



# **OptoFidelity Video Multimeter User Manual**

**Version 2018Q3.0**



© OptoFidelity 2013-2018

Microsoft and Excel are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

## Contents

OptoFidelity Video Multimeter.....	1
User Manual .....	1
1 General information on OptoFidelity Video Multimeter .....	6
2 Start Window .....	6
3 Frame rate measurement task .....	7
3.1 Overview tab .....	7
3.2 Statistics tab .....	9
3.3 Configuration tab .....	10
3.4 Color calibration .....	11
3.5 Saved data files .....	11
4 Lip sync measurement option .....	12
4.1 Option license activation.....	12
4.2 Audio input cable connection.....	12
4.3 Framerate application's Lip sync tab.....	13
4.4 Saved data files with Lip sync option.....	15
5 USB connection .....	15
5.1 USB connection with Remote Control API.....	16
6 External trigger output option .....	17
6.1 Option license activation.....	17
6.2 External trigger configuration.....	17
6.3 External trigger usage.....	18
7 Camera viewfinder latency option.....	18
7.1 Option license activation.....	18
7.2 Camera viewfinder latency measurement setup .....	19
7.3 Camera viewfinder latency measurement.....	19
8 Video Transfer Performance.....	21
8.1 Video Transfer Performance Setup .....	21
8.2 Video Transfer Performance Application .....	22
8.3 Using Video Transfer Performance with recorded video .....	25
8.4 Video Transfer Performance self-verification .....	25
8.5 Video Transfer Performance License Activation .....	25
9 Dual FPS (Frames per Second) option .....	26

9.1	Dual FPS option license activation.....	26
9.2	Dual FPS measurement setup .....	26
9.3	Dual FPS measurement application .....	27
9.4	Dual FPS Color calibration.....	28
9.5	Dual FPS measurement .....	28
9.6	Dual FPS result saving .....	29
9.7	Dual FPS Graph view .....	30
10	Measure VR Displays option .....	31
10.1	Measure VR displays license activation .....	31
10.2	VR Display Measurement Setup .....	31
10.3	Measure VR Displays application .....	32
10.4	Measure VR Displays Measurement .....	32
10.5	Measure VR Displays Save Function .....	34
11	Mean Opinion Score (MOS) .....	35
11.1	File view .....	35
11.2	MOS score view .....	35
11.3	MOS Graph view .....	36
11.4	MOS Configuration (OptoFidelity default) .....	38
12	Measure Motion Blur option.....	40
12.1	Measure Motion Blur license activation .....	40
12.2	Motion Blur measurement method .....	40
12.3	Motion Blur measurement setup .....	42
12.4	Motion Blur latency measurements .....	42
12.5	Motion Blur latency results analysis & saving.....	44
13	Timebase Calibration option.....	46
13.1	Timebase Calibration license activation.....	46
13.2	Timebase Calibration application usage .....	46
13.3	Valid result for Timebase Calibration .....	47
14	Software update.....	47
15	Technical specifications .....	50
16	References .....	51
17	Change history.....	51

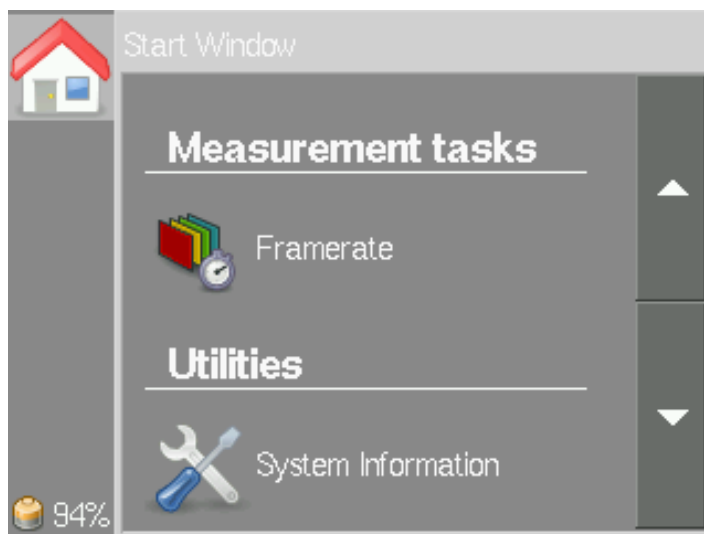


## 1 General information on OptoFidelity Video Multimeter

OptoFidelity Video Multimeter is a compact desktop solution for measuring the true and objective video playback performance of a mobile, tablet or any multimedia device directly from the display of that device. It is controlled with a resistive touch display which works best with, for example, a fingernail or stylus.

## 2 Start Window

When power is switched on the device starts and the *Start Window* opens. All installed applications are listed in this window. You can browse the list by dragging or using the arrow buttons on the right.



**Figure 1: Start Window after turning on the device**

Applications are classified according to their purpose:

- Measurement tasks: Measurement applications which are used to determine some feature of the device under test (DUT).
- Utilities: General utility programs for using and configuring Video Multimeter.
- Result Analysis: Analysis of saved results.

### 3 Frame rate measurement task

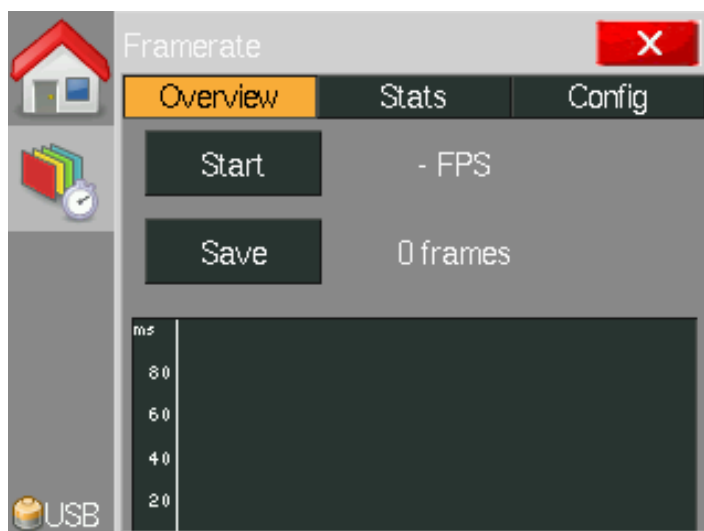
The frame rate measurement task determines the playback smoothness of the device under test (DUT) with a test video. A blinking marker is measured from the display of device and this marker helps to determine frame intervals and missing frames. The basic measurement setup is shown in Figure 2.



**Figure 2: Example of using Video Multimeter for frame rate measurement**

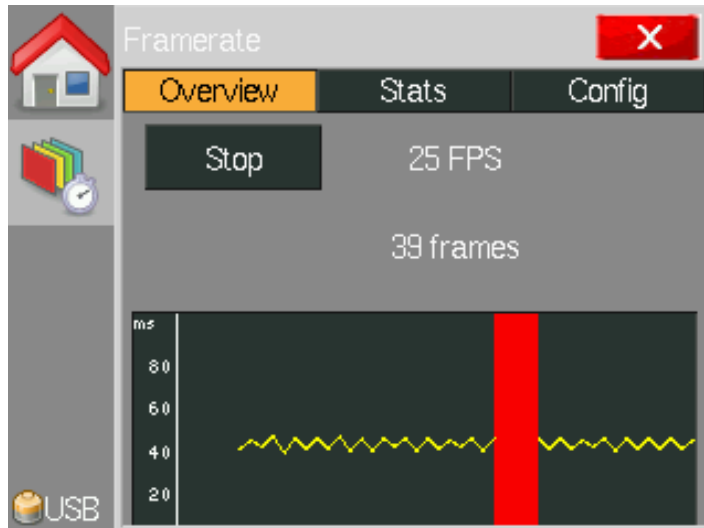
#### 3.1 Overview tab

When the Framerate measurement application is started, it opens with the *Overview* tab shown in Figure 3. On this tab, you can start and stop measurements, have an overview of the results and save them. The overview tab shows the average frames per second (FPS) over the whole measurement and the total number of frames.



**Figure 3: View of the Framerate application before measurement**

To begin a new measurement press the *Start* button. The measurement will start immediately and continue until you press the *Stop* button. While the measurement is ongoing the graph will scroll to show the results, as shown in Figure 4.



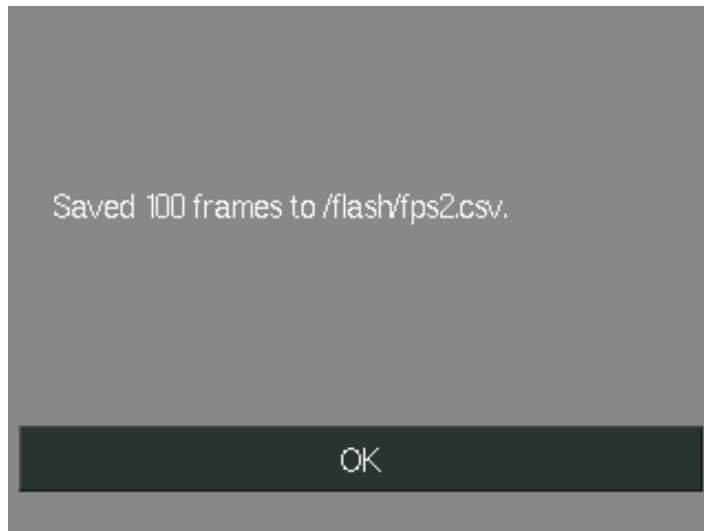
**Figure 4: Frame rate measurement in progress**

The vertical axis of the graph indicates the time that each frame is on the screen. Readings on the vertical axis are in milliseconds, so for example a frame interval of 40 milliseconds equals a frame rate of  $1/0.040 = 25$  FPS. Dropped frames are shown as red vertical bars, if they occur.

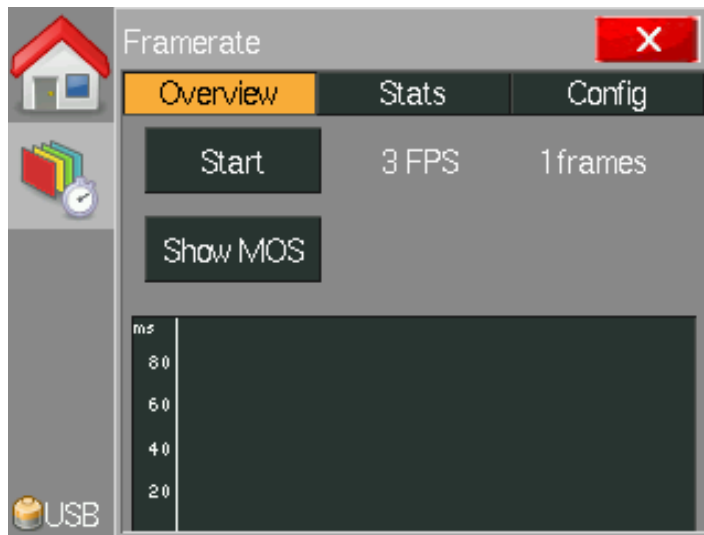
**Note:** To get repeatable results start and stop the measurement in the white period at the start and end of the video. Such videos can be generated in OptoFidelity Test Video Generator (TVG) by using the setting *calibration=both*.

After stopping the measurement, you can study the results on the *Stats* tab, or you can save them using the *Save* button. After saving the results a message window shows the name of the saved file, as shown in Figure 5. After the file is saved you can view the Mean Opinion Score (MOS) of results in a separate application (See Chapter 10). The application can be launched from *Show MOS* button (Figure 6) or from *Start Window*.





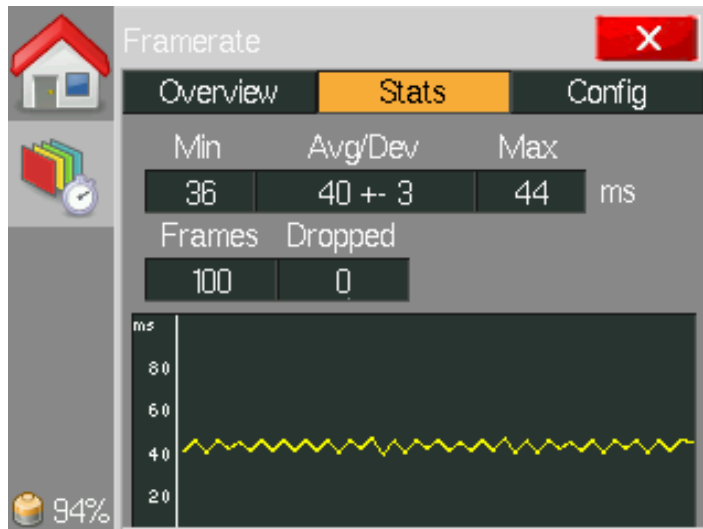
**Figure 5: Message window after saving the measurement results**



**Figure 6. "Show MOS" button is available after the file is saved.**

### 3.2 Statistics tab

During or after performing a measurement you can switch to the *Stats* (Statistics) tab to see further information. The view is shown in Figure 7.

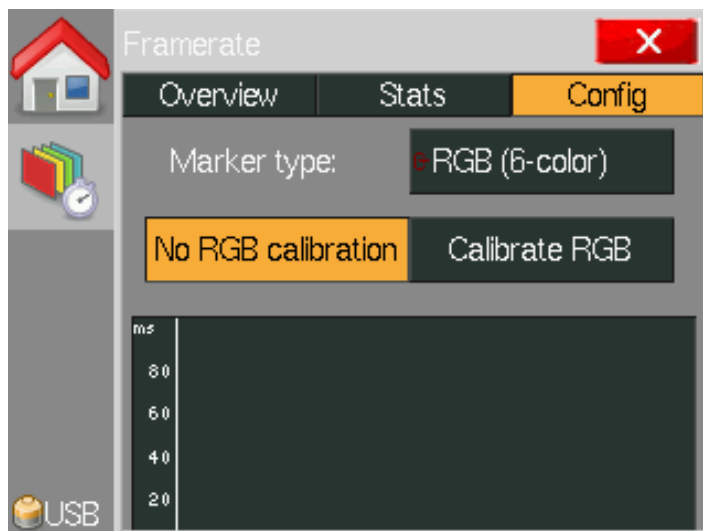


**Figure 7: Statistics tab**

The upper row displays the minimum, average, standard deviation and maximum values of the frame intervals. The lower row displays the total number of frames and the amount of dropped frames.

### 3.3 Configuration tab

By default the application uses an RGB marker with built-in color calibration. This is suitable for most measurements with LCD displays. For other kinds of displays adjustments on the *Config* tab may be necessary.



**Figure 8: Configuration tab**

As shown in Figure 8 the Configuration tab allows the selection of marker type and color calibration. The available marker types are:

1. RGB (6-color): Marker with specific color sequence of 6 different colors. This measures frame intervals and detects dropped frames.
2. Black & White: Black and white marker. A simple method for testing frame intervals, but detecting dropped frames is not possible.
3. Any change: Any large change of color will be considered as a change of frame. This marker type can measure frame intervals of any marker, but dropped frames will not be detected.

The selected marker type must match the type of the marker in the test video used.

### 3.4 Color calibration

The functionality of the RGB marker depends on the color space of the DUT since the RGB marker is based on colors. Default settings can be applied for most LCD displays, but OLED displays and other display technologies may require calibration. You can easily see that calibration is needed if red bars appear on the graph constantly. This indicates that some colors have not been detected.

Calibration is performed as follows:

1. Position the fiber on a color marker on the display. The video must be running.
2. Press the *Calibrate* button on the *Config* tab. Calibration takes a few seconds and the fiber must be kept still on the marker during this time.
3. The new calibration is valid immediately. If required you can do calibration again or deactivate the calibration by pressing the *No calibration* button.

**Note:** Color calibration is only necessary for the RGB marker. It is not necessary and cannot be successfully performed for other kinds of markers.

### 3.5 Saved data files

The saved data files from the frame rate measurement are in semicolon separated CSV format. Each row corresponds to one frame and has the following columns:

- A) Microsecond timestamp of the frame start.
- B) Microsecond length of the frame (-1 for dropped frames).
- C) Color of the marker in the frame.
- D) Cumulative count of frames dropped since start of measurement.

	A	B	C	D
1	# Recorded at 2013-05-27 08:39:18 using OptoFidelity Video Multimeter			
2	# Timestamp (us)	Frame time (us)	Color	Total dropped frames
3	0	42560	r	0
4	42560	36640	y	0
5	79200	42560	g	0
6	121760	38620	c	0
7	160380	43550	b	0
8	203930	36620	p	0
9	240550	42590	r	0
10	283140	36620	y	0

**Figure 9: Data file saved from frame rate measurement**

The CSV format is supported by Microsoft Excel and many other data analysis tools.

## 4 Lip sync measurement option

When activated the frame rate measurement task shall contain an additional tab for lip synchronization (Lip sync) measurement. The lip sync measurement option measures the audio leading/lag values in milliseconds. This feature requires audio input, which is implemented by connecting a 3.5mm audio jack to the Video Multimeter's Sensor interface.

### 4.1 Option license activation

The Lip sync option is activated by copying a valid license file into the Video Multimeter's SD card. The license file name is "Lip sync.ini", and it should be copied into folder /frm/license/. The file contents is as follows (an example):

```
; OptoFidelity Video Multimeter license file
; Device serial number: 5
; Feature name: Lip sync
```

```
[License]
salt = 1706318843
key = 2287536893
expire = 0
```

The device serial number must match the physical Video Multimeter device. License files are generated by OptoFidelity only. License files should not be edited manually.

### 4.2 Audio input cable connection

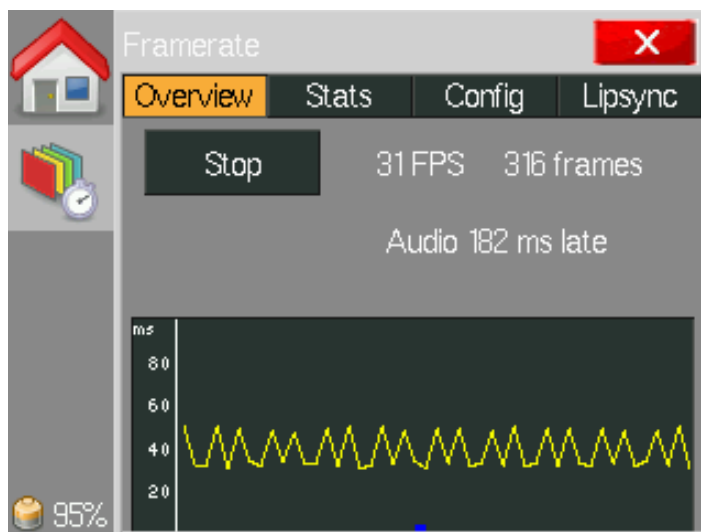
This feature requires an audio input. A 3.5mm audio jack cable must be connected to Sensor 1 interface. **NOTE:** The Lip sync feature is activated only if the audio cable is physically connected to Video Multimeter before powering it up.



**Figure 10: Lip sync audio cable connected to Sensor 1 input**

### 4.3 Framerate application's Lip sync tab

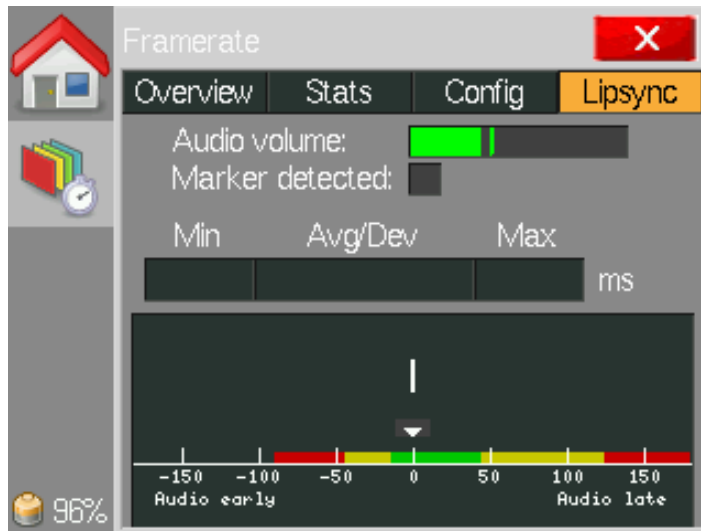
When you have completed successfully the previous actions (valid license file copied and audio cable connected), the Framerate task shows an additional tab in the Video Multimeter UI as shown in Figure 11.



**Figure 11: Framerate application Overview tab with lip sync feature activated**

Additionally the *Overview* tab contains an indicator for momentary lip sync value. The small blue marker in the graph shows the position where audio markers were detected.

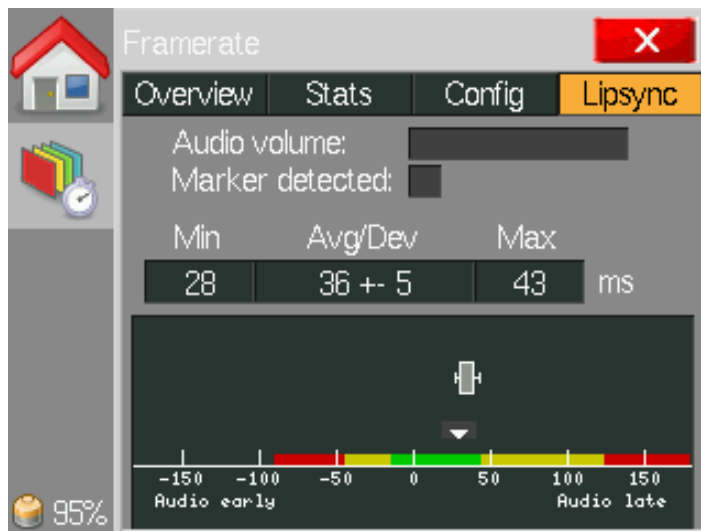
The *Lip sync* tab contains tools for adjusting the audio level and indicators for visualizing the lip sync measurement statistics.



**Figure 12: Lip sync tab's Audio volume indicator**

The audio volume indicator value should be observed especially during the audio markers. The 'Marker detected' indicator flashes with a blue color when the marker is detected.

Statistics show the minimum, maximum, average and deviation for lip sync measurements.



**Figure 13: Lip sync tab's graph showing measurement statistics**

The graph visualizes the statistical results. The square-shaped indicator's width corresponds to the deviation, and the location corresponds to the average value of lip sync over the whole measurement. Minimum and maximum values are visualized by small markers located at both sides of the square. The scale of the graph is -200...+200 milliseconds, where a negative value indicates that the audio was early. Correspondingly a positive value indicates that audio was late.



Graph scale colors (green, yellow, red) come from different standards and suggestions. Limits, which are only instructive, are set as follows:

- Green (Good): within -15 ... +45 ms (Acceptance limit according to ATSC IS-191)
- Yellow (Moderate): within -45 ... +125 ms (Human noticeable limit according to ITU-R BT.1359-1)
- Red (Poor): over -45 ... +125 ms (Human noticeable limit according to ITU-R BT.1359-1)

It is important to understand that, for example, a moderate result does not necessarily indicate that the measured video is perceived as bad. This is because the final user experience also depends on the video content and watching context (large TV set versus small mobile terminal). The above-mentioned standards and suggestions are useful references when product/service-specific acceptance limits are defined.

#### 4.4 Saved data files with Lip sync option

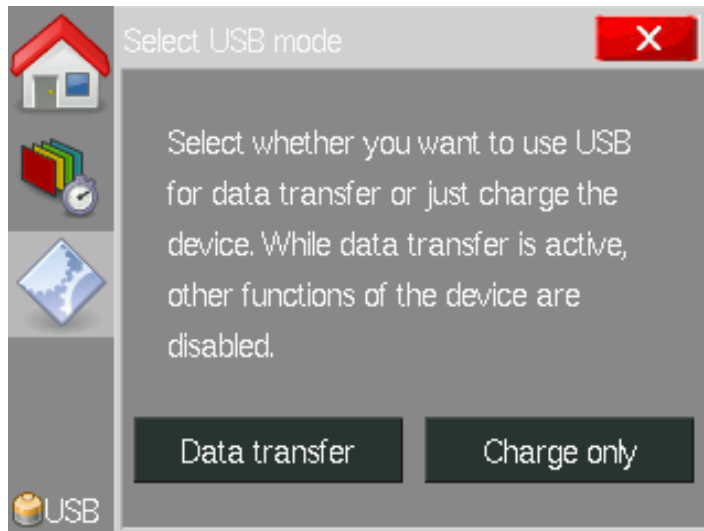
When the *Lip sync* feature is activated an additional column of results appears in the results data file. The column is named 'Lip sync (ms)'. The measured lip sync value is printed at each detected 'k' frame (black color marker).

	A	B	C	D	E
1	# Recorded at 2000-02-25 00:08:01 using OptoFidelity Video Multimeter				
2	# Timestamp (us)	Frame time (us)	Color	Total dropped frames	Lip sync (ms)
3	0	52000	k	0	91
4	52000	18000	y	0	
5	70000	34000	g	0	
6	104000	54000	c	0	
7	386000	52000	b	0	
8	...				
9	1790000	36000	c	0	
10	1826000	52000	b	0	
11	1878000	35000	p	0	
12	1913000	35000	k	0	97
13	1948000	54000	y	0	
14	2002000	34000	g	0	

**Figure 14: Data file saved from frame rate measurement, including lip sync**

## 5 USB connection

Video Multimeter can be connected to a computer by a USB cable for battery charging and data transfer. Charging will begin as soon as the USB cable is connected and is indicated by a red LED next to the USB connector. When the battery is full, the LED will turn off. Note that if the device is on, the LED will not turn off because power is being used.

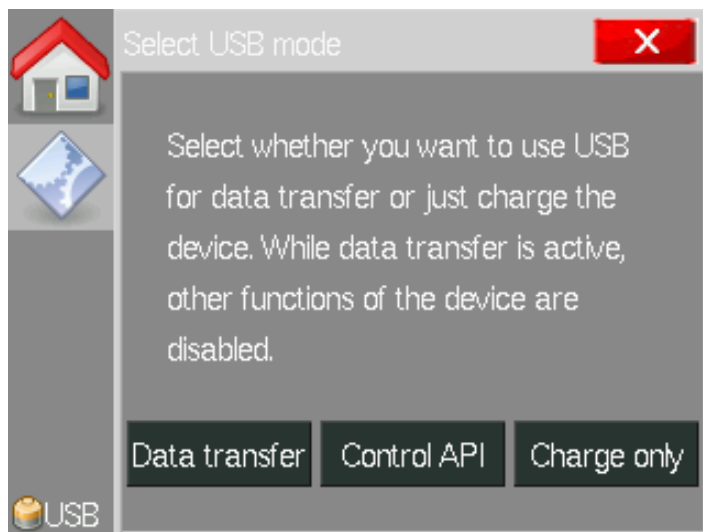


**Figure 15: USB mode selection screen**

When the USB cable is connected and the device is on, a selection window such as in Figure 15 opens on the display. The window has options *Data transfer* and *Charge only*. If *Data transfer* is selected, the device will appear as a USB memory on the computer. Other functions of the device will not be available while the data transfer is active. Selecting *Charge only* will simply close the dialog so that the device can be used normally while it is being charged.

## 5.1 USB connection with Remote Control API

If the Remote Control feature is activated on the device, the USB mode selection screen has an additional choice:



**Figure 16: USB mode selection screen with Control API feature activated**



By selecting *Control API* it is possible to control the device remotely via the USB connection. Please refer to [1] for further information.

## 6 External trigger output option

*Video Multimeter* can be used to trigger external devices by the External trigger output option. The physical BNC connector in the side of the device receives a controlled trigger pulse each time Video Multimeter detects a frame change.

### 6.1 Option license activation

The External trigger option is activated by copying a valid license file into the Video Multimeter's SD-card. The license file name is 'camera\_trigger.ini', and it should be copied into folder /frm/license/. The file contents is as follows (an example):

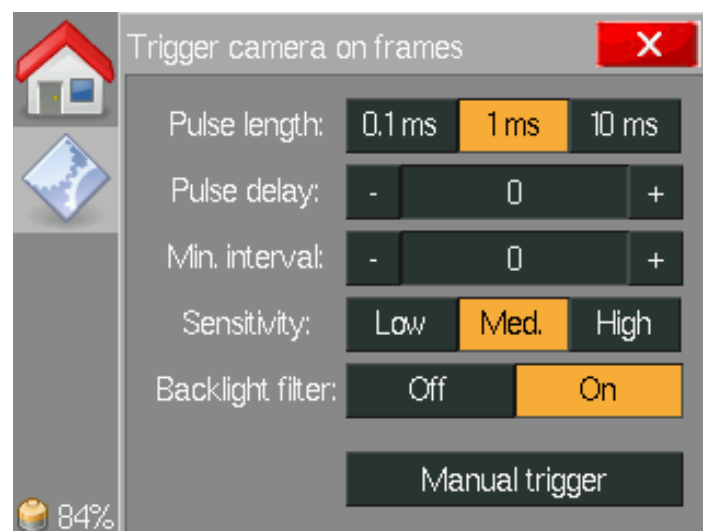
```
; OptoFidelity Video Multimeter license file
; Device serial number: 5
; Feature name: camera_trigger
```

```
[License]
salt = 1706318843
key = 2287536893
expire = 0
```

The device serial number must match the physical Video Multimeter device. License files are generated by OptoFidelity only. License files should not be edited manually.

### 6.2 External trigger configuration

The External trigger feature is active when the corresponding application is started from the main menu. The *Trigger camera on frames setup* screen shows the parameters that can be controlled:



**Figure 17: External trigger output control application.**

The functions of this screen are as follows:

- **Pulse length (ms):** the length of the positive pulse in milliseconds that is generated at the moment of a detected video frame
- **Pulse delay (ms):** the delay in milliseconds between the video frame detection and the rising edge of the pulse
- **Min. interval (ms):** the time that Video Multimeter waits before outputting new pulses when new video frames are detected
- **Sensitivity:** adjusts the sensitivity, meaning how small color changes are considered as frame changes. For most cases, 'Med.' (Medium) sensitivity is adequate.
- **Backlight filter:** controls whether the Video Multimeter's automatic backlight compensation is active or not. This feature speeds up the reaction time around 1ms. It is suggested that the display brightness is set to 100% if filter is off.
- **Manual trigger:** pressing this button generates a single pulse (for example, for testing purposes)

### 6.3 External trigger usage

The external trigger feature is active when the *Trigger camera on frames* application page is open. Other applications like Framerate can be used simultaneously.

Typical use case is to measure black/white marker with fiber. Color change indication at BNC connector can be visualized with oscilloscope. Note that if other than black/white marker types are measured there is significant delay from frame change to BNC output signal.

## 7 Camera viewfinder latency option

The signal path from a digital camera to a display causes always some delay, typically between 100 and 150 milliseconds. Less latency is always best, but the practical limit for good user experience for sports/action photography is somewhere around 200 milliseconds.

*Video Multimeter* can be used to measure any device camera-to-display signal path latency. These devices include smartphone cameras, tablets, pocket cameras and DSLRs. Nothing prevents measurement of true end-to-end latency of IP camera-PC setup as well.

### 7.1 Option license activation

The Camera viewfinder latency option is activated by copying a valid license file into the Video Multimeter's SD-card. The license file name is 'viewfinder\_latency.ini', and it should be copied into folder /frm/license/. The file contents is as follows (an example):

```
; OptoFidelity Video Multimeter license file  
; Device serial number: 5  
; Feature name: viewfinder_latency
```

```
[License]  
salt = 1706318843
```

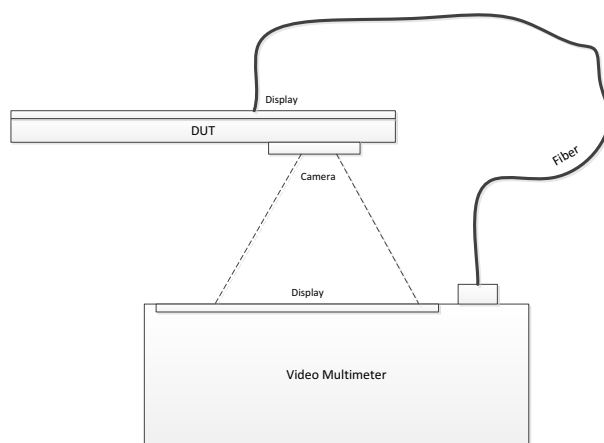
*key = 2287536893*  
*expire = 0*

The device serial number must match the physical Video Multimeter device. License files are generated by OptoFidelity only. License files should not be edited manually.

## 7.2 Camera viewfinder latency measurement setup

The measurement setup is very simple; Video Multimeter shows a blinking marker, which is captured by the camera of the device under test (DUT). The DUT display, for example, a camera's viewfinder, shows this blinking marker. Video Multimeter's fiber is then placed on the viewfinder display at the location of the marker.

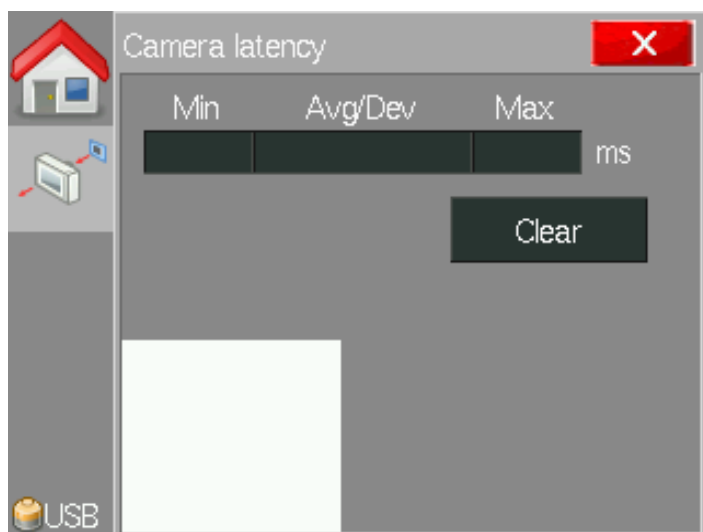
The following diagram illustrates a typical setup:



**Figure 18: Typical setup for measuring camera viewfinder latency**

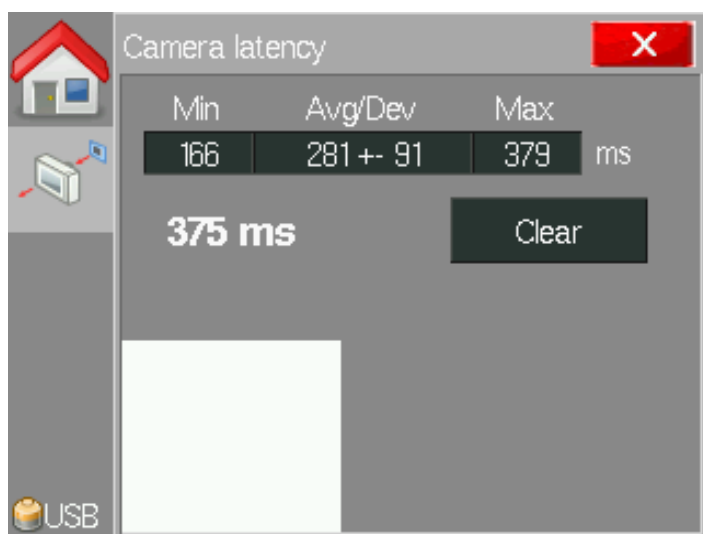
## 7.3 Camera viewfinder latency measurement

The measurement is activated by opening the *Camera latency* application from the Main menu.



**Figure 19: Camera latency application just started**

In the Camera latency application the marker (black-white) blinks at one second intervals. The interval is fixed and enables the measurement of a latency of a maximum of 500 milliseconds. Pressing the *Clear* button starts a new measurement. Statistics are updated accordingly.



**Figure 20: Camera latency application showing the measurement statistics.**

The white text values show the instantaneous and most recent latency values. Minimum, maximum, average and standard deviation values are shown as well.

## 8 Video Transfer Performance

The Video Transfer Performance measurement determines end-to-end characteristics of a video transfer system, such as a video call. It differs from Camera Framerate option by only measuring end-to-end characteristics: framerate on display, video latency and lipsync. Not measuring the camera-side exposure characteristics allows a simpler measurement method that requires no color calibration and is more tolerant of color distortions in the camera and the display.

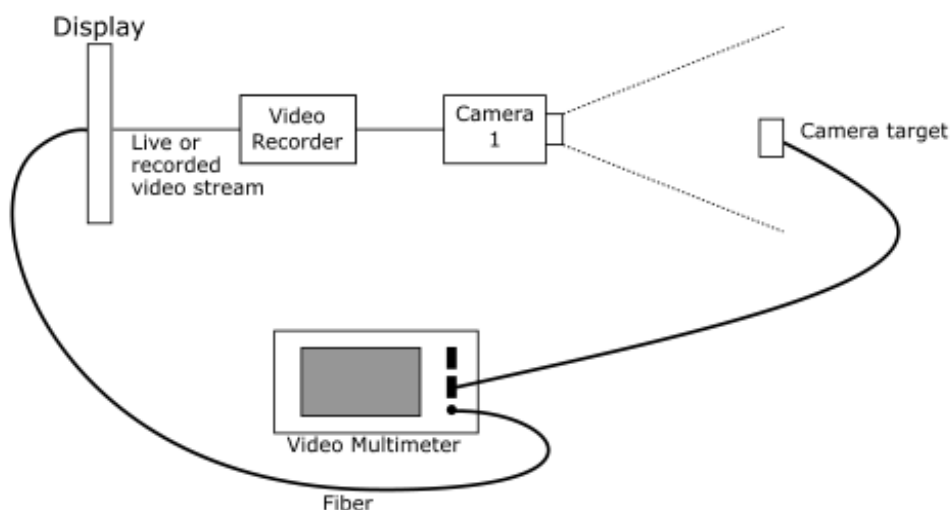
Measurement characteristics of Video Transfer Performance:

	Range	Resolution	Accuracy
Display framerate / frame time	5.5 to 60 FPS (16 to 180 ms frame time)	1 ms	+ - 2 ms
Video latency	0 to 4900 ms	1 ms	+ - 50% of frame time
Lipsync	-1000 to +1000 ms	1 ms	+ - 50% of frame time

When measuring framerates outside the specified range, the displayed framerate may be smaller than the actual framerate. If the video latency is outside the range, the value displayed will be accurate but modulus 5 seconds, i.e. a latency of 9 seconds shows as 4 seconds. For lipsync, values outside the range will be ignored and the measurement shows no lipsync results.

### 8.1 Video Transfer Performance Setup

The measurement setup for Video Transfer Performance consists of optical fiber and an RGB led target attached to the Video Multimeter. The system under test consists of a camera and a display, possibly on two separate DUTs connected by a network. This setup is illustrated in Figure 21.



**Figure 21: Video Transfer Performance measurement setup**

The camera takes images of the color marker on the RGB led target. The color displayed will change for every frame the camera takes. The fiber on the receiving end monitors the color on the display and detects the frame timing by accurately measuring the changes.

In addition to the color changes, the color brightness is modulated. The receiving end monitors the brightness over 5 second window and uses the modulation pattern to calculate the latency between brightness on the RGB led and brightness on the display.

Lipsync can optionally be measured by connecting an audio in-out cable to the other sensor port. The audio output will give a beep tone every 5 seconds. The audio input is monitored for this tone, and when detected the timing is compared to the detected video latency.

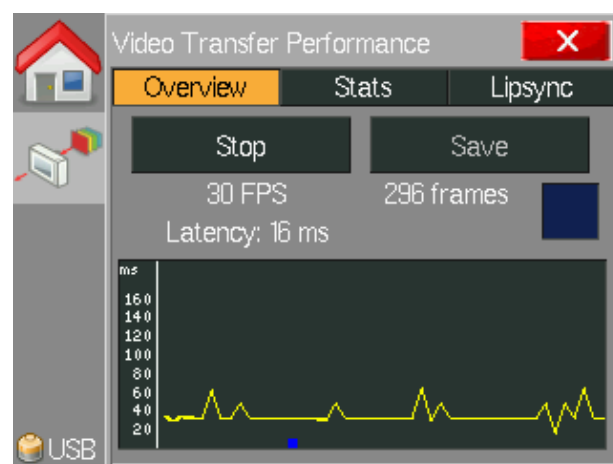
## 8.2 Video Transfer Performance Application

The Video Transfer Performance application consists of three tabs: Overview, Stats and Lipsync.

On the Overview tab, there are measurement Start/Stop button and Save button. Pressing Start begins the measurement, and the graph at the bottom of the screen shows frame times for each frame on the display. The X axis is the frame number, and the Y axis is the frame time in milliseconds. Blue dots at the bottom of the graph indicate lipsync markers in the audio stream, if the audio cable is connected.

Below the buttons, there are indicators for current FPS reading, total number of measured frames and the current latency. After the measurement is stopped, the indicators will read the average FPS and average latency over the whole measurement duration.

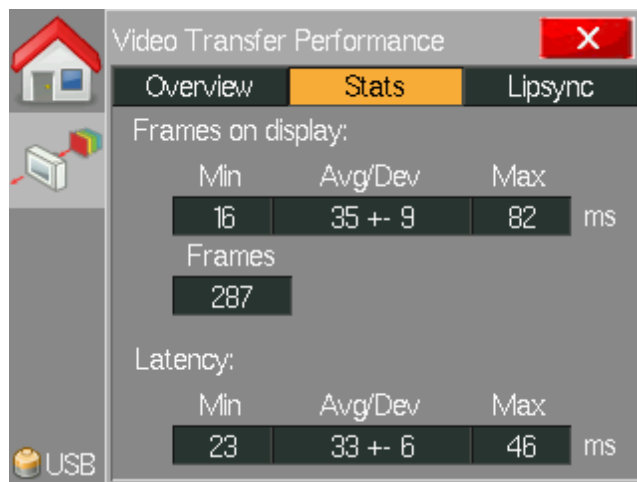
To the right of the text indicators, there is a color rectangle that displays the current color detected by the fiber. This helps verifying the fiber placement and display brightness.



**Figure 22: Video Transfer Performance application during measurement**

More detailed measurement results can be seen on the Stats tab. The "Frames on display" section displays the minimum and maximum frame time during the measurement, the average frame time, and the standard deviation of the frame times. The Frames box indicates the total number of measured frames.

Latency section similarly shows minimum and maximum values, the average latency and the standard deviation of the latency values. All of the **latency** statistics are calculated from 5-second sliding window average values, as opposed to the latencies of individual frames that may have a higher variation.



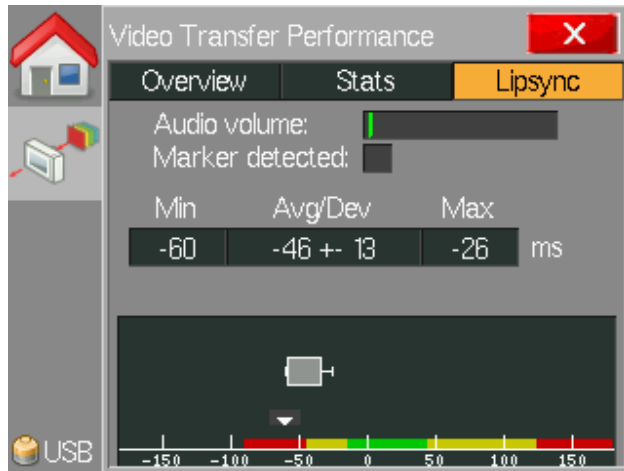
**Figure 23: Video Transfer Performance statistics tab**

Synchronization between audio and video playback can be monitored on the Lipsync tab. The top section displays current audio volume, which can include e.g. background music in addition to the beep markers. The "Marker detected" indicator blinks each time a beep tone is detected in the audio stream.

The lipsync values are measured as milliseconds difference between timing in audio and video. Positive values indicate that audio is late, and negative values indicate that video signal is late. The minimum, maximum, average and standard deviation are calculated over all lipsync markers detected during the measurement.

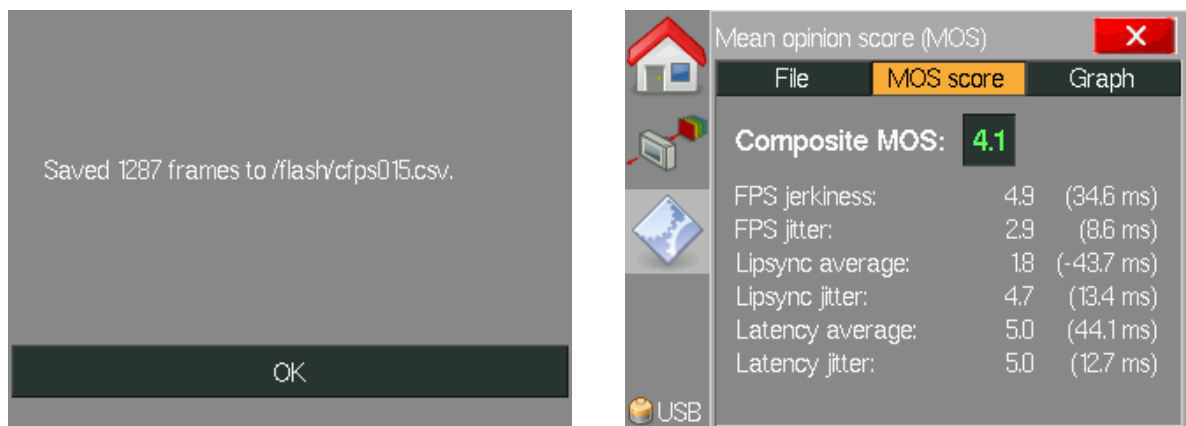
The graph at the bottom visualizes these results. The box diagram shows the minimum and maximum values with a white line, and the standard deviation range with a gray box. The arrow indicates the latest lipsync value. The colors on the scale show the subjective lipsync quality, where humans are usually more sensitive to late video than late audio.





**Figure 24: Video Transfer Performance lipsync tab**

After stopping the measurement, the results can be saved to a CSV file by pressing Save button on the Overview tab. A message box will show the path where file has been saved and the number of frames in the measurement. After saving, user can optionally open the MOS Analyzer (see section 11) to further study the results.



**Figure 25: Video Transfer Performance Save function and MOS results**



The saved CSV files are separated by semicolons and can be opened using e.g. Microsoft Excel. Columns of the result file are described in table below:

Column	Measurement unit	Description
1: Timestamp	microseconds ( $\mu$ s)	Start of the frame display, running timestamp from the start of the measurement.
2: Frame length	microseconds ( $\mu$ s)	Length of the frame display, i.e. the difference between timestamps of this and next row.
3: Color	#RGB	Detected color of the frame, used only for diagnostic purposes.
4: Lipsync	milliseconds (ms)	Detected lipsync value, or empty if no lipsync marker occurred during this frame.
5: Latency	milliseconds (ms)	Detected latency value.

### 8.3 Using Video Transfer Performance with recorded video

Video Transfer Performance application can be used to measure both live streams and video recordings. When used with video recordings, latency measurement may show spurious values as the actual delay between recording and playback is longer than the 5 seconds measurement range. To disable latency measurement during video recording measurements, disconnect the RGB led and restart the Video Multimeter.

### 8.4 Video Transfer Performance self-verification

If required, the functionality of the fiber sensor and the RGB led target can be verified by pointing the fiber sensor directly towards the target. In this configuration, the measurement results should show 60 FPS video with 0 ms latency as the average. Individual readings will vary by some amount according to the measurement accuracy specified above.

### 8.5 Video Transfer Performance License Activation

The Video Transfer Performance option is activated by a license file on Video Multimeter's SD card. The file name of the license is "camera\_fps\_v2.ini", and it should be copied into the folder /frm/license/.

Lipsync feature can be used when the Video Transfer Performance option is enabled and the audio in/out cable has been connected.

## 9 Dual FPS (Frames per Second) option

Video content can be shown on multiple displays simultaneously, for example when presenting content to an audience. If videos on different displays are not shown simultaneously it may have an effect on the user experience. If the audio is in synchronization with one of the display contents, a delay between videos can cause disturbing lip sync error on the other display.

Video Multimeter can be used to measure the quality of video simultaneously from two separate displays. It is also possible to measure how well the monitors are synchronized.

### 9.1 Dual FPS option license activation

The dual FPS option is activated by copying a valid license file into Video Multimeter's SD card. The license file name is 'dual\_fps.ini', and it should be copied into the folder /frm/license/. The file contents is as follows (an example):

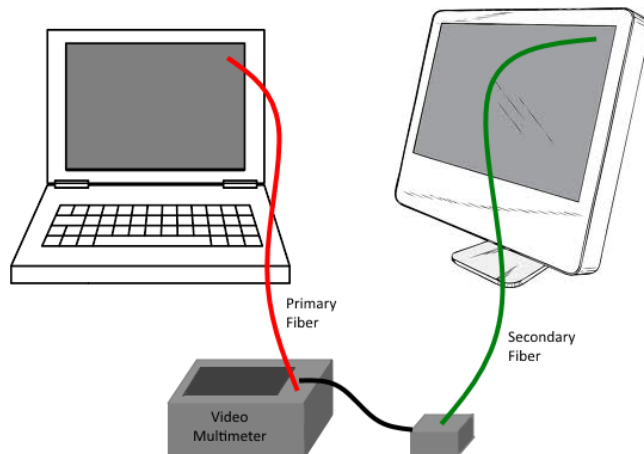
```
; OptoFidelity Video Multimeter license file  
; Device serial number: 5  
; Feature name: dual_fps
```

```
[License]  
salt = 1706318843  
key = 2287536893  
expire = 0
```

The device serial number must match the physical Video Multimeter device. License files are generated by OptoFidelity only. License files should not be edited manually.

### 9.2 Dual FPS measurement setup

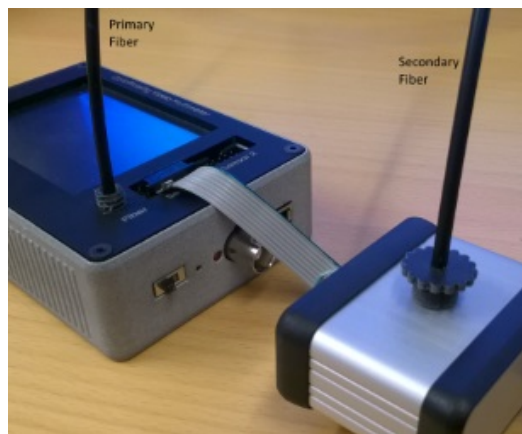
In Dual FPS measurement setup the test video is shown on both primary and secondary displays. Video Multimeter's fiber is then placed on the primary display at the location of the marker. The secondary fiber is placed on the secondary display marker. Figure illustrates a typical setup.



**Figure 26: Typical setup for measuring two displays simultaneously**

The test video used in Dual FPS measurement must have the 6-color RGB marker. Dual measurement does not support other marker types.

For Dual FPS measurement the secondary fiber must be connected to the Video Multimeter Sensor port. See the example in Figure 22.



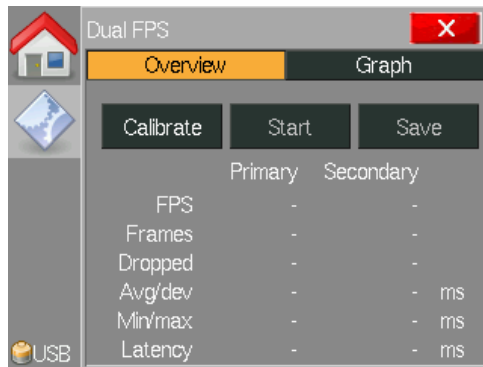
**Figure 22. Two fibers connected to Video Multimeter**

**NOTE:** If a secondary fiber is not connected, the Dual FPS application cannot be used. The application does not start and error message is shown. You must then carry out the following procedure:

- Shut down Video Multimeter
- Connect the secondary fiber to the sensor port.
- Power on Video Multimeter and open the Dual FPS application.

### 9.3 Dual FPS measurement application

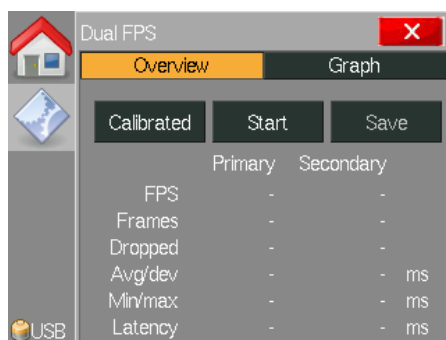
The measurement is activated by opening the *Dual FPS* application from the Main menu. The application's *Overview* page is shown on startup, see the Figure below:



**Figure 28: Dual FPS application just started**

## 9.4 Dual FPS Color calibration

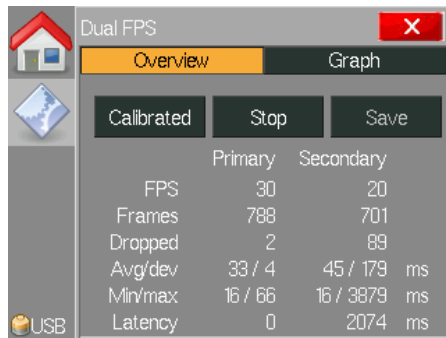
Color calibration must be done before measurement can be started; therefore, *Calibrate* is the only active button on Dual FPS application initially. Calibration is started from *Calibrate* button. If calibration succeeds, *Start* is enabled and the *Calibrate* button text is updated to *Calibrated*, see Figure 23. If calibration fails, retry and make sure that both fibers are placed over the test video marker firmly during calibration and that the test video is running.



**Figure 239. Dual FPS application after successful calibration**

## 9.5 Dual FPS measurement

Measurement is started using the *Start* button. During measurement the results are shown as seen in Figure 24. The *Stop* button is used for ending the measurement. To get repeatable results, start and stop the measurement in the white period at the start and end of the video similarly to one display measurement.



**Figure 24. Dual FPS application during measurement.**

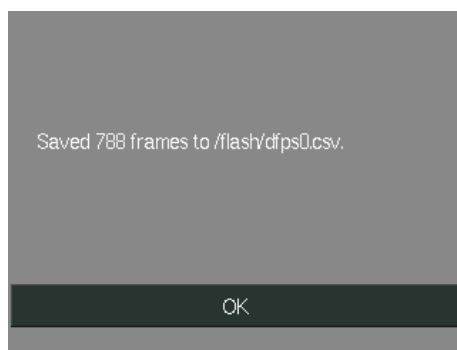
After stopping the measurement, the *Overview* page shows the results from the previous measurement.

The result table includes the following results for primary and secondary measurements:

- **FPS:** Frames per second.
- **Frames:** Number of detected frames.
- **Dropped:** Number of dropped frames.
- **Avg/dev:** Average and standard deviation of frame intervals in milliseconds.
- **Min/max:** Minimum and maximum of frame intervals in milliseconds.
- **Latency:** Millisecond value of the delay between primary and secondary measurements. Zero value for *Primary Latency* indicates that the secondary measurement is behind. Zero value for *Secondary Latency* indicates that the primary measurement is behind. **NOTE:** During measurement *Latency* value is the latest measured delay. After measurement the *Latency* value is the average from the whole measurement.

## 9.6 Dual FPS result saving

Results can be saved using the *Save* button. After saving successfully, a message window shows the name of the saved file. See the example in Figure 25.



**Figure 25. Dual FPS results saved**

The saved data files from the Dual FPS measurement are in semicolon separated CSV format, which is supported by Microsoft Excel and many other data analysis tools. See

the example of result data file content in Figure 26. Each row corresponds to one frame, and has the following columns:

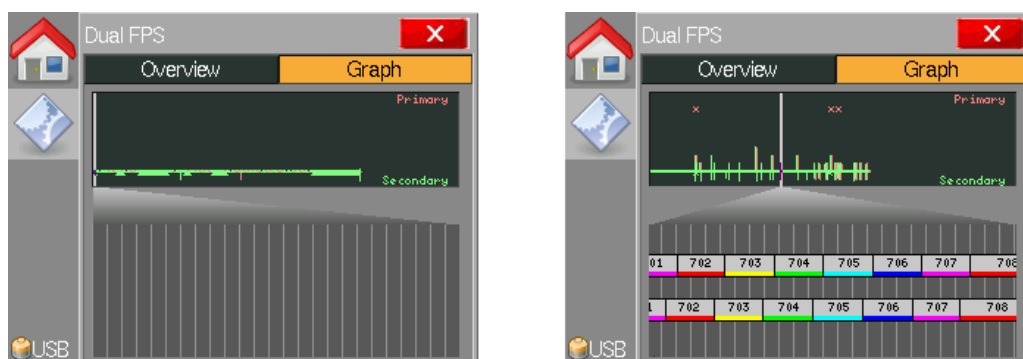
- A) Microsecond timestamp of the frame start for primary measurement.
- B) Microsecond length of the primary frame (-1 for dropped frames).
- C) Cumulative count of dropped primary frames since start of measurement.
- D) Microsecond delay of secondary measurement compared to primary measurement. Negative value indicates that a secondary measurement frame was detected first.
- E) Microsecond length of the secondary frame (-1 for dropped frames).
- F) Cumulative count of dropped secondary frames since start of measurement.
- G) Color of the marker in the frame. The value is same for both primary and secondary measurements.

	A	B	C	D	E	F	G
1	# Recorded at 2015-12-16 10:21:42 using OptoFidelity Video Multimeter						
2	# Frame start A (us)	Frame length A	Drop count A	Frame delay B (us)	Frame length B (us)	Drop count B	Color
3	0	32980	0	-13782	35000	0	k
4	32980	33020	0	-11762	32000	0	y
5	66000	34090	0	-12782	34000	0	g
6	100090	33050	0	-12872	34000	0	c
7	133140	33950	0	-11922	34000	0	b
8	167090	33090	0	-11872	32000	0	p
9	200180	33000	0	-12962	33000	0	r
10	233180	33080	0	-12962	33000	0	y

**Figure 26: Data file saved from Dual FPS measurement**

## 9.7 Dual FPS Graph view

The graph view of the *Dual FPS* application presents the frame length over time. During measurement the graph is continuously updated. After measurement the graph can be viewed in detail. See examples of the graph view during and after measurement in Figure 27. The primary frame time result is presented in red color and secondary result in green. Note that if results are very close to each other they may overlap as in the example figures.



**Figure 27. Dual FPS Graph view during and after measurement**

When detailed results are visible it is possible to select the place where detailed results are shown from the upper part of the graph view. The bottom view shows the detailed



results. The detailed results are scrollable. The explanation of the detailed view is as follows:

- Primary frames are presented on the top and secondary frames on the bottom.
- The width of the frame box shows the frame interval.
- The number in the frame box is the running frame number starting from 0.
- X indicates a missing frame.
- The color of the frame is visible in the box.
- The vertical help lines are in 10ms intervals.

## 10 Measure VR Displays option

### 10.1 Measure VR displays license activation

The Measure VR displays option is activated by copying a valid license file into Video Multimeter's SD card. The license file name is 'vr.ini', and it should be copied into the folder /frm/license/. The file content is as follows (an example):

```
; OptoFidelity Video Multimeter license file  
; Device serial number: 6  
; Feature name: vr
```

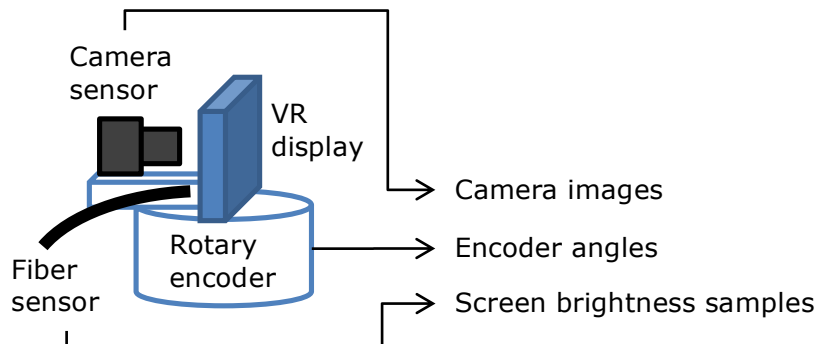
```
[License]  
salt = 8903670837  
key = 1935295630  
expire = 0
```

The device serial number must match the physical Video Multimeter device. License files are generated by OptoFidelity only. License files should not be edited manually.

### 10.2 VR Display Measurement Setup

In VR Display measurement, the device under test is attached to the rotating disk. Movement of the disk is measured by the rotary encoder. The display of the device is measured with the fiber and camera sensors. The fiber sensor measures the refresh rate and pixel persistence of the display. This information is used for synchronizing the camera sensor with the display.

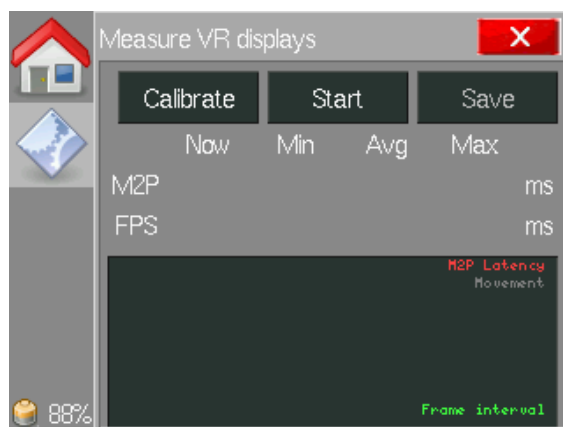
The device under test is running a measurement application that shows the measurement pattern on the screen. The pattern is updated according to the movements of the device. The 'motion-to-photon' latency of screen updating is measured by comparing the position data from the rotary encoder and the visual data from the camera sensor.



**Figure 28 VR display measurement setup**

### 10.3 Measure VR Displays application

The measurement application is started by selecting *Measure VR displays* from the main menu. The initial view of the application is shown in Figure 29.



**Figure 29 Measure VR displays application after the start**

### 10.4 Measure VR Displays Measurement

First step is to start the test application (e.g. Futuremark VRMark Twist, OptoFidelity WMRH Test App) on the device under test.

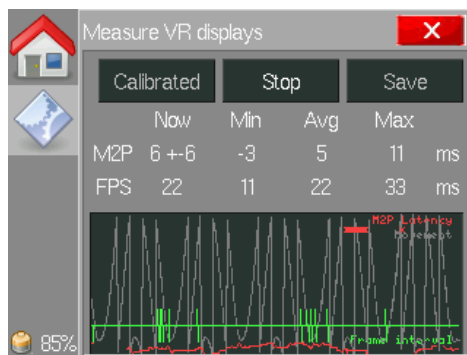
If the test case includes (video/application/game) framerate measurement, color calibration must be first carried out. Once the 6RGB color cycle is running on the device under test, pressing *Calibrate* button starts the calibration sequence. If the calibration is successful, button caption changes to *Calibrated*.

Restart the test application on the device under test. To synchronize the measurement properly, it is important to start and stop the measurement during test application's white content. There are white contents both in the start and end of the test application sequence.



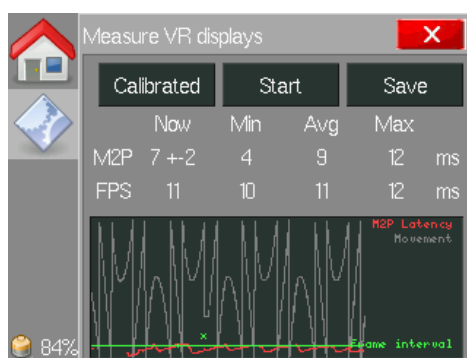
Once the test application shows **completely white content**, the measurement is started with *Start* button. During the measurement, the label of the push button is updated as *Stop* (see Figure 30). When the device under test is moving and the measurement produces data, the application updates the latency graph and the following data fields:

- **M2P**: The measured motion-to-photon latency between the movement of the device and the updates of the display content (in milliseconds). Most recent value (now), min, avg and max values are displayed. The estimated accuracy of the latency measurement (in +/-milliseconds, after the most recent value (now))
- **FPS**: The measured frame intervals (in milliseconds) of the displayed content are displayed. The values include most recent measured value (now), min, avg and max.



**Figure 30 Measure VR displays application during the measurement**

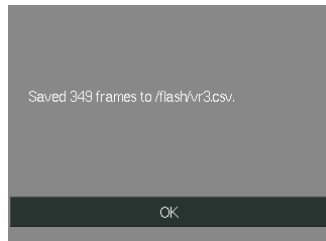
When the measurement is stopped, **during the white content** (see Figure 31), the label of the Start/Stop push button is updated as *Start* again. The *Save* button is also enabled. The data fields and the latency graph show the results in the end of the measurement.



**Figure 31 Measure VR displays application after the measurement**

## 10.5 Measure VR Displays Save Function

Measurement results can be saved by pushing the Save button. After saving successfully, the message window shows the name of the saved file. See the example in Figure 32.



**Figure 32 Save dialog in Measure VR displays application**

The saved data files are in the semicolon separated CSV format which is supported by Microsoft Excel and many other data analysis tools. See the example of result data file content in Figure 33. Each row corresponds to one observation and has the following columns:

- A) Frame start time: The observation time expressed as microseconds from the beginning of the measurement.
- B) M2P Latency: Motion-to-photon latency (in milliseconds)
- C) Latency accuracy: Estimated accuracy of the observation (in milliseconds)
- D) Backlight on time: Duration (in microseconds) which the display backlight was switched on. The value reflects the pixel persistence of the display.
- E) Backlight period: Display backlight period (in microseconds). The display refresh rate (in Hz) is  $10e6$  divided by the value of this field.
- F) Frame length: The measured video frame interval (in milliseconds)
- G) Frame color: The detected frame marker 6RGB color

	A	B	C	D	E	F	G
1	# Recorded at 2000-01-09 05:26:29 using OptoFidelity Video Multimeter						
2	# Frame start (us)	M2P Latency (ms)	Latency accuracy (ms)	Backlight on	Backlight period (us)	Frame length (us)	Frame color
3	3255570	6	2	2651	11120	11120	r
4	3266690	6	2	2651	11130	11300	y
5	3277990	6	2	2651	11120	10940	g
6	3288930	6	2	2651	11130	11100	c
7	3300030	6	2	2651	11120	11140	b
8	3311170	6	2	2651	11120	11120	p
9	3322290	6	2	2651	11120	11120	r
10	3333410	5	2	2651	11120	11030	y
11	3344440	6	2	2651	11120	11210	g
12	3355650	6	2	2651	11120	11030	c
13	3366680	8	2	2651	11120	11120	b
14	3377800	8	2	2651	11120	11120	p
15	3388920	8	2	2651	11120	11120	r
16	3400040	7	2	2641	11120	11050	y
17	3411090	7	2	2651	11120	11190	g
18	3422280	7	2	2651	11120	11120	c

**Figure 33 VR Display measurement results**

## 11 Mean Opinion Score (MOS)

The saved video quality results can be further analyzed in the Mean Opinion Score (MOS) application. Each measured value is given a score from 1 to 5. A score of 5 is the best result and a score of 1 indicates poor quality video. MOS values are also color-coded, red indicating a poor result and green indicating a good result. See the categorization and color coding of MOS in Figure 34.

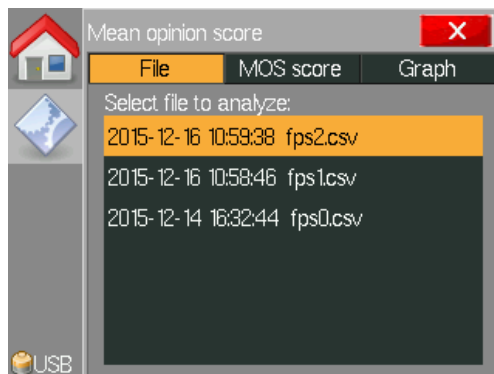
Scores	Quality	Impairment
5	Excellent	Imperceptible
4	Good	Perceptible, but not annoying
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying, unwatchable

**Figure 34. Mean Opinion Score interpretation**

### 11.1 File view

When the Mean Opinion Score application is started *File* view is opened, see Figure 35. A list of saved files is shown and a file can be selected. The listing of a file name indicates measurement. Note that some of the measurements require a separate license.

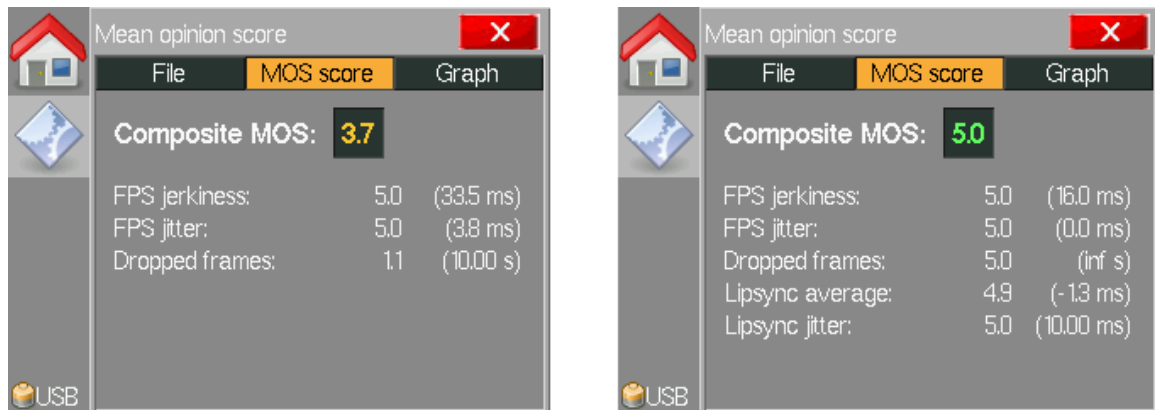
- **fps:** Framerate measurement
- **dfps:** Dual FPS or Dual Camera FPS measurement



**Figure 35. Initial view of the Mean Opinion Score application.**

### 11.2 MOS score view

When *MOS score* view is selected MOS values for the selected file are shown. *Composite MOS* value is a combination of all individual MOS values. Individual scores and actual results are listed below *Composite MOS*. Examples of MOS score views are presented in Figure 36.



**Figure 36. MOS view for FPS result without and with lip sync**

The FPS result consists of the following individual values:

- **FPS jerkiness:** Average of frame rates.
- **FPS jitter:** Standard deviation of frame rates.
- **Dropped frames:** Average delay between dropped frames. Infinity (inf) indicates no dropped frames.
- **Lip sync average:** Average of audio/video synchronization (lip sync). Available if the Lip sync option is enabled and file includes audio information.
- **Lip sync jitter:** Standard deviation of audio/video synchronization (Lip sync). Available if the Lip sync option is enabled and file includes audio information.

The Dual FPS result consists of the following individual values:

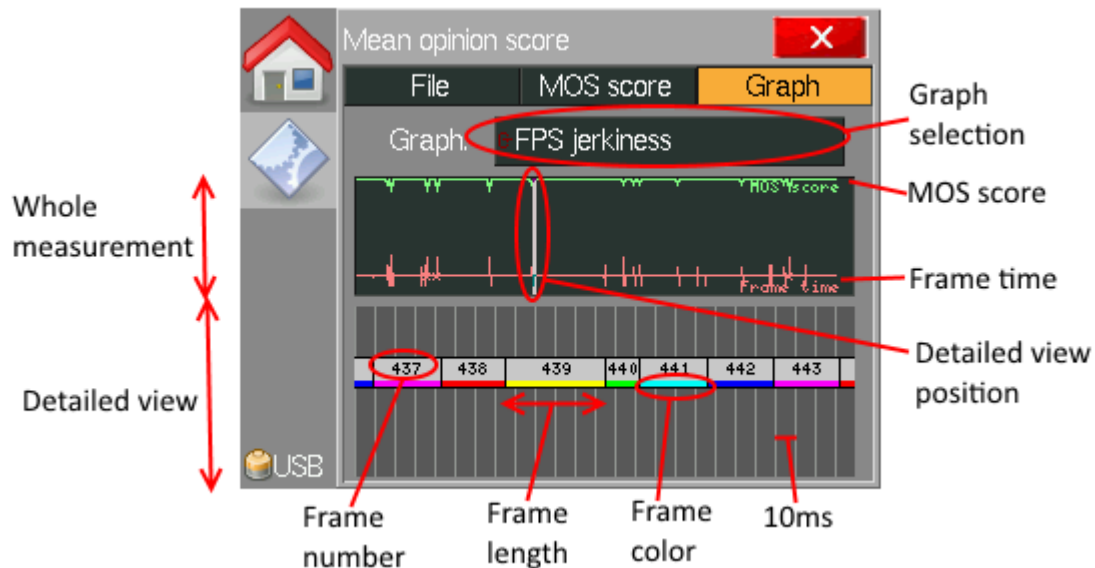
- **Prim. FPS jerkiness:** Average of frame rates for primary measurement.
- **Prim. FPS jitter:** Standard deviation of frame rates for primary measurement.
- **Sec. FPS jerkiness:** Average of frame rates for secondary measurement.
- **Sec. FPS jitter:** Standard deviation of frame rates for secondary measurement.
- **Dropped frames:** Average delay between dropped frames. Infinity (inf) indicates no dropped frames.
- **Latency average:** Average latency between primary and secondary measurements.
- **Latency jitter:** Standard deviation of latencies between primary and secondary measurements.

Dual Camera FPS result consists of the same fields as Dual FPS results. Additionally, if Lip sync was measured, the result includes **Lip sync Average** and **Lip sync Jitter** fields that are similar as in the FPS result.

### 11.3 MOS Graph view

When MOS *Graph* view is selected detailed values for the selected file are shown. The graph is available for all individual results that are available in the *MOS Score* view. An example of *Graph* view is shown in Figure 37. The graph selection is at the top of view. The upper graph shows the whole measurement for a selected result. The lower graph

shows a detailed view. The detailed view position can be selected from the upper graph. The detailed view is scrollable.



**Figure 37. MOS Graph view**

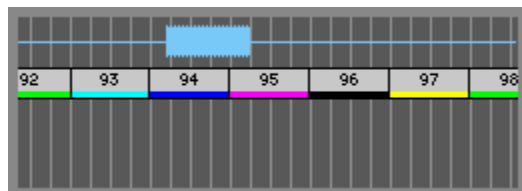
A guide to the whole measurement interpretation is as follows:

- The green line represents MOS scores for a selected feature over time.
- The red line represents frame times over time.
- The red 'X' markers indicate missing frames.
- The MOS value range is from 0 to 5 and the Frame time range is from 0ms to 200ms.

A guide to the detailed view is as follows:

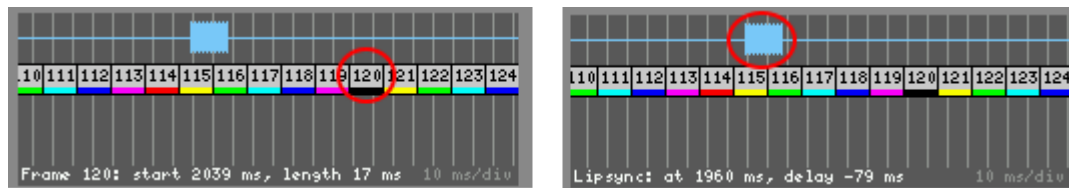
- The width of the frame box represents the frame interval/length.
- The number in the frame box is the running frame number starting from 0.
- 'X' indicates a missing frame.
- The color of a frame is visible in the box.
- Vertical help lines are in 10ms intervals.

If Lip sync feature is enabled audio information is available in the detailed view. See the example in Figure 38. The audio marker (a beep sound) is indicated as a blue box on top of the frames. In the example figure sound is detected before the audio marker color indicator (black frame).



**Figure 38. MOS Graph detailed view with audio marker**

Numerical values for frame and lip sync are visible at the bottom of the detailed view by selecting a frame. See examples in Figure 39.



**Figure 39. Single frame details.**

## 11.4 MOS Configuration (OptoFidelity default)

The Mean Opinion Score (MOS) is calculated separately for each individual result. The default configuration for each MOS value is described in Table 1. Raw values are given a corresponding MOS value, and values between raw values are interpolated linearly.

Result	Result identifier in mos.ini file	Unit	Raw value	MOS
<b>FPS jerkiness</b>	PrimaryFrameJerkiness/ SecondaryFrameJerkiness	ms	33.3	5.0
			40.0	4.5
			83.3	3.5
			200.0	2.2
			300.0	1.0
<b>FPS jitter</b>	PrimaryFrameJitter/ SecondaryFrameJitter	ms	1	5.0
			10	2.5
			20	1.0
<b>Dropped frames</b>	DroppedFrames	s	1	1.0
			5	4.0
			10	5.0
<b>Lip sync average</b>	Lip syncDelay	ms	-54	1.0
			-27	3.0
			0	5.0
			75	3.0
			150	1.0
<b>Lip sync jitter</b>	Lip syncJitter	ms	10	5.0
			30	3.0
			100	1.0
<b>Latency average</b>	LatencyDelay	ms	200	5.0



<b>Latency jitter</b>	LatencyJitter	ms	400	2.0
			550	1.0
			10	5.0
			100	3.0
			300	1.0

**Table 1. MOS default configuration**

The MOS configuration is changed by editing the mos.ini file that is found in the Video Multimeter file system in the frm folder. See the instructions for accessing Video Multimeter files in Chapter 5.

The Configuration file mos.ini is a text file that can be changed with any text editor. The file has the following format:

```
[ResultName]
; Description of Result
100.0 = 5.0
0.0 = 1.0
```

- [ResultName] defines the result item.
- Lines starting with ';' character are comment files.
- Other rows have the format: raw\_value = MOS\_value.
- Values between rows will be interpolated linearly.

The Composite MOS value is a weighted average of individual results. Relative weights can be edited in the mos.ini file. The default weights for Composite MOS in mos.ini format are shown below.

```
[Weights]
; Relative weights of the components for composite MOS.
PrimaryFrameJerkiness    = 1.0
PrimaryFrameJitter       = 1.0
SecondaryFrameJerkiness  = 1.0
SecondaryFrameJitter     = 1.0
DroppedFrames            = 1.0
Lip syncDelay            = 1.0
Lip syncJitter           = 0.0
LatencyDelay             = 1.0
LatencyJitter            = 1.0
```

## 12 Measure Motion Blur option

Motion Blur is a display phenomenon, that is typically caused by display's temporal characteristics, e.g. settling times, often together with user's eye tracking (often called "Retinal Blur"). Slow response times, badly synchronized backlight vs content or inappropriate persistence can cause visible, perceptual motion blur and ghosting.

Motion Blur has been traditionally measured by complex pursuit or high speed cameras, and the result has been expressed as blur edge width. This approach is prone to many issues, especially when dealing with low persistence VR or MR displays and projectors.

### 12.1 Measure Motion Blur license activation

The Measure Motion Blur option is activated by copying a valid license file into Video Multimeter's SD card. The license file name is 'motion\_blur.ini', and it should be copied into the folder /frm/license/. The file content is as follows (an example):

```
; OptoFidelity Video Multimeter license file
; Device serial number: 6
; Feature name: motion_blur
```

```
[License]
salt = 8903670837
key = 1935295630
expire = 0
```

The device serial number must match the physical Video Multimeter device. License files are generated by OptoFidelity only. License files should not be edited manually.

### 12.2 Motion Blur measurement method

Video Multimeter's tristimulus sensor is being used to measure the settling times for different colors. A special target pattern is used to stimulate the sensor:

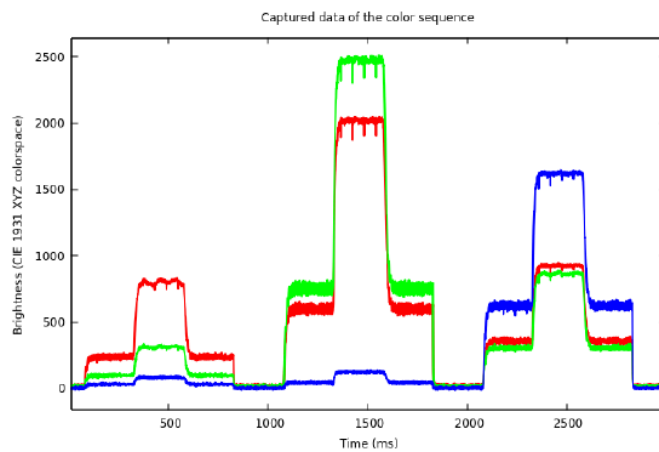


The following settling times are measured:

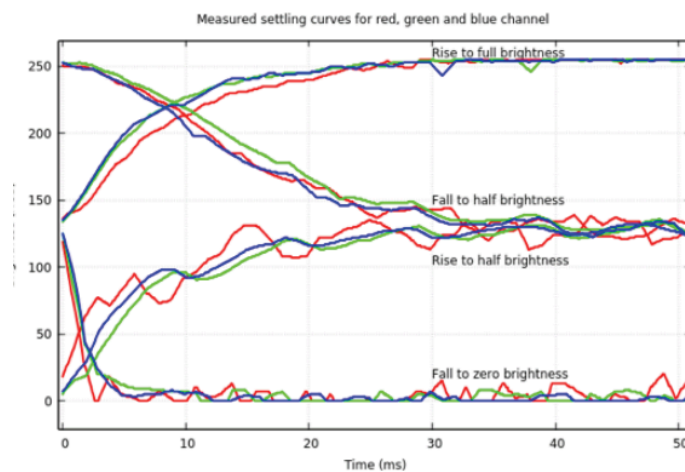
- Red channel 0% - 50% - 100% - 50% - 0%
- Blue channel 0% - 50% - 100% - 50% - 0%
- Green channel 0% - 50% - 100% - 50% - 0%

In general, the resulting waveform looks like this:

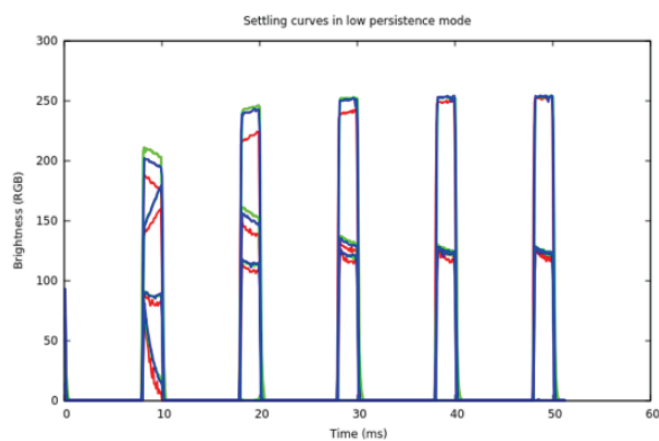




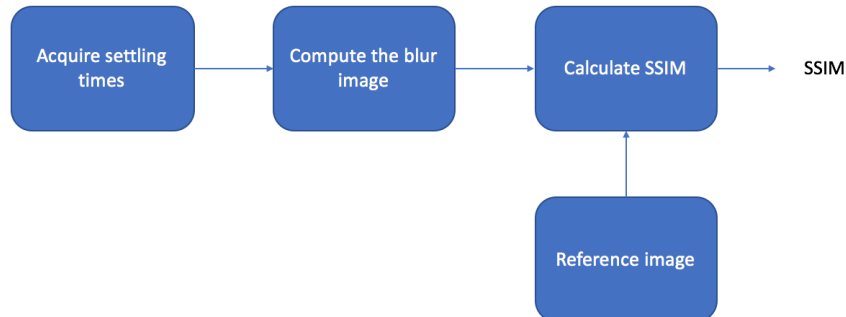
And the most interesting part, rise/fall part / settling (full persistence example):



Low persistence example looks like this:

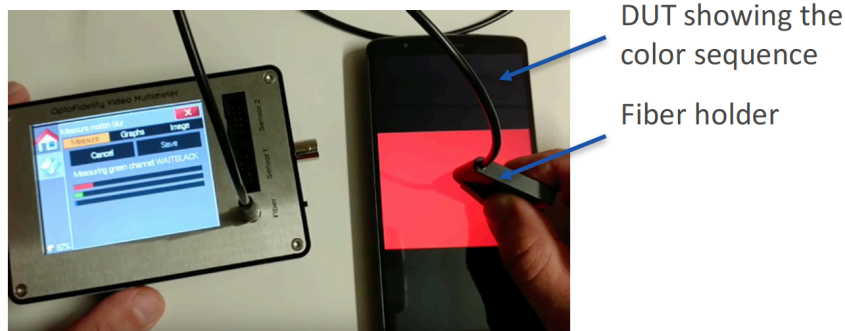


The definitive part of OptoFidelity’s Motion Blur assessment is the ability to calculate the computed blur image, and finally calculate the SSIM quality index.



### 12.3 Motion Blur measurement setup

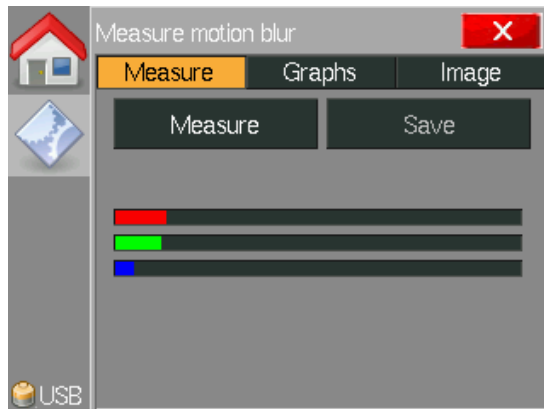
The following picture illustrates a typical mechanical setup for OptoFidelity Video Multimeter Motion Blur measurement.



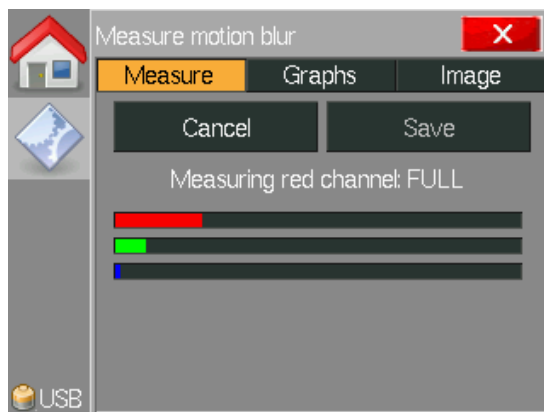
Attention must be paid for the ambient illumination effects. Especially when measuring low persistence displays, which are most of the time unilluminated, strong ambient illumination can cause variation to the measurement results. It is suggested to utilize dark room or dark chamber for the measurements.

### 12.4 Motion Blur latency measurements

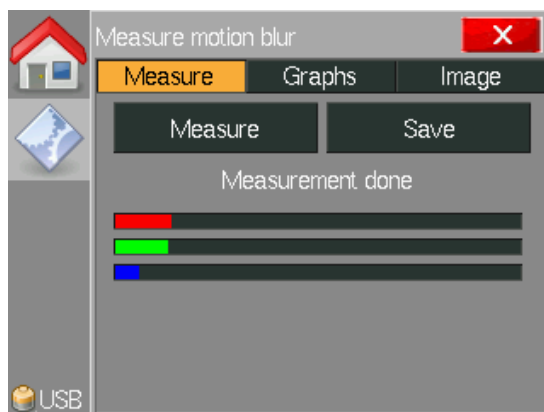
Once the mechanical measurement setup is ready, and device under test has the test target pattern video running, the measurement can be started by selecting “Measure”.



While measurement is on, the “Cancel” button is visible and “Measuring xxx channel yyy” text is updating. Also the red, green and blue bars, showing the relative intensity of corresponding color channels, are updating.



Once the measurement is complete, “Measure”-button becomes visible and “Save”-button activates. The detailed results are accessible in the “Graphs” and “Image” tabs.



See the following chapter for results analysis and saving functions.

## 12.5 Motion Blur latency results analysis & saving

“Graphs”-tab contains the settling curves for each color channel. The image pair below shows typical curves for full (left) and low persistence (right) display.

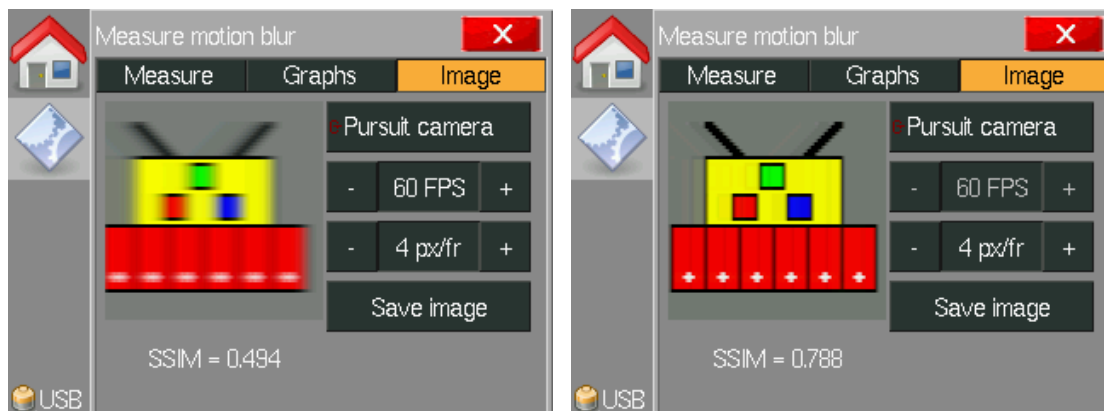


“Image”-tab contains the computed blur images. The image pair below shows example images for full and low persistence displays. The calculated SSIM (structural similarity) index value from 0..1 is shown below the computed blur image.

The SSIM value can be linearly converted to MOS scale 1..5, to more easily assess the perceptual quality. The following table is a good example of the MOS scale.

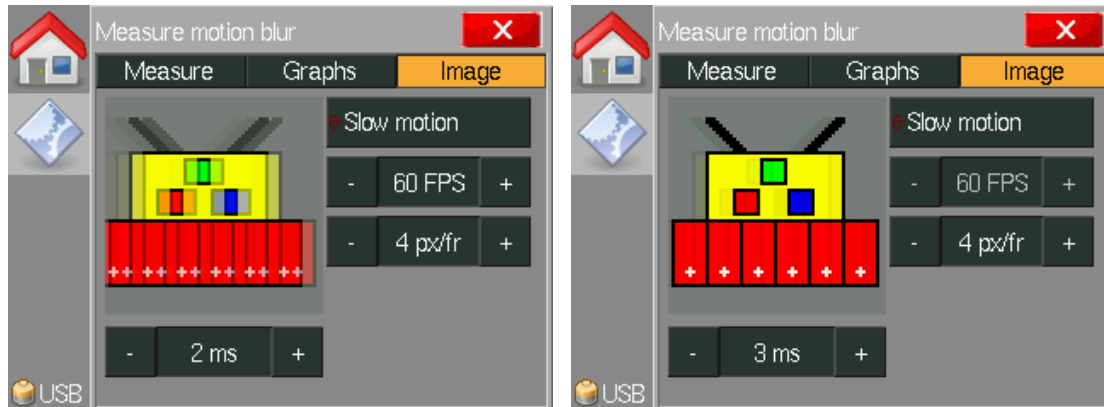
Scores	Quality	Impairment
5	Excellent	Imperceptible
4	Good	Perceptible, but not annoying
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying, unwatchable

The equation for the conversion is **MOS = SSIM\*4+1**.

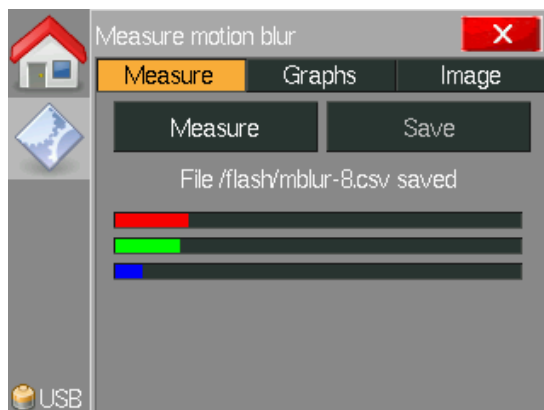


As an example, the SSIM values above would be converted to MOS like this:  
 $MOS_{full\_pers} = 0.494 \times 4 + 1 = 3.0$ ,  $MOS_{low\_pers} = 0.788 \times 4 + 1 = 4.2$

By clicking the "Pursuit camera" button, it is possible to toggle to "Slow motion" mode. Slow motion –mode simulates, how the blur image would look like, during the display update process. The slow motion –image is updated in one millisecond intervals.



Measurement results are saved into a CSV-file by clicking "Save"-button.



The results contain all settling curve data for separate color channels.

	A	B	C	D	E	F
1	# Recorded at 2017-07-18 13:05:50 using OptoFidelity Video Multimeter					
2	# Time (us)	Color chann	Rise-to-half	Rise-to-full	Fall-to-half	Fall-to-zero
3	# Color channel: r					
4	# Capture times: 358442167 0 498100 999300 1498200					
5	# Backlight period: 0					
6	# Brightness levels: 283 1403					
7	0	r	37	142	246	125
8	100	r	41	148	244	121
9	200	r	42	154	243	120
10	300	r	42	158	242	118
11	400	r	42	164	240	116
12	500	r	47	165	240	113
13	600	r	44	170	237	111
14	700	r	46	173	237	109
15	800	r	50	175	235	109
16	900	r	53	180	234	107
17	1000	r	47	182	233	104
18	1100	r	52	183	232	104
19	1200	r	53	188	230	102
20	1300	r	56	188	228	100

## 13 Timebase Calibration option

Sometimes Video/VR Multimeter needs to be included in the Quality Control, and by traceable calibrated ("NIST") devices, such as oscilloscopes, it is possible to calibrate the Video/VR Multimeter.

### 13.1 Timebase Calibration license activation

The Timebase Calibration option is activated by copying a valid license file into Video Multimeter's SD card. The license file name is 'calibration.ini', and it should be copied into the folder /frm/license/. The file content is as follows (an example):

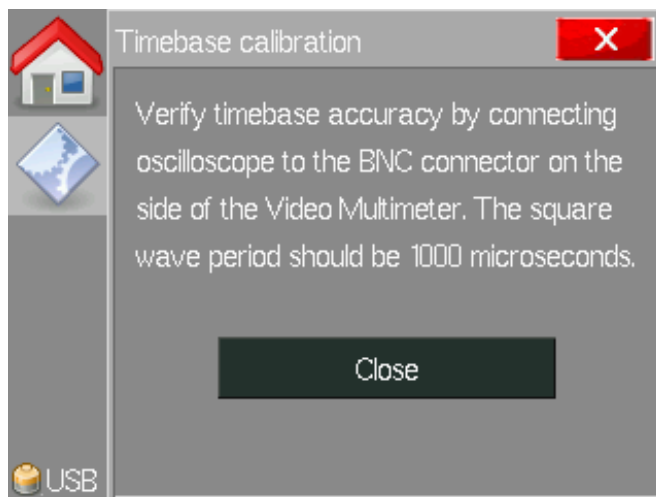
```
; OptoFidelity Video Multimeter license file
; Device serial number: 6
; Feature name: calibration
```

```
[License]
salt = 8903670837
key = 1935295630
expire = 0
```

The device serial number must match the physical Video Multimeter device. License files are generated by OptoFidelity only. License files should not be edited manually.

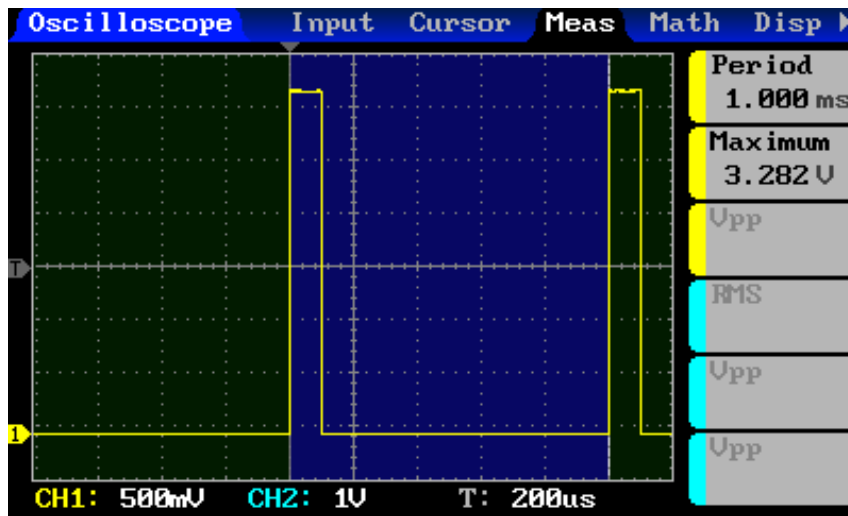
### 13.2 Timebase Calibration application usage

Open the Timebase Calibration application by navigating and tapping the corresponding application in the main menu. The following window is shown:



**Figure 40. Timebase Calibration application window**

Once opened, the application controls the system clock signal and directs a square wave with 1000 microseconds period, to the physical BNC connector on the side of the Video/VR Multimeter. Wave period can then be measured with e.g. an oscilloscope:



**Figure 41. Timebase Calibration waveform example**

Close the Timebase Calibration application to stop the waveform generation.

### 13.3 Valid result for Timebase Calibration

The target value for the waveform period is 1.000 milliseconds, but it is acceptable to be in the range of 0.995..1.005 milliseconds (+/- 5 microsecond jitter is acceptable). The expiration time of a calibration is one (1) year.

## 14 Software update

To update the software connect the device to a computer with a USB cable. Switch the power on while holding down the button next to power switch, for example with a pen. Video Multimeter's display shows a random noise (salt and pepper) image.





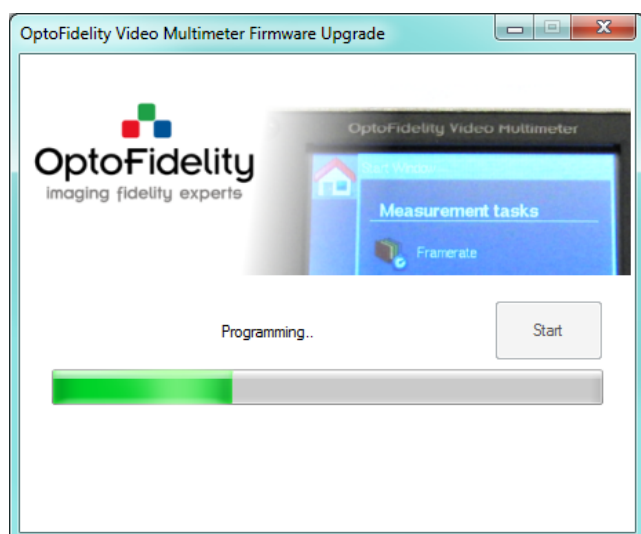
**Figure 42: Video Multimeter's display showing random noise, indicating firmware upgrade mode.**

The device should become visible as a USB DFU device, and drivers should be installed automatically.

Start the *Firmware Upgrade* application on the computer, and click the *Start* button. The application tells you when the software upgrade is done. Finally detach the device from the computer and switch it off to exit the upgrade mode.

If the software update is interrupted for some reason you can run the upgrade again as described above. Upgrade mode is separate from the main software so damaged software does not prevent upgrading.

**Note:** When the device is started in the firmware upgrade mode the screen will display random noise. Reboot the device to exit the upgrade mode.



**Figure 43: Firmware Upgrade application**

## 15 Technical specifications

<b>External dimensions:</b>	12x8x3 cm
<b>Operating temperature range:</b>	-10 C to +40 C
<b>Storage temperature range:</b>	-20 C to +60 C
<b>Internal memory:</b>	4 GB
<b>Operating time using the battery:</b>	6 hours
<b>Battery:</b>	Li-Ion Panasonic PA-L2, 1950 mAh, 7 Wh
<b>Operating current:</b>	300 mA
<b>Built-in fiber sensor bandwidth:</b>	4 kHz
<b>Built-in fiber sensor sample rate:</b>	100 kS/s
<b>Trigger output voltage (low):</b>	0.0 V to 0.4 V
<b>Trigger output voltage (high):</b>	2.9 V to 3.3 V
<b>Trigger output impedance:</b>	50 ohms

## 16 References

[1] OptoFidelity, "Protocol for Control API, VideoMultimeter\_Control\_Protocol.pdf".

## 17 Change history

Ver.	Status	Date	Author	Remarks
1.0	Draft	5.3.2013	KRY	First release
1.1	Release	7.5.2013	JPA	Release 2013Q1.0
1.2	Release	27.5.2013	JPA	FPS UI + file format
1.3	Release	27.6.2014	KJO	Lip sync option, Remote control option
1.4	Release	25.9.2015	KJO	Trigger out option, Camera latency option
1.5	Release	6.4.2016	RJ	Dual FPS option, MOS
1.6	Release	1.12.2016	MVA, JL	Camera Framerate and Dual Camera FPS options
1.7	Draft	14.2.2017	JL	Measure VR displays application
1.8	Release	18.8.2017	KJO	Motion Blur, Timebase calibration application
1.9	Pre-Release	29.8.2017	KJO	Measure VR displays application, combined m2p and fps
2.0	Release	23.10.2018	TBJ	Video Transfer Performance