been used for the `dct_differential` field at bitstream byte address 0x1000, bit 5.
7. Click **Continue**. Ensure that the **Skip this Error only in the future** check box is not selected. Repeat this step for an additional error message that appears.
8. Resume playing the video. Observe that the error is visible in frame 1, as shown in Figure 48.



Figure 48: Error in image

9. Click the the **Pause, Step forward** icon . An error message appears.
10. Click **Continue**. An Invalid VLC error message appears, as shown in Figure 49.
11. From the **Goto** menu, click **Hex**.
12. Click **Continue**, and then view the **HexView window**, as shown in Figure 50. Note that the error is highlighted automatically.
13. Observe the bits surrounding the error and consider whether it is a start code emulation.

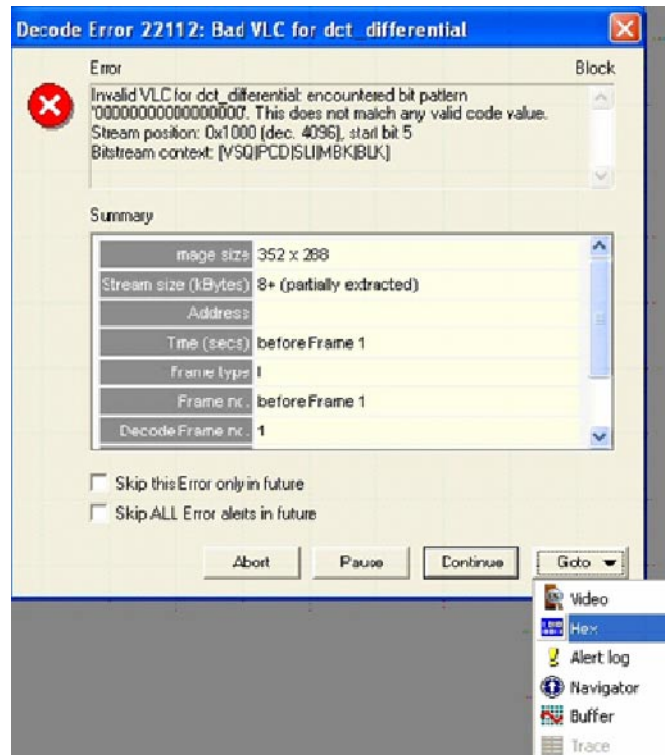


Figure 49: Invalid VLC error message

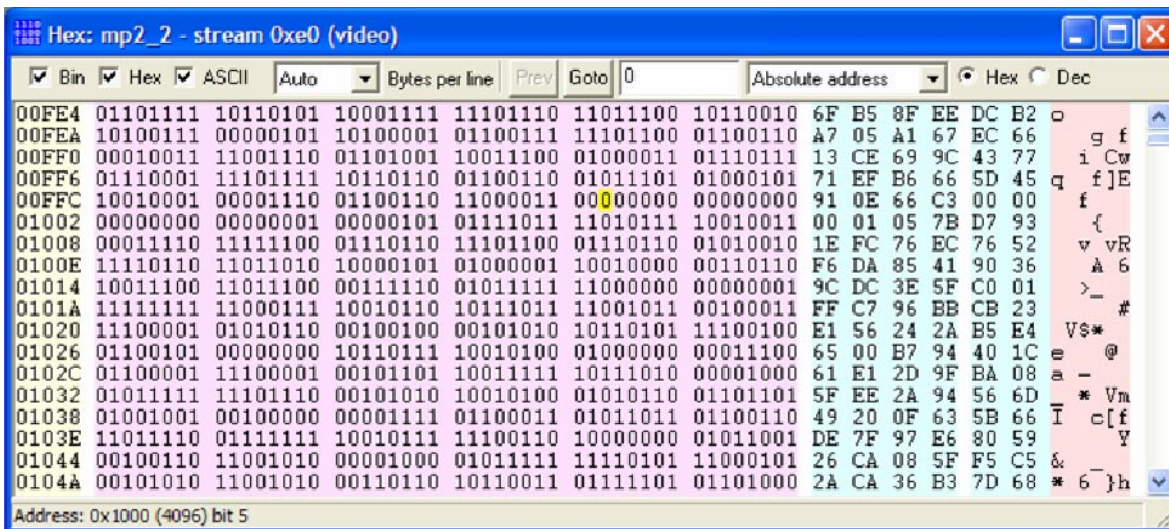


Figure 50: HexView window

14. To open the Grenadier Guards program stream, Click **File > Example files > MPEG-2 Program Streams> Grenadier Guards**. An error message appears, as shown in Figure 51.
15. View the details of the error message: the value of the denominator of frame_rate_extension is 1, but it must be 0 in Main Profile.

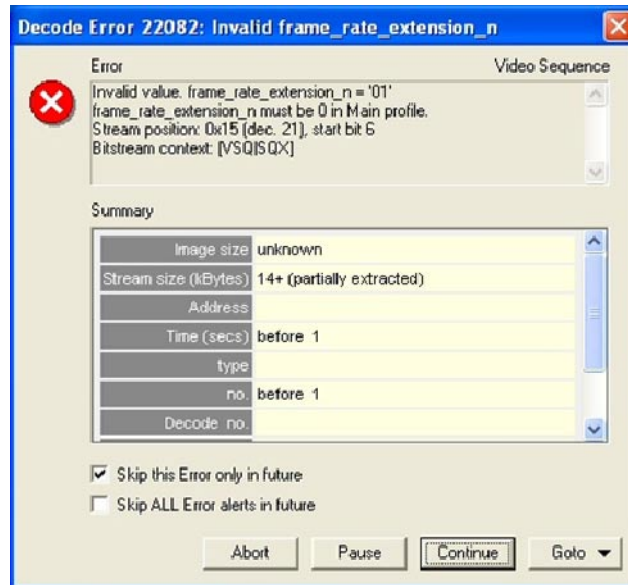


Figure 51: Error message

16. Select **Skip this Error only in the future**, and then click **Continue**. The status bar indicates one disabled alert, as shown in Figure 52. An error message and a warning message appear, as shown in Figure 53 and Figure 54.



Figure 52: Disabled alert indicator

17. For both error messages, select **Skip this Error** or **Warning in the future**, and then click **Continue**. Do not resume playing the video.

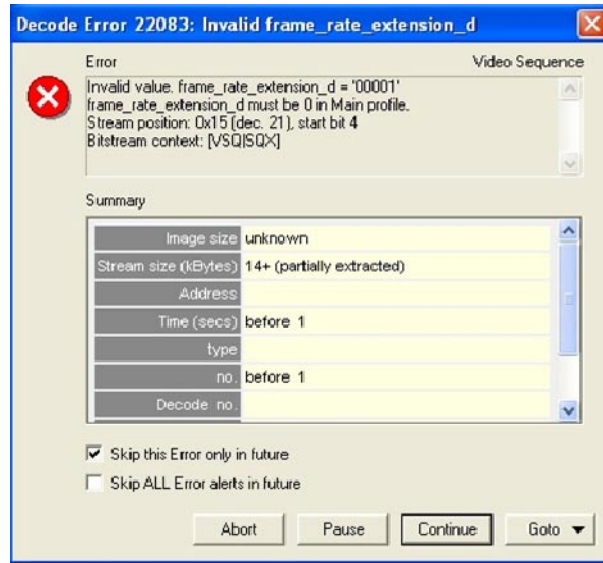


Figure 53: Error message

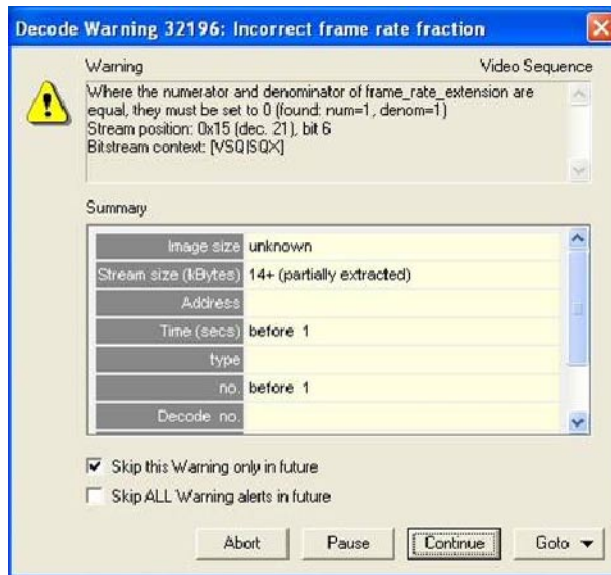


Figure 54: Warning message

18. From the **Analysis** menu, select **View video stream structure**. The **Structure** window appears, as shown in Figure 55.
19. View the top-level atoms in the MPEG-2 program stream. Click the **+** next to each atom to view the data for the atom.

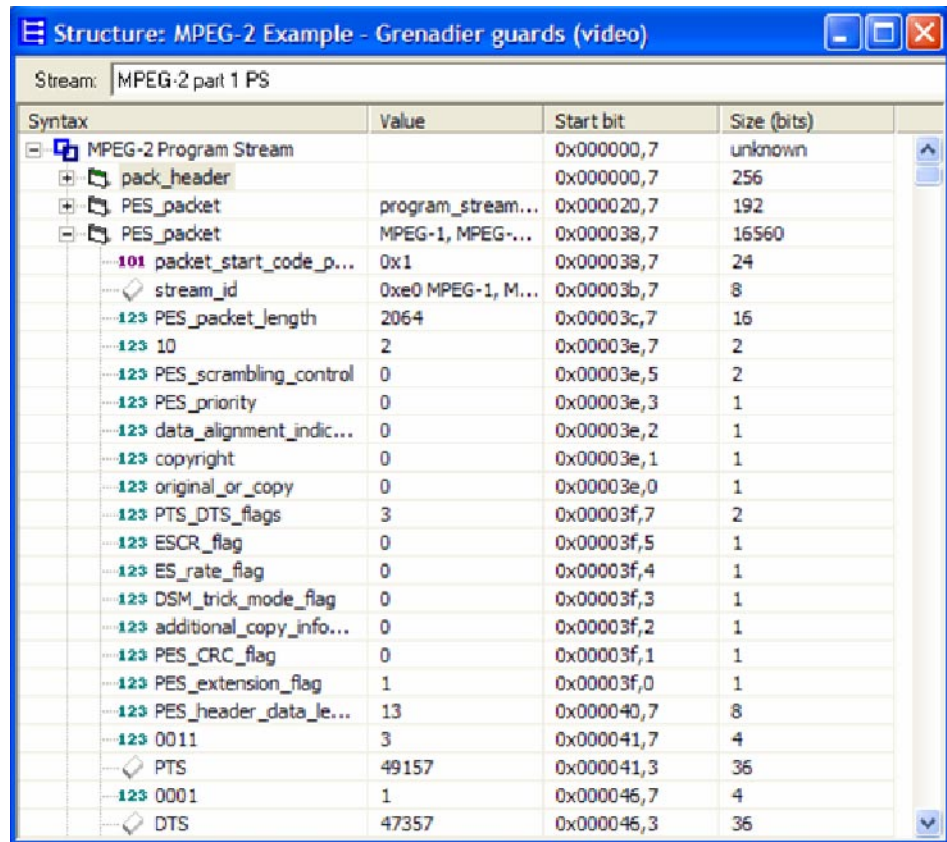


Figure 55: Structure window

20. Resume playing the video. The **Interlace** toolbar appears, as shown in Figure 56.



Figure 56: Interlace toolbar



21. Click the **Pause, Step Forward** icon  to view frame 2.
22. On the **Interlace** toolbar, click the **Split fields view** icon . The top and bottom fields are displayed separately, as shown in Figure 57.



Figure 57: Frame 2

23. Maximize the video window.
24. Click the  icon. Different MB types appear in the top and bottom fields, as shown in Figure 58.

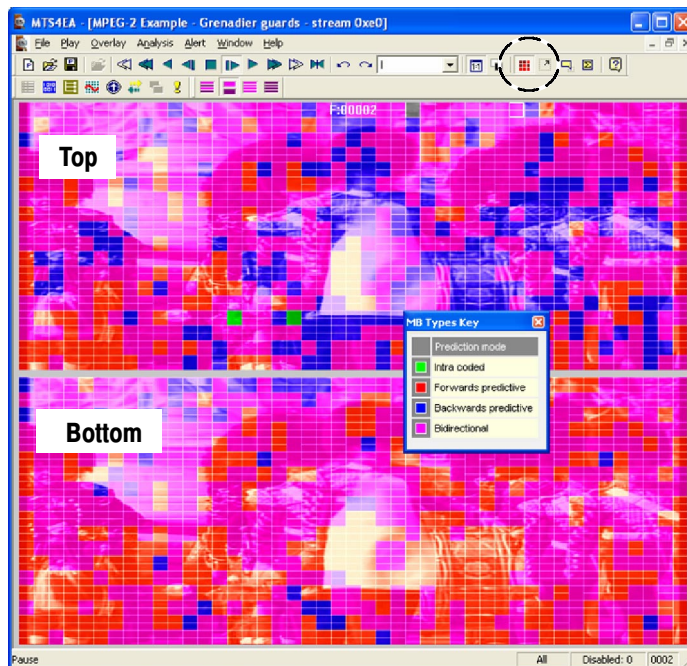


Figure 58: Varied MB types

Conclusion

This tutorial demonstrated the following:

- There is one error in the Person Track stream:
 - The error is frame 1, at bitstream location 0x1000, bit start 5.
 - This error affects the visual quality.
- There are two errors and one warning message in the Grenadier Guards stream:
 - The errors are in the header (before frame 1), at bitstream location 0x15, bit start 6.
 - The warning message highlights the same error.
 - This does not appear to affect the visual quality.
- You can see the different MacroBlock types in the top and bottom fields.

Tutorial 7: Fidelity Analysis

This tutorial covers the following:

- Fidelity analysis in real-time (PSNR).
 - Using a YUV source reference file.
 - Fidelity metrics.
 - Graph navigation.
- Comparing the fidelity of the same bitstream compressed with either MPEG-2 or H.264/AVC.
- Viewing the visual difference between the compressed bitstream and the YUV source reference video.

This tutorial requires that you have completed the previous tutorials and that you can:

- Open example streams.
- Play, stop, step forward, and rewind a video.
- Use and interpret alert pop-up messages.
- Use the icons and controls on the buffer analysis graphical display.

This tutorial also requires that you already understand the principles of fidelity analysis (MTS4CC does not cover this; however, the user manual contains descriptions of the fidelity metrics).

Procedure

1. To load the tutorial, click **File > Example files > MPEG-4 Elementary Streams > Man Walking**. Ensure that the video is not playing.
2. From the **Analysis** menu, click **Enable fidelity analysis**. The **Video analysis options** dialog box appears (see Figure 59) for the YUV reference file. This file will later be used for comparison with the compressed video file. The YUV reference file is provided as an example, as indicated by the text under the **Reference filename** field, shown in Figure 59.
3. Set the **Frame rate** to 30, as shown in Figure 59.

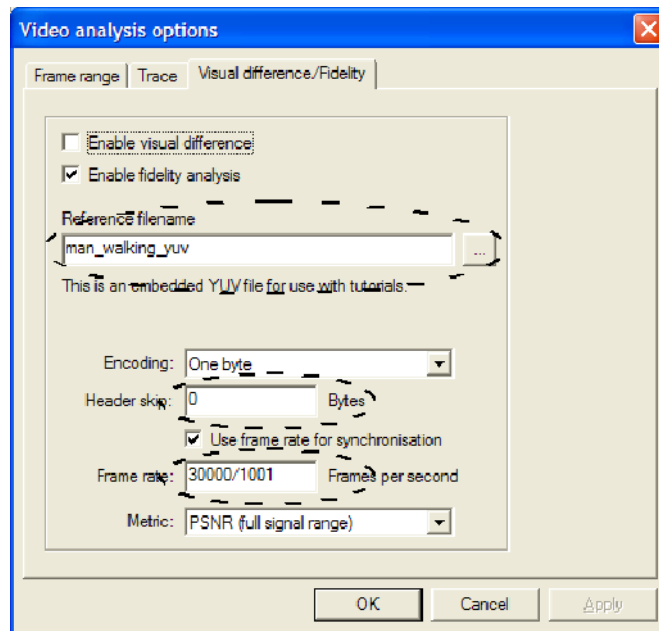



Figure 59: Video analysis options

4. From the **Metric** drop-down menu, select **PSNR (full signal range)**, and then click **OK**. (A detailed description of each fidelity metric is available in the user manual).
5. From the **Analysis** menu, click **Enable fidelity trace**.
6. On the **Trace** tab, select the **Enable** check box, choose the filename **mp4asp_1_video** and then, under **Options**, select **VOP Fidelity**, as shown in Figure 60.
7. On the **Frame range** tab, select the **All frames** check box, as shown in Figure 61, and then click **OK**. The video window appears with the fidelity analysis icon  enabled in the **Views** toolbar.

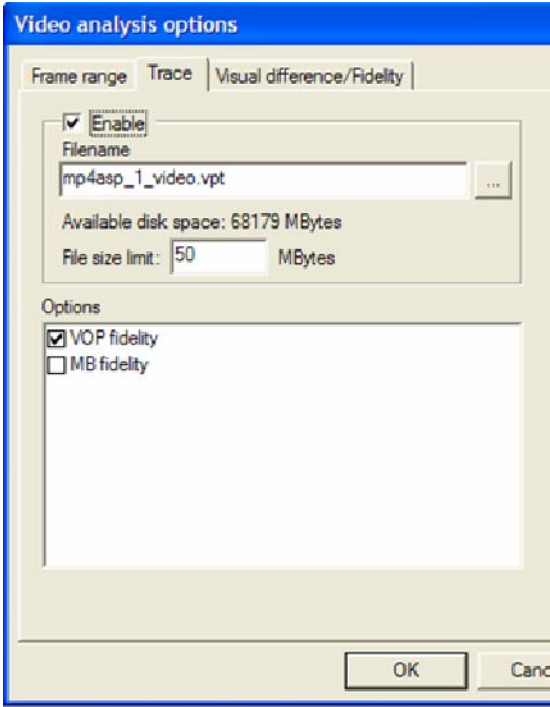


Figure 60: Video analysis options

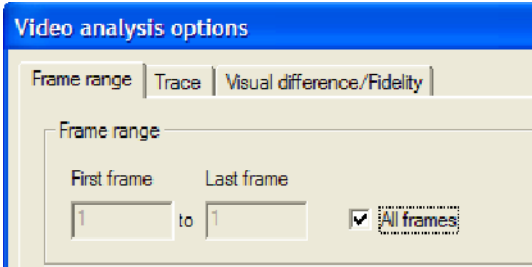





Figure 61: Frame range tab

8. Click the **Fidelity analysis** icon . The **Fidelity analysis** graph view appears, as shown in Figure 62. Observe that the graph is empty because a video has not been played.
9. Click the  icon four times. A graph appears, as shown in Figure 63.
10. Observe the following about the graph shown in Figure 63:
 - The graph area is not filled with each click because the bitstream includes B-VOPS, and a certain number of frames must be decoded before each frame can be displayed.
 - Some of the YUV PSNR values are not visible. This is because the graph auto-scales with the first few values. You can click the  icon to rescale the graph.
 - The thumbnail bar view shows that the fidelity data has been collected.
11. View the descriptions of the **Fidelity analysis** window, as shown in Figure 64 and Table 6.

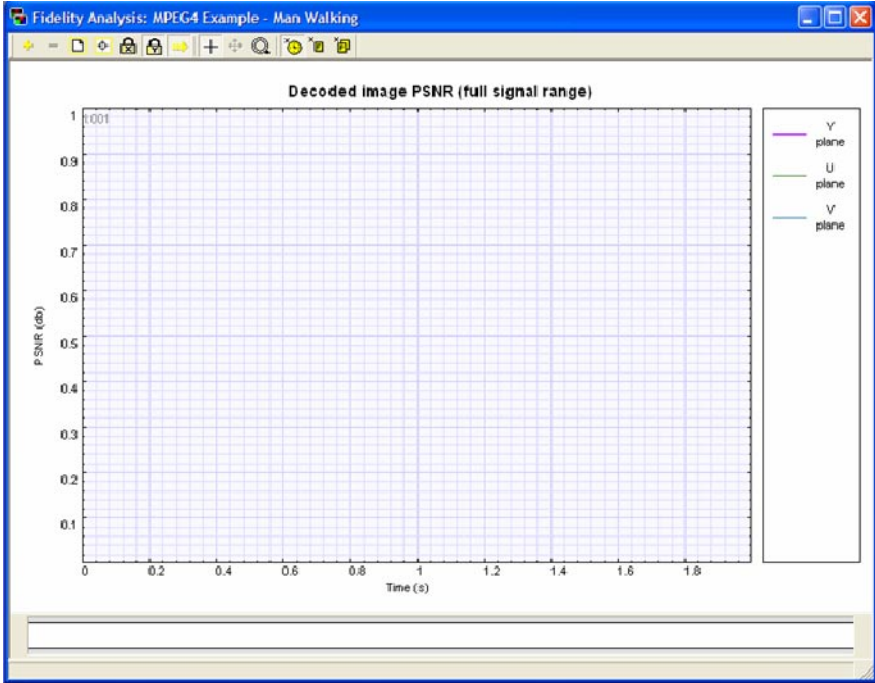


Figure 62: Fidelity analysis graph

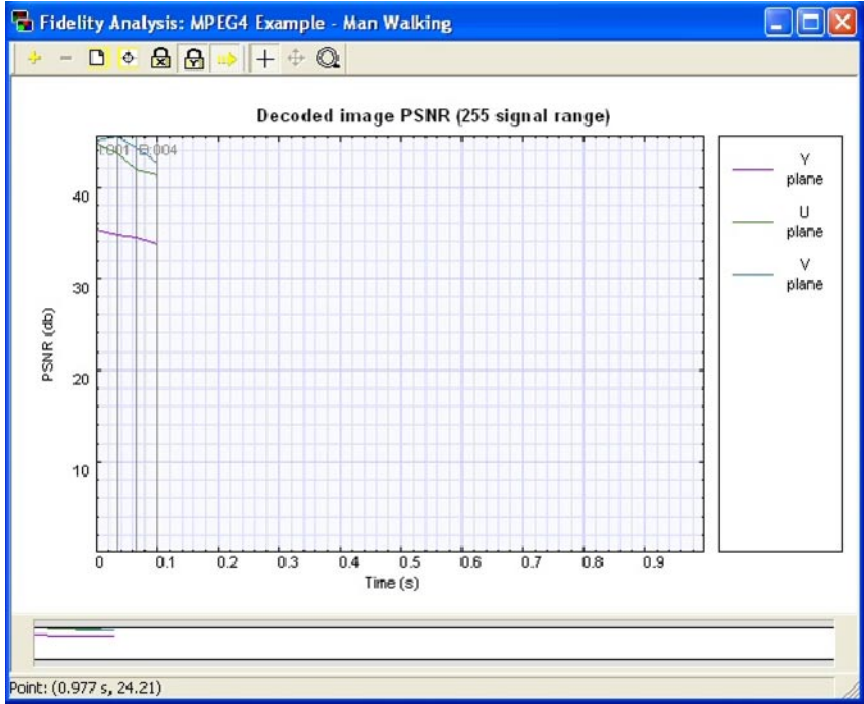


Figure 63: Fidelity analysis graph

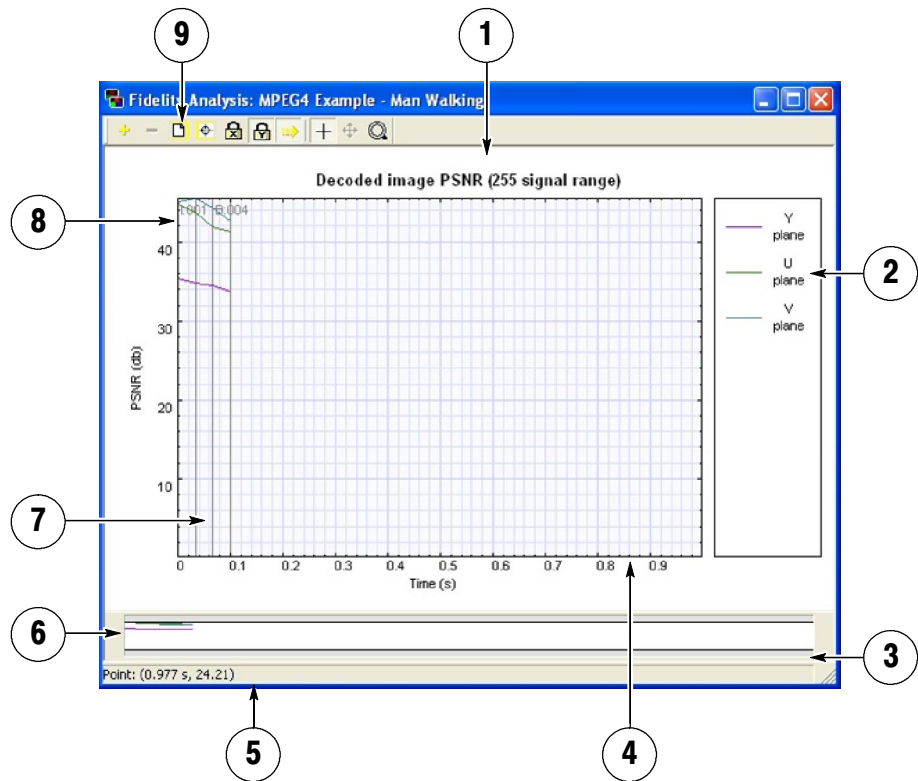


Figure 64: Fidelity analysis window descriptions

Table 6: Fidelity analysis window descriptions

Area	Description
1	Graph window
2	YUV color key
3	Scroll bar; appears and disappears according to zoom scale
4	Time through sequence
5	Status line; display measurements
6	Thumbnail bar line; displays overview
7	Vertical blue line at time=0; vertical gray lines at each VOP decode time
8	Frame type, number
9	Graph window control toolbar

12. To open the Grenadier Guards program stream, Click **File > Example files > MPEG-2 Program Streams > Grenadier Guards**. An error message appears.
13. Select **Skip this Error only in the future**, and then click **Continue**.
14. From the **Analysis** menu, select **View analysis options**.
15. On the **Visual difference/ Fidelity** tab, set the **YUV frame rate** to 25, and then click **OK**.
16. An error message appears because there are only 10 frames of YUV data. Click **OK**, and then view the graph result, as shown in Figure 65.
17. Load the MPEG-2 program stream example, Grenadier Guards, as shown in Figure 66.
18. Compare the MPEG-2 program stream in Figure 66 with the H.264/AVC PSNR example shown in Figure 67. Note that the PSNR is higher for H.264/AVC in Y, U, and V.

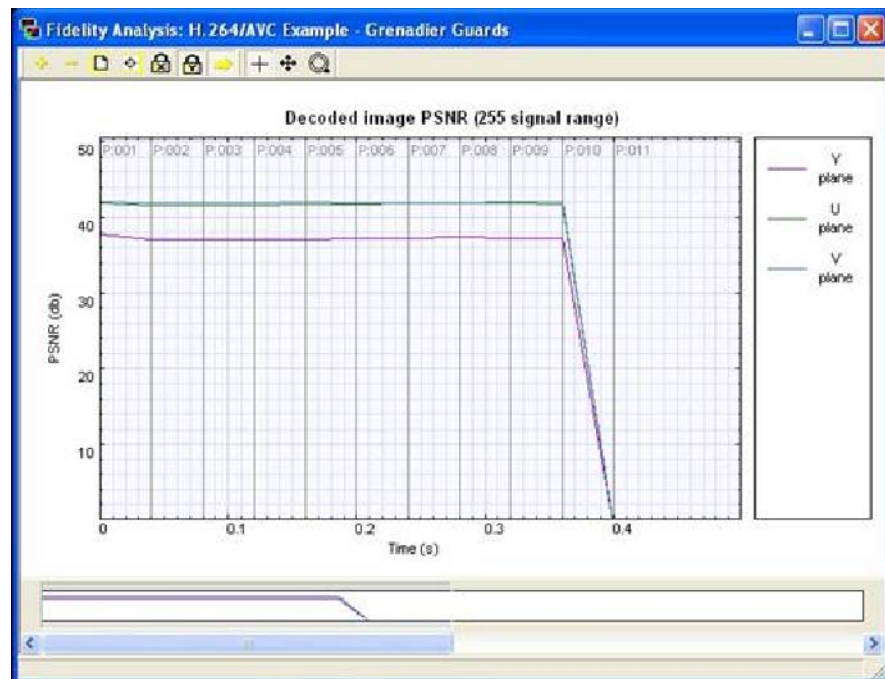


Figure 65: Graph result, YUV frame rate 25

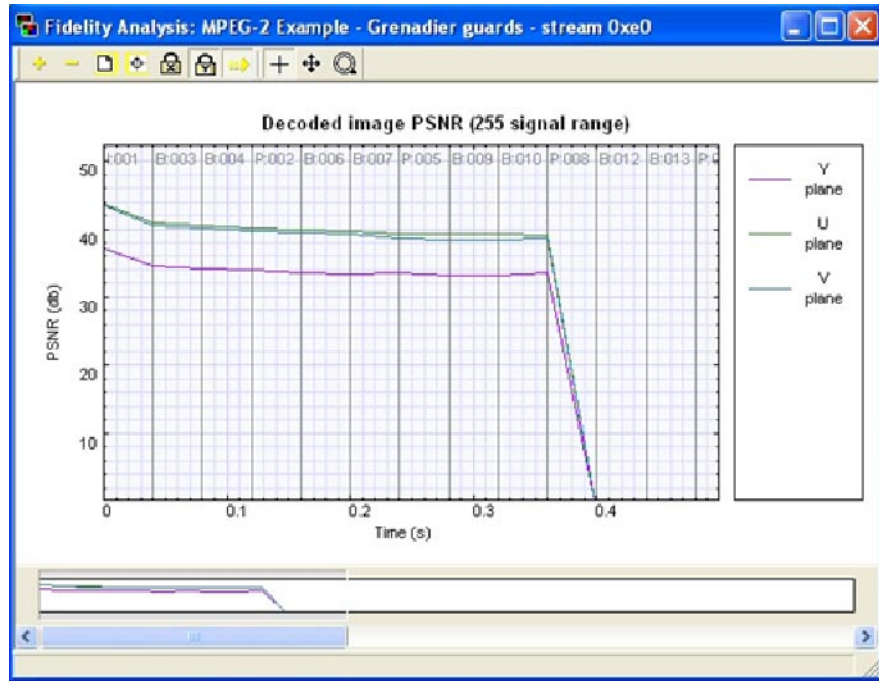


Figure 66: MPEG-2 program stream, Grenadier Guards



Figure 67: H.264/AVC stream, Grenadier Guards

19. Click the **View trace** icon as shown in Figure 68.



Figure 68: View trace icon

20. The trace view gives the numerical values for the pictures' PSNR, as shown in Figure 69.

21. Consider the following:





- What encoder parameters, such as frame type, were used for H.264/AVC and MPEG-2?
- Could the H.264/AVC or the MPEG-2 encoding parameters be changed to improve the areas of lower PSNR?
- Compare other fidelity analyses; do the same kinds of differences occur?
- Although the PSNR is better for the H.264/AVC sequence, it does not necessarily look better. Consider the visual differences.

Frame	Field	PSNR(Y)	PSNR(U)	PSNR(V)
1	0	38.1551205054	44.1527441439	44.1070618585
1	1	36.2410429823	43.1333866825	42.6906976668
2	0	34.2408434076	41.0828362775	40.5498890441
2	1	34.8244399239	40.8747086796	40.3956140428
3	0	34.1695327233	40.5571772657	40.1094564965
3	1	34.1792323830	40.5634068211	39.9926959618
4	0	34.1895275709	40.0741906012	39.7654673373
4	1	33.7246588453	40.1144933741	39.7156833394
5	0	33.4360061215	40.0695929584	39.6645788375
5	1	33.6821124513	39.7911766114	39.4529675380
6	0	33.5875051373	39.8044087588	39.2026888440
6	1	33.2754493764	39.7546294297	39.1679362998
7	0	33.1654188777	39.1565268088	38.6190367668
7	1	33.7616897922	39.4076668535	38.8532040654
8	0	33.0906394850	39.5244317504	38.7354762727
8	1	33.0525714220	38.9345453769	38.1391305374
9	0	33.4113761027	39.2114152344	38.4411214339
9	1	33.0349589228	39.1469252959	38.4015575604
10	0	33.4844855563	39.1007939494	38.4926066341
10	1	33.7436073016	39.0919941194	38.5918053711
11	0	error		

Figure 69: H.264/AVC sequence

22. Load the MPEG-2 stream, Grenadier Guards.
23. From the **Overlay** menu, click **Visual difference**, and then select the **Enable** check box.
24. Set the **Frame rate** to 25, and then click **OK**. The **Visual difference** toolbar appears.
25. Use the following icons to view the visual difference.

Table 7: Visual difference icons

Icon	Function
	View encoded
	View YUV reference
	View difference
	View luma only (not U or V)

26. Load the H.264/AVC stream, Grenadier Guards. Consider whether there is a difference in visual quality between the two streams.

Conclusion

This tutorial demonstrated the following:

- A method for assessing visual quality through:
 - The use of metrics such as PSNR.
 - Identifying the visual difference between the encoded video and the reference (source) video that is used for the encoding.
- Visual quality analysis and visual quality improvement require that you consider encoding parameters (such as frame types and motion vectors) and bit-rates of encoding.

This tutorial provided the tools to help you begin your visual analysis in a quantifiable and logical fashion.

❏ **End of document** ❏