MTS4EAV7
HEVC / AVC Video and Compressed Audio Analyzer

Tutorials

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Tektronix

MTS4EAV7
HEVC / AVC Video and Compressed Audio Analyzer

Tutorials

This document applies to software version 7.0 and above.

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Getting started

This set of eleven tutorials helps you learn more about operating the Tektronix MTS4EAV7 HEVC / AVC Video and Compressed Audio Analyzer. Perform tutorials 1 through 11 in the order they are presented, regardless of the video standard of interest. Tutorial 10 relates only to MPEG-2 and interlaced video.

NOTE. *Although the order code for this product is MTS4EAV7, the product is generally referred to as the MTS4EA throughout the software and documentation.*

For information about H.265/HEVC stream analysis, see the MTS4EAV7 User Manual (Tektronix part number 071-3228-XX).

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
- Are you optimizing your Codec
- 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

A description for each tutorial follows. (See Table 1.)

Table 1: Tutorial descriptions

Tutorial	Name	Standard	Areas Covered
1	H.261	H.261	Syntax error; compression optimization; graph analysis
2	H.263 Compliance and Motion Vectors	H.263 Baseline	Errors and error log; motion vectors.
3	MPEG-4 Compliance	MPEG-4 Simple Profile	Common errors; searching for areas of codec optimization.
4	MPEG-4 Optimization	MPEG-4 Adv. Simple Profile	Common errors; HexView bitstream analysis; video navigator; synchronize views; project files
5	MP4 Compliance Basics	MP4/ Simple Profile/ L1(2)	Extract and examine container files; level conformance error.
6	MP4 Optimization	MP4/ Simple Profile/ L1(2)	Using MB type overlays and searching for areas of optimization.

Table 1: Tutorial descriptions (cont.)

Tutorial	Name	Standard	Areas Covered
7	3GPP/MPEG-4 Compliance	3GPP/MPEG-4 Simple Profile/ L1	Common errors; searching for areas for optimization
8	H.264/AVC Syntax Error	H.264/AVC Extended Profile/ L3	Syntax error in PPS; trace analysis of syntax
9	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.
10	MPEG-2 Compliance	MPEG-2 Main Profile / Main Level	Syntax errors; MPEG structure analysis; interlace.
11	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 following basic functions. (See Table 2.) To perform the desired function, click 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 MTS4EA, 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 MTS4EA will only play the provided example video files.

Tutorial 1: H.261

This tutorial shows non-compliance issues with the H.261 standard using temporal references and graphical analysis.

Procedure

1. To load the H.261 tutorial, click **File** > **Example files** > **H.261 stream** > **Conference Room**. The window title changes to **MTS4EA-H.261 Example - Conference Room**, and a warning message appears. (See Figure 1.)

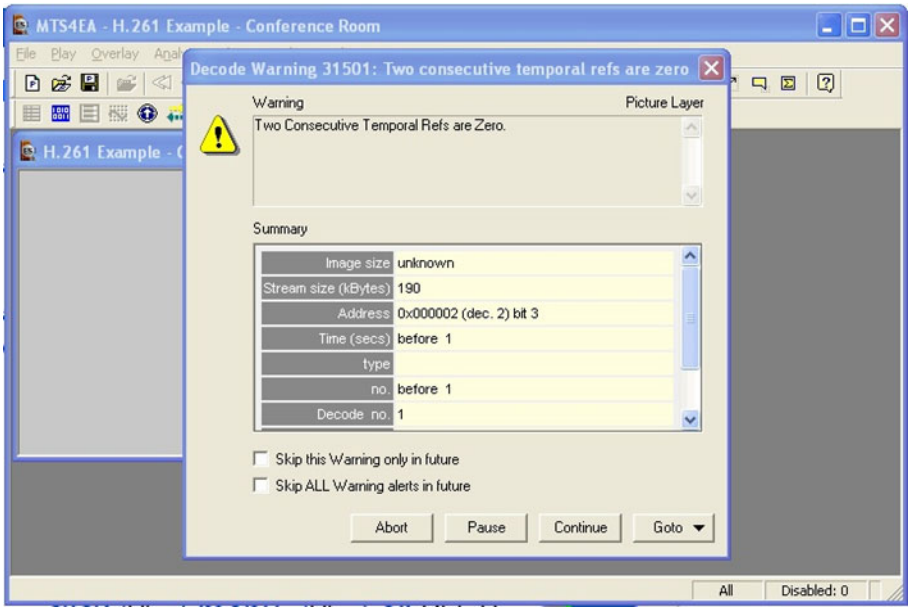

Figure 1: Initial warning message

NOTE. *The H.261 standard states that the temporal reference (TR) value is the previous TR value + 1 + the number of skipped or non-reference pictures at the picture clock frequency (PCF). TR is 8 bits only, 0–255, at the standard PCF of 29.97 frames per second. However, if a custom PCF is used, then TR is 10 bits: 8 LSBs are denoted as TR and 2 MSBs are ETR, but they are taken together as a single 10-bit number.*

2. View the warning message elements:
   - **Warning** - Indicates that two consecutive temporal references are zero.
   - **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.
5. As you view the video, notice the following: (See Figure 2.)
   - Movement in the video is too quick (requires PC with processing speed of greater than or equal to 1 GHz)
   - Unwanted noise (visual artifacts) is visible when the man waves his arm (starting around frame 128, continuing into frame 161, with some artifacts remaining until frame 203)
   - Status bar notes that one alert is disabled

   Although the video stream will play and will probably be decoded by other H.261 decoders, the H.261 sequence was incorrectly encoded, showing temporal issues.

Figure 2: Visual artifacts

6. Click **Overlay** on the menu and select **MB Types**, or click the Overlay icon on the toolbar. MB (macroblock) Types are color coded and can be undocked, resized, or switched off. (See Figure 3.)

NOTE. *The H.261 standard has 10 MB types. For more information on using these, see the user manual.*

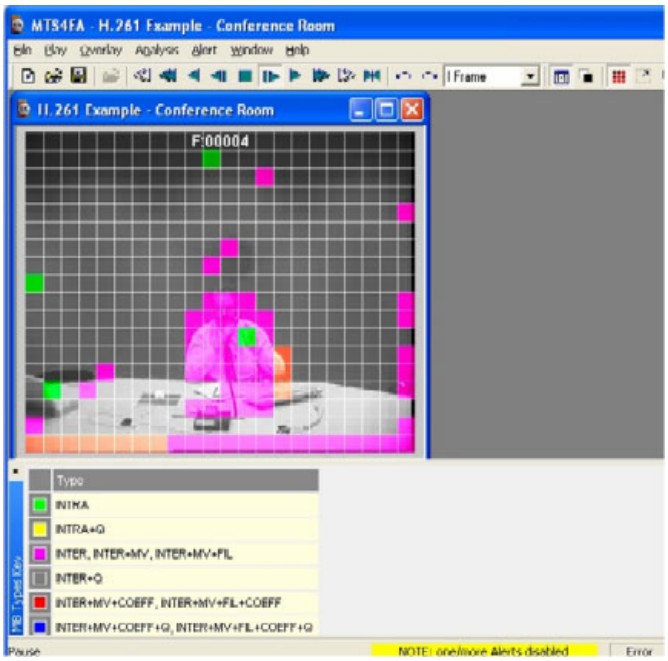

Figure 3: MB overlay

7. Check that the video is in either **Play** or **Pause** mode.

8. Click the MB Tooltip icon on the toolbar. The Tooltip typically docks at the left edge of the window, but you can undock it by pressing <CTRL> on your keyboard while dragging the Tooltip with your mouse.

9. Move the mouse over the video. A white box will display around the MB from which data is being read. The Tooltip shows information about that MB. (See Figure 4.)

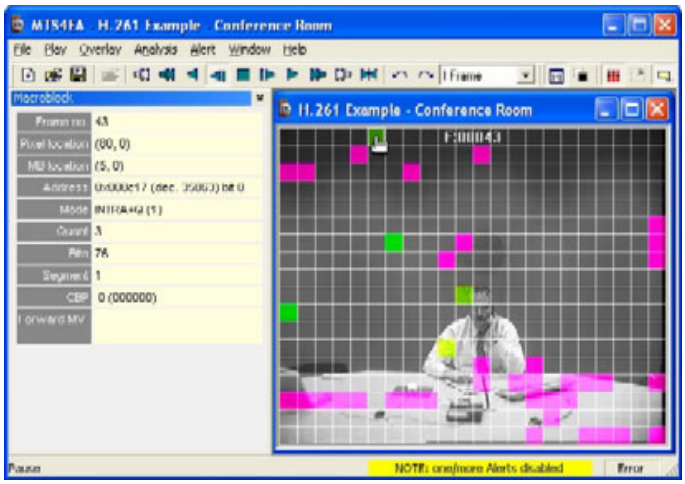

Figure 4: MB types and data

10. Advance through the video frame by frame, noting many green Intra MBs in the background wall. These block types use the most bits. (See Figure 5.)

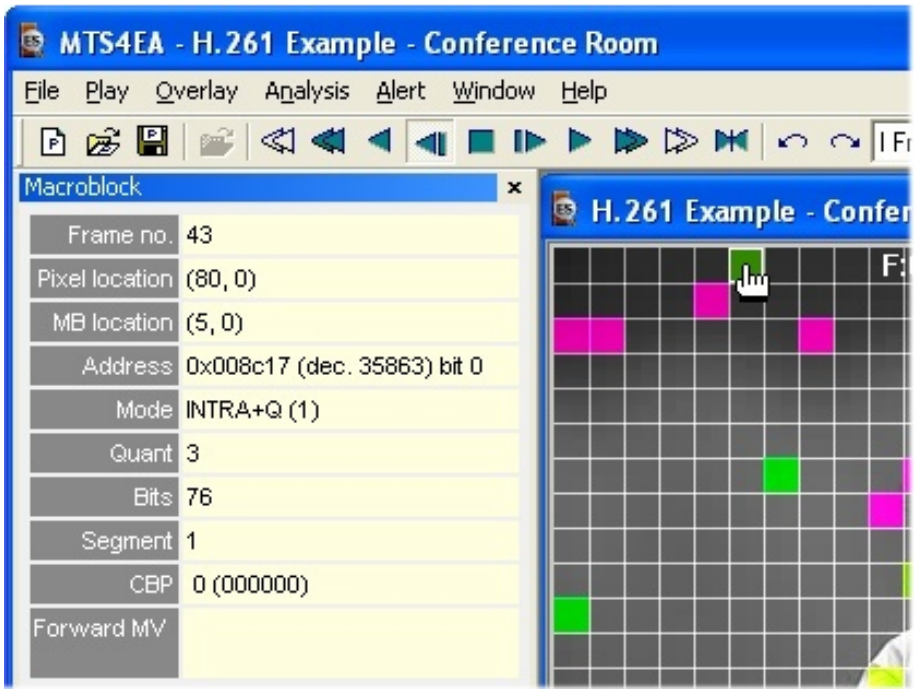

Figure 5: Intra MBs in the background wall and MB data

11. Stop the video sequence.

12. To analyze the MB data, select **Analysis** from the menu and select **Video graph enable**. A dialog box will appear. (See Figure 6.)

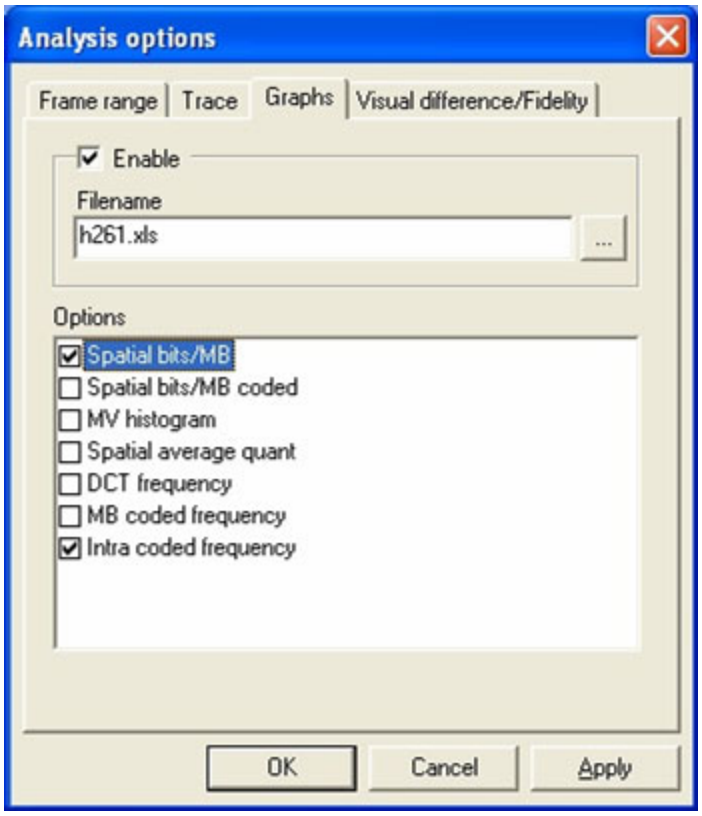

Figure 6: Analysis dialog box

13. Check the **Enable**, **Spatial bits/MB**, and **Intra coded frequency** boxes in the Analysis dialog box.
14. Select the output filename: h261.xls.
15. Click **OK** and then play the video.
16. When play ends, the data is exported to the .xls file and MS Excel will open. Click **Enable macros**. The screen will flash as the macros run.
17. Click **Spatial Bits per MB** to view a graph of the spatial bits per MB. (See Figure 7.)

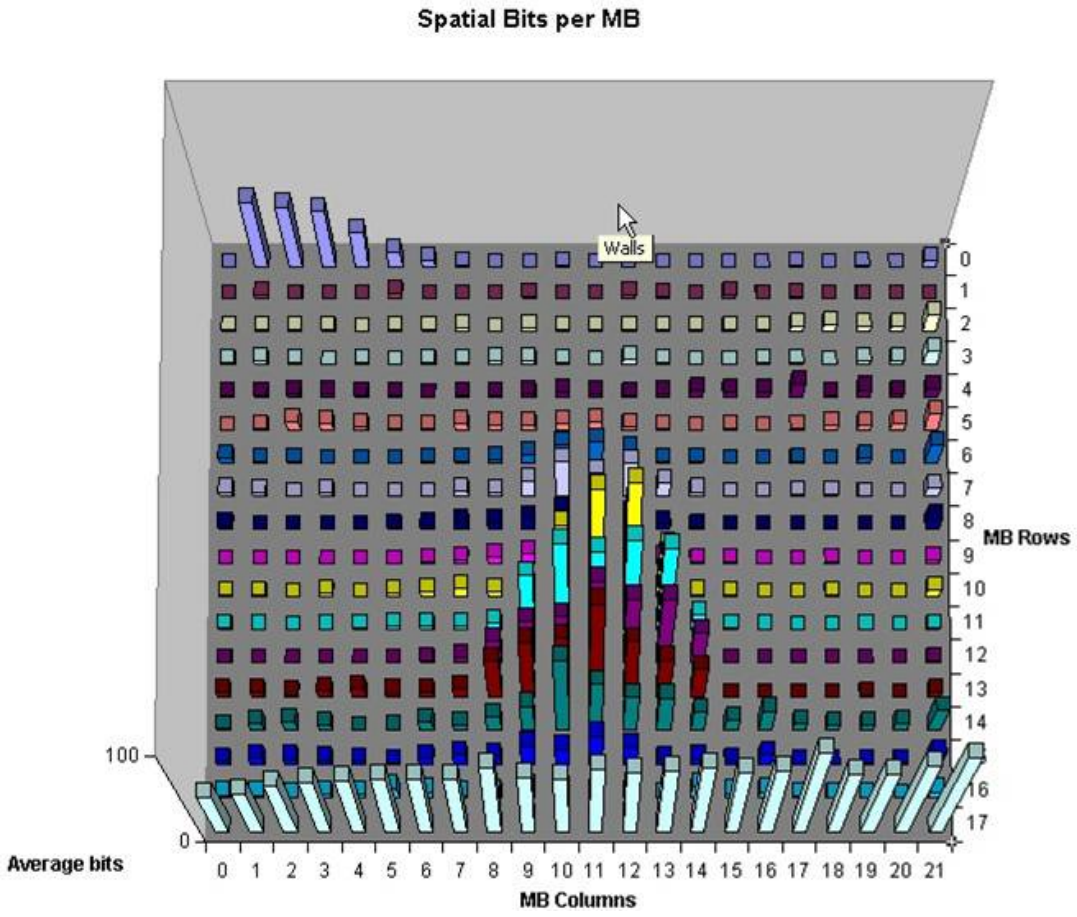

Figure 7: Spatial bits per MB

NOTE. *Notice that many bits are used in the center (by the man), top left (too many), and along the bottom edge (too many). These last two are errors.*

18. Click the **Intra Coded Frequency** tab to view a graph of the Intra Coded Frequency. (See Figure 8.)

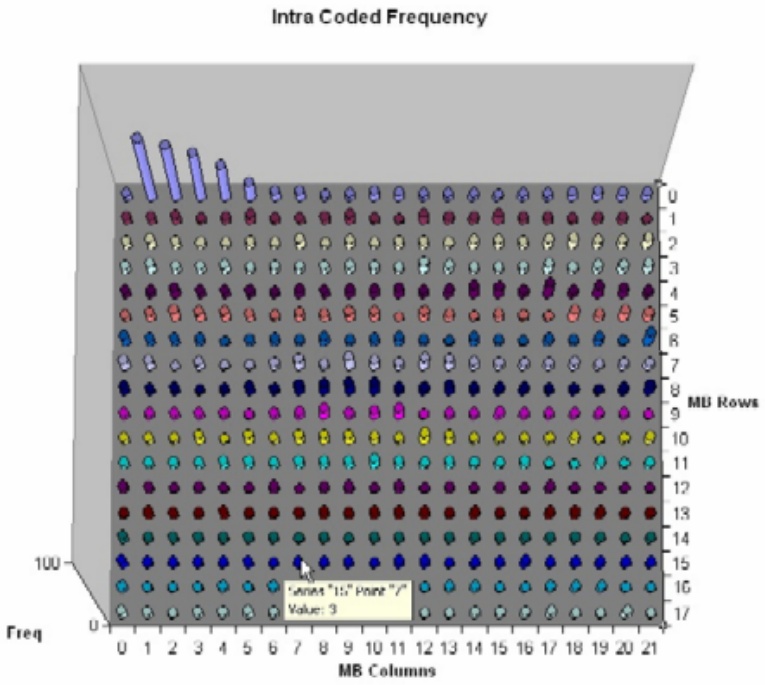

Figure 8: Intra coded frequency

NOTE. *Notice that there are many Intra-coded MBs at the top left of the graph. This indicates that there is an error with Intra-coding in the encoder.*

Conclusion

This tutorial demonstrated that the H.261 bitstream is not standard compliant and that there were coding inefficiencies. These problems were discovered through TR errors and frequency of playing. Coding inefficiencies were discovered through graphical analysis.

Tutorial 2: 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 **MTS4EA-H.263 Example - Rally (250k)**, and a warning message appears. (See Figure 9.)

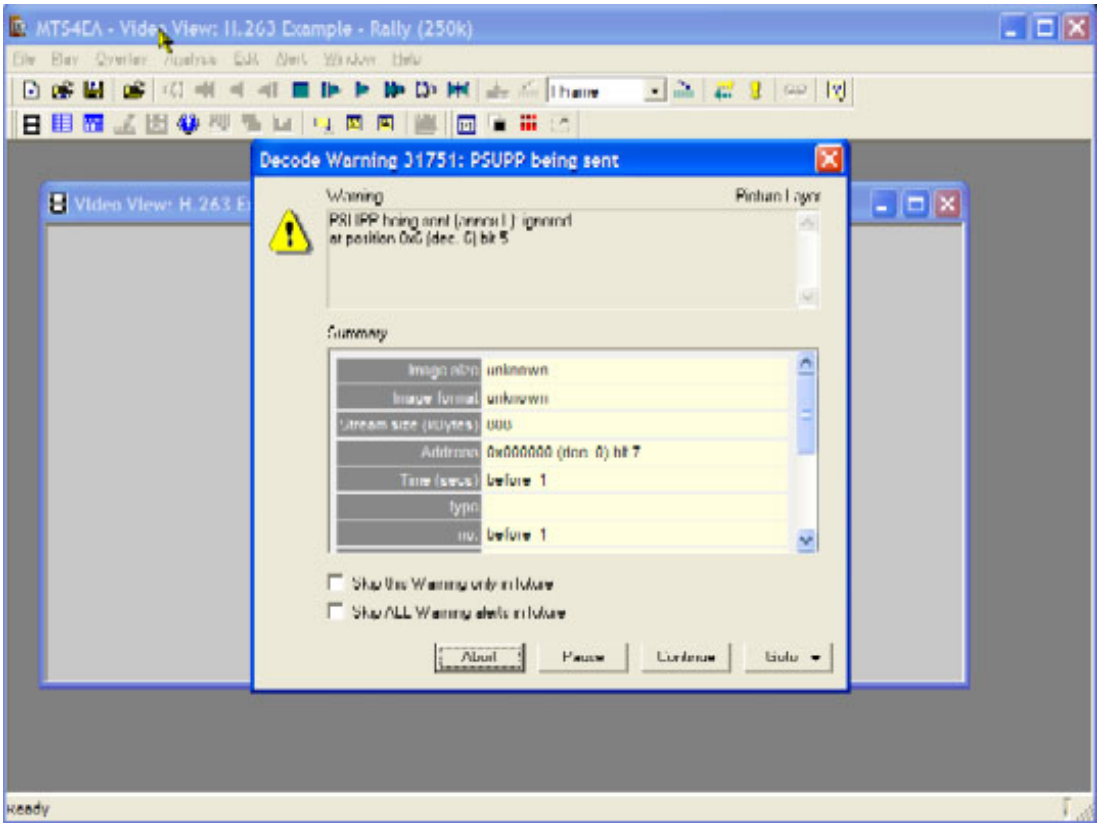

Figure 9: Initial warning message

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. Another error message appears. (See Figure 10.)
5. View the error information provided, which indicates a more serious error that occurs at bitstream byte address 0x0c9cfa, bit 3, after frame 326.

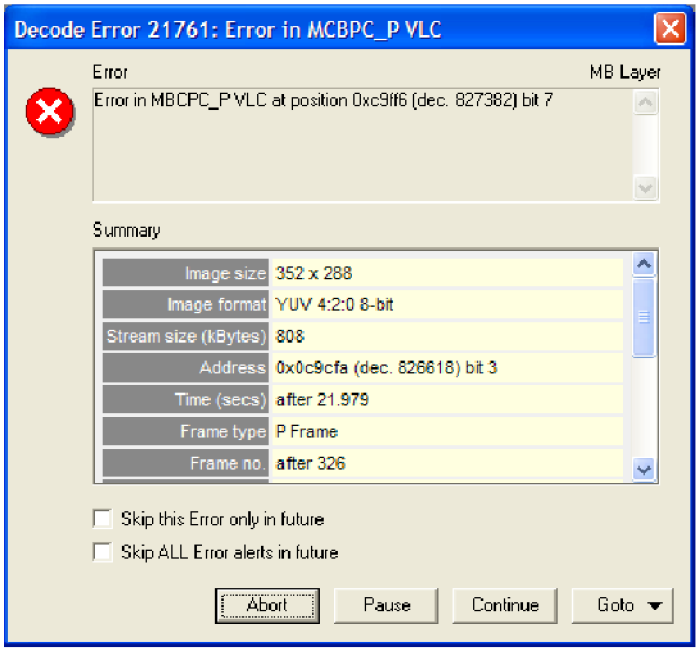

Figure 10: Initial error message

6. Click **Continue**. Another error message will appear. (See Figure 11.)
7. Note that it was an MBCPC error that resulted in the Out of Sync alert message. This often occurs when one syntax error triggers a series of alerts.

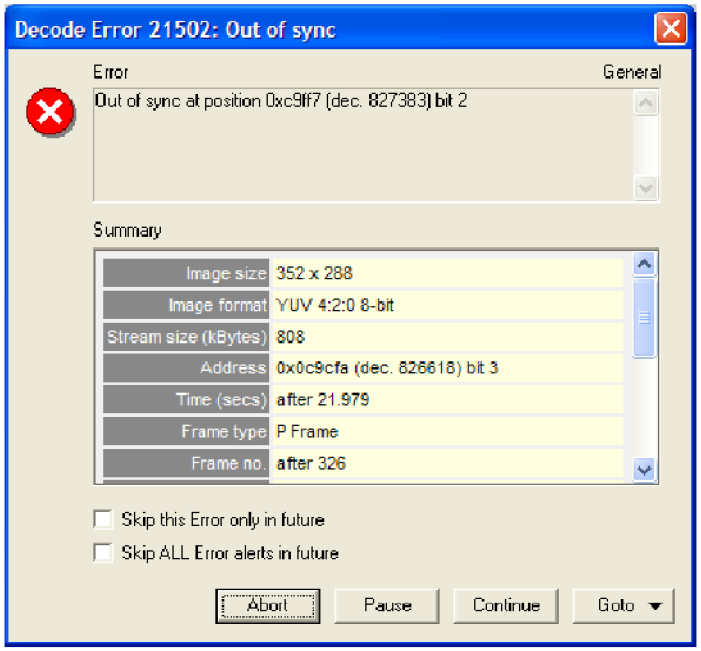

Figure 11: Out of sync error message

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 will appear. (See Figure 12.)

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. (See Figure 13.)

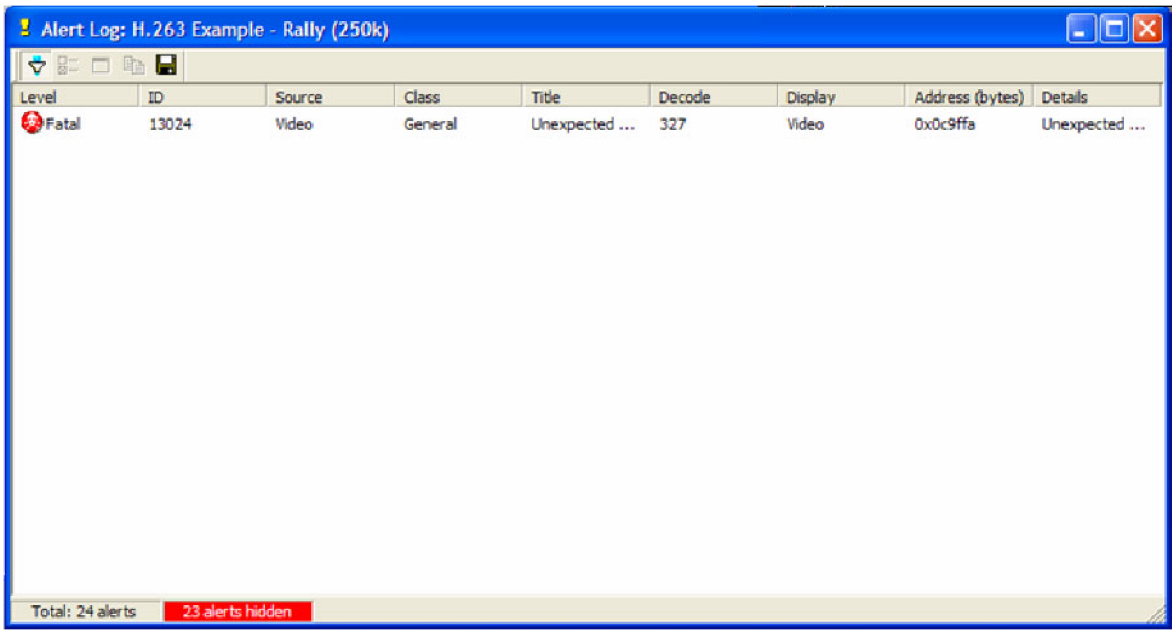

Figure 12: Alert Log window, filtered

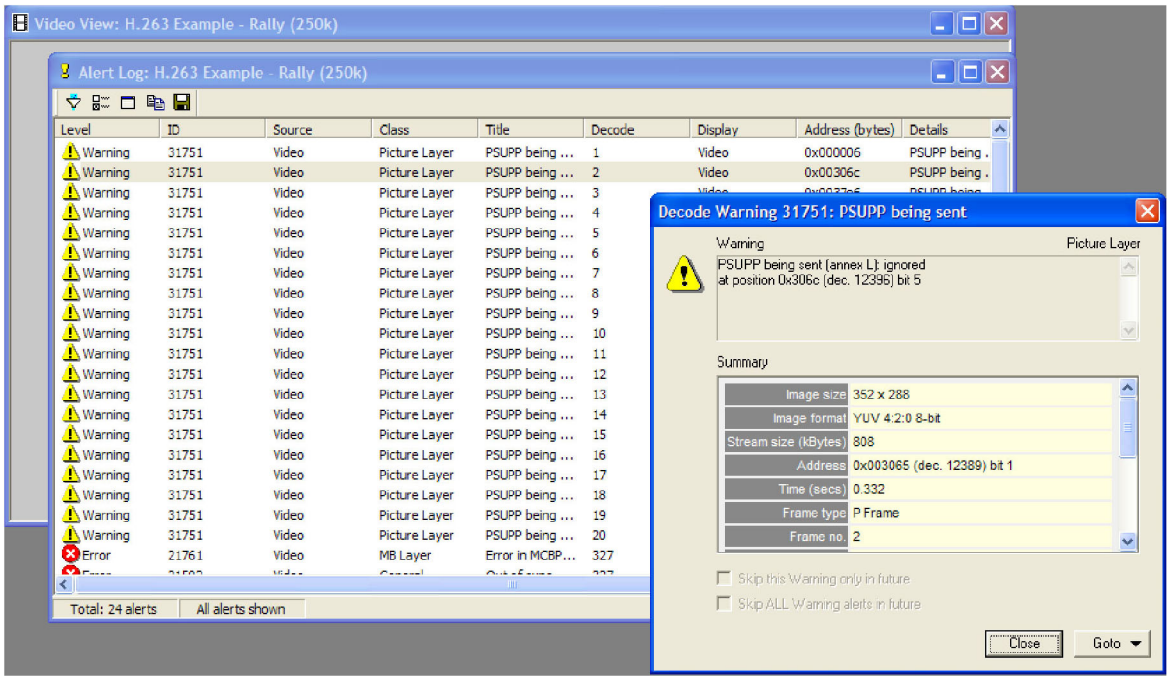

Figure 13: Alert Log and Alert Details

12. Double-click an alert to view the alert details and then click **Close**. View the columns that appear in the alert log and note the column descriptions that follow. (See Figure 14.)
    - **Level** - the severity level for the alert. Levels include **Info**, **Warning**, **Error**, and **Fatal**.
    - **ID** - MTS4EA 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 14: 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. (See Figure 15.)
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.

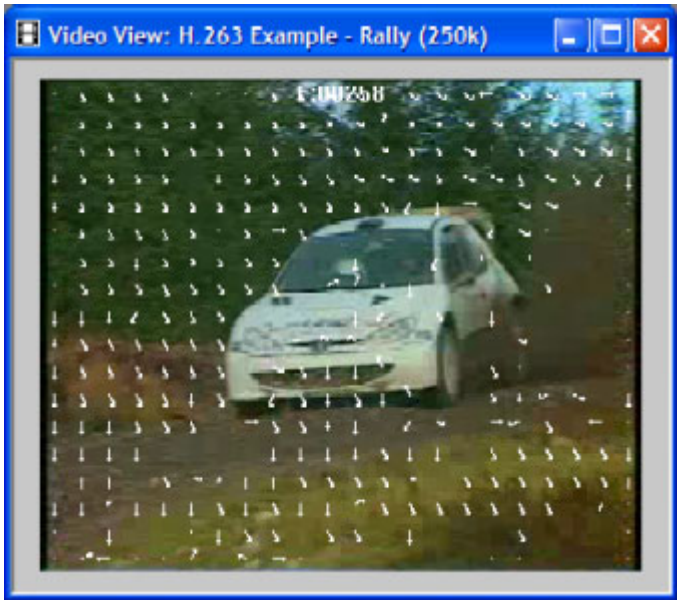

Figure 15: Video image

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 3: 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 will appear. (See Figure 16.)
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 MTS4EA 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**. MTS4EA loads the stream, and the window title changes to **MTS4EA-MPEG4 Example-Space**.
4. Click the icon or type **CTRL** + **P** to resume playing the stream. The same error message will appear. (See Figure 16.)
5. Click **Continue**. A warning message will appear. (See Figure 17.)

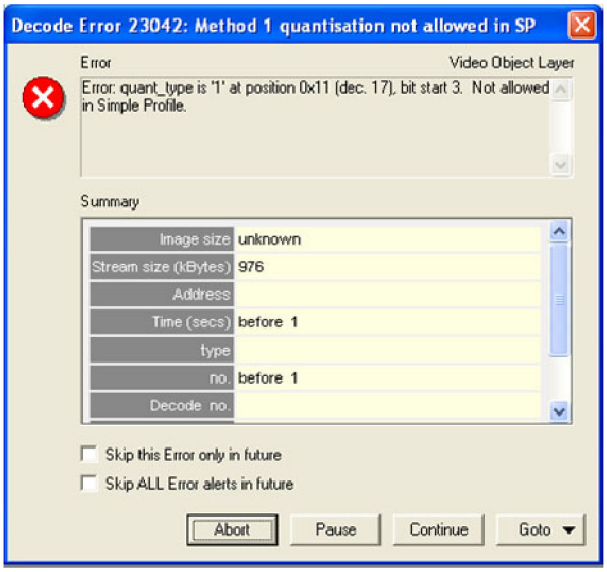

Figure 16: Initial error message

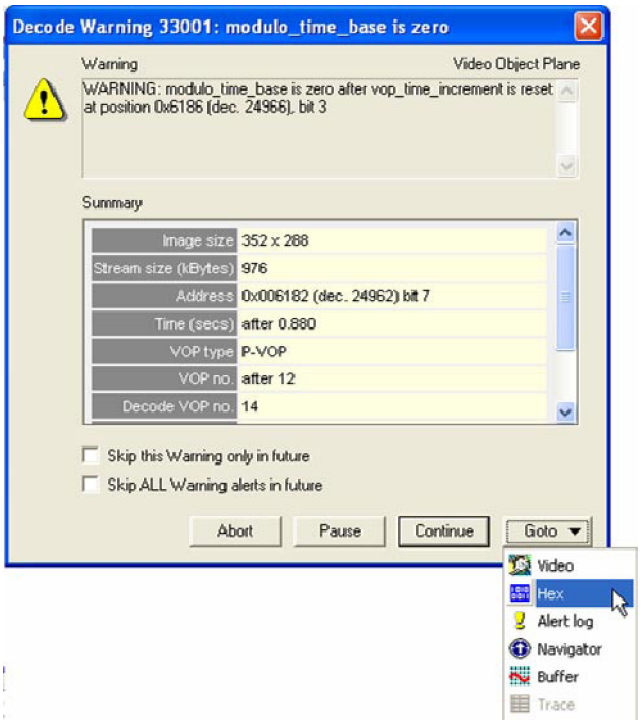

Figure 17: Initial warning message

6. Click **Goto,** and then click **Hex**. (See Figure 17.) The Hex view appears with the error location highlighted. (See Figure 18.)

7. Close the Hex view and again view the initial error shown message. 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. An alert appears again. (See Figure 17.)

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.

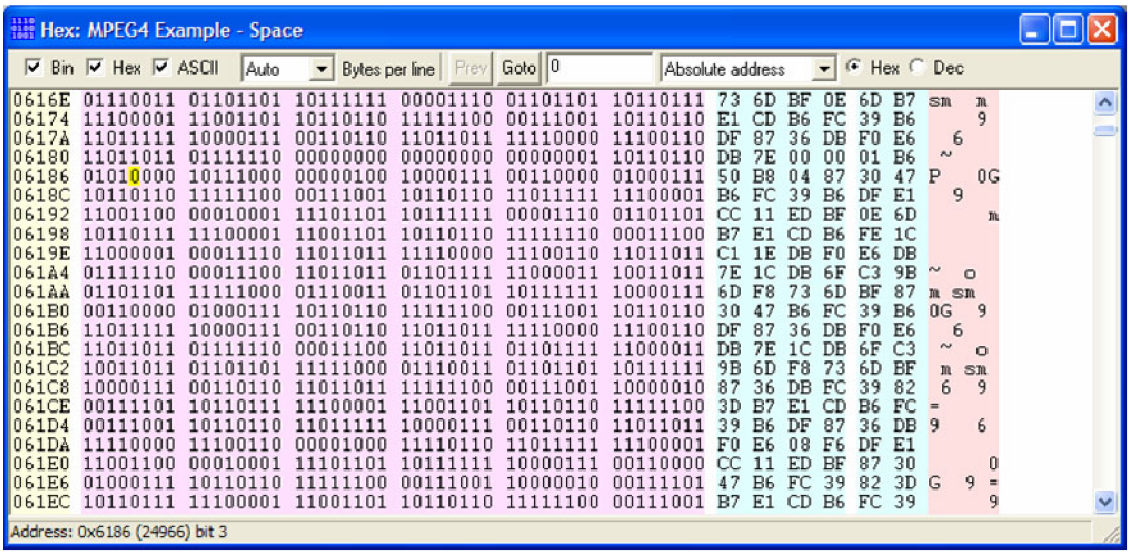

Figure 18: Hex view with error location

11. From the **Overlay** menu, click **Video summary tooltip** to enable the Video Summary tooltip.

12. View the **Final Video Summary Tooltip** and note these field descriptions. (See Figure 19.)

    - 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.

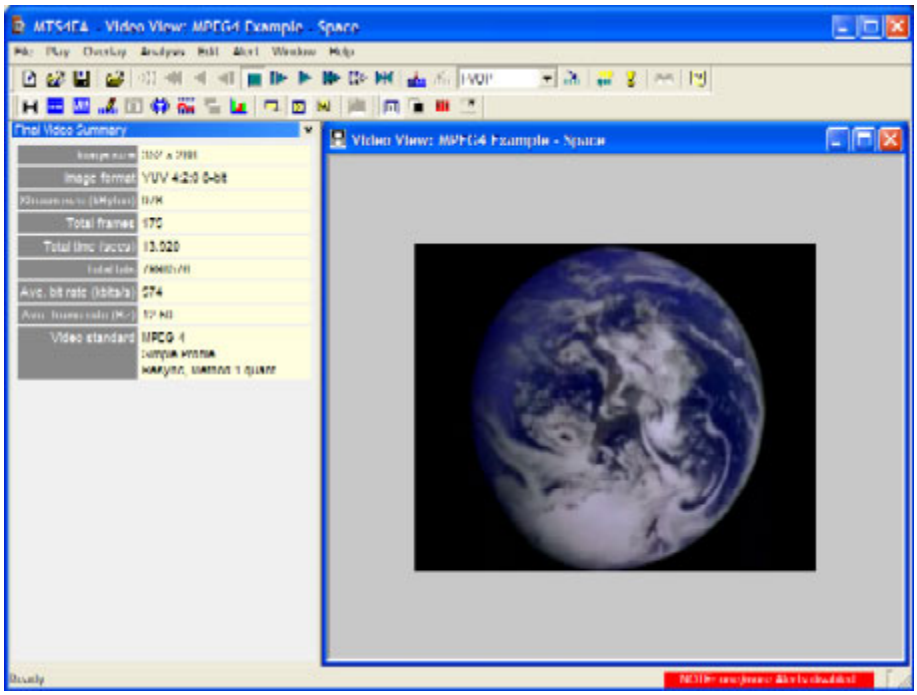

Figure 19: Final video summary tooltip

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. (See Figure 20.)

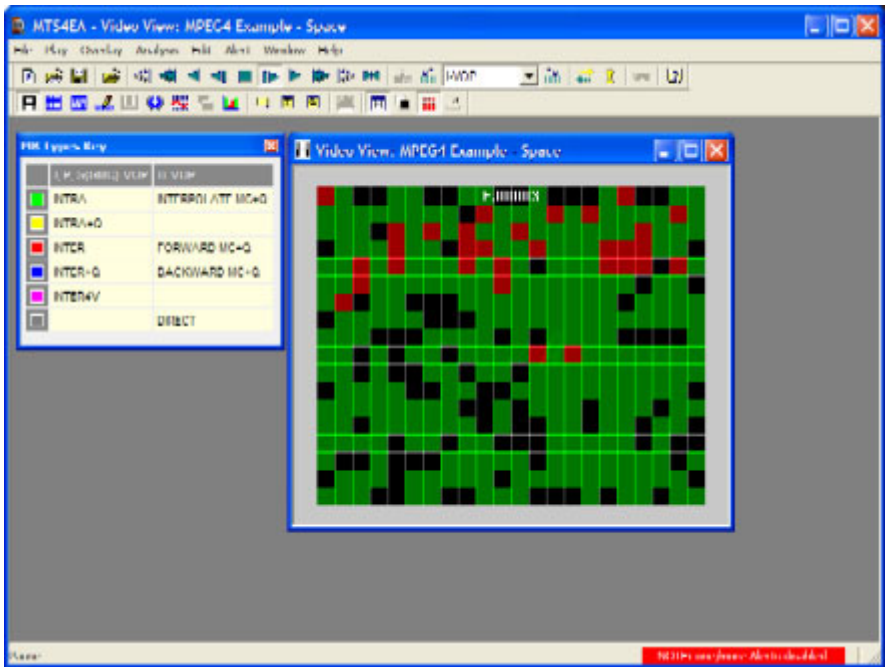

Figure 20: MB Types color key

16. Move forward to frame 34. Note that there are several green (intra) coded MacroBlocks in the static black background (intra coded MBs generally use the most bits). (See Figure 21.)
17. View frames 35, 36 and 37, and observe that the MacroBlocks disappear. (See Figure 22.)
18. Go back to frame 34.
19. From the **Overlay** menu, click **MB Statistics**, and then click **Bits**. Note that the black background uses a high number of bits. (See Figure 23.)
20. View frames 35, 36 and 37, and observe that the background uses progressively fewer bits. (See Figure 24.)
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.

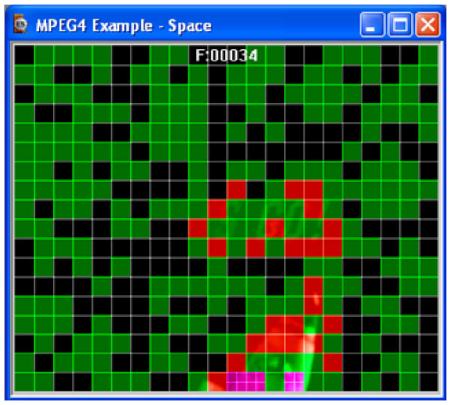

Figure 21: Frame 34, color key

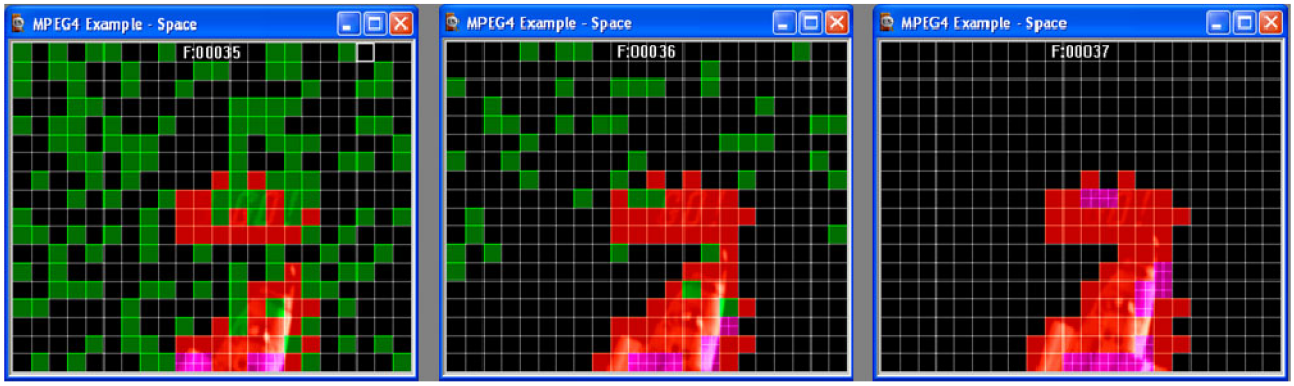

Figure 22: Frames 35, 36, and 37, color key

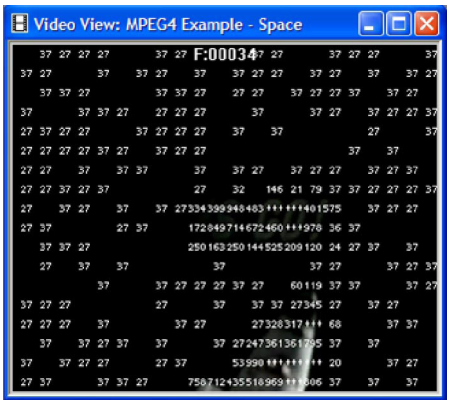

Figure 23: Frame 34

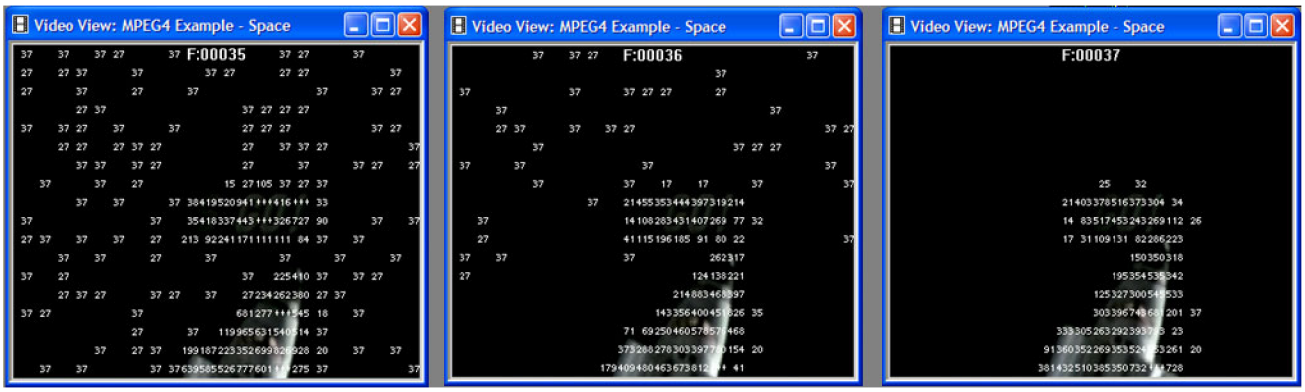

Figure 24: Frames 35, 36 and 37

Conclusion

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 4: MPEG-4 optimization

This tutorial covers the following:

- Use of the video navigator view.
- Use of trace.
- Common error: stuffing bits; using HexView to examine bitstream data.
- Synchronizing views.
- Saving a setup in project files.

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 MacroBlock and Summary tooltips.
- Use the hexview bitstream viewer.
- View Trace files: Parse bitstream and interpret.

Procedure

1. To load the MPEG-4 tutorial, click **File** > **Example files** > **MPEG-4 Elementary streams**> **Window Car**. A **stuffing_bits** error occurs at stream address 0x9, bit 1, when the file is loaded. (See Figure 25.)
2. Check the box next to **Skip this**, and then click **Continue** when the **stuffing_bits** alert appears.

Figure 25: Stuffing_bits alert

3. Play the video to the end. Select **Skip this** and then click **Continue** when the **VCV overflow** alert appears. (See Figure 26.)

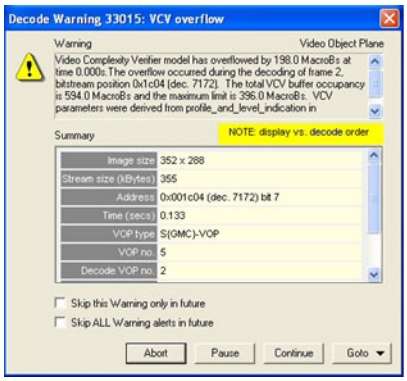

Figure 26: VCV overflow alert

4. Click the Video Navigator icon . The Video Navigator window will appear in either Detail (See Figure 27.) or Thumbnail view. (See Figure 28.)

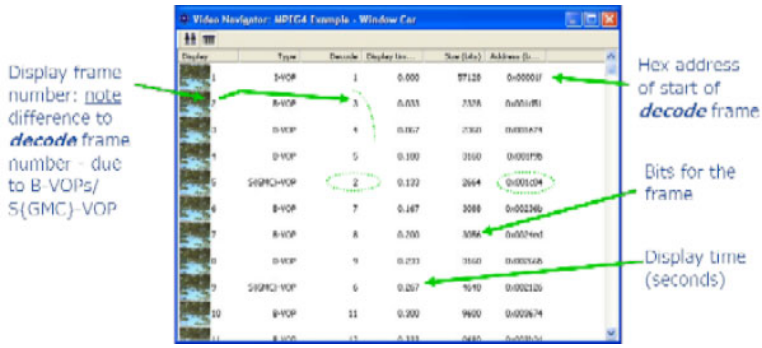

Figure 27: Video Navigator window, detail view

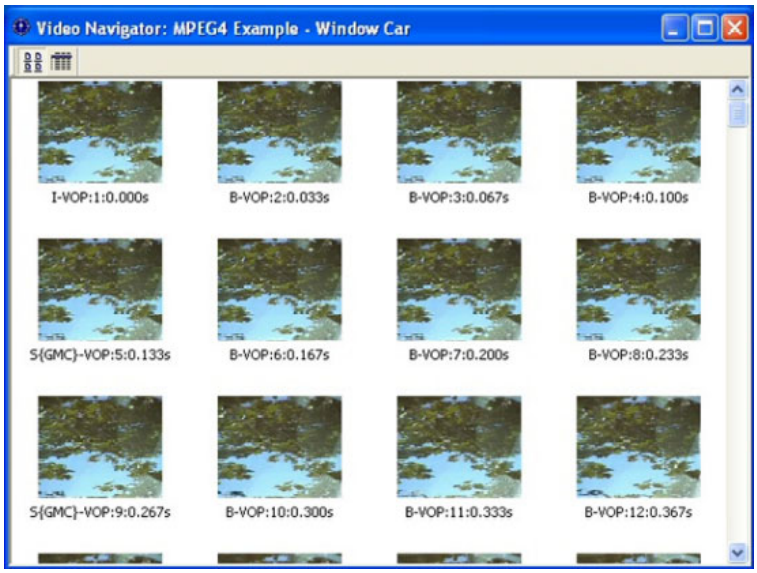

Figure 28: Video Navigator window, thumbnail view

5. To synchronize the video window and the video navigator, start by selecting **Tile Horizontally** on the **Window** menu to view the tiles horizontally. The following views can also be synchronized:

   - Buffer analysis
   - HexView
   - Alert log
   - Fidelity analysis
   - Trace/Parse bitstream and Trace/Interpret

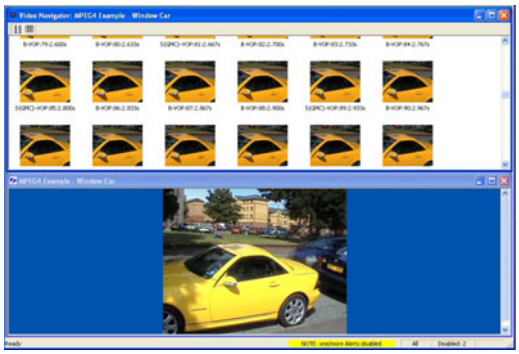

Figure 29: Horizontal view

6. Click the synchronize views icon. (See Figure 30.)

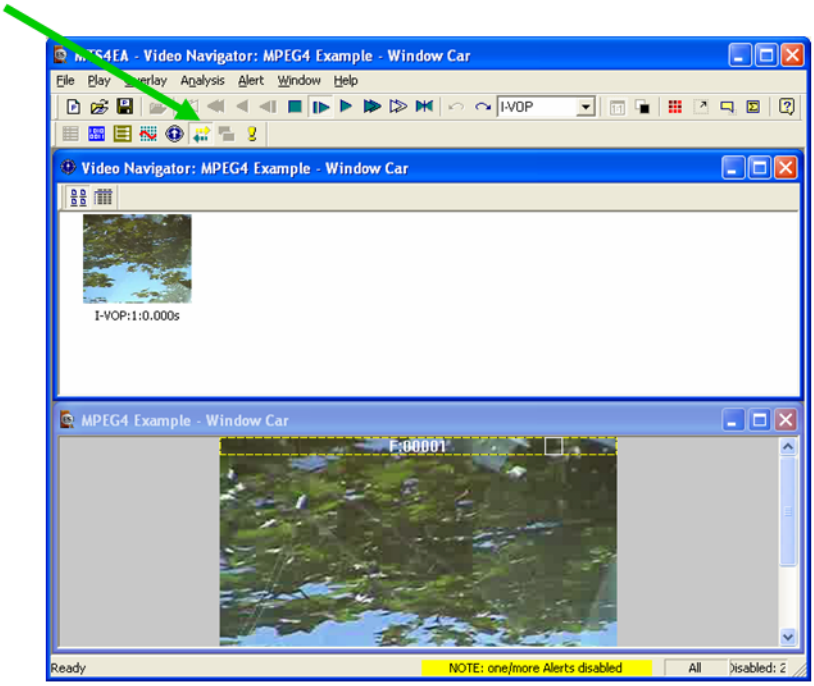

Figure 30: Synchronizing views

7. Play through the entire sequence again. This time, the video navigator and the video views are synchronized.

8. Click the icon at the top left corner of the video navigator window to see the thumbnail view. Each thumbnail is labeled with the frame type, display frame number, and the display time (in seconds). (See Figure 31.)

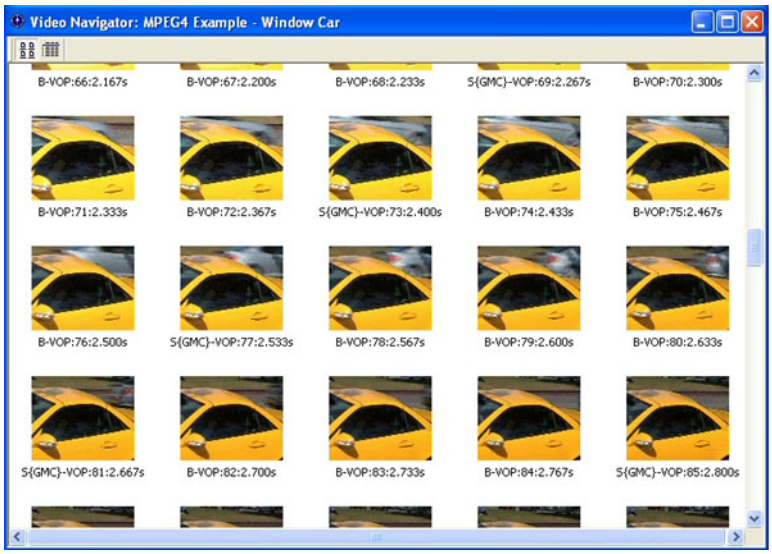

Figure 31: Video Navigator window, thumbnail view

NOTE. *The last frame should now be displayed in the video window.*

9. Double-click on frame 57. Decoding restarts from the beginning and stops at frame 57. (See Figure 32.)

Figure 32: Synced navigator and video window views of frame 57 and frame 51

10. Double-click on frame 51 and note that the view immediately changes and does not start from the beginning again. (See Figure 32.)

NOTE. *MTS4EA has a cache of data, the size of which is selectable in the Play menu under Decoder Options and then the General tab. However, if the video is stopped (for example, played to the end), then the cache must be refilled.*

11. Right-click on any view. Select **Goto view**, and then select **Trace/Interpret** from the drop-down menu. View the Trace files, frames 1–3. An alert will appear. (See Figure 33.)

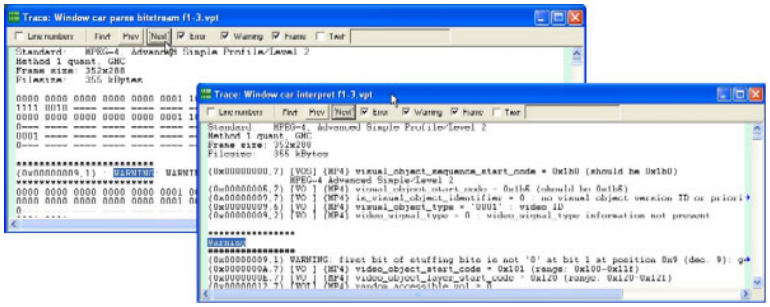

Figure 33: Trace files warning, frames 1–3

NOTE. *Warnings, errors, and fatals are always shown in the Trace/Parse bitstream and Trace/Interpret files, whether or not the pop-up alerts are enabled.*

12. In the Trace/Interpret window, select the address 0x00000009,1 and right-click. Select **Goto view** and then **Hex**. The HexView will open with the selected location highlighted. MTS4EA shows exactly where the problem is: bits 1 and 0 of byte 9 are both 1, but for stuffing bits, they should be 01. (See Figure 34.)

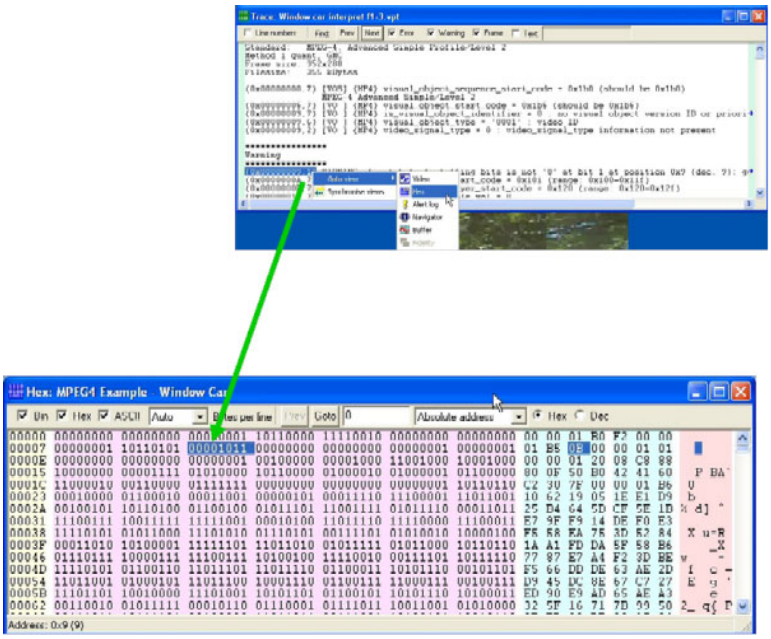

Figure 34: Selecting Hex from the Trace window

13. View the HewView window and its information. You can search for items using "." as a wildcard character. For example, you can enter the start code 0001b. to find 0001b1, 0001b5, and 0001b6. (See Figure 35.)

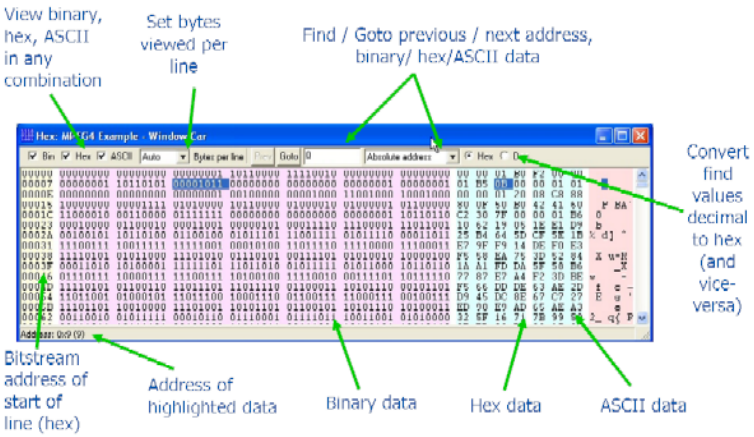

Figure 35: HexView window

14. Save your setup by clicking **File** and then selecting **Save project**. You can change the filename. (See Figure 36.)

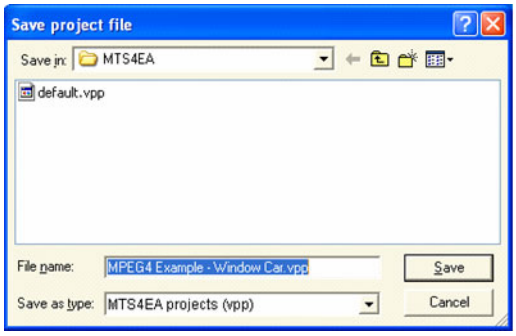

Figure 36: Saving a project file

15. Close MTS4EA completely.
16. Restart MTS4EA.
17. Select the project file that you saved previously from the **File** drop-down menu. An alert will pop up when the video file is loaded. Dismiss it by selecting **Skip this** and **Continue**. (See Figure 37.)

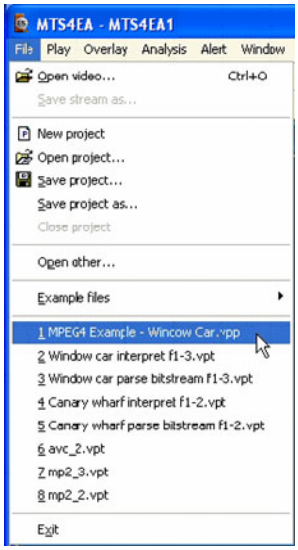

Figure 37: Opening the project file

Conclusion

This tutorial demonstrated how to:

- View different video data and navigate between different views.
- Store setups.
- Identify stuffed bit errors.

Tutorial 5: 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. (See Figure 38.)
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. (See Figure 39.)
4. View the error message details: (See Figure 39.)
   - 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.

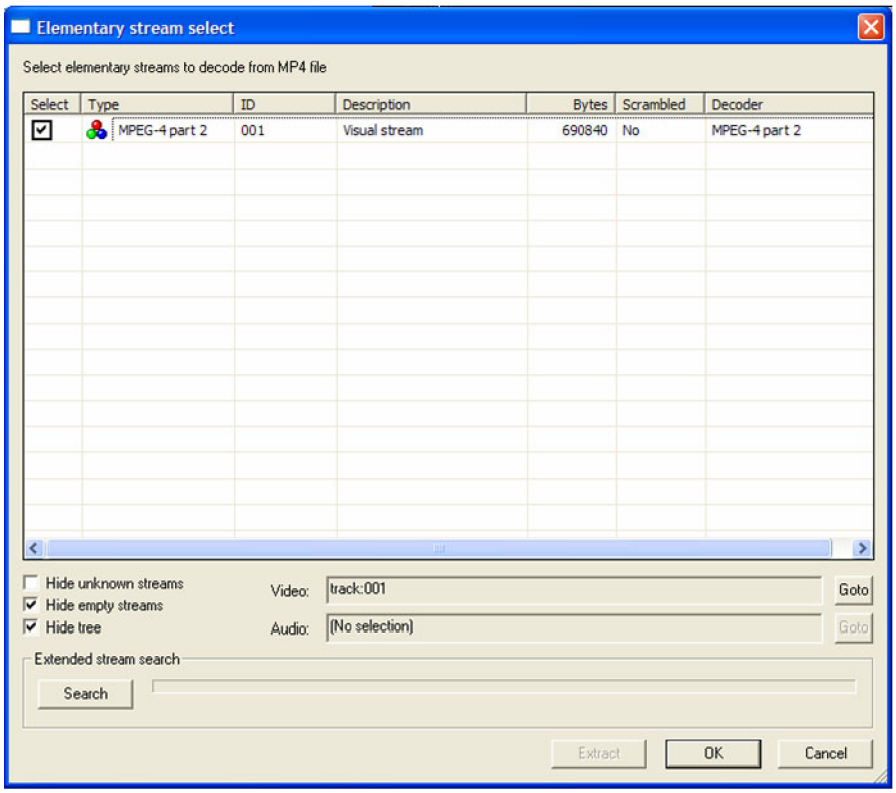

Figure 38: Track list

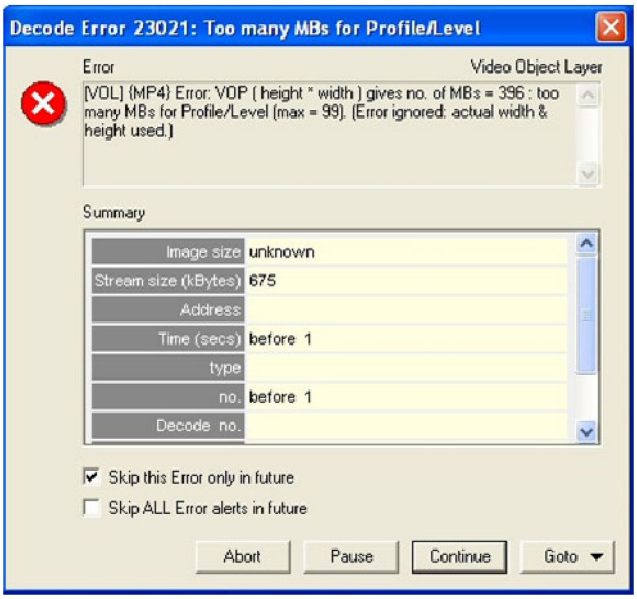

Figure 39: Initial error message

5. Select **Skip this Error only in the future**, and then click **Continue**. MTS4EA will continue, by using the actual size. A buffer conformance warning message appears. (See Figure 40.)

6. View the warning message details: (See Figure 40.)

   - 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).

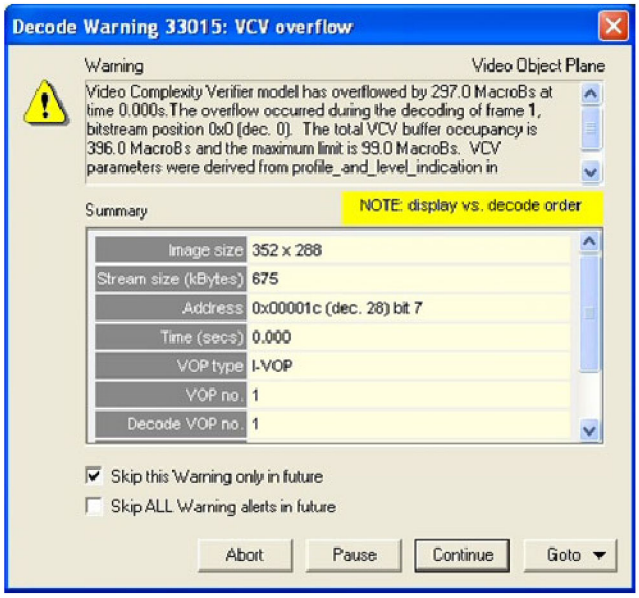

Figure 40: VCV overflow warning message

7. Select **Skip this Warning only in the future**, and then click **Continue**. Another buffer conformance warning message appears. (See Figure 41.)

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. (See Figure 42.)

11. View the top-level atoms in the MP4 file. Click the + next to each atom to view the data for the atom.

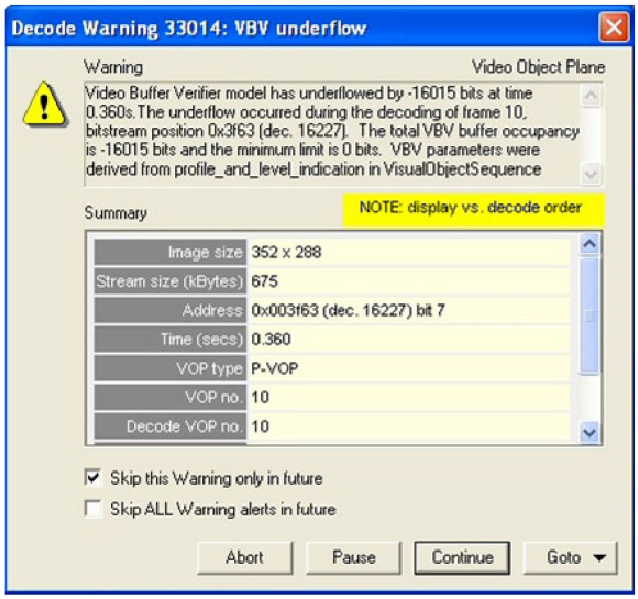

Figure 41: VBV underflow warning

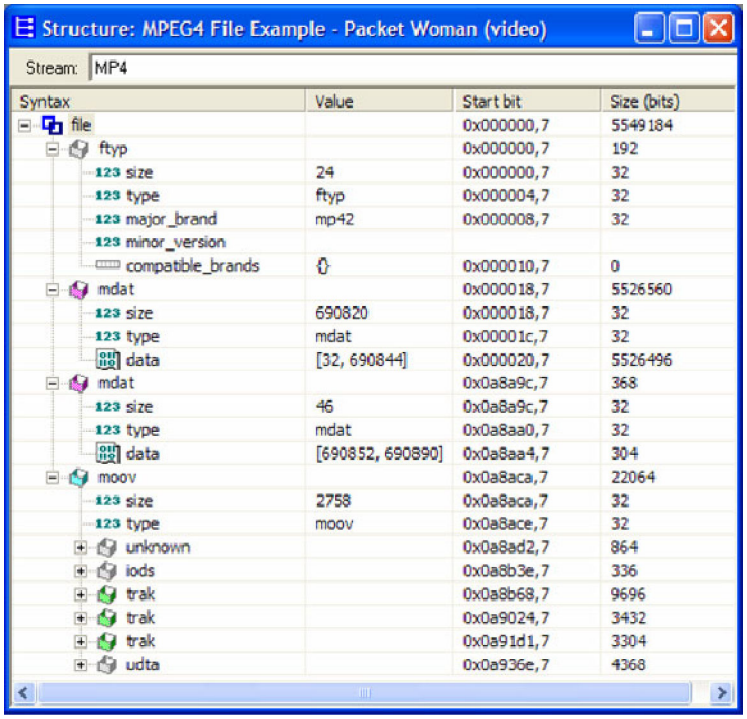

Figure 42: Structure window

12. From the **File** menu, click **Close stream**, and then reopen the stream.
13. When the track list appears, click **Extract**. (See Figure 43.) The **Save stream file as** dialog box appears. (See Figure 44.)

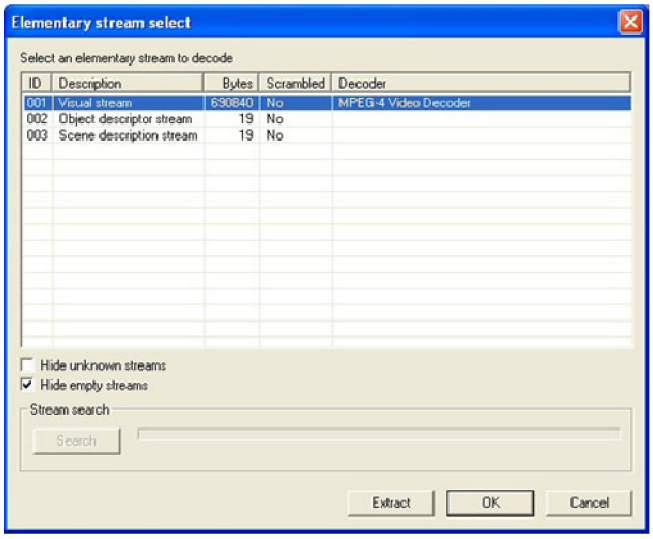

Figure 43: Track list

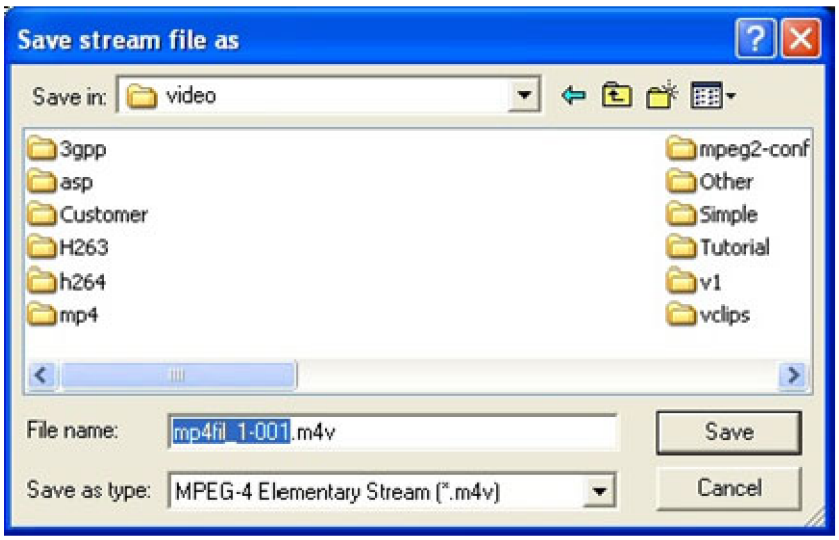

Figure 44: Save stream file as dialog box

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 6: 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. (See Figure 45.)
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. (See Figure 46.)

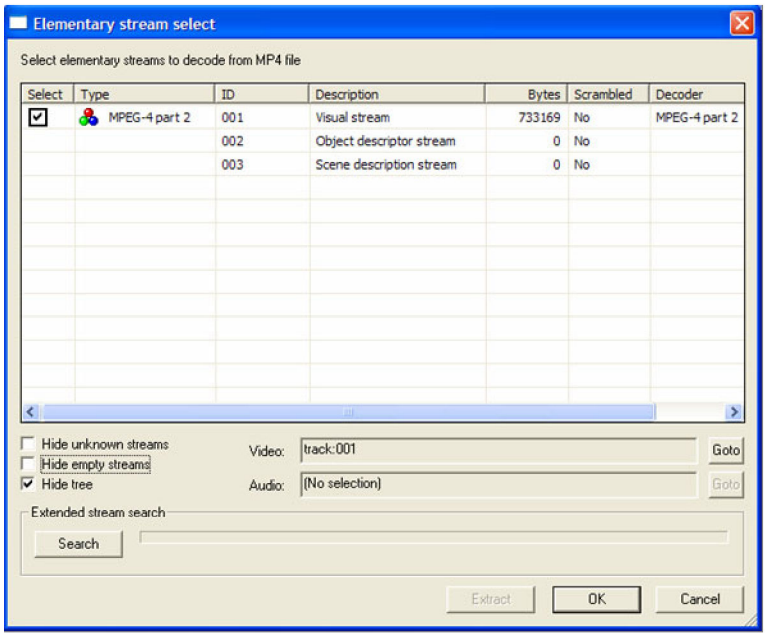

Figure 45: Track list

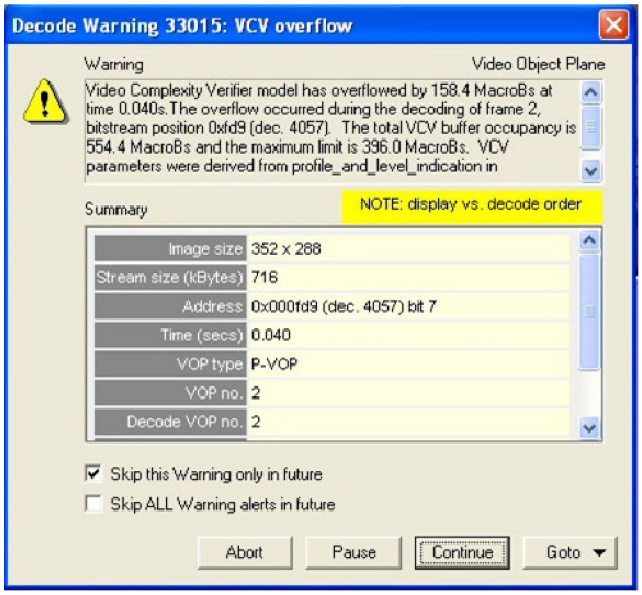

Figure 46: VCV buffer conformance warning message

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). (See Figure 47.) Another buffer conformance warning message appears. (See Figure 48.)

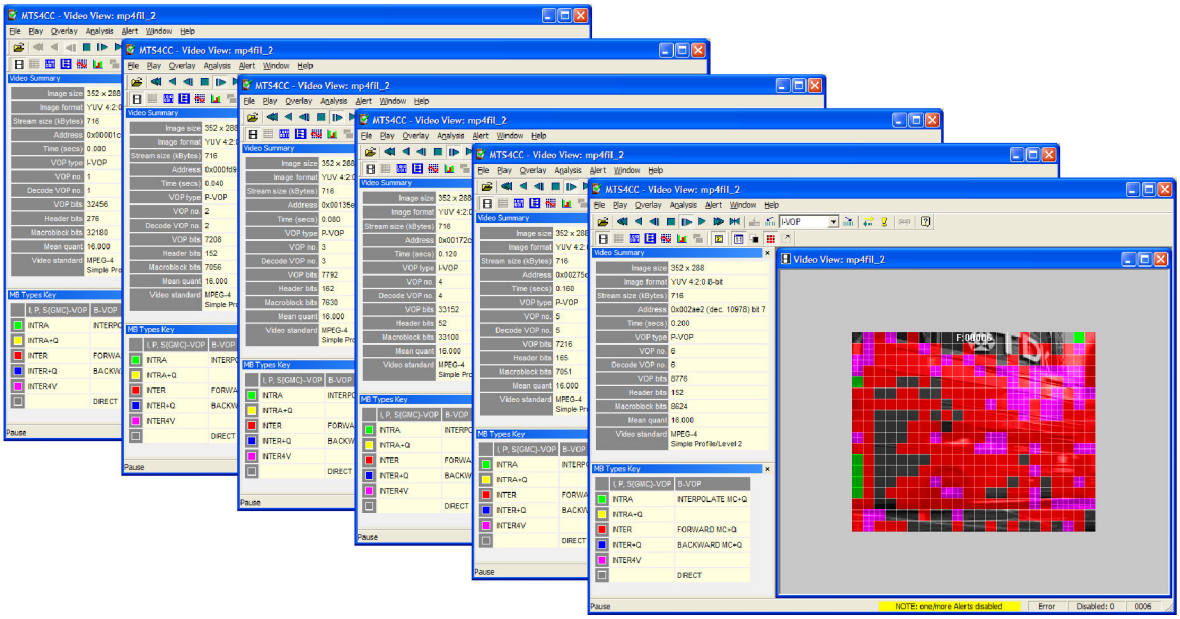

Figure 47: Progression of frames

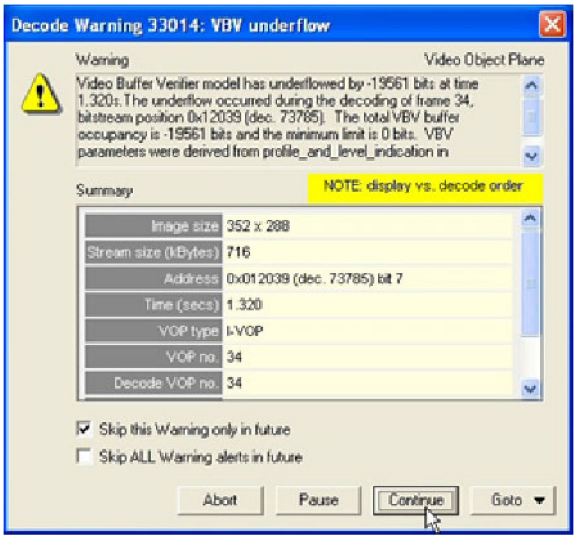

Figure 48: VBV underflow warning

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. (See Figure 49.)

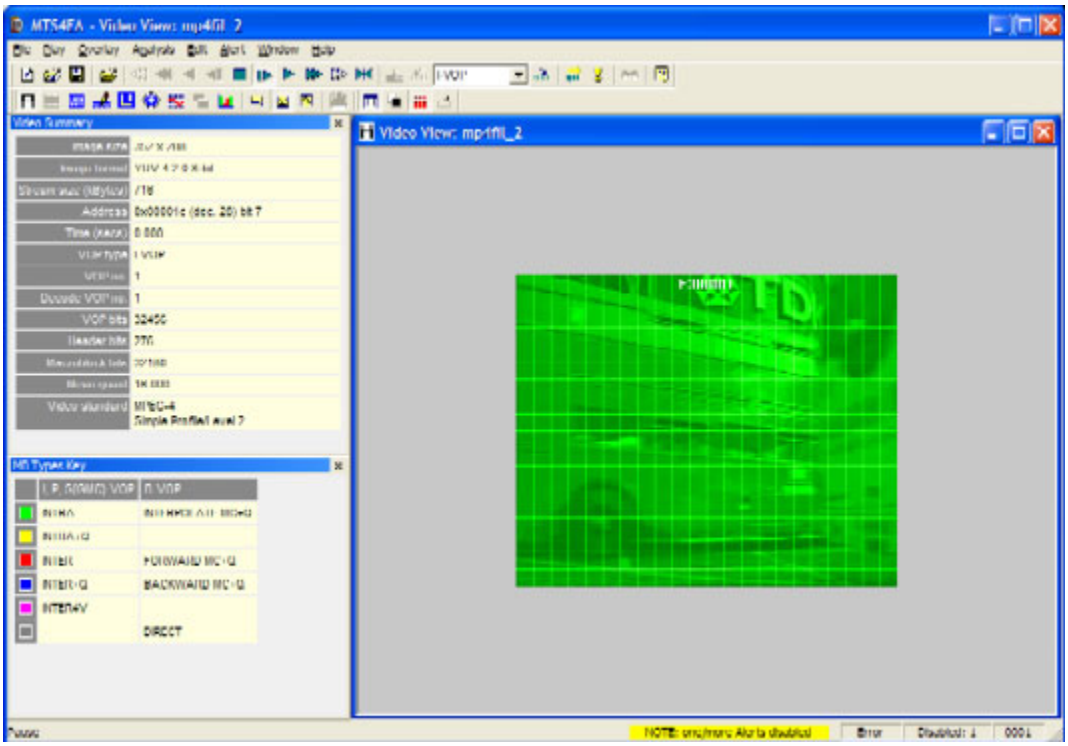

Figure 49: Frame 1

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. (See Figure 50.)
15. For each frame, view the details, which are outlined in Table 3.

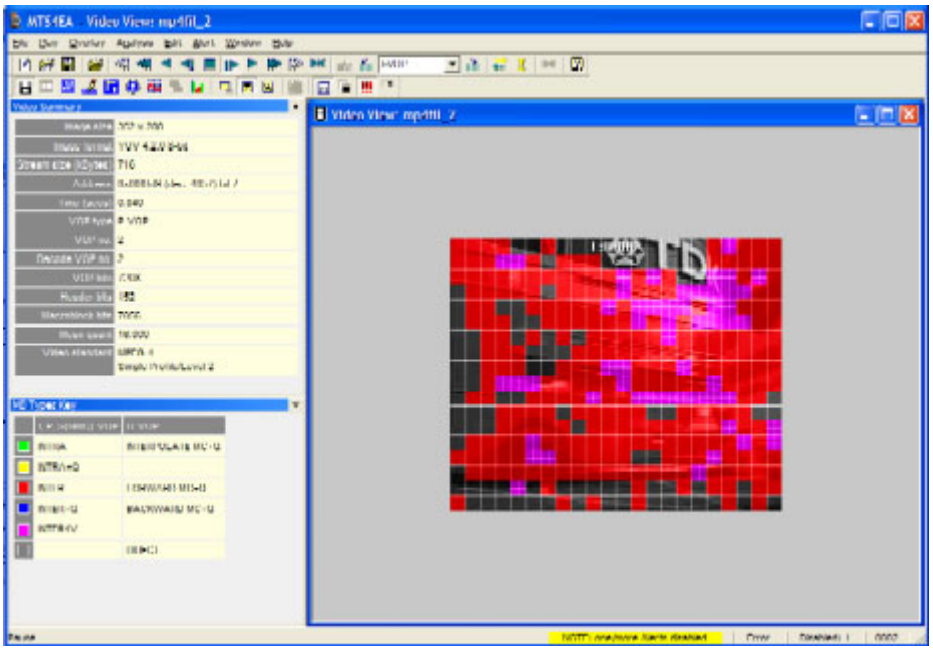

Figure 50: Frame 2

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 7: 3GPP/MPEG-4 compliance

This tutorial covers the following:

- Opening a 3GPP file and viewing the tracks.
- Viewing syntax errors using reserved Profile/Level indication.
- Performing optimization checks that may or may not be applicable in a wireless environment.

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 3GPP tutorial, click **File** > **Example files** > **3GPP File** > **Mobile Hands**. A list of tracks included in the 3GPP appears in a dialog box. The first video track is automatically selected. (See Figure 51.)

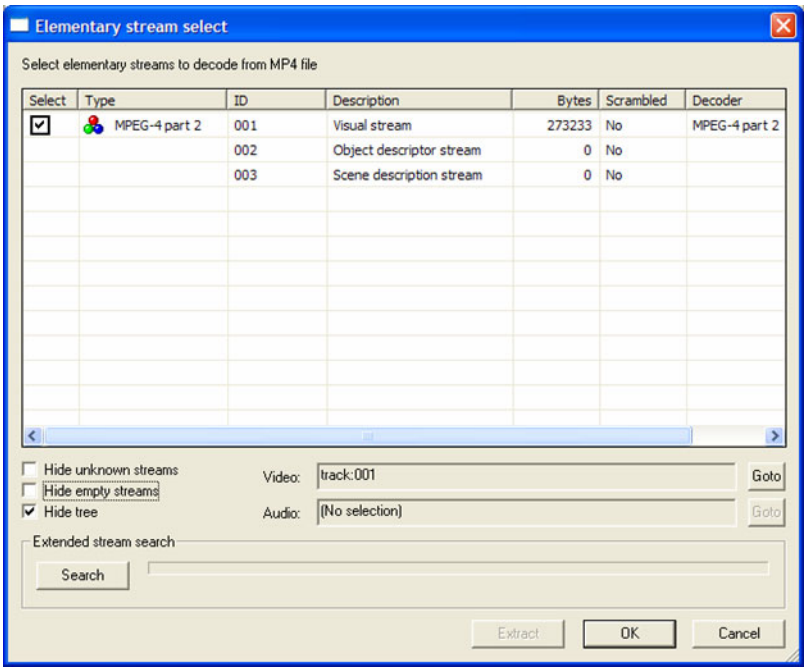

Figure 51: 3GPP track list

2. Click **OK**.
3. An alert will appear for a syntax error. This error shows as a reserved value (0) for **profile_and_level_indication**. (See Figure 52.)
4. Click **Continue** and do not enable Skip.

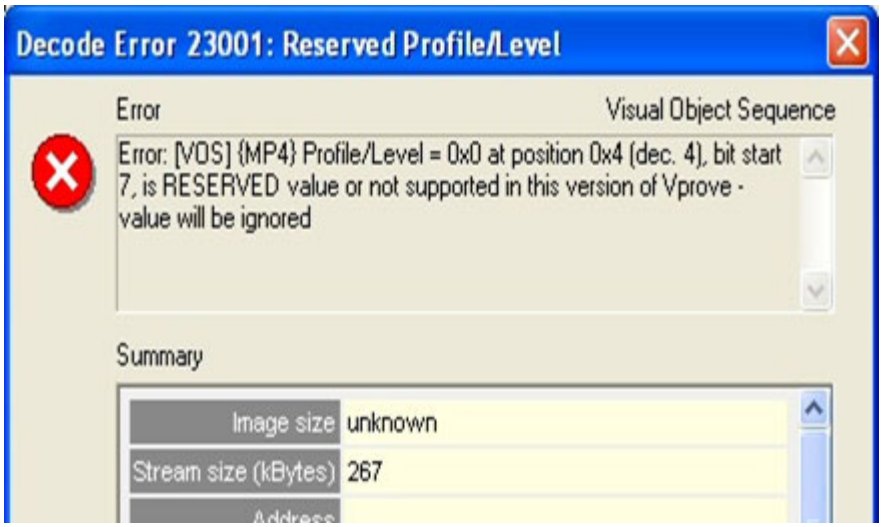

Figure 52: Syntax error alert

5. Run Trace/Interpret (frame 1) and look at the error at address 4, bit 7. (See Figure 53.)

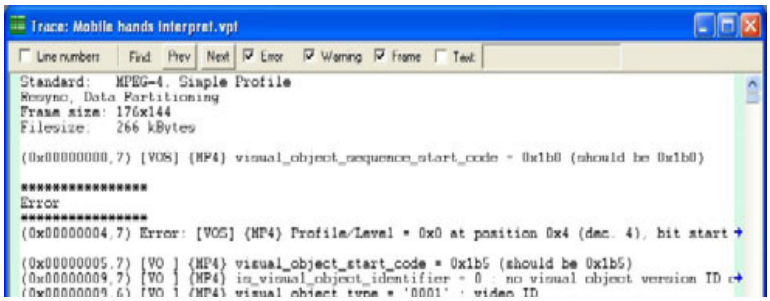

Figure 53: Trace/Interpret error at address 4, bit 7

6. Play the video again and at the error, click **Goto** and then select **Hex** from the drop-down menu. (See Figure 54.)

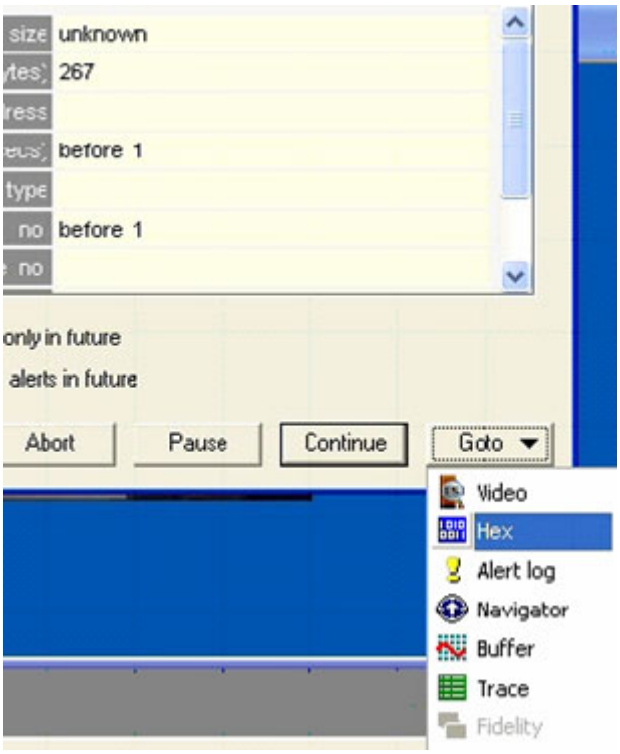

Figure 54: Selecting Hex from the Goto drop down menu

7. The HexView window will appear with the location of the error bits highlighted. (See Figure 55.)

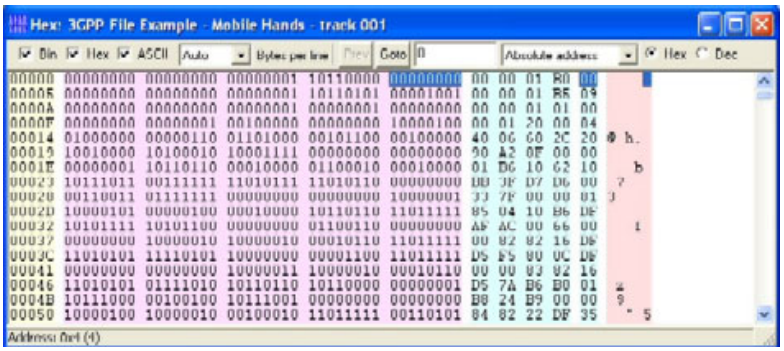

Figure 55: HexView window with error locations highlighted

8. To look at the VOP types, first stop the stream if it is playing.
9. Click the Summary tooltip icon to turn on the tooltip.
10. Click the MB Types Overlay icon to turn on the overlay.
11. **Play** or **Pause/Step** forward through the sequence to the end. Notice that the first frame and every second frame are Intra-MBs. (See Figure 56.)

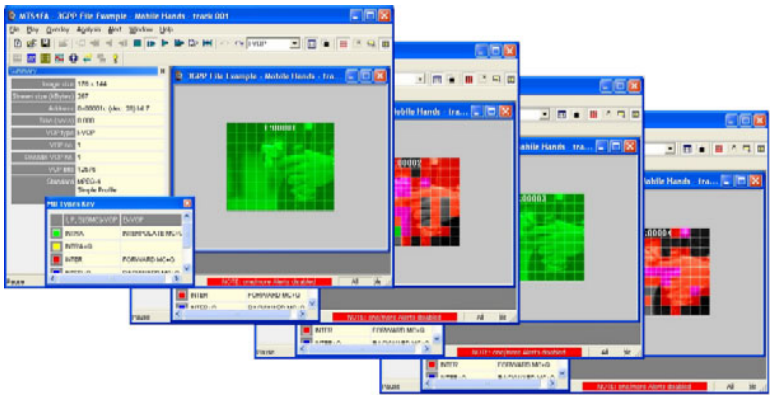

Figure 56: Viewing VOP types

12. Now examine the error resilience by clicking the Summary tooltip icon to turn the tooltip on again, if it is not already on.

13. Click the Pause/Step Forward icon to move to frame 1.

14. Notice in the Summary window that **resync markers** and **data partitioning** are both on. This is vital for good error resilience in a mobile environment. (See Figure 57.)

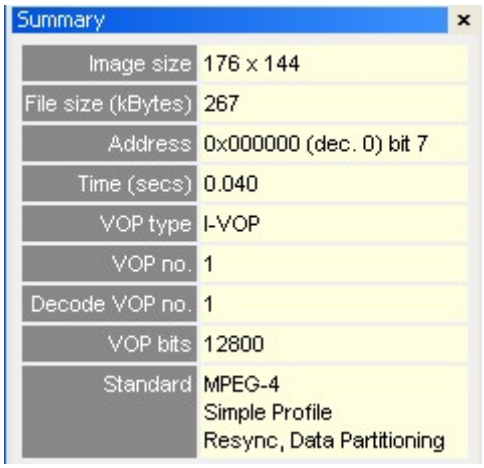

Figure 57: Summary window data

Conclusion

This tutorial demonstrated the following:

- Using the Summary tooltip allows you to look at VOP types.
- Reducing the frequency of I-VOPs can allow for better quality video in the same bit-rate.
- With error resilience tools in use, the frequency of I-VOPs can be reduced, reducing the bit-rate by approximately 15%.

Tutorial 8: H.264/AVC syntax error

This tutorial covers the following:

- Opening an H.264/AVC byte stream.
- Syntax error in PPS
- Finding the frame number of the error.
- Examining the byte stream syntax and finding the error using Trace/Parse bitstream and Trace/Interpret.

Procedure

1. To load the tutorial, click **File** > **Example files** > **H.264/AVC Byte Streams**> **Canary Wharf**.
2. An incorrect **direct_8x8_inference_flag** error will occur at address 0x0, bit 7, when the file is loaded. (See Figure 58.)

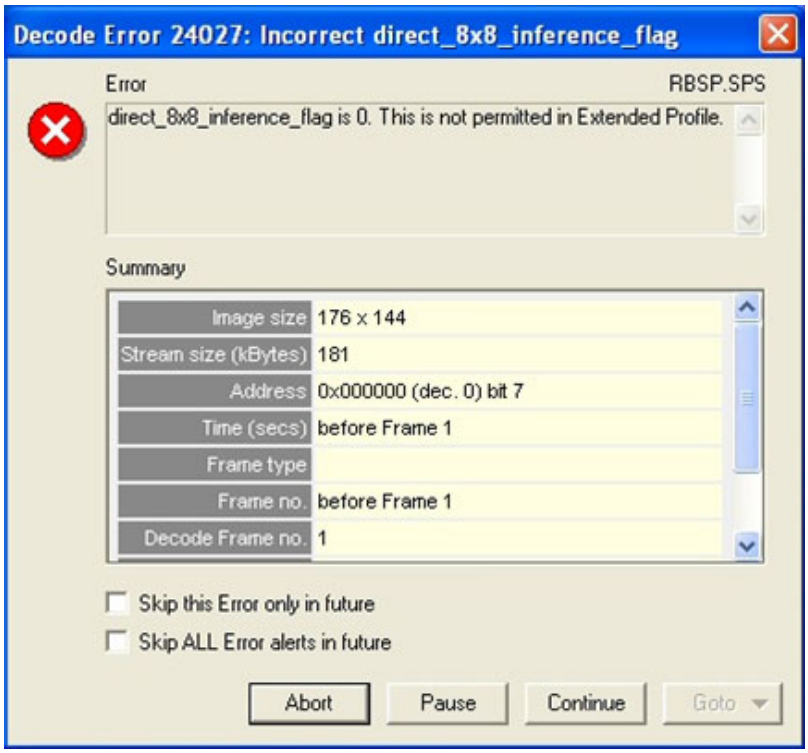

Figure 58: Direct_8x8_inference_flag error alert

3. Notice that the syntax error occurs before frame 1. This is the displayed frame number. Check the **Skip this** box and then click **Continue**. (See Figure 58.)

4. An invalid Picture Parameter Set ID error will occur during the decode of frame 1. Use the scroll bar to view all of the information in the error dialog box. (See Figure 59.)

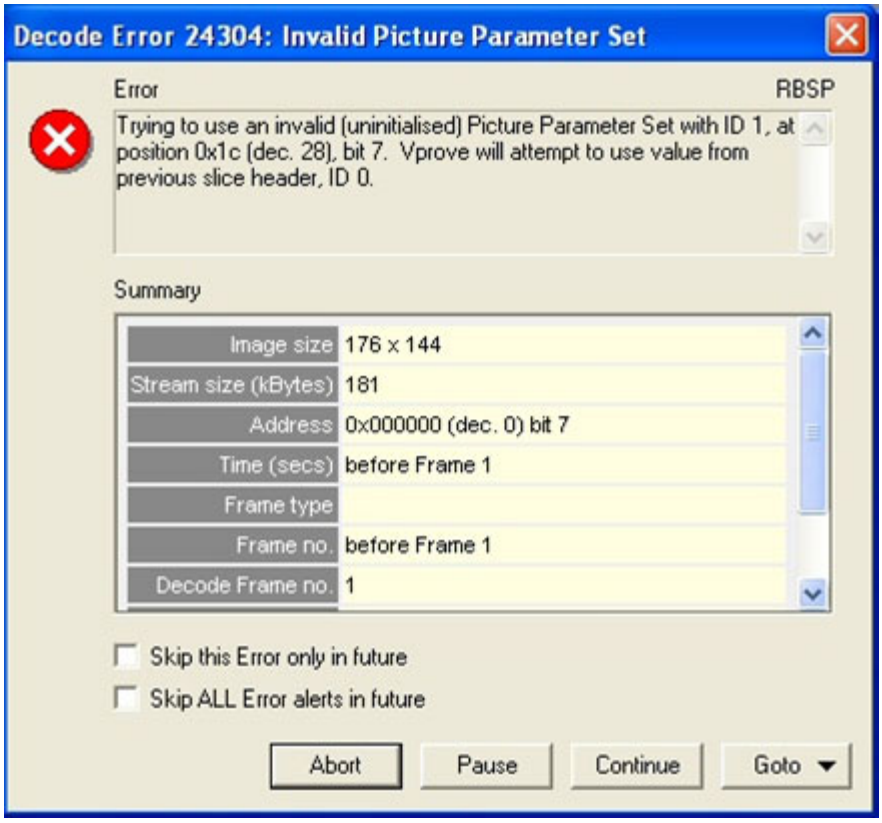

Figure 59: Invalid Picture Parameter Set ID error

5. Click on **Analysis** in the menu. Select **Trace enable** and then select **Frame range** from the drop-down menu.

6. Set the frame range from 1 to 2. This will run the Trace/Interpret and Trace/Parse bitstream on frames 1 and 2.

7. View the Trace file and clear the **Frame** box. Click **Find Next** three times. An error alert will appear. (See Figure 60.)

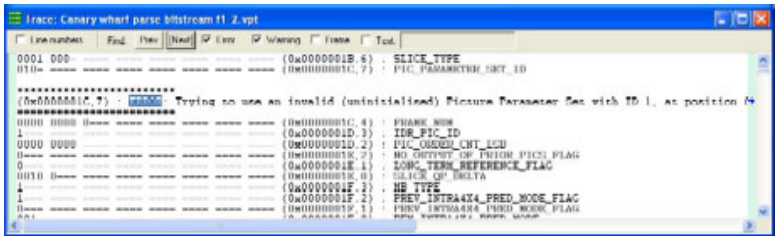

Figure 60: Trace/Parse bitstream error

8. View the Trace/Interpret for the same range. Clear the **Frame** box and click **Find Next** twice. An error alert will appear. (See Figure 61.)

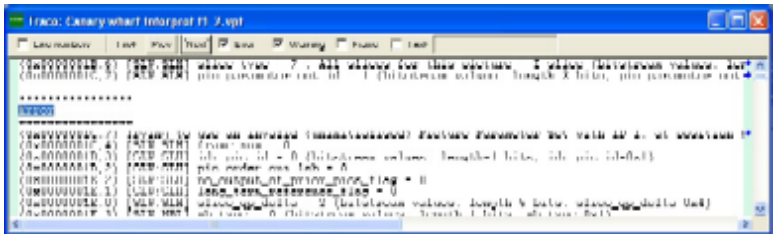

Figure 61: Trace/Interpret error alert

9. To determine if the **pic_parameter_set_id** number 1 has been set, search for it in the Trace/Interpret file that is already open (frames 1 and 2).

10. Select the **Text** box in the Trace/Interpret window and type **pic_parameter_set_id=** in the text box.

11. Click Find **Prev** to search for an occurrence of **pic_parameter_set_id** before the error. Note that it does not occur before the location of the PPS ID error (at 0x1c, 7). (See Figure 62.)

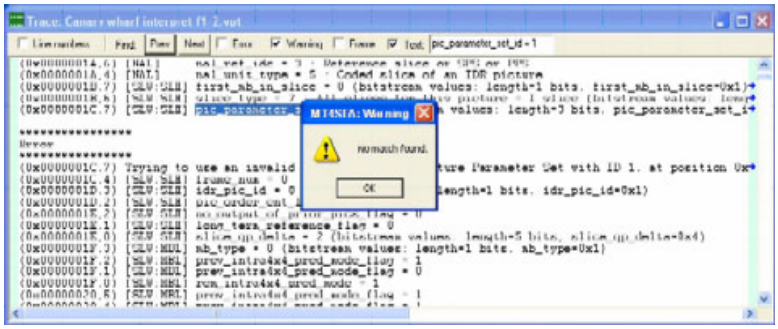

Figure 62: Pic_parameter_set_id error location search

Conclusion

This tutorial demonstrated the following:

- The pic_parameter_set_id=1 did not occur before the slice header tried to use this in frame 1, and therefore caused an error.
- It is an error to set the PPS ID to 1 at stream address 0x1c, bit 7.

- With this error, the MTS4EA decoder uses the data from the last known good pic_parameter_Set_id (ID 0) and continues decoding.

NOTE. *This may not always be possible and could generate other consequential errors.*

- THE MTS4EA showed what the error was and where it occurred.

Tutorial 9: 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).

The following table provides the functions of each Buffer Analysis toolbar icon. (See Table 4.)

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.

Table 4: Buffer analysis icons (cont.)

Icon	Function
	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. (See Figure 63.)
3. View the buffer analysis graph example, as well as the descriptions in the table. (See Table 5.)

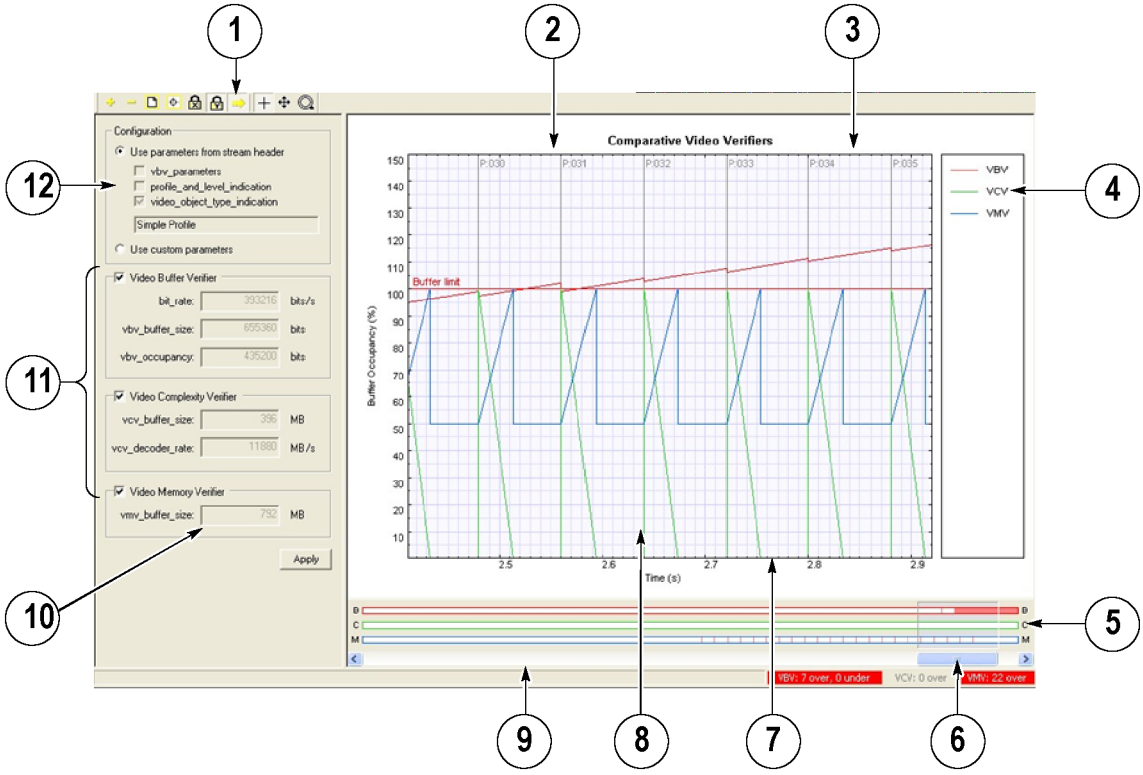

Figure 63: Buffer analysis window, example graph

Table 5: Buffer analysis descriptions

Area	Description
1	Graph window control toolbar.
2	Frame type, number.
3	Graph window.
4	List of analyses for VBV, 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 VBV, VCV, VMV graphs.
12	Source of buffer analysis values.

4. Observe the VBV, VCV and VMV values that appear beside the graph. (See Figure 64.) 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**.

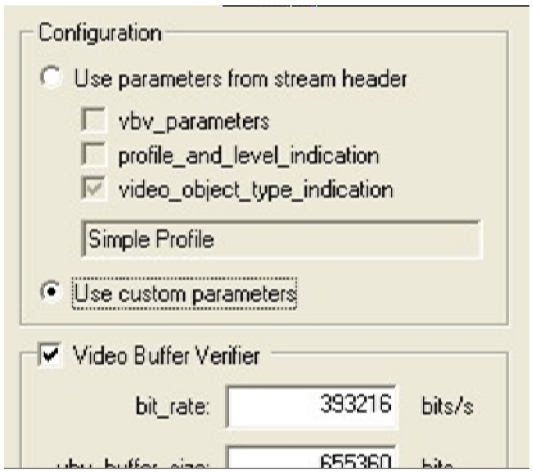

Figure 64: VBV, VCV and VMV values

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. (See Figure 65.)
8. Click the **Fast forward** icon . A warning message occurs. (See Figure 66.)
9. Note that the VBV overflow occured while decoding frame 55 (the display frame number is 54).

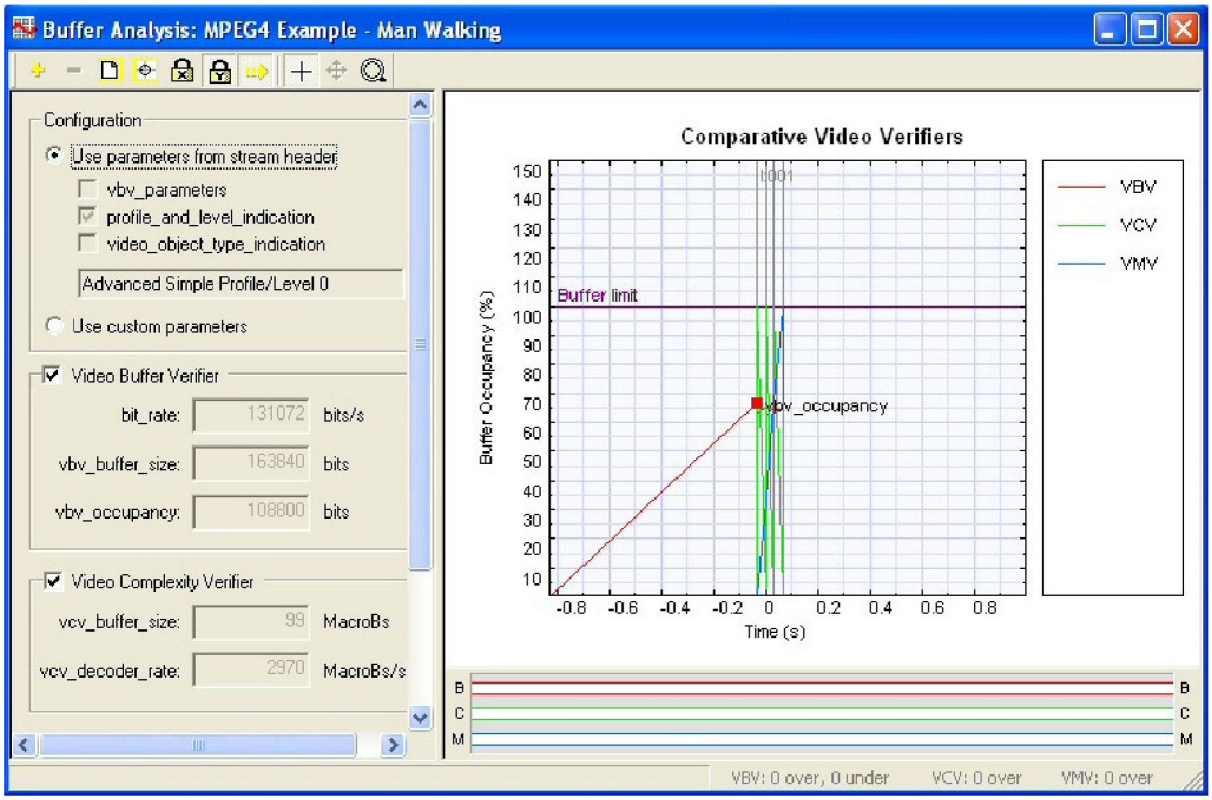

Figure 65: Buffer analysis graph, detailed view

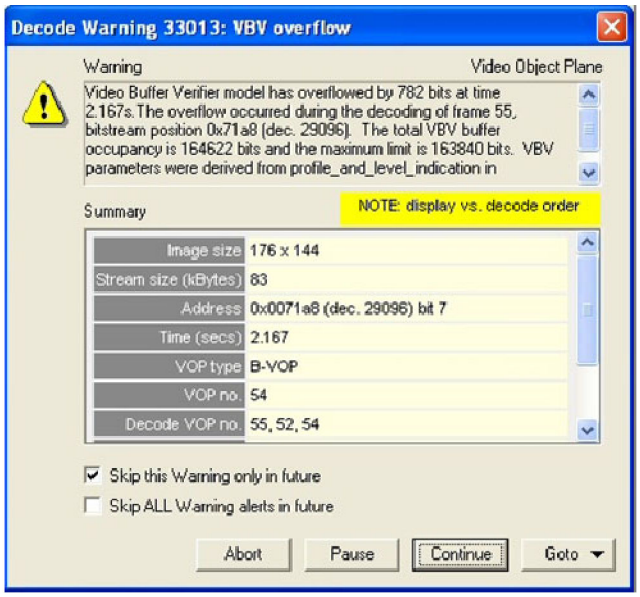

Figure 66: VBV overflow warning

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. (See Figure 67.)

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.

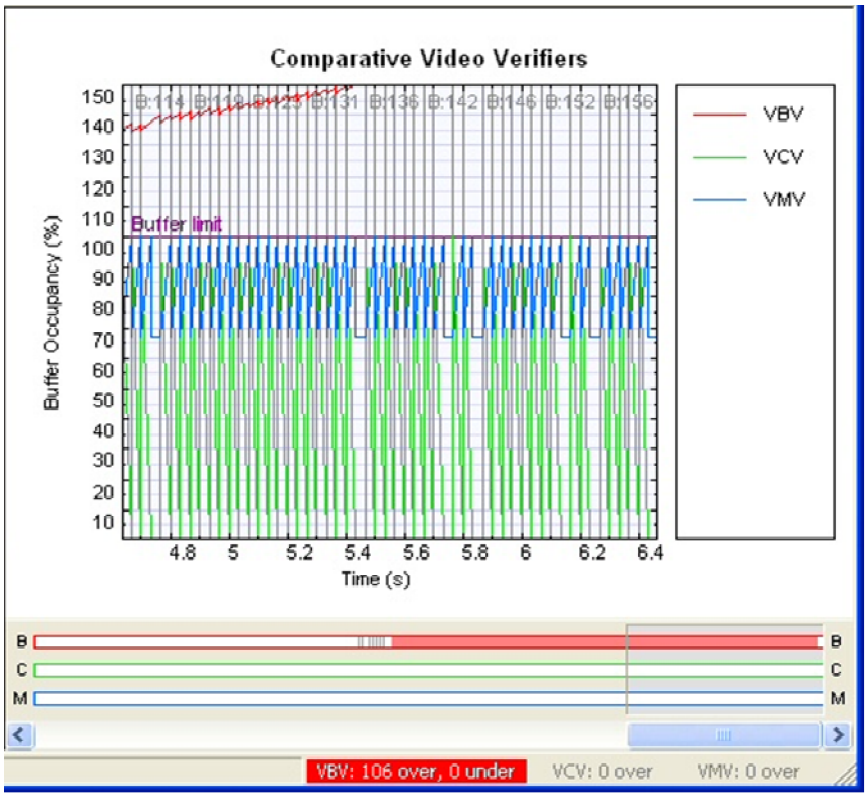

Figure 67: Buffer limit graph

13. To fit the graph to the window, click the icon on the **Buffer Analysis** toolbar. The red line displays the VBV overflow. (See Figure 68.)

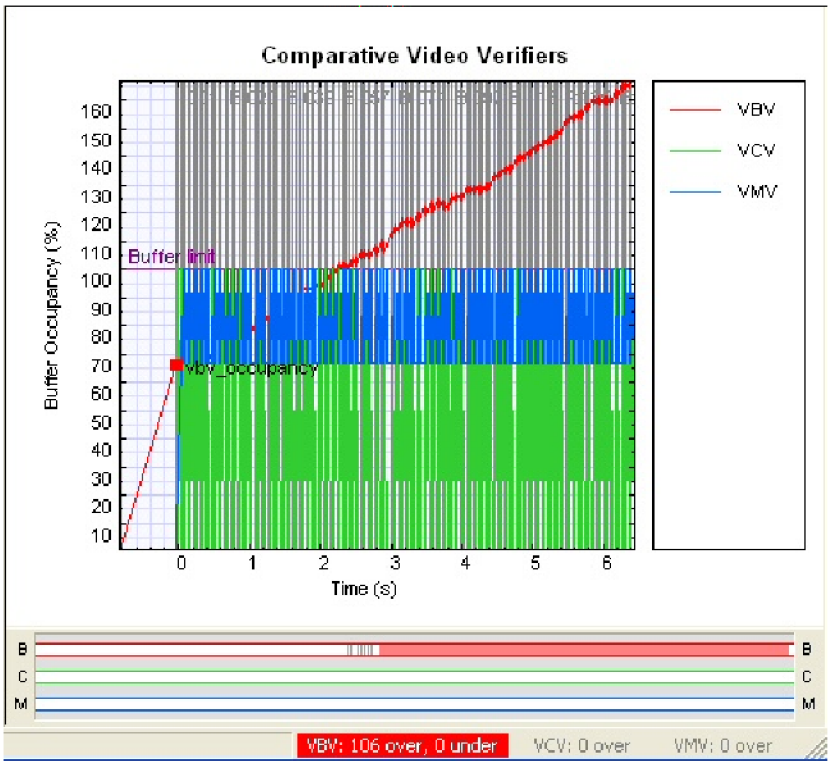

Figure 68: Comparative video verifier graph

14. Consider the information presented by the graph. The standard values used for a frame result in a VBV 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 vbv_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 vbv_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 %. (See Figure 69.)

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. (See Figure 70.)

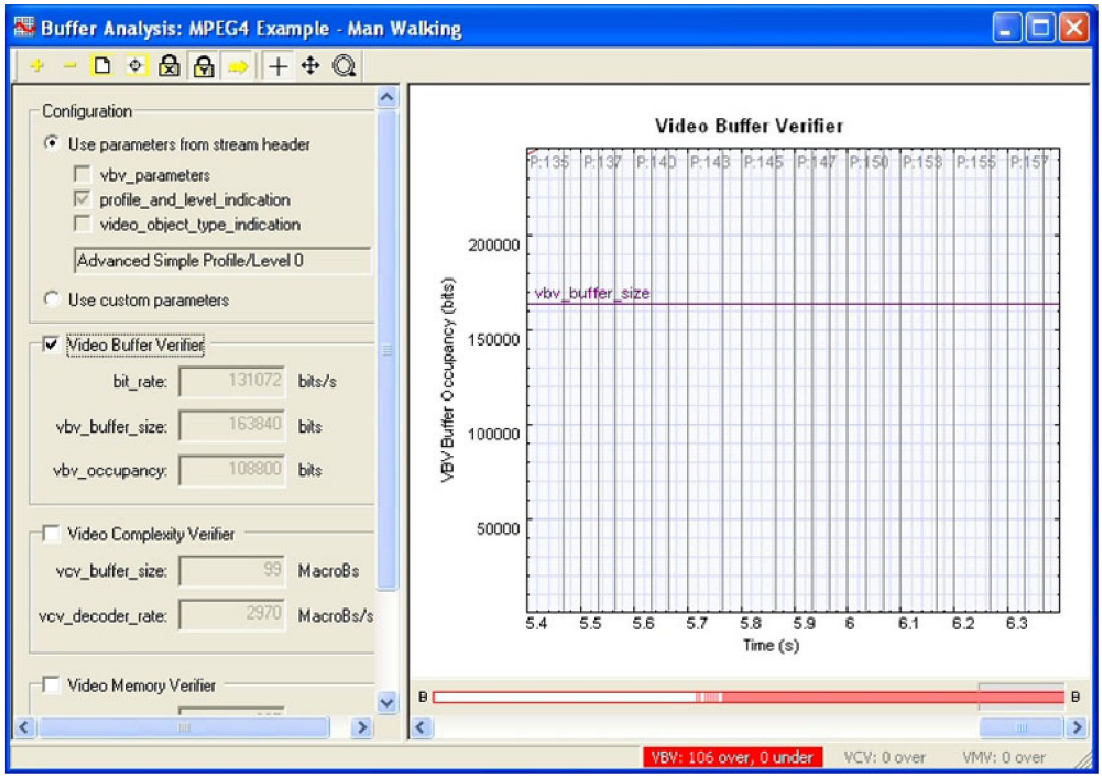

Figure 69: Frame 2

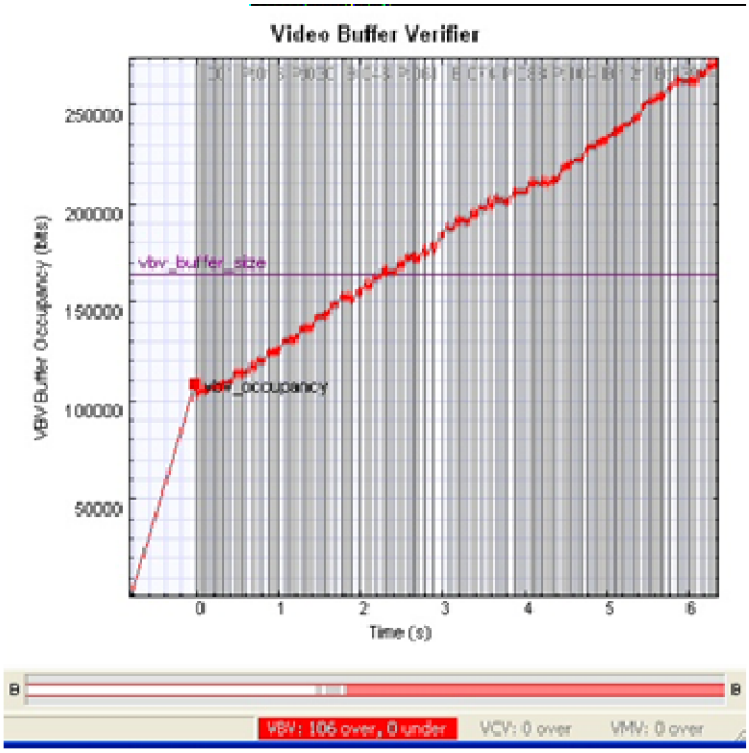

Figure 70: Graph details

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. (See Figure 71.) The word **BUF** appears in a yellow box in the main MTS4EA status bar, indicating that custom buffer parameters are in use. (See Figure 72.)

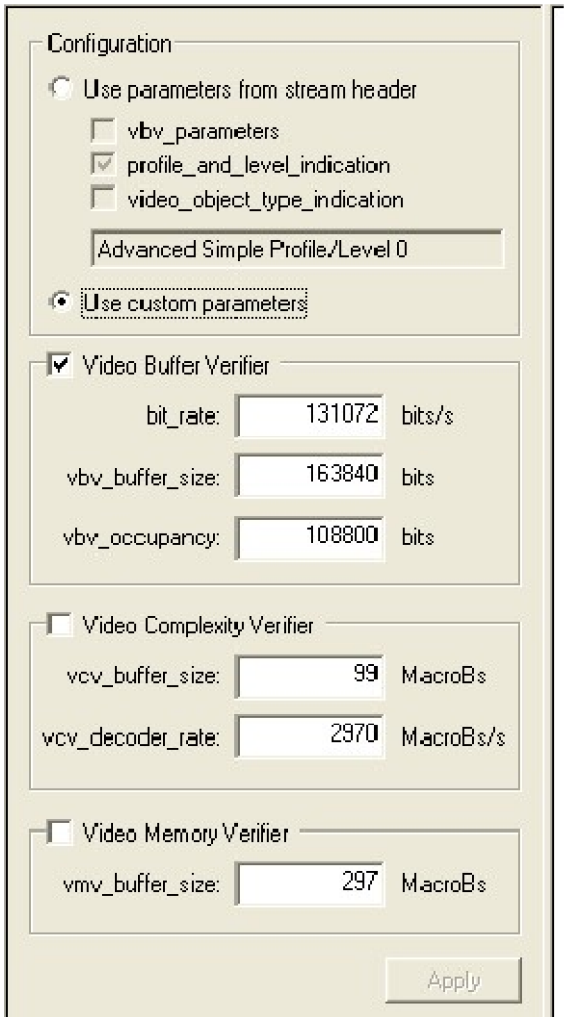

Figure 71: Buffer analysis configurations

Figure 72: Buffer parameter indicator

21. View the video buffer verifier. (See Figure 73.) 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?

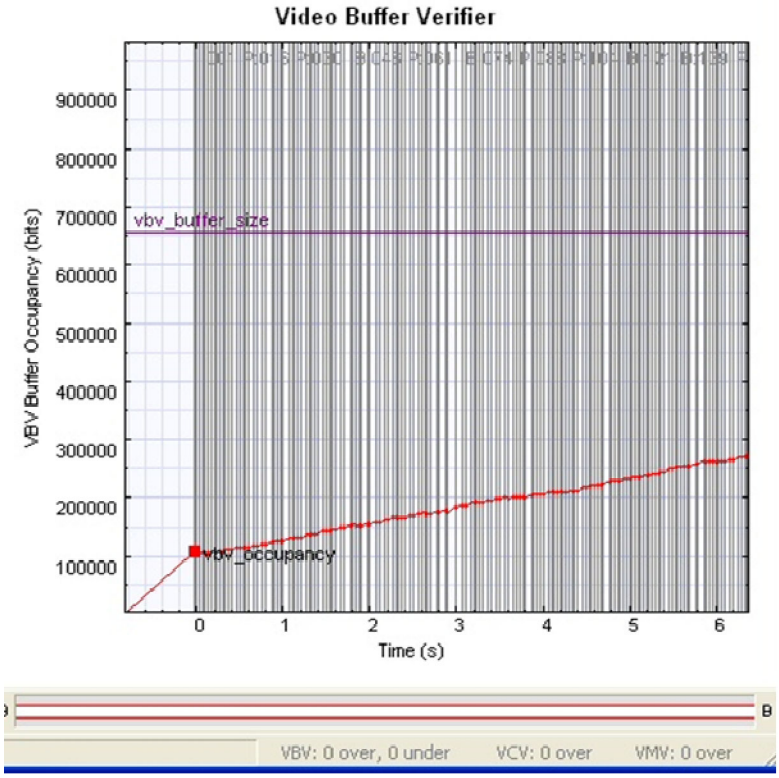

Figure 73: Video buffer verifier graph

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, and then click **Apply**. (See Figure 74.) The graph goes up slightly and there are fewer frames with overflow. (See Figure 75.)

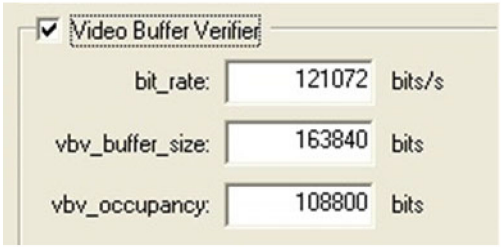

Figure 74: Bit rate configurations

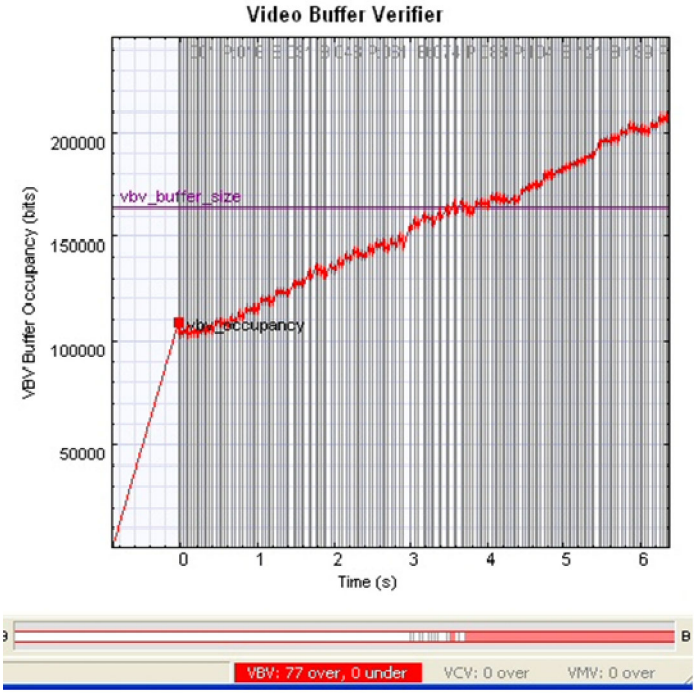

Figure 75: Video buffer verifier graph

26. Reduce the bit rate to 111072 bits and then click **Apply**. (See Figure 76.)

27. Observe that the graph line now stays below the buffer limit. (See Figure 77.)

28. Consider whether the maximum rate of 111,072 bits meets your network's specifications.

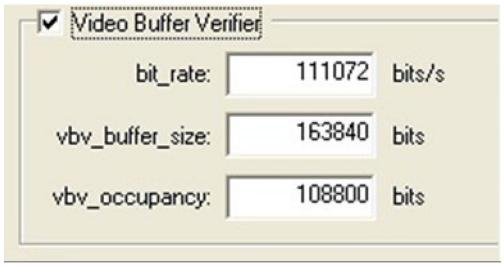

Figure 76: Video buffer verifier configurations

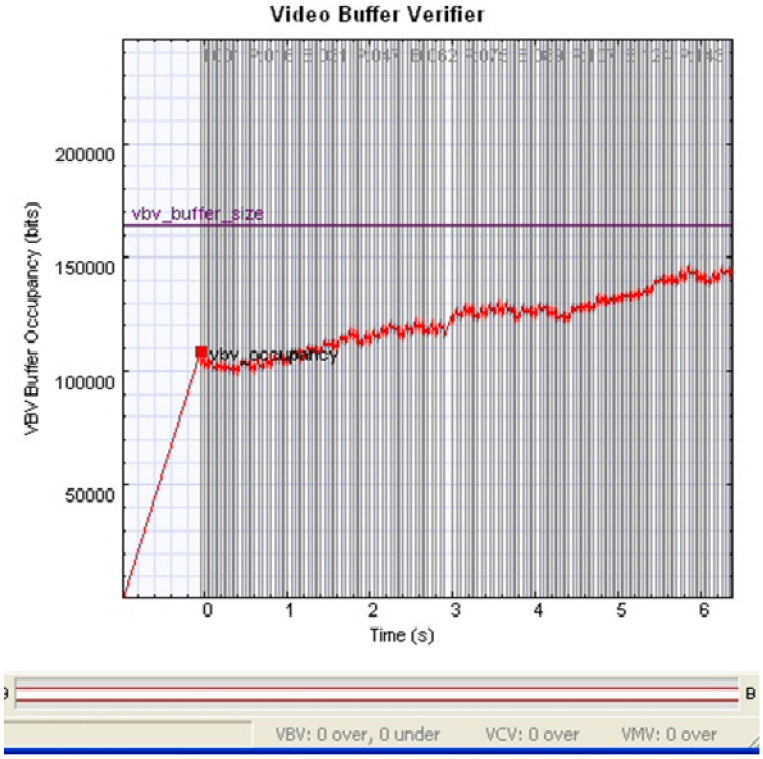

Figure 77: Video buffer verifier graph

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 10: 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. (See Figure 78.)
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.

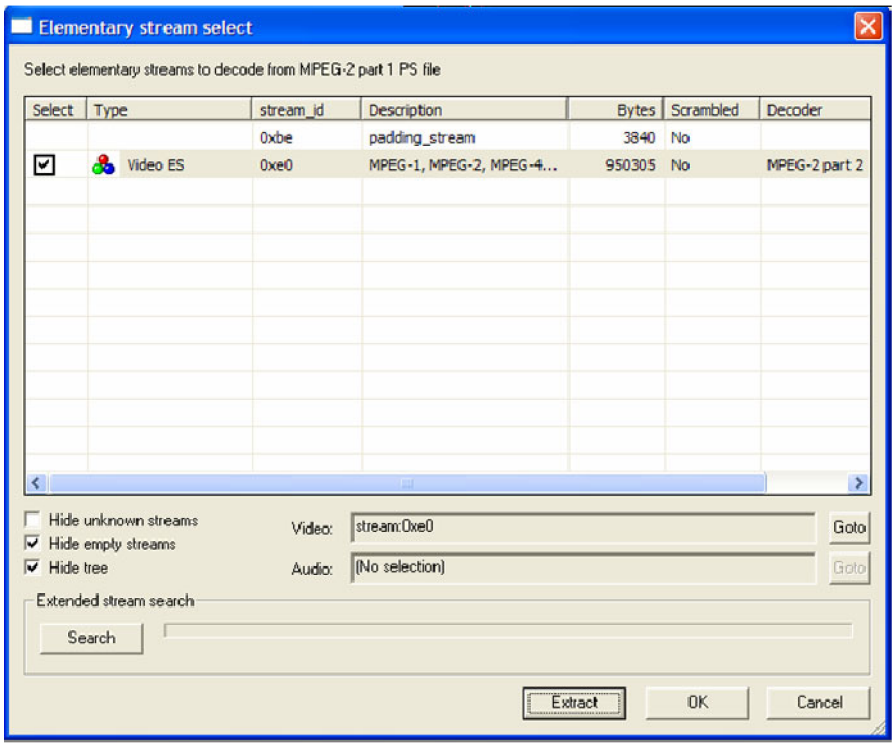

Figure 78: Track list

3. Click **OK**. The video track is analyzed and an error appears. (See Figure 79.)
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. (See Figure 80.)

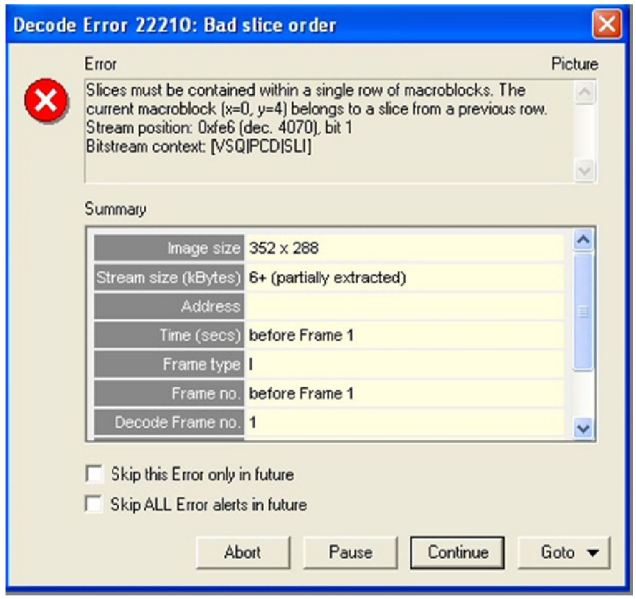

Figure 79: Initial error message

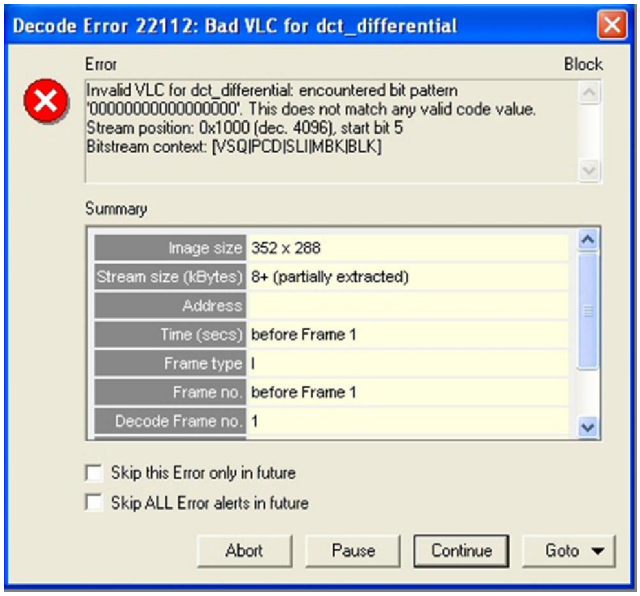

Figure 80: Invalid VLC error message

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. (See Figure 81.)

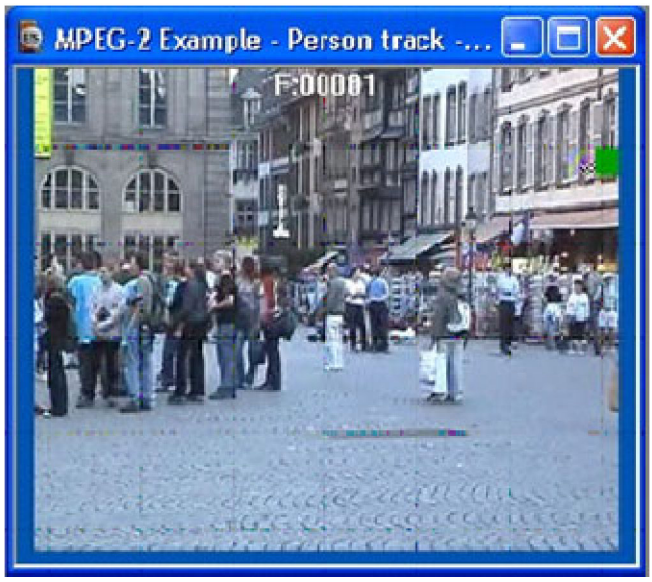

Figure 81: Error in image

9. Click the **Pause, Step forward** icon . An error message appears.
10. Click **Continue**. An Invalid VLC error message appears. (See Figure 82.)
11. From the **Goto** menu, click **Hex**.
12. Click **Continue**, and then view the **HexView window**. Note that the error is highlighted automatically. (See Figure 83.)
13. Observe the bits surrounding the error and consider whether it is a start code emulation.

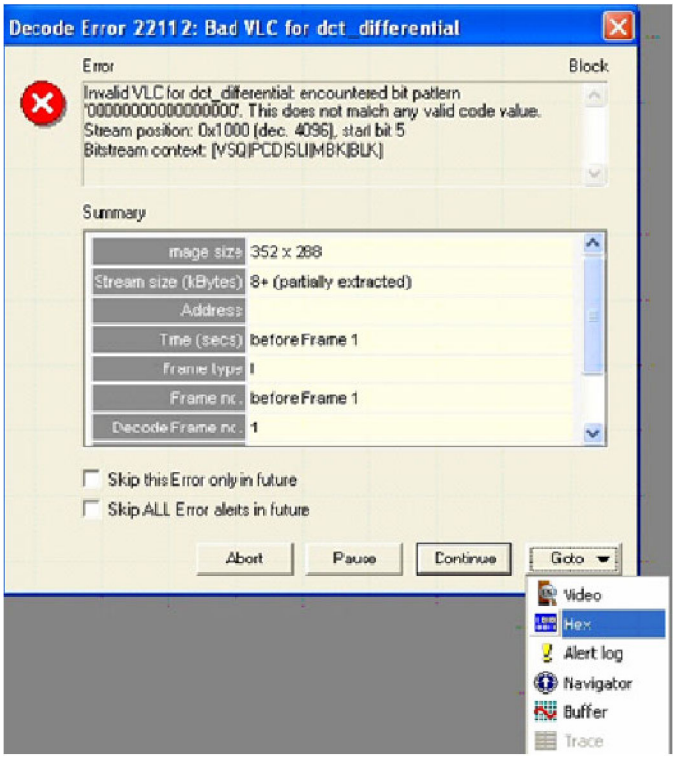

Figure 82: Invalid VLC error message

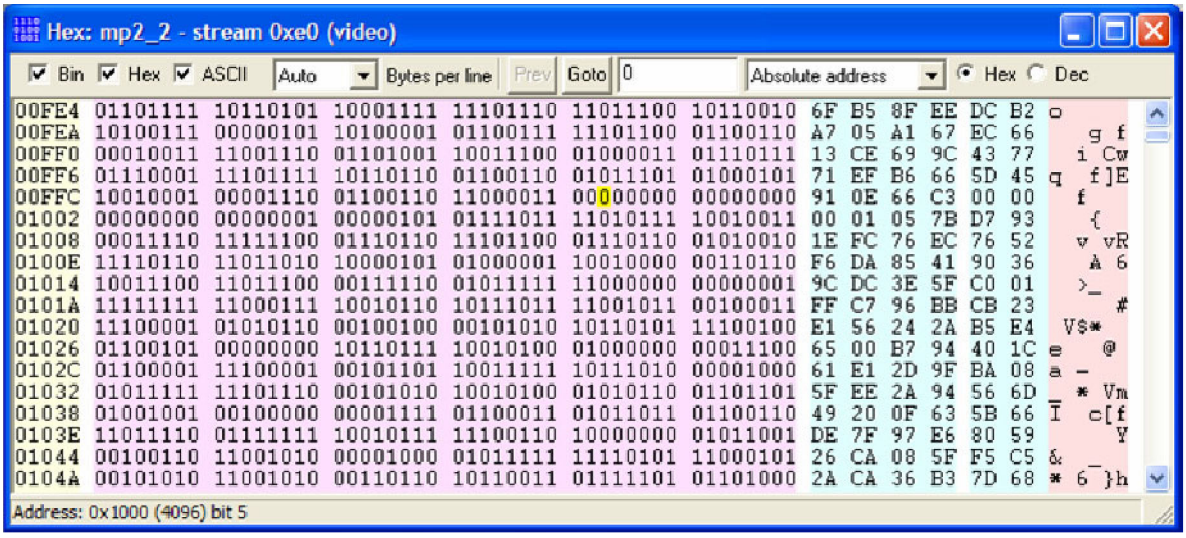

Figure 83: HexView window

14. To open the Grenadier Guards program stream, Click **File** > **Example files** > **MPEG-2 Program Streams**> **Grenadier Guards.** An error message appears. (See Figure 84.)

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.

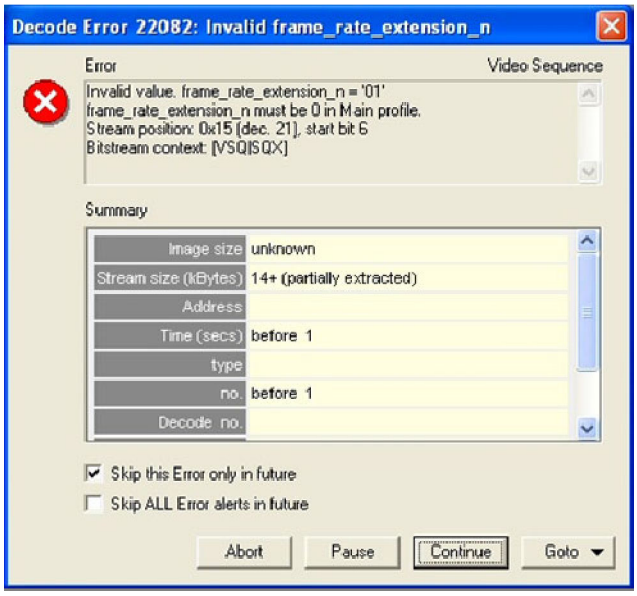

Figure 84: Error message

16. Select **Skip this Error only in the future**, and then click **Continue**. The status bar indicates one disabled alert. (See Figure 85.) An error message (See Figure 86.) and a warning message (See Figure 87.) appear.

Figure 85: 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.

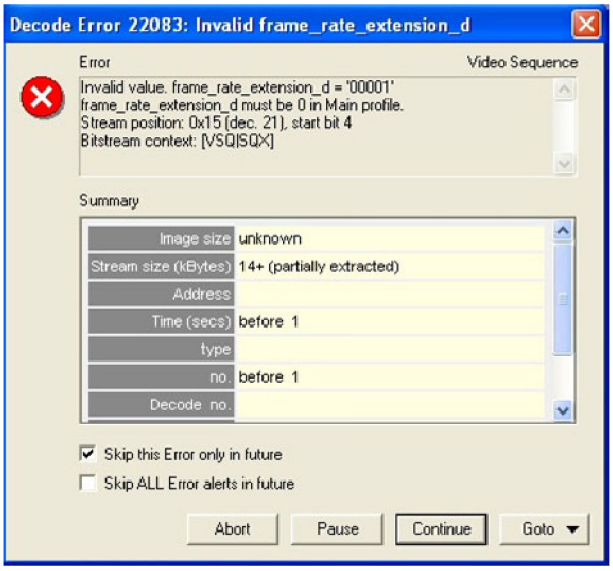

Figure 86: Error message

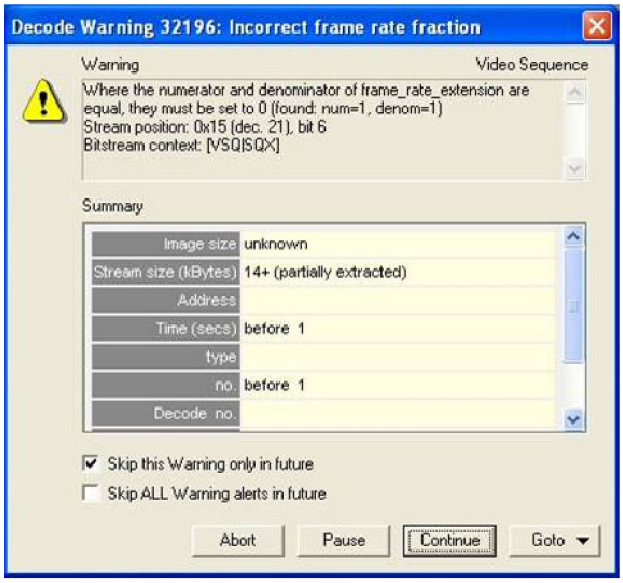

Figure 87: Warning message

18. From the **Analysis** menu, select **View video stream structure**. The **Structure** window appears. (See Figure 88.)

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.

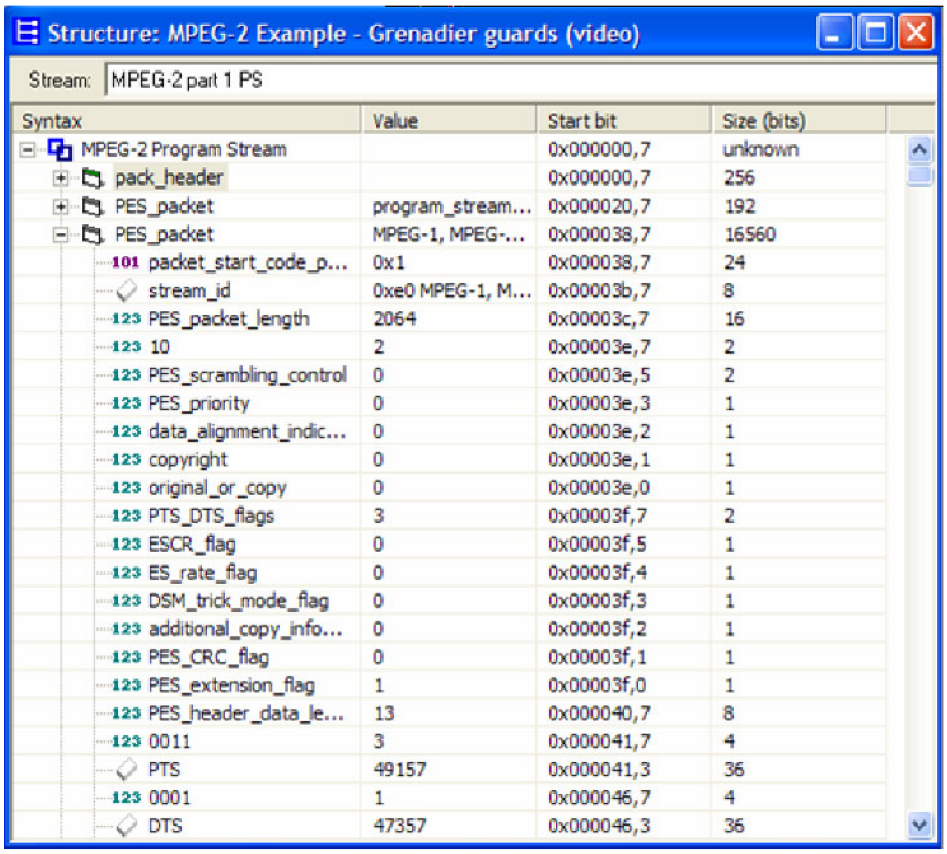

Figure 88: Structure window

20. Resume playing the video. The **Interlace** toolbar appears. (See Figure 89.)

Figure 89: 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. (See Figure 90.)

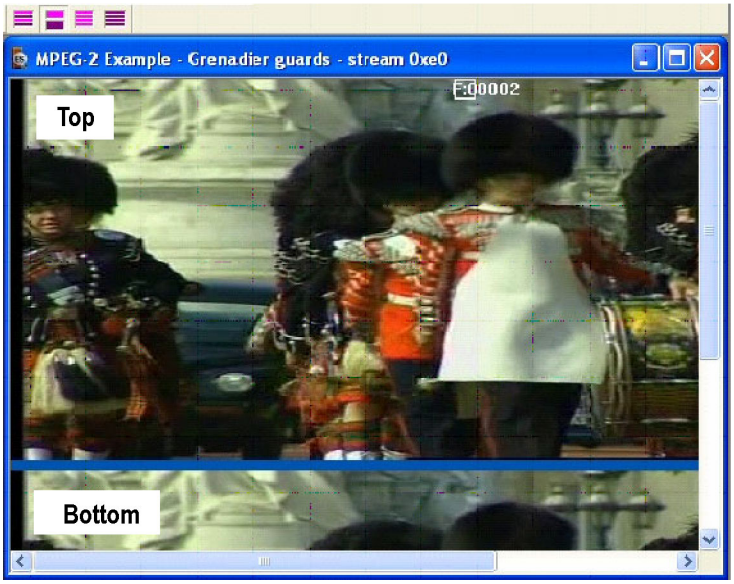

Figure 90: Frame 2

23. Maximize the video window.

24. Click the icon. Different MB types appear in the top and bottom fields. (See Figure 91.)

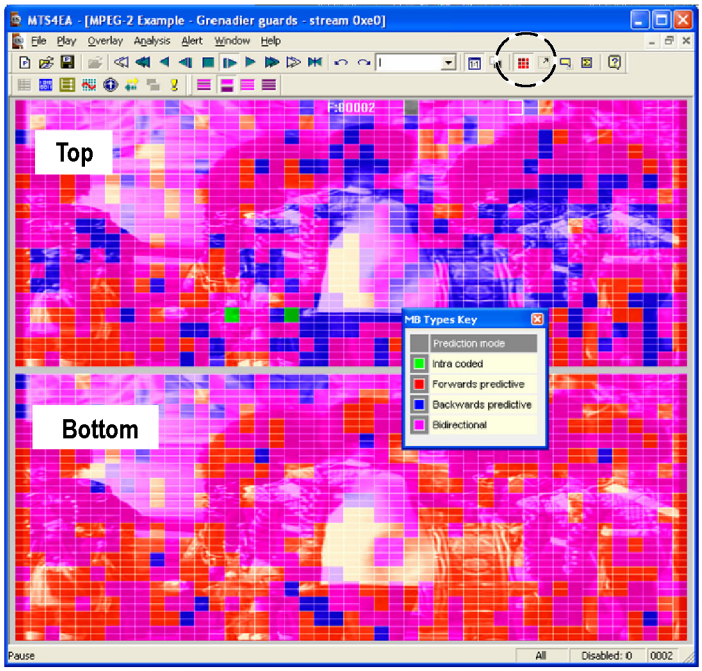

Figure 91: Varied MB types

Conclusion

This tutorial demonstrated the following:

- There is one error in the Person Track stream:
  - The error is in 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 11: 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 (this topic is not covered in this tutorial; 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 for theYUV 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. (See Figure 92.)
3. Set the **Frame rate** to 30. (See Figure 92.)

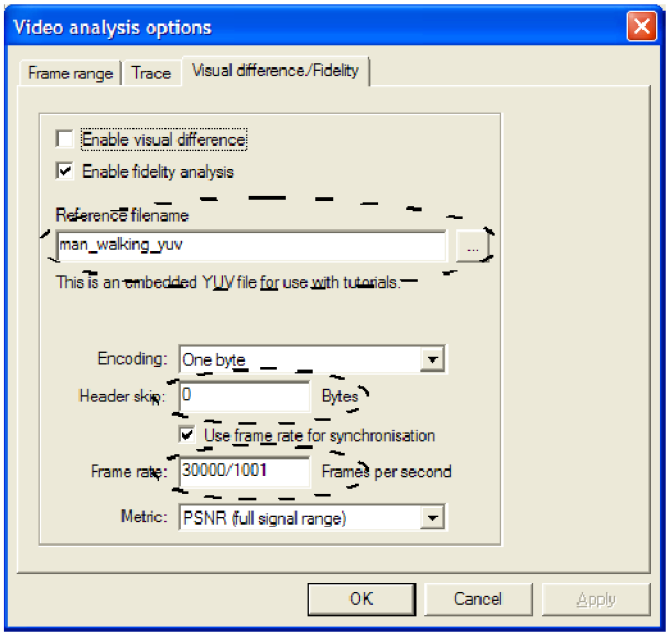

Figure 92: Video analysis options

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**. (See Figure 93.)

7. On the **Frame range** tab, select the **All frames** check box and then click **OK**. The video window appears with the fidelity analysis icon enabled in the **Views** toolbar. (See Figure 94.)

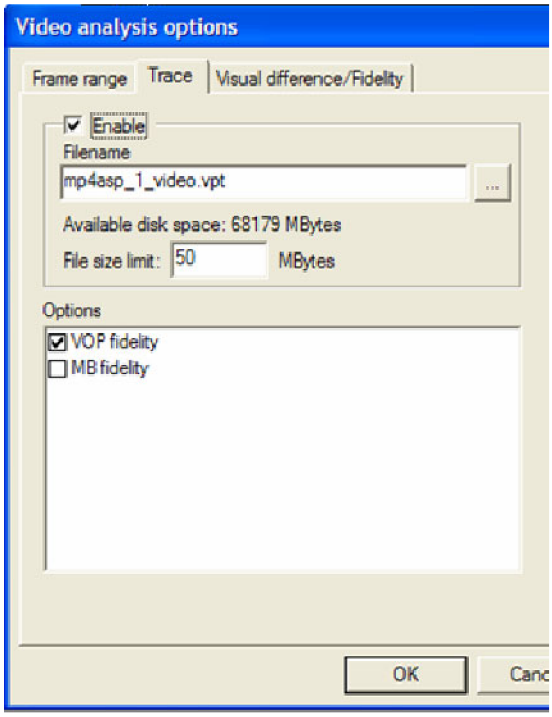

Figure 93: Video analysis options

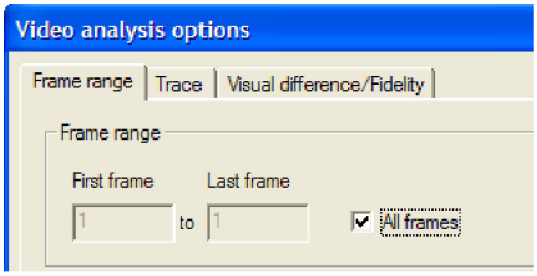

Figure 94: Frame range tab

8. Click the **Fidelity analysis** icon . The **Fidelity analysis** graph view appears. Observe that the graph is empty because a video has not been played. (See Figure 95.)

9. Click the icon four times. A graph appears. (See Figure 96.)

10. Observe the following about the graph:

- 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 in the figure and the table. (See Figure 97.) (See Table 6.)

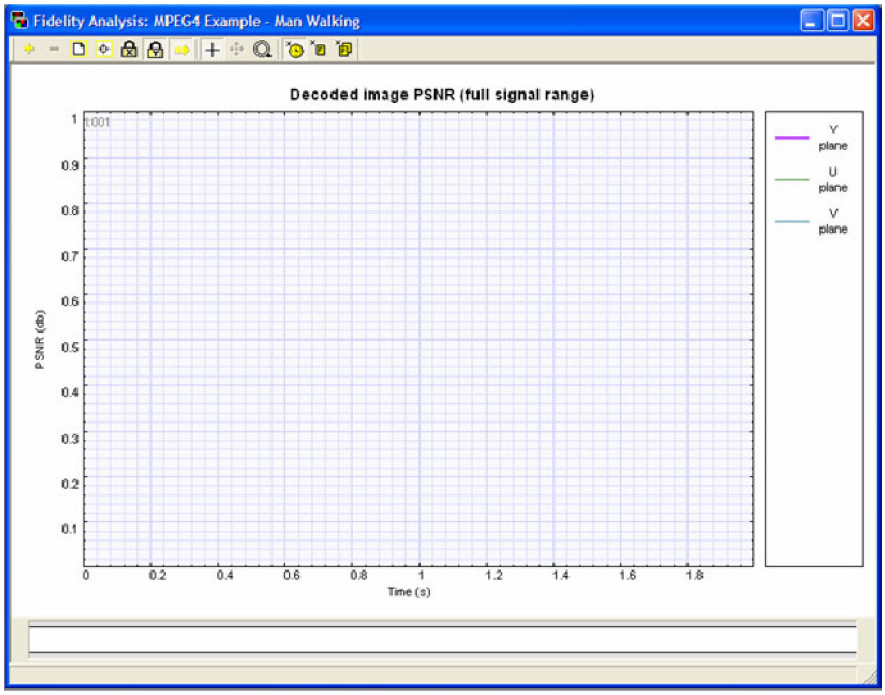

Figure 95: Fidelity analysis graph

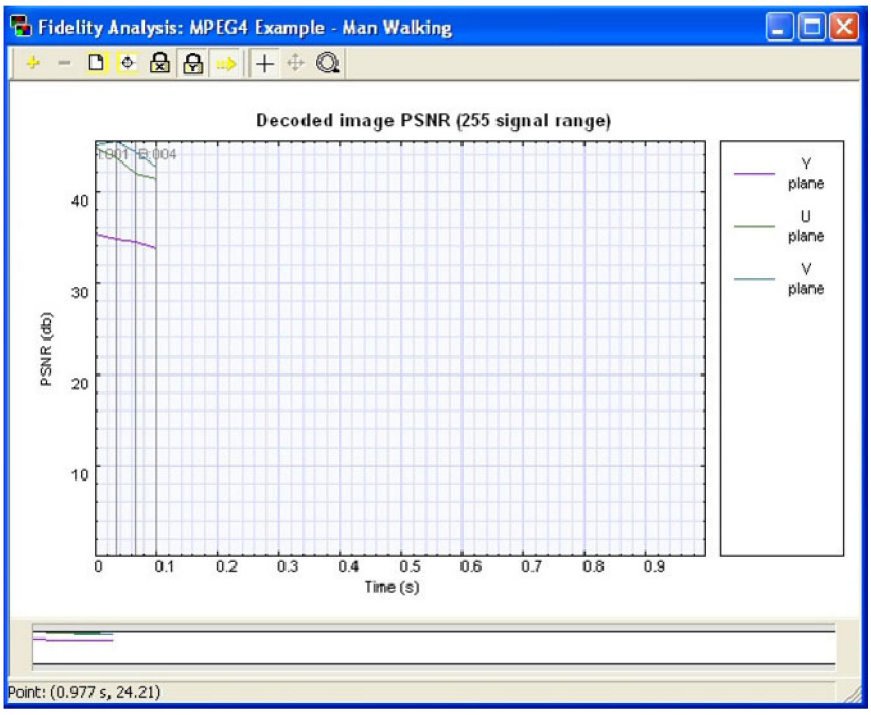

Figure 96: Fidelity analysis graph

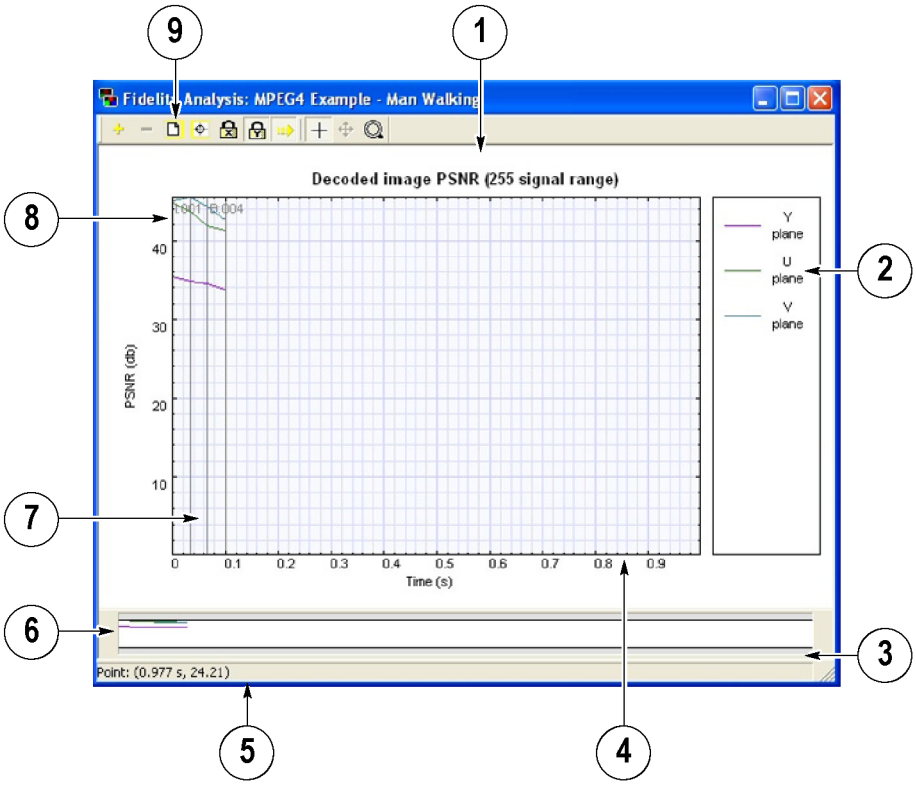

Figure 97: Fidelity analysis window descriptions

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. (See Figure 98.)

17. Load the MPEG-2 program stream example, Grenadier Guards. (See Figure 99.)

18. Compare the first MPEG-2 program stream with the H.264/AVC PSNR example. (See Figure 99.) (See Figure 100.) Note that the PSNR is higher for H.264/AVC in Y, U, and V.

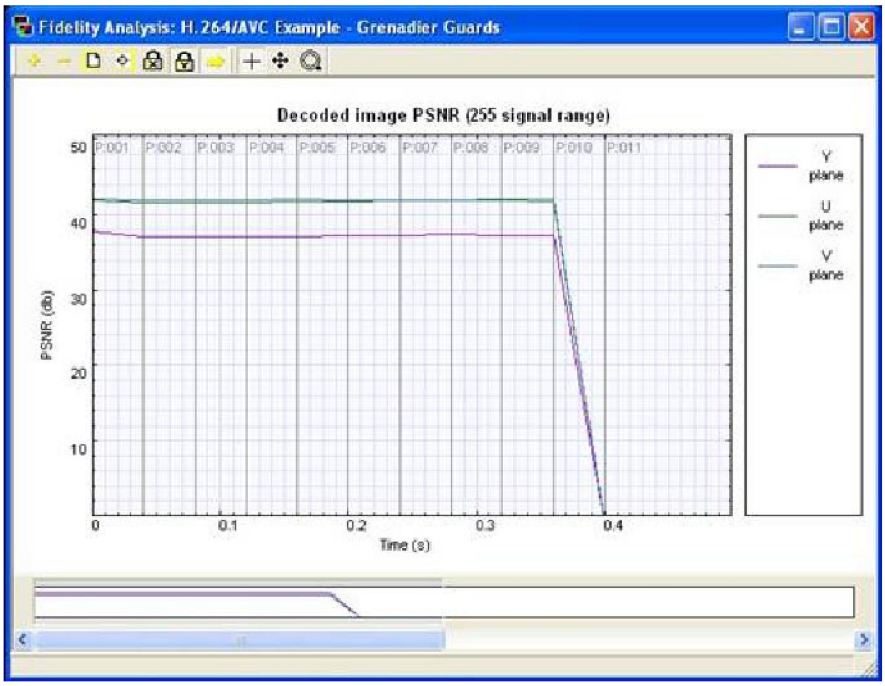

Figure 98: Graph result, YUV frame rate 25

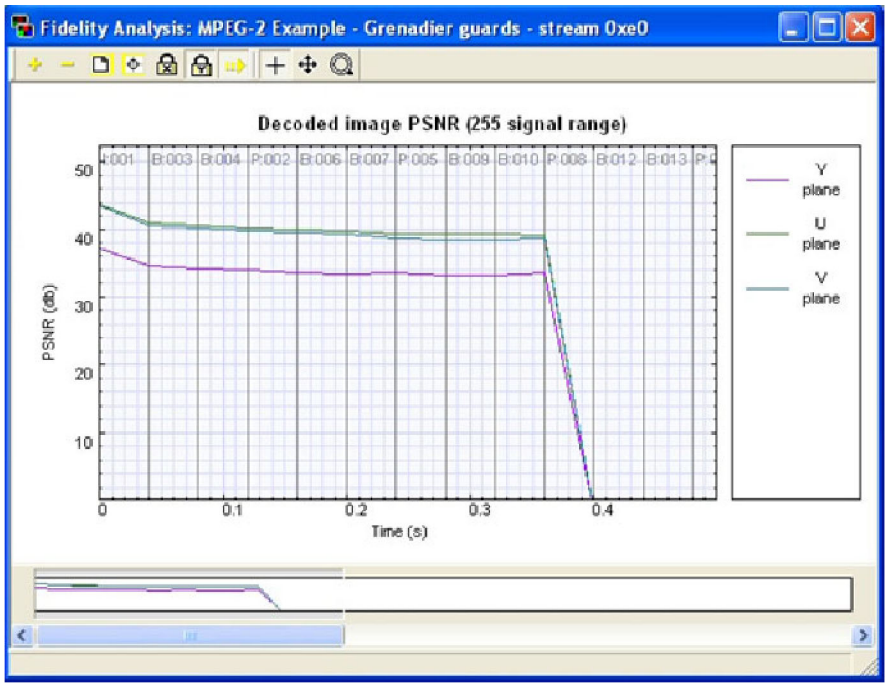

Figure 99: MPEG-2 program stream, Grenadier Guards

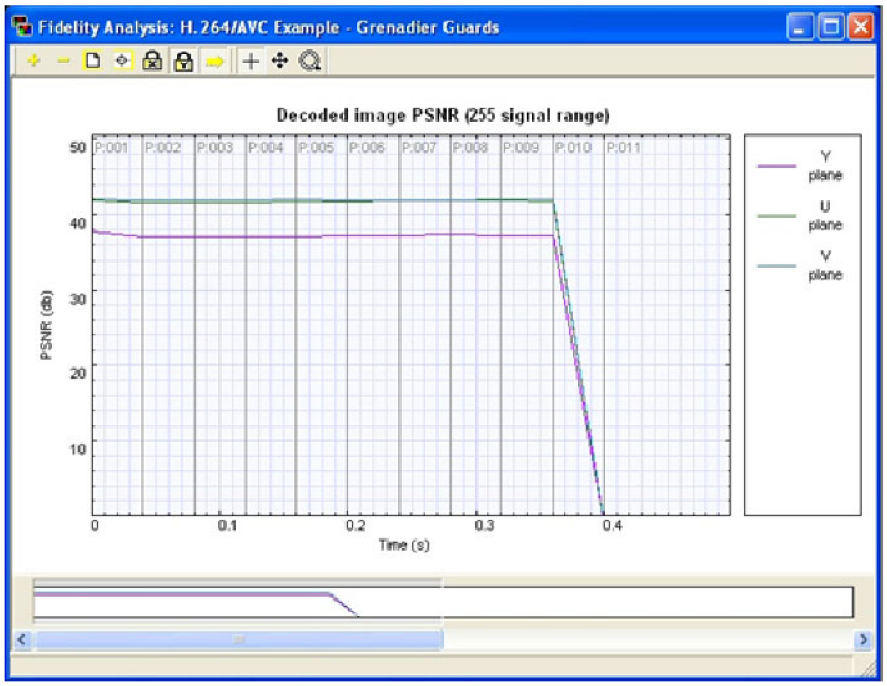

Figure 100: H.264/AVC stream, Grenadier Guards

19. Click the **View trace** icon. (See Figure 101.)

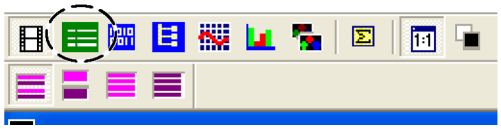

Figure 101: View trace icon

20. The trace view gives the numerical values for the pictures' PSNR. (See Figure 102.)

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.

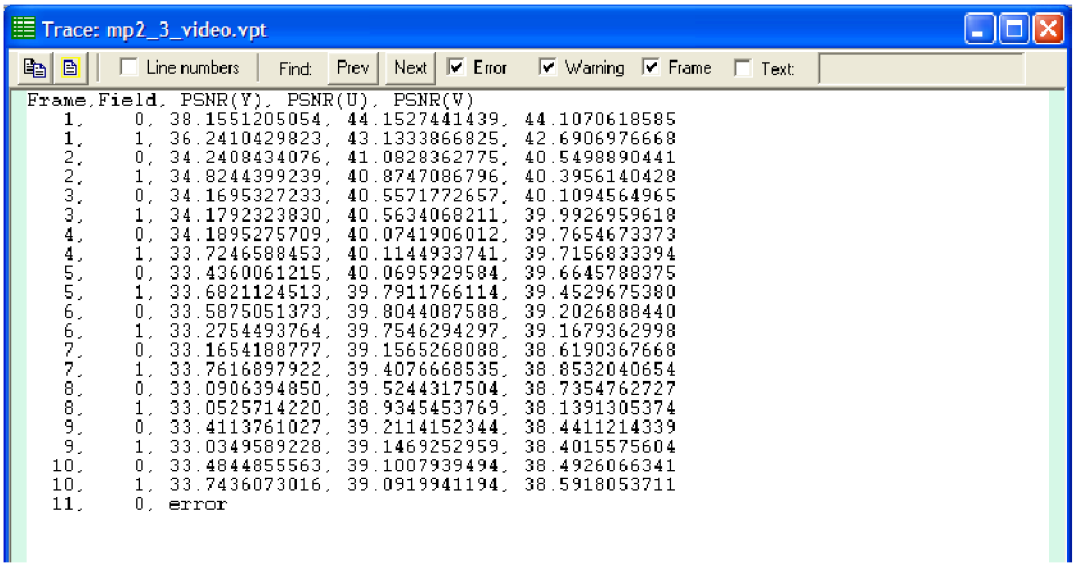

Figure 102: H.264/AVC sequence

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.