Skype Hardware Certification Specification

For <u>all</u> Skype Video Devices

Version 5.0

Document Version

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Revision History

Version	Date	Comments	Valid
5.0	2011-08-30	Accessories test specification is removed and the accessories will be tested against this specification. HD video framerate requirement is increased to 24 fps. Laptops will be also tested against this test specification. Enabled a possibility to enable 720x1280 send video resolution even if the aim is not to become Skype Certified. Video preview requirement is made easier under the entry criteria for SDK based video devices categories 'required' and 'HQV'. The depth of field requirement is clarified about how we test solutions with autofocus. Exception made for long range HD TV cameras with fixed focus. (The acuity in 300 lux is measured at 1m distance.)	2011-09-06
4.1.0	2011-06-29	SDK test specifications merged. Devices aiming to meet the preferred quality must support sending at least 640x480 video resolution. The categorization by usage distance is abandoned. The intended usage distance is considered only with Depth of field test. The preferred requirements remained the same, but the build up of the test cases changed so that the description is separated from the requirement and every requirement has a single value. The same was done with basic requirements, but additional requirements about framerate and exposure accuracy were added for the reduced light conditions. Test description is updated for the following tests: Delay – updated method SMIA distortion – updated method Stretch distortion – updated method	2011-07-01

Version	Date	Comments	Valid
		Acuity – updated test chart Depth of field – updated test chart and distance The entry criteria is clarified and split into headings to enable easier tracking and reporting problems. Video lab descriptions are updated.	
4.0.2	2011-02-14	Lost all the field of view requirements – only FOV consistency tests remain.	2011-02-14
4.0.1	2010-07-01	Changes: • Changed SQV frame rate requirement back to 15 fps – the requirement was unrealistic for mobile devices. • Adjusted preview requirements. • Added basic quality management requirement to entry criteria – device must adapt sending bit-rate when network conditions are not optimal. • Added degraded network tests under each frame rate test to make sure the device can adapt to low-bit-rate conditions.	2010-07-01
4.0.0	2010-06-01	Merged spec 3.0.1 and 3.0.3 to single SDK spec. Changed the structure of the file so that repeated tests would be linked to other smaller chunks instead of being independent..	2010-06-01

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1 Introduction

This specification defines Skype's video performance tests and their expect results for both the ***required*** and ***preferred*** certification levels. These test cases emphasize the end user experience—overall acuity and accuracy, depth of field/field of view, delays, and so forth—and do *not* replace other necessary testing and certification(s) that a vendor should and must perform, such as those relating to health and safety regulations, product durability, and so forth.

Required (can be applied only for SkypeKit based solutions) video certification focuses on verifying that your video components:

- comply with SQV standards—320×240 (QVGA) resolution at 15 fps in most lighting conditions
- have acceptable:
    - send path acuity
    - exposure accuracy
    - delay in send path, receive path, and local preview

Preferred video certification focuses on:

- verifying that your video components at the minimum comply with HQV or HD standards—send *and* receive respectively 640×480 (VGA) and 1280x720 (HD) resolution
- distortion
- noise
- color accuracy
- artifacts
- depth of field/field of view

If you're shipping SkypeKit in your own hardware, your solution must meet all applicable ***required*** certification level requirements before you can obtain your distribution key pair. Your solution can then:

- use the *'plugged into Skype'* logo in your packaging and communications
- be listed in the Skype Shop

However, you should seriously consider designing and engineering your solution to pass all applicable ***preferred*** video performance tests.

If your solution is a PC accessory then it must comply with the ***preferred*** *level. Your solution* can then:

- use the 'Skype' logo in your packaging and communications
- enable the solution in 720x1280 if the *preferred HD* requirements are met
- be listed in the Skype Shop

Note: All SkypeKit solutions and PC accessories must meet the applicable user interface/functionality and packaging requirements. Those that include audio components must additionally meet all applicable audio requirements for its target certification level.

1.1 Entry criteria

Each device must work as a video input device during a Skype Video Call when called to a PC. Video must be visible on receiver's side. In order to enter the testing it must be clear against which category it will be tested.

SkypeKit based solution must have a camera and a video display. In case the device does not have a display, video output (VGA, DVI, HDMI) must be present and functional. In case multiple outputs are enabled then HDMI will be tested.
Two-way Skype video call with another Skype device must work (video must be visible on both sides) to enter video testing. If a device has a different use case to videoconferencing and video calling, like a security camera, an object tracking system, etc, then entry requirement may be changed based on the individual use case.

Each device must also comply with the specific *Entry Criteria* for its category. The specific entry criteria are described below.
If the solution can be used as an accessory for SkypeKit based solution and as a PC accessory then both entry criterias must be met.

1.1.1 Skype SDK based video device – *required level*

The solution is accepted for testing against the Minimum requirements *(required level)* only if all the requirements listed in this chapter are fulfilled.

The device must:

1.1.1.1 *Be able to initiate and receive two-way Skype video call with another Skype device and the latest PC client and video must be visible on both sides when the two-way video call is made.*

1.1.1.2 *Support sending and receiving resolutions 320x240 and 160x120 at 15fps .*

1.1.1.3 *Support bit rates from 25 kbps to 200 kbps or more.*
In the perfect network conditions at least 200kbps video stream must be sent.

1.1.1.4 *Be able to adapt to above-given bit-rates when the network bandwidth is changed within these limits during a call. If bit-rate is changed, video should not freeze permanently. Packet loss has to disappear within one minute after the network bandwidth has been decreased within the limits.*

1.1.1.5 *When the received video window is maximized, device display (if included) must provide at least 160 pixels in width and 120 pixels in height for the video window or equivalent resolution for analog-display.*

1.1.1.6 *Local preview video window must be available during the video call with at least 15fps@160x120 pixels resolution.*

1.1.2 Skype SDK based video device –*preferred* level: HQV

This chapter is applicable if the maximum sending resolution of the device is not more than 640x480 and the device aims to meet the preferred quality of the HQV requirements for Video Certification.

The solution is accepted to testing against the HQV Requirements *(preferred level)* only if all requirements listed in this chapter are fulfilled.

The device must:

1.1.2.1 *Be able to initiate and receive two-way Skype video call with another Skype device and the latest PC client. Video must be visible on both sides when the two-way video call is made to enter video testing..*

1.1.2.2 *Support sending and receiving resolutions 640x480, 320x240 and 160x120 at 30fps .*

1.1.2.3 *Respond to frame rate requests for 15fps and 30fps.*

1.1.2.4 *Support bit rates from 25 kbps to 800 kbps or more.*
In the perfect network conditions at least 800kbps video stream must be sent.

1.1.2.5 *Be able to adapt to above-given bit-rates when network bandwidth is changed within these limits during a call. If bit-rate is changed, video should not freeze permanently. Packet loss has to disappear within one minute after the network bandwidth has been decreased within the limits.*

1.1.2.6 *When the received video window is maximized, the device display must provide at least 640 pixels in width and 480 pixels in height for the video window or equivalent resolution for analog-display.*

1.1.2.7 *Calls must not drop within 30 minutes in the perfect network conditions. If more than 1 call out of 3 is dropping then the testing will be cancelled.*

1.1.2.8 *Local preview video window must be available during the video call with at least 15fps@160x120 pixels resolution.*

1.1.2.9 *Original video aspect ratio must be kept in all modes (including full screen) for receive video.*

1.1.2.10 *Original video aspect ratio must be kept in all modes (including full screen) for local preview.*

1.1.2.11*Original video aspect ratio must be kept for send video.*

1.1.3 Skype SDK based video device – *preferred* level: HD

This chapter is applicable if the device sends 1280x720 resolution and aims to meet the preferred quality according to the HD requirements for Video Certification.

The solution is accepted for testing against the HD Requirements *(preferred level)* only if all requirements listed in this chapter are fulfilled.

The decvice must:

1.1.3.1 *Be able to initiate and receive two-way Skype video call with any another Skype device and the latest PC client. Video must be visible on both sides when the two-way video call is made to enter video testing.*

1.1.3.2 *Support sending resolutions 640x480, 320x240 and 160x120 at 30fps and 1280x720 at 22 or more fps.*
Support receiving resolutions 640x480, 320x240 and 160x120 at 30fps.
IF the device display provides at least 1280 pixels in width and 720 pixels in height for the video window then receive resolution 1280x720 at 22 or more fps .

1.1.3.3 *Support frame rates from 15 fps to 24 fps or more at 1280x720. Respond to frame rate requests for 15fps and 30fps.*

1.1.3.4 *Support bit rates from 25 kbps to 1.5 Mbps or more.*
In the perfect network conditions at least 1.5Mbps video stream must be sent.

1.1.3.5 *Device must be able to adapt to above-given bit-rates when network bandwidth is changed within these limits during a call. If bit-rate is changed, video should not freeze permanently. Packet loss has to disappear within one minute after the network bandwidth has been decreased within the limits.*

1.1.3.6 *In case of only analog output being available, the device must enable to scale the received video to size equivalent to VGA.*

1.1.3.7 *Local preview video window must be available during the video call with at least 15fps@320x240 pixels resolution.*

1.1.3.8 *Original video aspect ratio must be kept in all modes (including full screen) for receive video.*

1.1.3.9 *Original video aspect ratio must be kept in all modes (including full screen) for local preview.*

1.1.3.10*Original video aspect ratio must be kept for send video.*

1.1.4 PC accessory –preferred level: HQV

This chapter is applicable if the maximum sending resolution of the PC accessory is not more than 640x480 and the device aims to meet the preferred quality of the HQV requirements for Video Certification.

The solution is accepted to testing against the HQV Requirements *(preferred level)* only if all requirements listed in this chapter are fulfilled.

The device must:

1.1.4.1 *Must work as a video input device during a Skype Video Call when connected to a PC. Video must be visible on receiver's side.*

1.1.4.2 *Must support resolutions 640x480, 320x240, 160x120.*

1.1.4.3 *Must support media subtypes I420 or NV12.*
Also, YUY2 is accepted, but not preferred – NV12 is a UVC Specification compatible format. In case performance and quality are not impacted, other color spaces could be accepted.

1.1.4.4 *Must support frame rates 15 fps and 30 fps.*

1.1.4.5 *Must provide a power line frequency adjustment option or automatically eliminate flicker.*

1.1.5 PC accessory and Laptop / Notebook –preferred level: HD

This chapter is applicable if the PC accessory is capable to send 1280x720 resolution over Skype Video Call and aims to meet the preferred quality according to the HD requirements for Video Certification.

The solution is accepted for testing against the HD Requirements *(preferred level)* only if all requirements listed in this chapter are fulfilled.

The decvice must:

1.1.5.1 *Must work as a video input device during a Skype Video Call. Video must be visible on receiver's side.*

1.1.5.2 *Support sending resolutions 640x480, 320x240 and 160x120 at 30fps and 1280x720 at 22 or more fps.*

1.1.5.3 *Must support media subtypes I420 or NV12 for resolutions up to 640x480.*
Also, YUY2 is accepted, but not preferred – NV12 is a UVC Specification compatible format. In case performance and quality are not impacted, other color spaces could be accepted.

1.1.5.4 *Support frame rates from 15 fps to 24 fps or more at 1280x720. Respond to frame rate requests for 15fps and 30fps.*

1.1.5.5 *Support bit rates from 25 kbps to 2.5 Mbps or more.*
In the perfect network conditions at least 2.5Mbps video stream must be sent.

1.1.5.6 *Must provide a power line frequency adjustment option or automatically eliminate flicker.*

1.1.6 Laptop / Notebook – required level: HD (a subset of preferred HD)

This chapter is applicable if the laptop is capable to send 1280x720 resolution over Skype Video Call and does NOT aim to achieve Video Certification. The purpose of such test would be to confirm it the laptop is good to be enabled to send 1280x720 resolution over Skype Video call.

The solution is accepted for testing against the subset of the HD Requirements *(preferred level)* only if all requirements listed in the chapter 1.1.5 PC accessory and Laptop / Notebook –preferred level: HD are fulfilled.

In order to get such approval the solution must comply with the following tests:

- *2.4.1 – 2.4.2*
- *2.4.4 - 2.4.5*
- *2.4.31 – 2.4.35*
- *2.4.53 – 2.4.59*
- *2.4.63*
- *2.4.65*

1.2 Definitions

Algorithm	A process to be followed in calculations or other problem solving operations.
Autofocus convergence delay	The time it takes for the camera to automatically refocus.
Autofocus sensitivity to movement	The change in focusing distance in relation to change of target's location.
Block distortion (or tilling)	Distortion of the image characterized by the appearance of an underlying block encoding structure.
Blurring	Global distortion of the entire image, characterized by reduced sharpness of edges and spatial detail.
Capture gamma	A measure of camera contrast. It is the average power of the function that relates scene luminance to image pixel level. Approximately, log (pixel level) = (capture gamma)*log (luminance).
Color accuracy	Ability to reproduce colors with minimal chromatic distortion so that they are as close to real-life as possible, given the color-space limitations of the video standard being used.
Color uniformity	Alteration in image color at the edges of the image versus the center of the image.
Daylight light conditions	Light with color temperature of 5000 K.
Delay	A period of time by which something is late or postponed.
Distortion	An alteration of viewed images.
DUT (Device Under Test)	Solution being tested against the video test specification.
Dynamic range	The range of luminance levels (from lowest to highest) that the video acquisition system can capture with reasonable quality without clipping.
Encoding camera	A USB video input device that encodes video in hardware and transmits it to the PC. In current specification, H.264 and MJPEG encodings are assumed.

Exposure accuracy	The ability of the video acquisition system to properly match the grayscale tonal levels of the scene being shot.
Field of view	The angular extent of the observable world that is perceived by the camera at any given moment.
Frame	One complete still image of video media.
Frame rate	The measurement of the frequency (rate) at which an imaging device produces unique consecutive images called frames.
Gain convergence delay	The time it takes for the camera to stabilize its gain.
Gain sensitivity to movement	The change in gain in relation to change in target's movement.
Gradient	A graded change in the magnitude of some physical quantity or dimension.
Gray board	Background of the test charts, also used as a test target on certain tests.
Grayscale	An image representation in which each pixel is represented by a single sample value representing overall luminance (on a scale from black-0 to white-255).
High Definition video (HD)	720p video with 24fps or more.
High Quality Video (HQV) web camera	A camera that can produce 640x480 resolution with constant frame rate of 30 fps and passes the tests described in this specification.
Jerkiness (jerky motion)	Motion that was originally smooth and continuous perceived as a series of distinct 'snapshots'.
Laptop	A portable computer that can run on batteries. In this context, Medium standalone video device should also be able to run Skype and have audio & video input & output devices and a screen-size over 13 inches.
Lens distortion	The deformation of the image visible as straight lines in the subject being rendered as curved lines in the image from the camera. Also linear spatial deformation – horizontal or vertical stretch of the image.
Local preview during call	Video window of locally captured video during Skype video call where user can see possibly downscaled version of the video he/she is sending.

Motion blur	The apparent streaking of rapidly moving objects in a still image or a sequence of images such as a movie or animation.
MTF (Modulation Transfer Function)	The measurement of optical equipment blurs the image of an object using Spatial Frequency Response.
MTF50	A spatial frequency at which the spatial frequency response has dropped to 50% of the value compared with the component with zero frequency.
Noise	Unwanted random spatial and temporal variations (e.g., snow) in the video picture.
Output	The required value to pass a specific test case.
Reduced light intensity	Light intensity of 30 lux.
ROI (Region Of Interest)	Selected subset of the test target used for conducting the measurements.
Sharpness	An image quality parameter that characterizes the richness of detail on the image. It is the opposite of blurriness.
Skype	A social networking software for making free calls over the internet to anyone else who has Skype (www.skype.com).
SMIA	Standard Mobile Imaging Architecture (www.smia-forum.org)
Snapshot	Still image capture on the PC. Also referring to snapshot function during Skype video call.
SNR (Signal to Noise Ratio)	Ratio of signal power to the noise power corrupting the signal.
Spatial edge noise	A form of edge busyness characterized by spatially varying distortion in close proximity to the edges of objects.
Spatial noise	Unwanted random spatial variations in one video frame.
Standard light intensity	Light intensity of 300 lux.
Standard Quality Video (SQV) camera	A camera that operates with Skype in 320x240 and 160x120 resolutions with constant frame rate of 15 fps in all lighting conditions.
Stretch	Linear distortion in width or height of the image.
Still image	Non-moving visual information.
Temporal edge noise	A form of edge busyness characterized by time-varying sharpness (shimmering) to edges of objects.
Temporal noise	Unwanted random temporal variations in the video image.

Test case	A specification that describes the goal of a test, containing algorithm, test target, test conditions and output.
Tungsten light condition	Light with color temperature of 3000 K.
UVC	USB Video Class; a USB device class that describes devices capable of video streaming.
Video phone	Any standalone video device that has display size less than 13 inches, runs Skype and has A/V input/output.
White balance convergence delay	The time it takes for the camera to stabilize its white balance.
White balance sensitivity to movement	The change in white balance in relation to change in target's movement.

2 General Video quality related tests

2.1 Test instructions and algorithms

2.1.1 Positioning the DUT in video lab

The web cameras for Skype calling have very different field of view angle. Thus it is not feasible to give the same fixed test distance for all cameras. Instead we relate the test distance to a reference test target and then change the distance of camera from the test target until the pre defined area becomes visible.

Position 1

Skype uses the test position 1 for positioning the camera for the following tests cases

Acuity

Oversharpening

Spatial noise deviation

Temporal SNR

Color accuracy

Skin tone accuracy

Saturation

Exposure accuracy

Dynamic range

Capture gamma

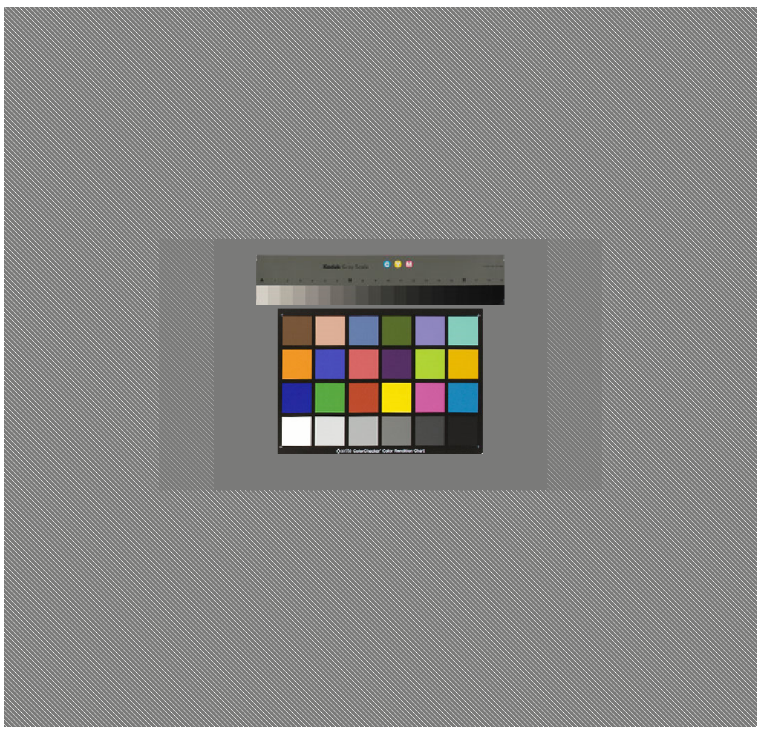


Figure 1. Position 1 for the DUT (the clear area in middle indicates the field of view captured by the camera under test – the hatched surrounding indicates the neutral gray board outside the field of view of the camera)

As a first step a camera has to be positioned so that its lens would point to the center point of test targets. This can be done the following way:

- Place the laser distance meter to the center of alignment test chart and point toward the camera (red rectangle on above image shows the intended position for the laser meter).Then adjust the camera holder so that the ray from the laser distance meter would reflect from the casing right next to the lens. In other words, the camera is placed so that the red laser dot would be located next to the lens of the camera.

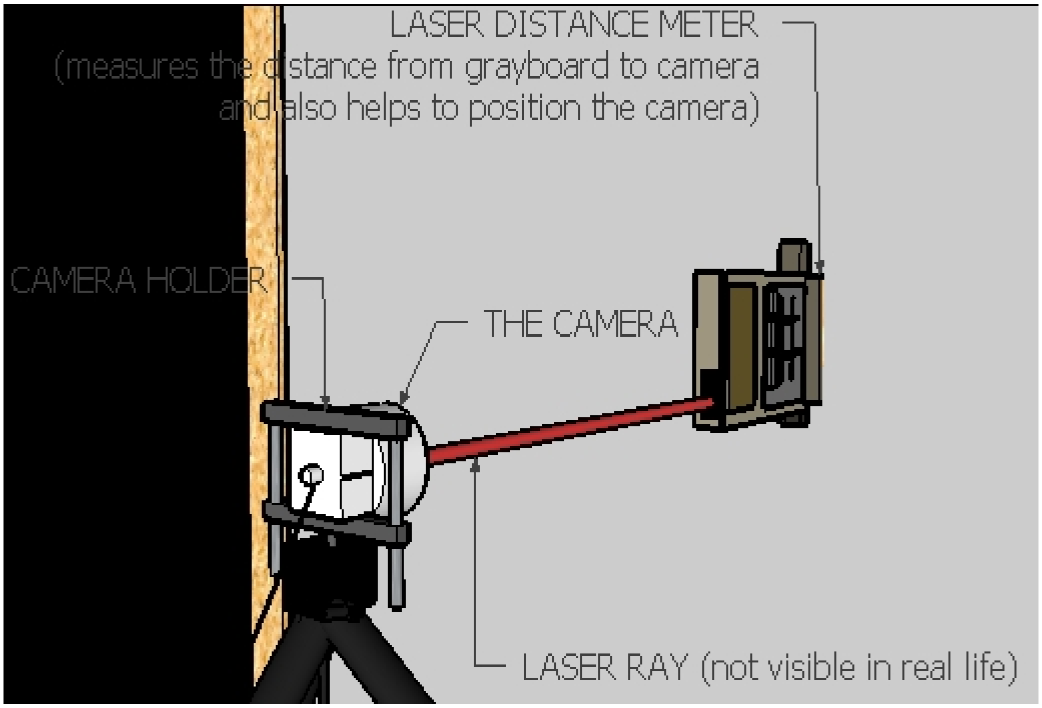


Figure 1. Using laser distance meter to position the camera

- If the camera is vertically and horizontally fixed, we will move it back or forth so that the black horizontal stripes on the alignment test target just become visible in the camera send video frame.
- When the camera is adjusted use the laser meter to capture the test distance used.
- In case the camera has a manual focus, adjust it to get the target in focus. For that purpose we are using the relative sharpness parameter of the video image. The target is assumed to be in focus when the relative sharpness has a local maximum.

Position 2

Skype uses the test alignment 2 for positioning the camera for the following tests cases

SMIA distortion

Stretch distortion

Light falloff

Color uniformity R/G

Frame rate

Delay

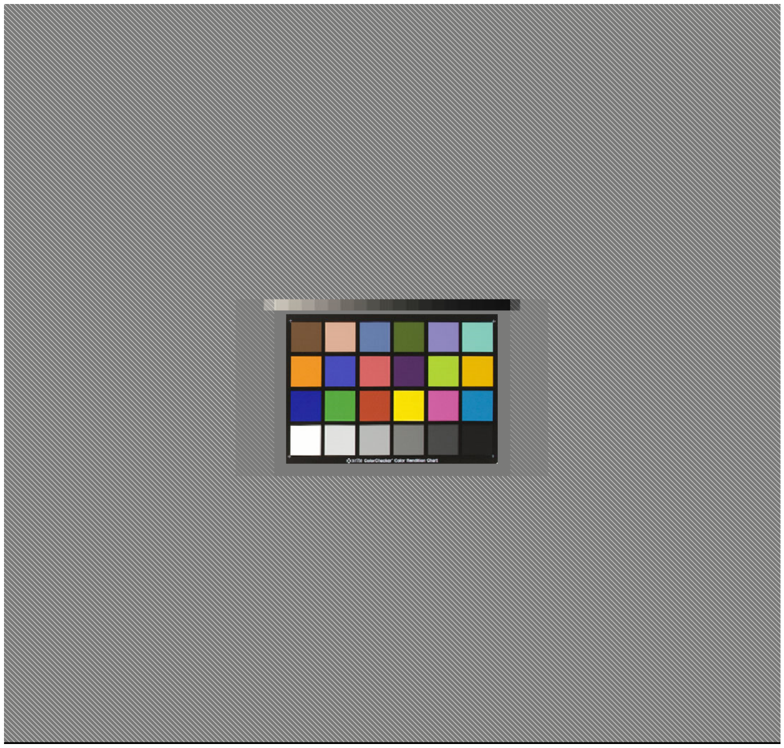


Figure 3. Position 2 for the DUT (the clear area in middle indicates the field of view captured by the camera under test – the hatched surrounding indicates the neutral gray board outside the field of view of the camera)

For position 2 the camera is moved closer to the target.

The reasons for doing this are the following:

- the precision of SMIA and Stretch distortion calculation is increased
- the illumination uniformity is even more even in a smaller region on the Gray chart test target, thus improving the test condition for Light falloff and Color Uniformity tests

If the DUT has display then the display should be covered to block the extra light illuminated from the DUT screen.

The image on left is a sample of handheld video device testing (a tablet device). The screen is covered to block the extra illumination on test targets, but the camera on top middle is left uncovered.

Figure 4. Covering additional light sources

2.1.2 Acuity – MTF50 and Oversharpening

Purpose: To ensure that image would not be blurry in target resolution and enough detail would be visible, also to make sure image would not be overly oversharpened. Oversharpening, besides being perceptually unpleasant, may lead to further artifacts and increased bandwidth usage during a video call.

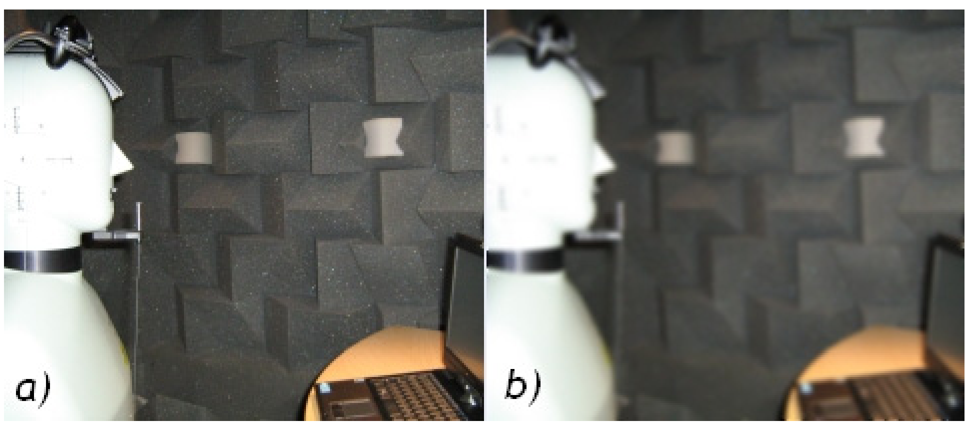


Figure 5. Blurring. a) original image; b) blurred image

Test target: Small SFR Plus chart

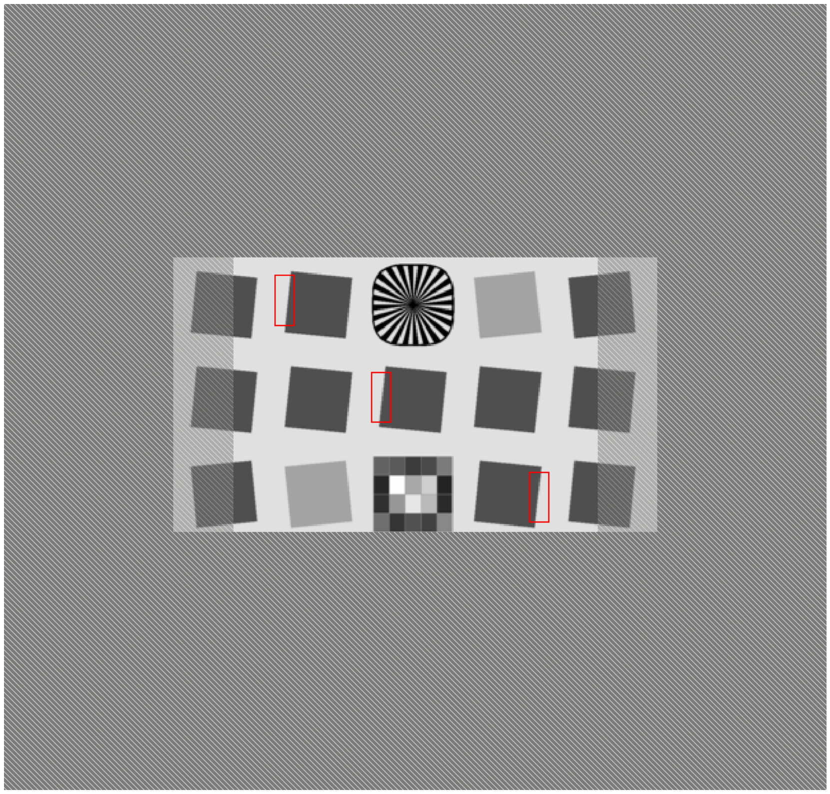


Figure 6. ROI in MTF50 measurement (the clear area in middle indicates the field of view captured by the camera under test – the hatched surrounding indicates the neutral gray board outside the field of view of the camera).

Algorithm: 1:10 contrast edge is used to avoid clipping and detect oversharpening effects. The regions of interest are marked with red rectangles on the image above. The lowest measured MTF50 value is considered the end-result.
The same target is used to measure oversharpening, only now the end result is the highest oversharpening measured with different regions of interest.

Imatest is used to obtain the results of MTF50 and oversharpening.

2.1.3 Lens distortion – SMIA distortion

Purpose: To ensure that the camera would not distort the image unnaturally. Both pincushion and barrel distortion are measured.

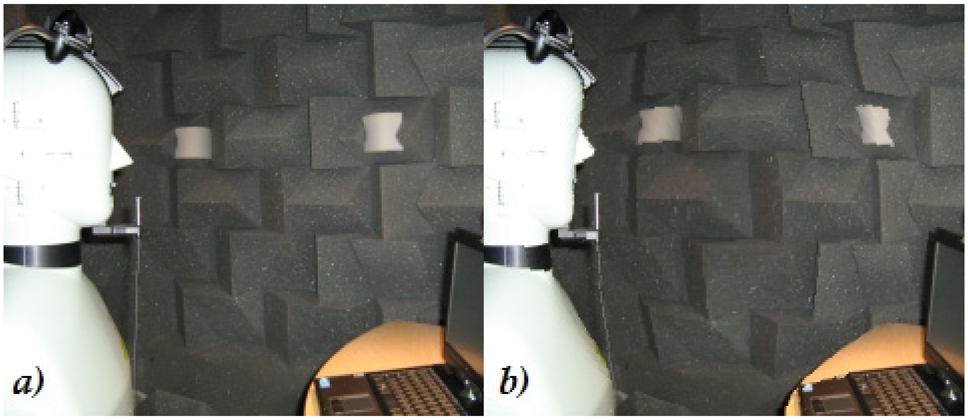


Figure 7. Barrel distortion. a) original image; b) barrel-distorted image

Test target: Gretag Macbeth Colorchecker

Figure 8. Distances used in SMIA distortion measurement

Algorithm: The vertical distances $d_1 \ldots d_6$ (in pixels) between patch centers in the first and fourth row of the chart are fitted with a square equation $d_i = ai^2 + bi + c$, from which the extreme value d_{ex} is determined. The level of distortion is calculated according to the following formula:

$$D_{SMIA} = \frac{d_1 - d_{ex}}{d_{ex}} \cdot 100\%$$

2.1.4 Lens distortion – Stretch distortion

Purpose: To ensure that the camera would not distort the image by unequal stretching in horizontal and vertical direction. Resizing images from 4:3 aspect to 16:9 aspect ratio or vice versa without cropping or filling added in the edges is unacceptable.

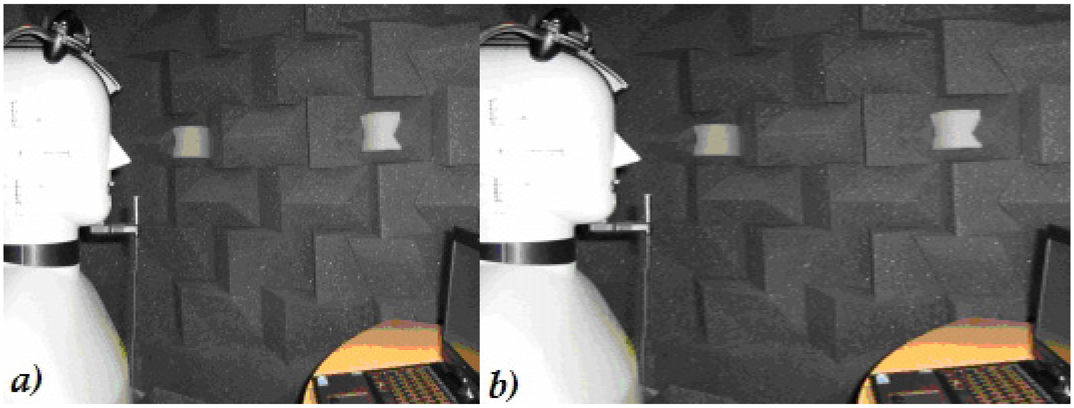


Figure 9 Distortion. a) original image; b) stretched image

Test target: Gretag Macbeth ColorChecker

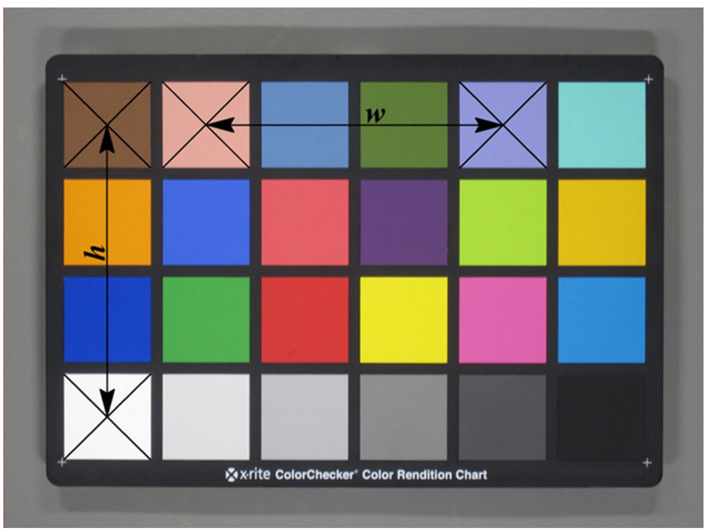


Figure 10 Distances used in stretch measurement

Algorithm: Distances w and h (in pixels) are measured between patch centers as shown above.

The level of image stretching is calculated from the distances using the following formula:

$$D_{Stretch} = \frac{w-h}{w} \cdot 100\%$$

2.1.5 SNR – Spatial noise deviation

Purpose: To ensure that the camera would have low enough noise deviation. Increased noise leads to both, direct perceived video quality reduction and useless waste of network bandwidth during a video call.

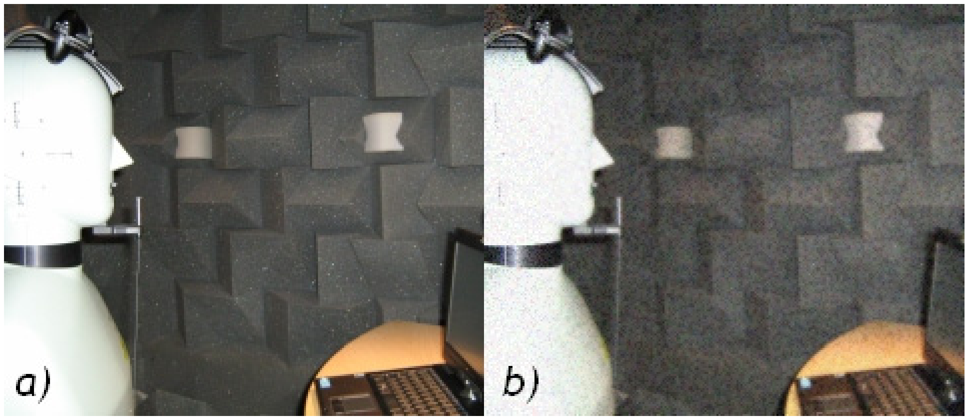


Figure 11. Noise. a) original image; b) noisy image

Test target: GretagMacbeth ColorChecker

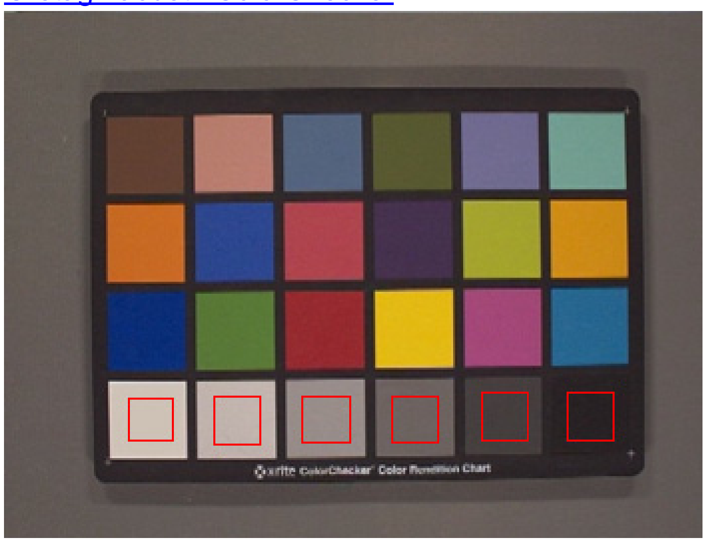


Figure 12. ROI for noise deviation measurement

Algorithm: Spatial noise will be evaluated through the deviation of pixel levels on the frame:

1. Extract a frame and convert it to grayscale image.
2. Find the locations of the color patches from the frame. Noise is calculated for grayscale patches only (bottom row on GretagMacbeth ColorChecker).
3. Extract a rectangular sub-region of each grayscale patch (with dimensions of ~70% of the original patch) to eliminate edge effects.
4. Find the mean pixel value of the patch $\overline{P} = \frac{1}{M \cdot N}\sum_{i=1}^{N}\sum_{j=1}^{M} x_{ij}$, where N and M are the height and width of the rectangular region and x_{ij} are the pixel values of this region.

5. Find the standard deviation $\sigma = \sqrt{\frac{1}{M \cdot N - 1} \sum_{i=1}^{N} \sum_{j=1}^{M} \left(x_{ij} - \overline{P}\right)^2}$ for each grayscale patch.

6. Find the maximum pixel value deviation for all the grayscale patches $\sigma_{max} = max(\sigma_i)$, $i = 1..6$.

2.1.6 SNR – Temporal noise

Purpose: To ensure that the camera would have decent SNR.

SNR corresponds better to human visual system, whereas noise deviation correlates more closely with compressed frame size. Noisy video tends to be distractive for the user – also noise may cover important spatial detail, thus reducing perceived video quality. In this section we use GretagMacbeth chart to measure temporal SNR.

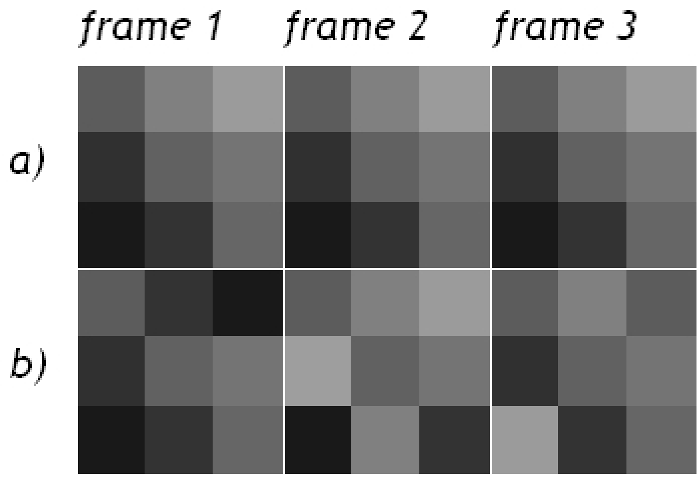


Figure 13. Temporal noise. a) original video frames; b) video frames with temporal noise

Test target: GretagMacbeth ColorChecker

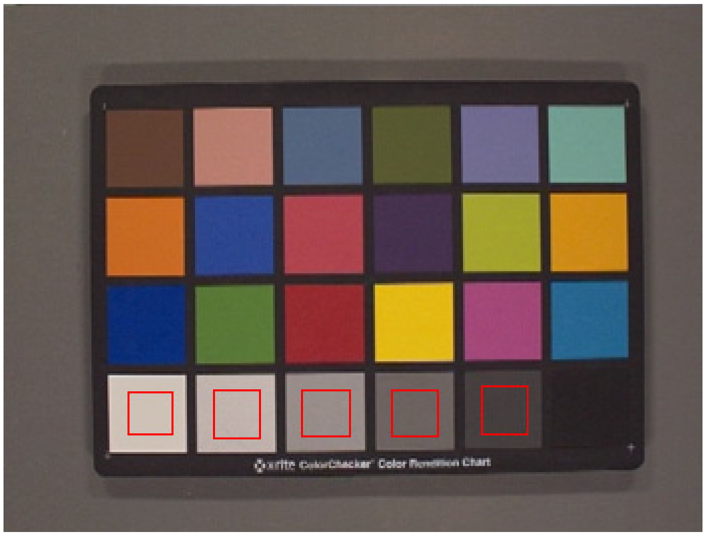


Figure 14. ROI for grayscale temporal SNR measurement.

Algorithm: Only grayscale patches are used and black patch is ignored, since it has very low signal value and thus, unstable results.

Temporal noise will be evaluated through the deviation of pixel levels on the frame.

1. Extract two following frames and convert them to grayscale.
2. Subtract one frame from another obtaining a difference image
3. Find the mean pixel value of the patch $\overline{P} = \frac{1}{M \cdot N} \sum_{i=1}^{N} \sum_{j=1}^{M} x_{ij}$, where N and M are the height and width of the rectangular region and x_{ij} is the current pixel value of the image.
4. Find the RMS of pixel values on the difference image $\sigma = \sqrt{\frac{1}{M \cdot N} \sum_{i=1}^{N} \sum_{j=1}^{M} x_{ijdif}^2}$, where x_{ijdif} is the pixel value of the difference image.
5. Calculate *SNR* for each patch *i*: $SNR_{itemp} = 20 \cdot \log_{10} \frac{\overline{P}}{\sigma / \sqrt{2}}$
6. Exclude the black patch and find the minimum SNR of five grayscale patches. It will probably be the 23rd patch on GretagMacbeth color chart.

$$SNR_{temporal} = min(SNR_{19temporal}, SNR_{20temporal}, SNR_{21temporal}, SNR_{22temporal}, SNR_{23temporal})$$

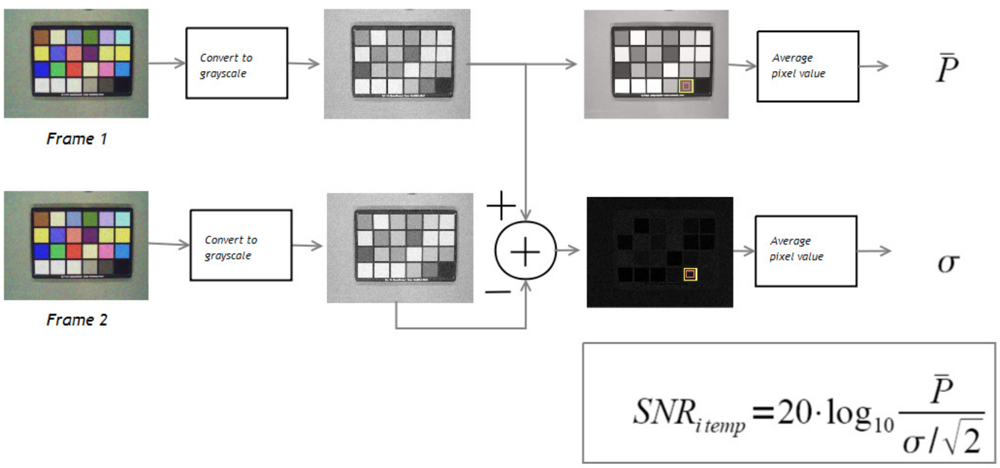


Figure 15. Flowchart illustrating how SNR is obtained using two sequential frames

2.1.7 Color accuracy and Saturation

Purpose: To verify if a video device portrays colors of the filmed object accurately. Special attention is paid to skin-tone, which has stricter requirements. Test mainly verifies the correct behavior or Auto White balance of the video input device.

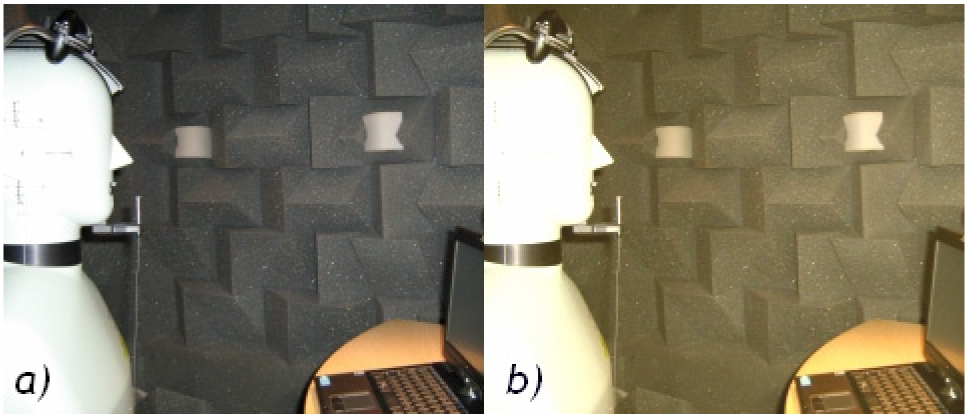


Figure 16. Color accuracy. a) original image; b) image with inaccurate colors due to incorrect auto white balancing

Test target: GretagMacbeth ColorChecker

Figure 17. Explanation of the patch numbering.

Algorithm: Test target is filmed and snapshots are taken. Then color errors are found in $L^*a^*b^*$ color space:

1. Color patches are found and average RGB pixel values are transformed to CIE L*a*b* space.
2. Euclid distances between measured a*b* coordinates and reference coordinates are calculated for each color patch.

$$\Delta C^*_{ab} = \sqrt{\left(a^*_{meas} - a^*_{ref}\right)^2 + \left(b^*_{meas} - b^*_{ref}\right)^2}$$

3. In order for the test case to be independent of saturation, mean chromic error is normalized against saturation.

$$\Delta C^*_{abcorr} = \Delta C^*_{ab} \,/\, \overline{C}r \text{ , where } \overline{C}r = \frac{\sum_{patch=1}^{18}\sqrt{\left(\overline{a}^*_{patch\ \ measured} + \overline{b}^*_{patch\ \ measured}\right)^2}}{\sum_{patch=1}^{18}\sqrt{\left(\overline{a}^*_{patch\ \ reference} + \overline{b}^*_{patch\ \ reference}\right)^2}}$$

Patch no 2 on GretagMacbeth ColorChecker is compared independently of average color error, because skin-tone accuracy is expected to satisfy stricter accuracy criteria.

$\Delta C^*_{avg-abcorr}$ denotes average chroma compensated color error (average of all the 24 patches). $\Delta C^*_{abcorr}(patch\ no\ 2)$ denotes chroma error of the second patch on ColorChecker that is supposed to represent skin tone.

2.1.8 Exposure accuracy

Purpose: To ensure that the video image is not too bright (overexposed) nor too dark (underexposed).

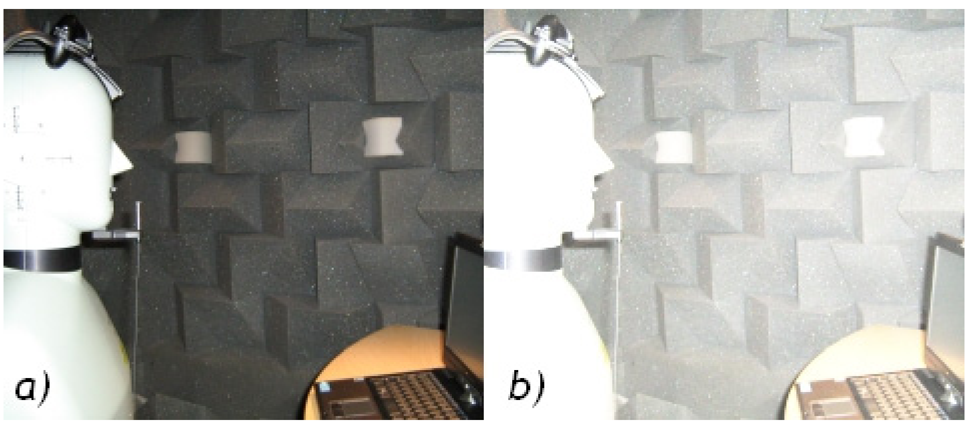


Figure 18. Exposure accuracy a) original image b) overexposed image

Test target: GretagMacbeth ColorChecker

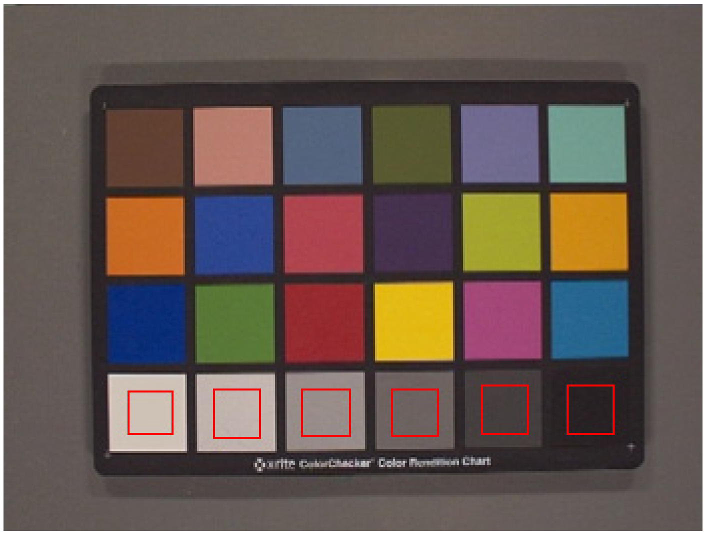


Figure 19. ROI for exposure accuracy measurement.

Algorithm: Test target is filmed and snapshots are taken. The exposure accuracy is obtained color errors in *f-stops*:

1. Frame is extracted. Average grayscale pixel values are found for the bottom row of grayscale patches on GretagMacbeth chart (0...255).

2. Measured grayscale pixel values are divided by reference values for each patch.

3. Average ratio is calculated and the result is converted to *f-stops*: $Err_{\exp}[fstops] = 3{,}32\dfrac{\overline{\log(P_i) - \log(P_{ri})}}{\gamma}$, where P_{ri} is the reference pixel value of the specific patch. Exposure errors over the patches are averaged.

2.1.9 Dynamic range

Purpose: To ensure that the camera delivers satisfactory distribution of lighting range across the image.

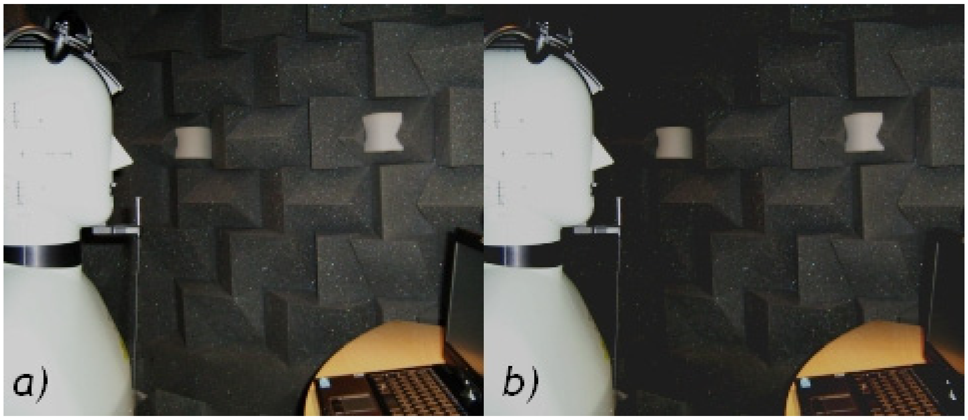


Figure 20. Dynamic Range a) original image b) image with reduced dynamic range - darker areas are clipping

Test target: Kodak Q-14 test chart

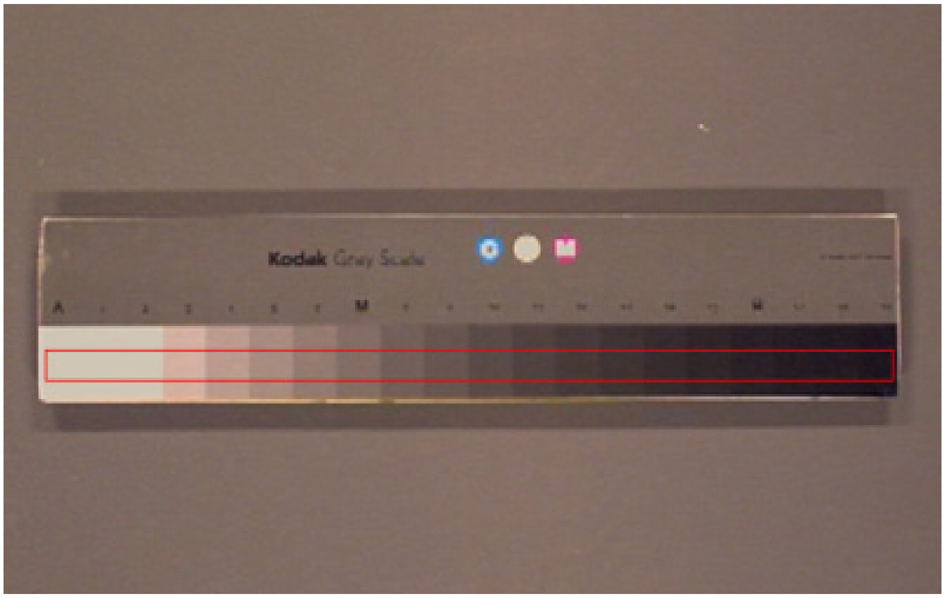


Figure 21. ROI for dynamic range measurement.

Algorithm: The average brightness is calculated for each vertical column of pixels within the ROI. The columns with minimum and maximum average brightness are detected and used as reference. The columns which have brightness difference less than a threshold value from either of the reference stripes, are discarded for clipping. The threshold value is 2% of the difference between the maximum and minimum of the brightnesses averaged over pixel columns. The remaining non-clipping width is used to calculate the dynamic range, which is represented as the number of separable patches:

*detected_patches = 20 * (full_width – clipping_black – clipping_white) / full_width*

2.1.10 Capture gamma

Purpose: To ensure that contrast of different grayscale values is distributed in a way it would not degrade image quality.

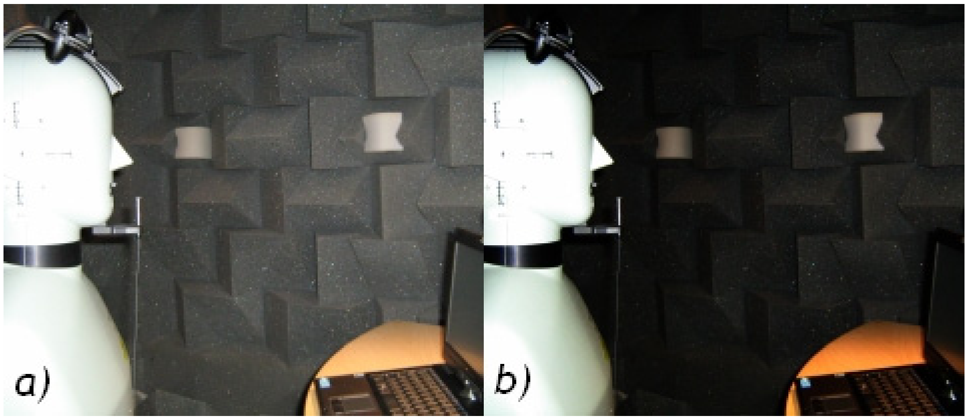


Figure 22. Capture gamma. a) original image b) inaccurately gamma-corrected image

Test target: GretagMacbeth ColorChecker

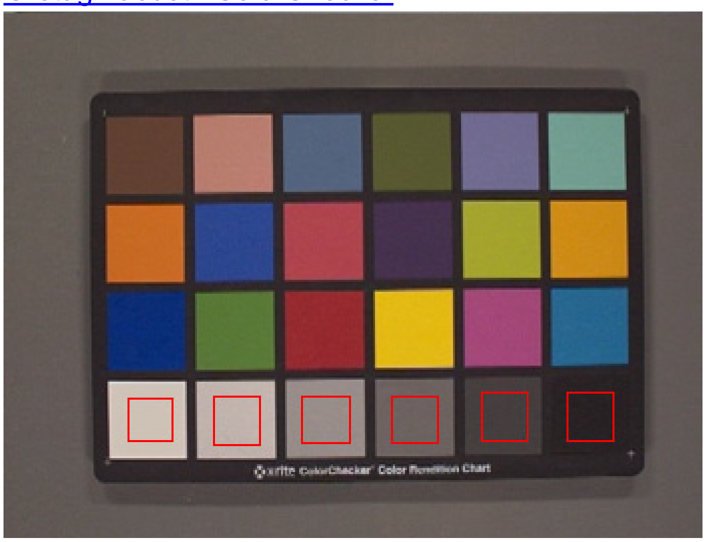


Figure 23. ROI for capture gamma measurement.

Algorithm: Test target is filmed and snapshots are taken. Obtain capture gamma from the bottom grayscale patches:

$\gamma = \frac{\log_{10}(P_1 / P_2)}{d_2 - d_1}$, where P_i is the average grayscale pixel value of patch *i* and d_i is the respective (reference) density.

2.1.11 Light falloff and Color uniformity

Purpose: To ensure that edges of the frame would not be significantly darker nor of different color to the center.

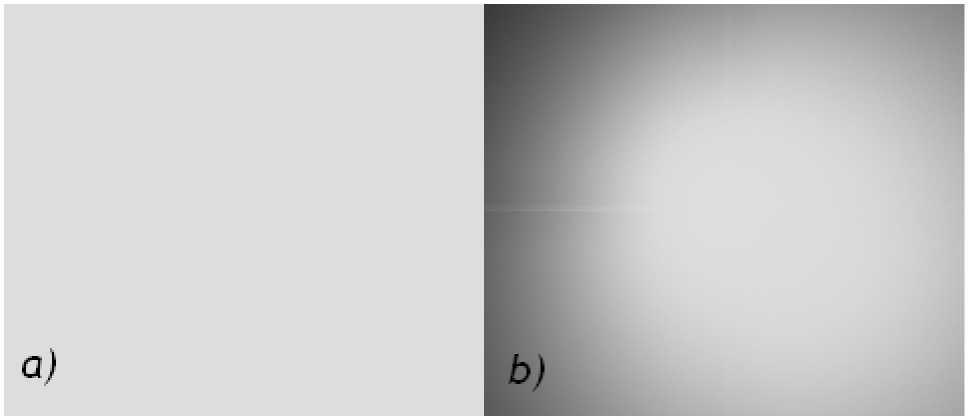


Figure 24. Light falloff. a) image without light falloff b) image with significant light falloff

Test target: [Gray board]

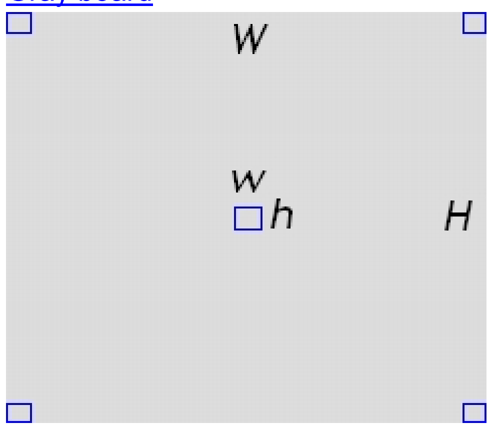


Figure 25. ROI for light falloff and color uniformity tests

Algorithm: Dimensions of the rectangle-regions are selected so that $w = \frac{W}{20}$ and $h = \frac{H}{20}$.

Relative illumination is found by $I_{rel} = \frac{P_{center}}{P_{corner}(worstcase)}$, where P_{center} is the average grayscale pixel value of the center of the image and P_{corner} is the average grayscale pixel value of one of the corners. Relative illumination is found for all four corners and the worst (closest to failure) case is taken as a final value.

Similarly, when measuring color uniformity, average pixel values for center and corners are found, but this time for all three RGB components.

Now, $ratio(R/G) = \frac{\overline{R}/\overline{G}(corner)}{\overline{R}/\overline{G}(center)}$ and $ratio(B/G) = \frac{\overline{B}/\overline{G}(corner)}{\overline{B}/\overline{G}(center)}$ are calculated for all four corners and the worst case is taken as a final value. $\overline{R}, \overline{G}, \overline{B}$ are the average RGB values of region of interest.

NB! It must be made sure that the gray board is illuminated uniformly over the whole field of view. In case of a very wide angle camera it might be necessary to move it closer to the test target for this test only.

2.1.12 Frame rate

Purpose: To ensure that frame rate – temporal resolution – would be high enough so that video runs smoothly without significant motion blur.

Test target: Gray board

Algorithm: Frames are counted in a 2 s interval. Frame rate is found by $f[fps] = \frac{N}{T[s]}$, where N is the number of unique frames and $T[s]$ is the time interval during which frames are counted.

Two or more following frames are considered to be one unique frame if the frames are identical. That enables to avoid artificially increased frame rate by frame repetition. If frames are repeated, counter N remains unchanged.

Also, if some frames are obtained by averaging following frames (resulting in motion blur), also if image is visibly more jerky then other cameras with the same frame rate or has some other motion artifacts, this test case fails automatically.

2.1.13 Delay

Purpose: To ensure that the video would not have too high latency in lossless network condition and using a maximum framerate.

Test target: Blinking LED. (Gray board is on the background).

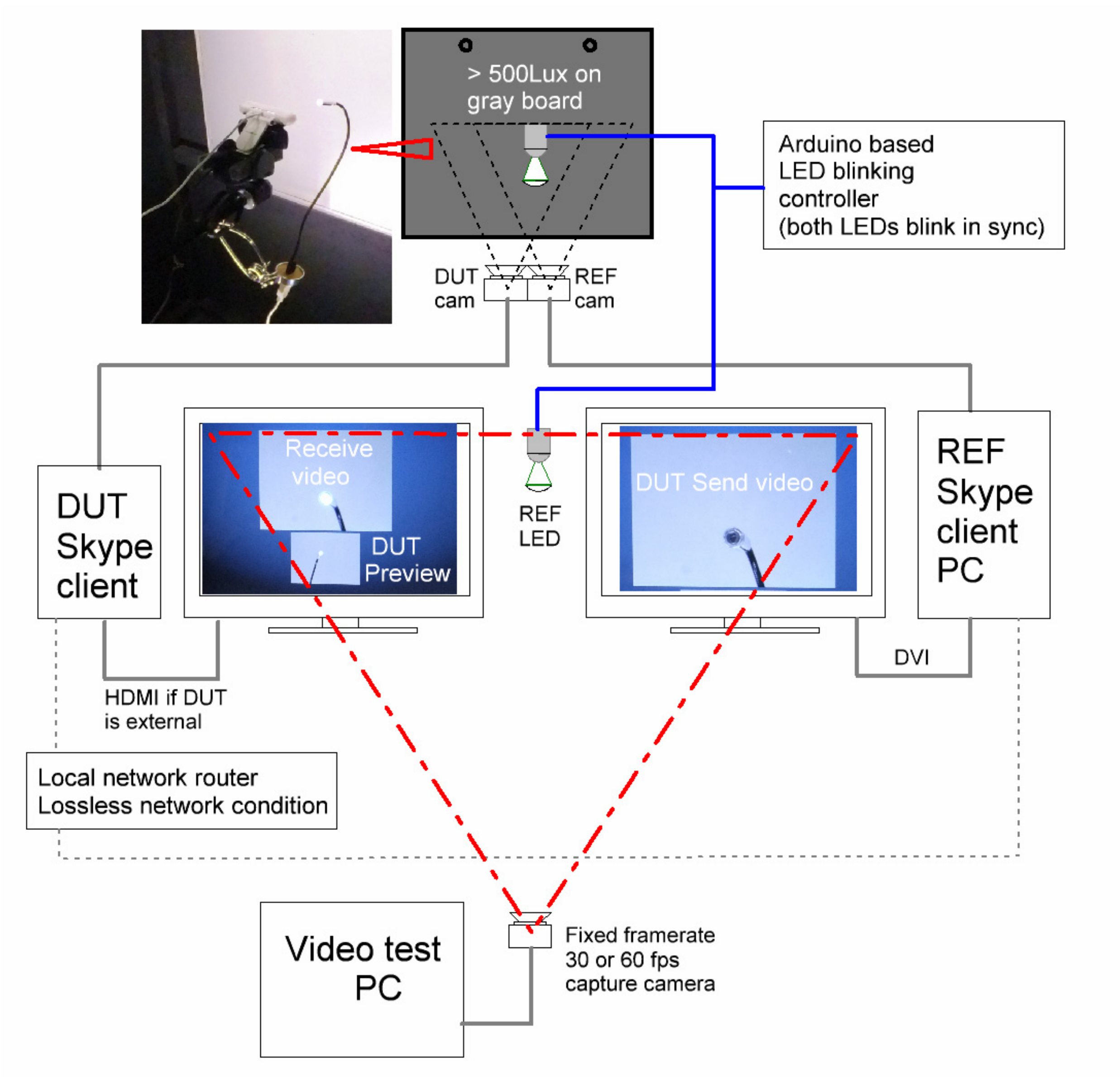


Figure 26. Explanation of the delay measurement setup.

Algorithm: The delay test setup is illustrated above. Two LEDs are used that blink in sync according to MLS sequence. A signal with sharp auto correlation function is needed for later analysis and for this MLS sequence gives good results. LEDs are driven by the small Arduino based microcontroller.

LEDs serve as a temporal change generator. Since a LED is small and takes only a few pixels on the video image, blinking does not influence AWB/AE much. Also, it should have a minimal impact on video encoding/bitrate and similar parameters.

One LED is placed in front of the DUT and REF Skype cameras that are both filming the brightly illuminated Gray Board to ensure maximum framerate.
As a result the blinking of this LED will pre presented in DUT screen as Preview video, on DUT screen as Receive video and on PC screen as a Send video.
A fixed framerate camera (camcorder) with FPS of 30 or 60 is used for filming all of the following signals

- Reference LED (second LED pointed to capture camera)
- Send video
- Receive video
- Preview video

A video is captured with all of the above blinking signals in view. A 40second to 1 minute recording usually gives reliable results.
The resulting video is analyzed by cross correlating the REF LED blinking to all of the Send / Receive / Preview delays.
Result is presented as a graph of the Send / Receive / Preview delays versus time.

Notes:

- Correlation within 9 pixel brightness's within the selected regions is used for delay calculation.
- Max delay is 1500ms
- Correlation function window length is 2600ms

2.1.14 Depth of field

Purpose: To ensure that the camera has enough depth of field. Depending on the type of device the minimum and maximum distances may be very different.

For handheld device the maximum distance is about 0.7m as the hands would not allow holding the device further (in case of a front facing camera). Whereas the closest distance might be in order of 0.3 meters.

For a personal webcam users would also expect a sharp and detailed image when they leans back in the chair for instance.

In case of Skype in Living room use case people might be sitting as far as 5 meters away, but when trying to show a photo over a Skype call they might place the photo very close to the camera.

Thus the depth of field is tested at different distances based on the main use case of the device under test.

Test target: SFRPlus chart (Small SFR chart for up to 1 m, Large SFR chart for > 1 m)

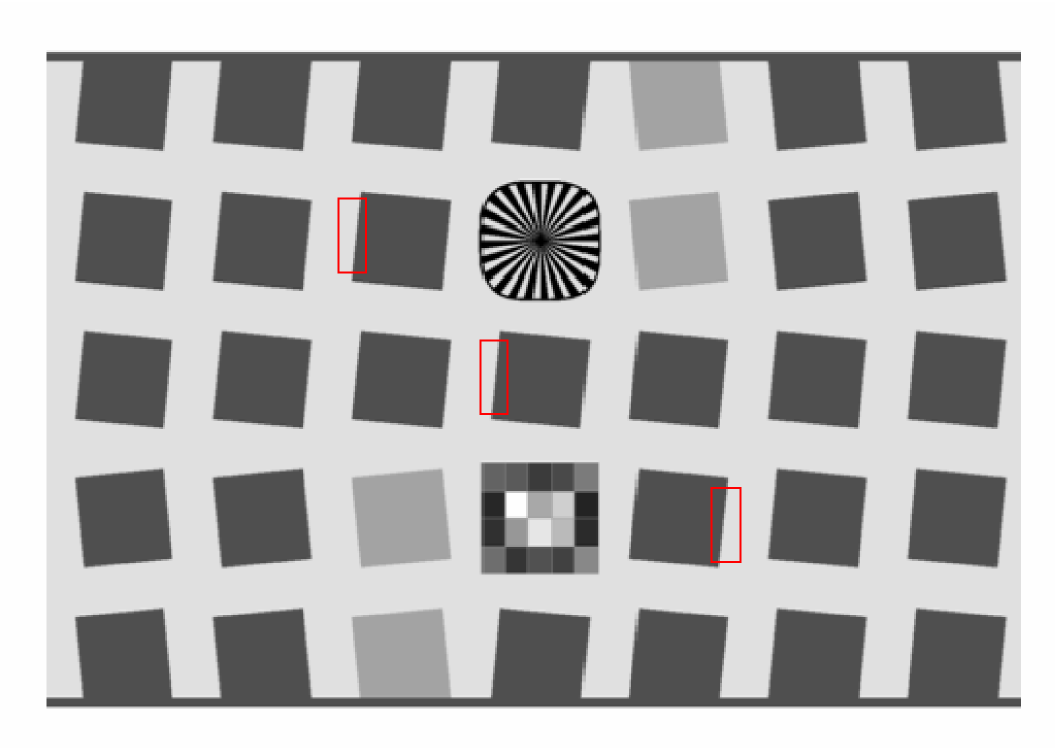


Figure 27. ROI for the MTF50 measurement.

Algorithm: The test distances based on main usage scenarios are following:

Handheld device	d_{min} = same as used for the acuity measurement in 300lux	d_{max} = 0.7 meters
Personal speakerphone or webcam		d_{max} = 1.2 meters
Living room or Group video calling solution		d_{max} = 4 meters

Distances d_{min} and d_{max} are chosen according to the device use case.
Camera is focused on d_{min} and $MTF50(d_{min})$ is measured at that distance.
Then, camera is moved to the next distance d_{max} and corresponding $MTF50$ is measured. Cameras without autofocus are not refocused between the measurements.

2.1.15 Field of view consistency

Purpose: To ensure that device has consistent field of view among the resolutions with the same aspect ratio and consistent vertical angle of view between 16:9 and 4:3 resolutions.

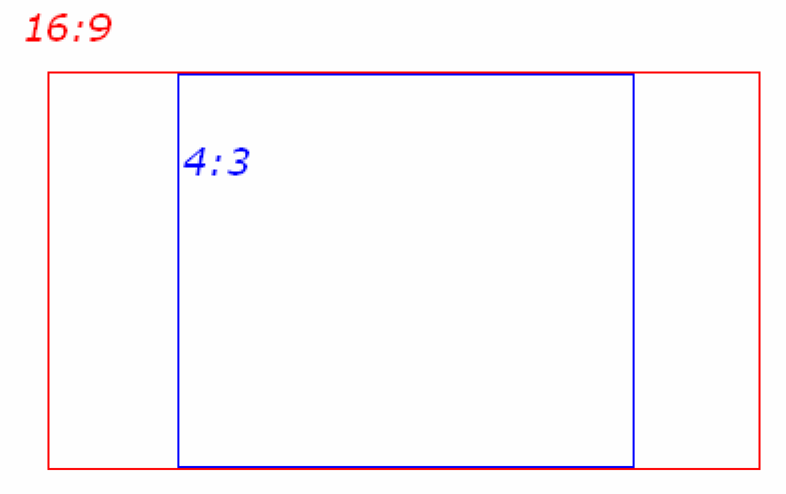


Figure 28. Vertical field of view must remain consistent in all supported resolutions and aspect ratios.

Test target: GretagMacbeth ColorChecker

Algorithm: We calculate field of view in the following way. First we define two constants:

- Distance between centers of leftmost and rightmost patch of the ColorChecker
$b_{horizontal}\,[cm] = 23{,}2cm$

- Distance between centers of top and bottom patches of the ColorChecker
$b_{vertical}\,[cm] = 13{,}7cm$

Now, the center points of ColorChecker corner patches are detected on the video frame. We get respective distances to $b_{horizontal}\,[cm]$ and $b_{vertical}\,[cm]$ in pixels – let's call them $b_{horizontal}\,[px]$ and $b_{vertical}\,[px]$.

Distance d from the target to the camera is measured.

Assuming image is not significantly non-linearly distorted, we obtain the dimensions of video frame in cm by

$$a_{horizontal}\,[cm] = \frac{b_{horizontal}\,[cm]}{b_{horizontal}\,[px]} \cdot a_{horizontal}\,[px],$$

where $a_{horizontal}[px]$ is image width in pixels and $a_{horizontal}[cm]$ is the frame width in cm.

Respectively $a_{vertical}\,[cm] = \frac{b_{vertical}\,[cm]}{b_{vertical}\,[px]} \cdot a_{vertical}\,[px]$,

where $a_{vertical}[px]$ is image height in pixels and $a_{vertical}[cm]$ is the frame height in cm.

$$a_{diagonal}\,[cm] = \sqrt{a^2{}_{vertical}\,[cm] + a^2{}_{horizontal}\,[cm]}$$

All three angles, horizontal, diagonal and vertical, are calculated by the following formula: $\alpha = 2 \cdot \arctan\frac{a/2}{d}$, where α is the angle of view, a image frame width/height/diagonal and d is the distance from the target to the lens of the camera.

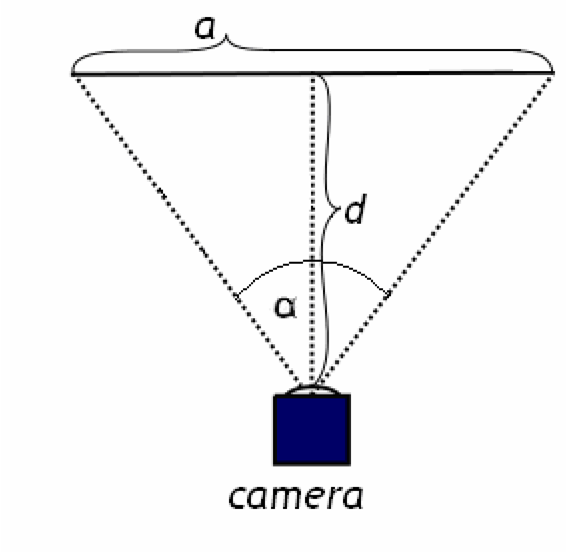


Figure 29. Calculation of angle of view.

Now, field of view is found for all required resolutions (see Entry criteria). Field of view must remain the same for all the different required resolutions with the same aspect ratio.

Minimum and maximum vertical field of view with different resolutions is found: $\alpha_{\min vertical}$ and $\alpha_{\max vertical}$ respectively. Now we find the relative variance of FOV, by

$$\Delta\alpha_{aspect}[\%] = \frac{\alpha_{\max vertical} - \alpha_{\min vertical}}{\alpha_{\max vertical}} \cdot 100\%$$

When both 16:9 and 4:3 aspect ratios are required, then 16:9 image frame should be as high as 4:3 – 16:9 should extend on the sides of 4:3 (see the illustration below). 16:9 should not be achieved cropping the top and bottom of 4:3.

2.1.16 Video Encoding and Rendering Quality Related Tests

The tests described in this section are only applicable for Skype SDK based devices video devices and encoding camera PC accessories. Tests are aimed to ensure the encoding quality of the encoder of device under test. The section can be skipped if the particular encoder performance has been verified before using the method described in this section.

Because SDK based devices and the encoding camera can use its own video encoder, Skype Certification needs to verify that encoding quality of this video encoder is sufficient.

Video quality tests will be conducted subjectively, comparing sent video of device under test to reference device video. Two feeds of displayed video are compared:

1. H.264 video (encoded by the in-built encoder of device under test, decoded by Spirit H.264 decoder in Skype PC client)
2. VP7 video from a reference PC camera (encoded on PC, decoded on PC)

Resolutions, bit rates and frame rates of reference device and device under test depend what resolutions the device under test supports, but generally it is made sure that the video parameters of reference and tested device would be similar or device under test would even have a bit-rate advantage:

QVGA testing		
Parameter	**Reference video**	**Video from device under test**
Video encoder	VP7	H.264 encoder of device under test
Video decoder	VP7	Spirit H.264 decoder
Bit rate	100kbps	200kbps
Resolution, Frame rate	320x240@15fps	320x240@15fps
Video send device	PC with Skype Certified camera	Device under test
Video receive device	PC	PC
Network conditions	LAN, roundtrip time 0, packet loss 0	

VGA testing (if supported)		
Parameter	**Reference video**	**Video from device under test**
Video encoder	VP7	H.264 encoder of device under test
Video decoder	VP7	Spirit H.264 decoder
Bit rate	300kbps	500kbps
Frame rate, resolution	640x480@30	640x480@30
Video send device	PC with Skype Certified camera	Device under test
Video receive device	PC	PC
Network conditions	LAN, roundtrip time 0, packet loss 0	

720p testing (if supported)		
Parameter	**Reference video**	**Video from device under test**
Video encoder	VP7	H.264 encoder of device under test
Video decoder	VP7	Spirit H.264 decoder
Bit rate	500kbps	1000kbps
Frame rate, resolution	640x480@30	1280x720@30
Video send device	PC with Skype Certified camera	Device under test
Video receive device	PC	PC
Network conditions	LAN, roundtrip time 0, packet loss 0	

Test is run with the test subject being located at the usage distance from both cameras, moving occasionally from side to side and back-and-forwards. Cameras should be placed and aimed so that they would have similar field of view.

Meanwhile, video artifacts are observed and documented. Higher resolution/bit-rate H.264 video should have equal or better perceived video quality compared to lower bit-rate VP7.1 encoded video. Specific quality parameters observed are described in this section.

2.1.16.1 Encoding quality - Jerkiness

Purpose: To ensure that motion in encoded video would feel natural and smooth. *Jerkiness* is defined in ANSI T1.801.02-1996 as *"Motion that was originally smooth and continuous is perceived as a series of distinct snapshots."*

Algorithm: User is moving hands/fingers, moving back and forwards in the chair and turning.

2.1.16.2 Encoding quality - Subjective resolution

Purpose: To ensure that the H.264 encoded video would have enough detail visible.

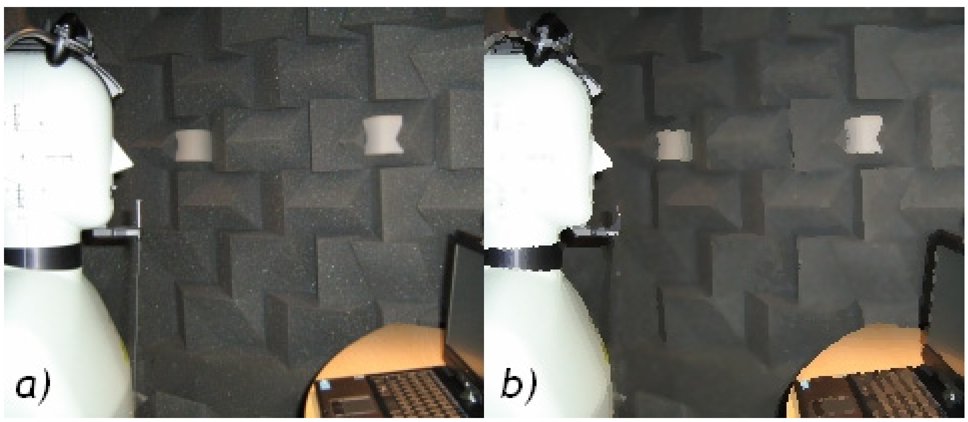


Figure 30. Subjective resolution: a) original detailed image b) image with significant loss in subjective resolution

On the above image there's clear loss in detail (the background surface), but most edges have remained sharp (possibly passed the MTF test above). Evaluating resolution also subjectively will make sure the possible issue won't remain unnoticed.

Algorithm: For a part of the time user is staying relatively still and for a part the user is slowly moving.
First, slowly changing gradients are observed like cheeks on user's face. Are the surfaces unnaturally smooth compared to VP7.1 video?
Then more detailed surfaces are observed, like a sheet with text and hair. Is there less detail than with VP7.1 encoding?
Same steps are repeated for slightly moving surfaces.

2.1.16.3Encoding quality - Block artifacts

Purpose: To ensure that H.264 image would not appear blocky compared to VP7.1 encoded image. Block distortion (or tiling) is defined in *ANSI T1.801.02* as "*distortion of the image characterized by the appearance of an underlying block encoding structure*".

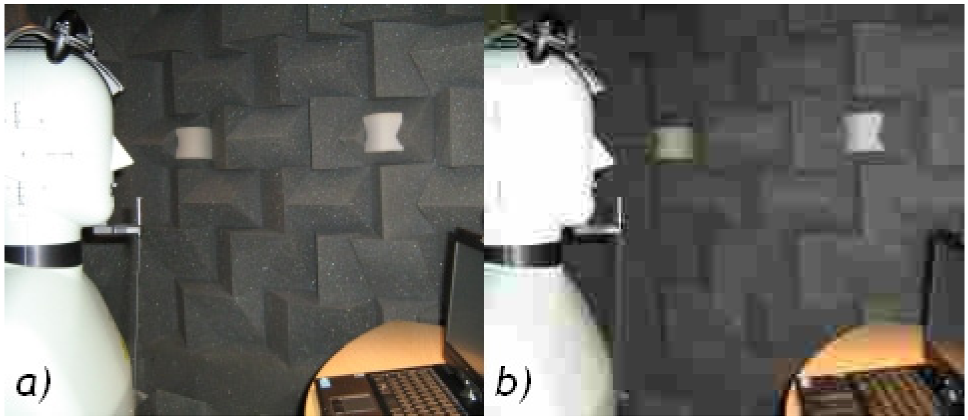


Figure 31. Block artifacts: a) original image b) block-distorted image

Algorithm: Is still scene blockier?

User is moving hands slowly and after that a bit quicker.
User is calmly changing the direction where the cameras points.
User is bringing an object very close to the camera and then taking it back again.

Did blocks appear in the movement region and were they more prominent in H.264 mode than with VP7?

2.1.16.4Encoding quality - Edge artifacts

Purpose: To ensure that compared edges wouldn't obtain disturbing artifacts after 1280x720@30fps 1Mbps H.264 encoding. Edge artifacts can be different, *ringing* is one example shown on below image.

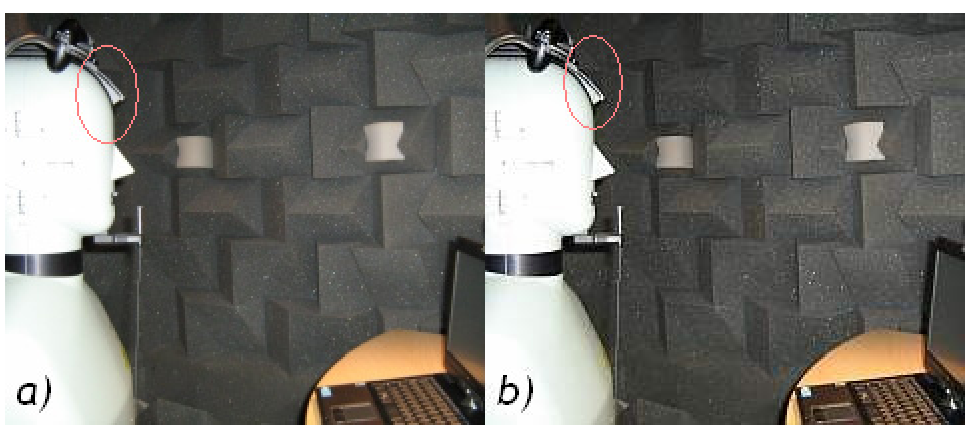


Figure 22. Edge artifacts: a) original image b) image with edge artifacts

Algorithm: User is performing the same actions as in 2.1.16.3 Block Artifacts test case.

2.1.16.5 Encoding quality - Other artifacts

Purpose: There's a wide variety of artifacts that appear during video coding. We described the most common ones above, but artifacts can have many different forms. Even on the image on Figure 31, we can observe different shades of color near the table on the right image that did not use to be there on the left image.
All of these have to be taken into account, during coder testing.

Algorithm: User is performing typical actions in typical conditions: moving slightly closer and further, talking, moving hands, placing an object near to the camera and taking it back, filming text/graphics and changing the viewing direction of the camera.
Meanwhile, any H.264 artifacts and subjective downfalls in quality compared to 640x480 VP7.1 are observed and documented.

2.1.16.6 Receive path - Artifacts

Purpose: To ensure the absence of video artifacts on rendering of received video.

Algorithm: Two Skype calls are made in parallel:

- call 1 is made between reference video devices
- call 2 is made between reference video device and device under test

Call 1 received video of one side is displayed (displayed video 1) and compared to received video on the display of device under test (displayed video 2).

While comparing displayed video 1 to displayed video 2, displayed video 2 must not have more visible artifacts, such as:

- corrupted areas on frame where colors, tones or image structure is perceptually different to displayed video 1
- significant loss of subjective resolution compared to displayed video 1
- block artifacts
- ringing artifacts
- motion artifacts

2.2 Minimum requirements *(required level)*

Only SkypeKit based solutions can be tested against this chapter. Accessories must comply with the HQV or HD video requirements.

2.2.1 Entry criteria

For the detailed description of the test please refer to chapter 1.1.1.

Output: All listed requirements are fulfilled.

2.2.2 Encoding quality

For the detailed description of the test please refer to chapter 2.1.16.

Output: All listed requirements are fulfilled.

2.2.3 Send path - Acuity @300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.2.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: MTF50 ≥ 0,25 cycles/pixel

2.2.4 Send path - Exposure accuracy @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $-1{,}5 \leq Err_{\exp} \leq 1{,}5$

2.2.5 Send path - Exposure accuracy @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $-1{,}5 \leq Err_{\exp} \leq 1{,}5$

2.2.6 Send path - Exposure accuracy @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $-1{,}5 \leq Err_{\exp} \leq 1{,}5$

2.2.7 Send path - Exposure accuracy @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $-1{,}5 \leq Err_{\exp} \leq 1{,}5$

2.2.8 Send path - Exposure accuracy @ 1000lux5000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $-1{,}5 \leq Err_{\exp} \leq 1{,}5$

2.2.9 Send path - Frame rate @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: f ≥ 15fps

2.2.10 Send path - Frame rate @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: f ≥ 15fps

2.2.11 Send path - Frame rate @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: f ≥ 15fps

2.2.12 Send path - Frame rate @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: f ≥ 15fps

2.2.13 Send path - Frame rate @ 100kbps

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 300lux
Color temperature: 3000K
Network conditions: during the call in perfect network the bandwidth is suddenly limited to 100kbps for Skype call.
Wait 15 seconds.

Output: f ≥ 5fps
The call does not drop
Packet loss is below 5% on both sides

2.2.14 Send path – Delay

For the detailed description of the test please refer to abovechapter 2.1.13.

Conditions: Light intensity: >800 lux (the scene must be bright enough to ensure that the maximum framerate is used)

Output: $d_{send} \leq 500ms$

2.2.15 Receive path – Delay

For the detailed description of the test please refer to abovechapter 2.1.13.

Conditions: Light intensity: >800 lux (the scene must be bright enough to ensure that the maximum framerate is used)

Output: $d_{receive} \leq 500ms$

2.2.16 Preview path – Delay

For the detailed description of the test please refer to abovechapter 2.1.13.

Conditions: Light intensity: >800 lux (the scene must be bright enough to ensure that the maximum framerate is used)

Output: $d_{preview} \leq 500ms$

2.3 HQV Requirements *(preferred level)*

This chapter is applicable to solutions aiming to meet Skype requirements at high level and support sending 640x480 video resolution. In case higher send video resolutions than 640x480 are supported then the device has to be tested against the HD requirements.

If not specified other way then the measurements are conducted in the perfected network conditions at least at 640x480 resolution.

2.3.1 Entry criteria

For the detailed description of the test please refer to chapter 1.1.2 (for SkypeKit based solutions) and chapter 1.1.4 (for PC accessory).

Output: All listed requirements are fulfilled.

2.3.2 Encoding quality

For the detailed description of the test please refer to abovechapter 2.1.16.

Output: All listed requirements are fulfilled.

2.3.3 Send path – Acuity @ 30lux3000K

For the detailed description of the test please refer to chapter 2.1.2.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: MTF50 ≥ 0,33 cycles/pixel

2.3.4 Send path - Acuity @300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.2.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: MTF50 ≥ 0,38 cycles/pixel

2.3.5 Send path - Oversharpening

For the detailed description of the test please refer to abovechapter 2.1.2.

Conditions: Same snapshots as for the test Acuity – MTF50 @300lux5000K

Output: Oversharpening ≤ 40%

2.3.6 Send path - SMIA distortion

For the detailed description of the test please refer to chapter 2.1.3.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $|D_{SMIA}| \leq 3\%$

2.3.7 Send path - Stretch distortion

For the detailed description of the test please refer to abovechapter 2.1.4.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $|D_{Stretch}| \leq 5\%$

2.3.8 Send path - Spatial noise deviation @ 30lux3000K

For the detailed description of the test please refer to chapter 2.1.5.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $\sigma_{MAX} < 2{,}7$

2.3.9 Send path - Spatial noise deviation @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.5.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $\sigma_{MAX} < 2{,}7$

2.3.10 Send path - Spatial noise deviation @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.5.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $\sigma_{MAX} < 1,7$

2.3.11 Send path - Spatial noise deviation @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.5.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $\sigma_{MAX} < 1,7$

2.3.12 Send path - Temporal SNR @ 30lux3000K

For the detailed description of the test please refer to chapter 2.1.6.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $SNR_{Temporal} \geq 30dB$

2.3.13 Send path - Temporal SNR @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.6.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $SNR_{Temporal} \geq 30dB$

2.3.14 Send path - Temporal SNR @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.6.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $SNR_{Temporal} \geq 35dB$

2.3.15 Send path - Temporal SNR @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.6.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $SNR_{Temporal} \geq 35dB$

2.3.16 Send path - Color accuracy @ 30lux3000K

For the detailed description of the test please refer to chapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $\Delta C^{*}_{avg-abcorr} \leq 20$

2.3.17 Send path - Color accuracy @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $\Delta C^{*}_{avg-abcorr} \leq 20$

2.3.18 Send path - Color accuracy @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $\Delta C^{*}_{avg-abcorr} \leq 13$

2.3.19 Send path - Color accuracy @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $\Delta C^{*}_{avg-abcorr} \leq 13$

2.3.20 Send path - Color accuracy @ 1000lux5000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $\Delta C^*_{avg-abcorr} \leq 13$

2.3.21 Send path - Skin tone accuracy @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $\Delta C^*_{abcorr}(patch\ no\ 2) \leq 15$

2.3.22 Send path - Skin tone accuracy @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $\Delta C^*_{abcorr}(patch\ no\ 2) \leq 15$

2.3.23 Send path - Skin tone accuracy @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $\Delta C^*_{abcorr}(patch\ no\ 2) \leq 10$

2.3.24 Send path - Skin tone accuracy @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $\Delta C^*_{abcorr}(patch\ no\ \ 2) \leq 10$

2.3.25 Send path - Skin tone accuracy @ 1000lux5000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $\Delta C^*_{abcorr}(patch\ no\ \ 2) \leq 10$

2.3.26 Send path - Saturation @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $80\% \leq \overline{C}r \leq 160\%$

2.3.27 Send path - Saturation @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $80\% \leq \overline{C}r \leq 160\%$

2.3.28 Send path - Saturation @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $80\% \leq \overline{C}r \leq 160\%$

2.3.29 Send path - Saturation @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $80\% \leq \overline{C}r \leq 160\%$

2.3.30 Send path - Saturation @ 1000lux5000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $80\% \leq \overline{C}r \leq 160\%$

2.3.31 Send path - Exposure accuracy @ 30lux3000K

For the detailed description of the test please refer to chapter 2.1.8.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $-1{,}0 \cdot \frac{\text{frame\_rate}}{15\,fps} \leq Err_{\exp} \leq 1{,}0$

2.3.32 Send path - Exposure accuracy @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $-1{,}0 \cdot \frac{\text{frame\_rate}}{15\,fps} \leq Err_{\exp} \leq 1{,}0$

2.3.33 Send path - Exposure accuracy @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $-1{,}0 \leq Err_{\exp} \leq 1{,}0$

2.3.34 Send path - Exposure accuracy @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $-1{,}0 \leq Err_{\exp} \leq 1{,}0$

2.3.35 Send path - Exposure accuracy @ 1000lux5000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $-1{,}0 \leq Err_{\exp} \leq 1{,}0$

2.3.36 Send path - Dynamic range @ 30lux3000K

For the detailed description of the test please refer to chapter 2.1.9.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: detected_patches ≥ 16,0

2.3.37 Send path - Dynamic range @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.9.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: detected_patches ≥ 16,0

2.3.38 Send path - Dynamic range @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.9.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: detected_patches ≥ 16,0

2.3.39 Send path - Dynamic range @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.9.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: detected_patches ≥ 16,0

2.3.40 Send path - Dynamic range @ 1000lux5000K

For the detailed description of the test please refer to abovechapter 2.1.9.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: detected_patches ≥ 16,0

2.3.41 Send path - Capture gamma @ 30lux3000K

For the detailed description of the test please refer to chapter 2.1.10.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $0,4 \leq \gamma \leq 1,0$

2.3.42 Send path - Capture gamma @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.10.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $0,4 \leq \gamma \leq 1,0$

2.3.43 Send path - Capture gamma @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.10.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $0,4 \leq \gamma \leq 1,0$

2.3.44 Send path - Capture gamma @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.10.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $0{,}4 \le \gamma \le 1{,}0$

2.3.45 Send path - Capture gamma @ 1000lux5000K

For the detailed description of the test please refer to abovechapter 2.1.10.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $0{,}4 \le \gamma \le 1{,}0$

2.3.46 Send path - Light falloff @ 30lux3000K

For the detailed description of the test please refer to chapter 2.1.11.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $0{,}90 \le I_{rel} \le 1{,}4$

2.3.47 Send path - Light falloff @300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.11.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $0{,}90 \le I_{rel} \le 1{,}4$

2.3.48 Send path - Color uniformity R/G @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.11.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: 0,90 ≤ ratio(R/G)≤ 1,2

2.3.49 Send path - Color uniformity R/G @300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.11.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: 0,90 ≤ ratio(R/G)≤ 1,2

2.3.50 Send path - Color uniformity B/G 0 @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.11.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: 0,90 ≤ ratio(B/G)≤ 1,2

2.3.51 Send path - Color uniformity B/G @300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.11.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: 0,90 ≤ ratio(B/G)≤ 1,2

2.3.52 Send path - Frame rate @7lux3000K

For the detailed description of the test please refer to chapter 2.1.12.

Conditions: Light intensity: 7lux
Color temperature: 3000K

Output: f ≥ 15fps

2.3.53 Send path - Frame rate @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: f ≥ 15fps

2.3.54 Send path - Frame rate @ 30lux5000K

For the detailed description of the test please refer to above[chapter 2.1.12].

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: f ≥ 15fps

2.3.55 Send path - Frame rate @ 160lux4000K

For the detailed description of the test please refer to above[chapter 2.1.12].

Conditions: Light intensity: 160lux
Color temperature: 4000K

Output: f ≥ 30fps

2.3.56 Send path - Frame rate @ 300lux3000K

For the detailed description of the test please refer to above[chapter 2.1.12].

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: f ≥ 30fps

2.3.57 Send path - Frame rate @ 300lux5000K

For the detailed description of the test please refer to above[chapter 2.1.12].

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: f ≥ 30fps

2.3.58 Send path - Frame rate @ 200kbps

For the detailed description of the test please refer to above[chapter 2.1.12].

Conditions: Light intensity: 300lux
Color temperature: 3000K
Network conditions: during the call in perfect network the bandwidth is suddenly limited to 200kbps for Skype call.
Wait 15 seconds.

Output: $f \geq 5fps$
The call does not drop
Packet loss is below 5% on both sides

2.3.59 Send path – Delay

For the detailed description of the test please refer to chapter 2.1.13.

Conditions: Light intensity: >800 lux (the scene must be bright enough to ensure that the maximum frame rate is used)

Output: $d_{send} \leq 300ms$

2.3.60 Send path - Depth of field

For the detailed description of the test please refer to chapter 2.1.14.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $MTF50_{min} \geq 0,35$ cycles/pixel

2.3.61 Send path - Field of view

The requirement is not applicable from test specification version 4.0.2. Kept as placeholder for consideration in future.

2.3.62 Send path - Field of view consistency

For the detailed description of the test please refer to chapter 2.1.15.

Conditions: Light intensity: 300lux
Color temperature: 5000K
Overload receive PC CPU.

Output: $\Delta\alpha < 13\%$

2.3.63 Receive path – Delay*

For the detailed description of the test please refer to abovechapter 2.1.13.

Conditions: Light intensity: >800 lux (the scene must be bright enough to ensure that the maximum frame rate is used)

Output: $d_{receive} \leq 300ms$

**Not applicable to PC accessories that are only input devices.*

2.3.64 Receive path – Artifacts*

For the detailed description of the test please refer to abovechapter 2.1.16.

Conditions: Maximum receive resolution

Output: No significant problems during subjective evaluation.
In case of a failure detailed description and sample video is provided.

**Not applicable to PC accessories that are only input devices.*

2.3.65 Preview path – Delay

For the detailed description of the test please refer to abovechapter 2.1.13.

Conditions: Light intensity: >800 lux (the scene must be bright enough to ensure that the maximum frame rate is used)

Output: $d_{preview} \leq 300ms$

2.3.66 Preview path – Acuity

For the detailed description of the test please refer to abovechapter 2.1.2.

Conditions: Screen capture is made with good still image camera.
The local preview window is scaled to VGA.

Output: MTF50 ≥ 0,02 cycles/pixel

2.4 HD Requirements *(preferred level)*

This chapter is applicable to solutions aiming to meet Skype requirements at high level and support sending 720x1280 video resolution.
If not specified other way then the measurements are conducted in the perfected network conditions at least at 720x1280 resolution.

2.4.1 Entry criteria

For the detailed description of the test please refer to chapter 1.1.3 (for SkypeKit based solutions) and chapter 1.1.5 (for PC accessory).

Output: All listed requirements are fulfilled.

2.4.2 Encoding quality

For the detailed description of the test please refer to abovechapter 2.1.16.

Output: All listed requirements are fulfilled.

2.4.3 Send path – Acuity @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.2. NB! For TV cameras with fixed focus we are willing to make an exception for positioning by increasing the testing distance to 1m. Such exception is done only if the product packaging is warning about not perfectly focusing to shorter distances than 1 meter.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: MTF50 ≥ 0,33 cycles/pixel

2.4.4 Send path - Acuity @300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.2. NB! For TV cameras with fixed focus we are willing to make an exception for positioning by increasing the testing distance to 1m. Such exception is done only if the product packaging is warning about not perfectly focusing to shorter distances than 1 meter.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: MTF50 ≥ 0,35 cycles/pixel

2.4.5 Send path - Oversharpening

For the detailed description of the test please refer to abovechapter 2.1.2.

Conditions: Same snapshots as for the test Acuity – MTF50 @300lux5000K

Output: Oversharpening ≤ 40%

2.4.6 Send path - SMIA distortion

For the detailed description of the test please refer to abovechapter 2.1.3.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $|D_{SMIA}| \leq 3\%$

2.4.7 Send path - Stretch distortion

For the detailed description of the test please refer to aboveabovechapter 2.1.4.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $|D_{Stretch}| \leq 5\%$

2.4.8 Send path - Spatial noise deviation @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.5.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $\sigma_{MAX} < 2{,}7$

2.4.9 Send path - Spatial noise deviation @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.5.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $\sigma_{MAX} < 2{,}7$

2.4.10 Send path - Spatial noise deviation @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.5.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $\sigma_{MAX} < 1{,}7$

2.4.11 Send path - Spatial noise deviation @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.5.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $\sigma_{MAX} < 1{,}7$

2.4.12 Send path - Temporal SNR @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.6.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $SNR_{Temporal} \geq 25dB$

2.4.13 Send path - Temporal SNR @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.6.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $SNR_{Temporal} \geq 25dB$

2.4.14 Send path - Temporal SNR @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.6.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $SNR_{Temporal} \geq 33dB$

2.4.15 Send path - Temporal SNR @ 300lux5000K

For the detailed description of the test please refer to above chapter 2.1.6.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $SNR_{Temporal} \geq 33dB$

2.4.16 Send path - Color accuracy @ 30lux3000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $\Delta C^*_{avg-abcorr} \leq 20$

2.4.17 Send path - Color accuracy @ 30lux5000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $\Delta C^*_{avg-abcorr} \leq 20$

2.4.18 Send path - Color accuracy @ 300lux3000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $\Delta C^*_{avg-abcorr} \leq 13$

2.4.19 Send path - Color accuracy @ 300lux5000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $\Delta C^*_{avg-abcorr} \leq 13$

2.4.20 Send path - Color accuracy @ 1000lux5000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $\Delta C^*_{avg-abcorr} \leq 13$

2.4.21 Send path - Skin tone accuracy @ 30lux3000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $\Delta C^*_{abcorr}(patch\ no\ 2) \leq 15$

2.4.22 Send path - Skin tone accuracy @ 30lux5000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $\Delta C^*_{abcorr}(patch\ no\ 2) \leq 15$

2.4.23 Send path - Skin tone accuracy @ 300lux3000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $\Delta C^*_{abcorr}(patch\ no\ 2) \leq 10$

2.4.24 Send path - Skin tone accuracy @ 300lux5000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $\Delta C^{*}_{abcorr}(patch\ no\ 2) \leq 10$

2.4.25 Send path - Skin tone accuracy @ 1000lux5000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $\Delta C^{*}_{abcorr}(patch\ no\ 2) \leq 10$

2.4.26 Send path - Saturation @ 30lux3000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $80\% \leq \overline{C}r \leq 160\%$

2.4.27 Send path - Saturation @ 30lux5000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $80\% \leq \overline{C}r \leq 160\%$

2.4.28 Send path - Saturation @ 300lux3000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $80\% \leq \overline{C}r \leq 160\%$

2.4.29 Send path - Saturation @ 300lux5000K

For the detailed description of the test please refer to above chapter 2.1.7.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $80\% \le \overline{C}r \le 160\%$

2.4.30 Send path - Saturation @ 1000lux5000K

For the detailed description of the test please refer to abovechapter 2.1.7.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $80\% \le \overline{C}r \le 160\%$

2.4.31 Send path - Exposure accuracy @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $-1{,}0 \cdot \frac{\text{frame\_rate}}{15\,fps} \le Err_{\exp} \le 1{,}0$

2.4.32 Send path - Exposure accuracy @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $-1{,}0 \cdot \frac{\text{frame\_rate}}{15\,fps} \le Err_{\exp} \le 1{,}0$

2.4.33 Send path - Exposure accuracy @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.8.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $-1{,}0 \le Err_{\exp} \le 1{,}0$

2.4.34 Send path - Exposure accuracy @ 300lux5000K

For the detailed description of the test please refer to above chapter 2.1.8.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $-1{,}0 \le Err_{\exp} \le 1{,}0$

2.4.35 Send path - Exposure accuracy @ 1000lux5000K

For the detailed description of the test please refer to above chapter 2.1.8.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $-1{,}0 \le Err_{\exp} \le 1{,}0$

2.4.36 Send path - Dynamic range @ 30lux3000K

For the detailed description of the test please refer to above chapter 2.1.9.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: detected_patches ≥ 16,0

2.4.37 Send path - Dynamic range @ 30lux5000K

For the detailed description of the test please refer to above chapter 2.1.9.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: detected_patches ≥ 16,0

2.4.38 Send path - Dynamic range @ 300lux3000K

For the detailed description of the test please refer to above chapter 2.1.9.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: detected_patches ≥ 16,0

2.4.39 Send path - Dynamic range @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.9.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: detected_patches ≥ 16,0

2.4.40 Send path - Dynamic range @ 1000lux5000K

For the detailed description of the test please refer to abovechapter 2.1.9.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: detected_patches ≥ 16,0

2.4.41 Send path - Capture gamma @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.10.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $0{,}4 \le \gamma \le 1{,}0$

2.4.42 Send path - Capture gamma @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.10.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: $0{,}4 \le \gamma \le 1{,}0$

2.4.43 Send path - Capture gamma @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.10.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: $0{,}4 \le \gamma \le 1{,}0$

2.4.44 Send path - Capture gamma @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.10.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $0{,}4 \leq \gamma \leq 1{,}0$

2.4.45 Send path - Capture gamma @ 1000lux5000K

For the detailed description of the test please refer to abovechapter 2.1.10.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $0{,}4 \leq \gamma \leq 1{,}0$

2.4.46 Send path - Light falloff @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.11.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: $0{,}90 \leq I_{rel} \leq 1{,}4$

2.4.47 Send path - Light falloff @300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.11.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: $0{,}90 \leq I_{rel} \leq 1{,}4$

2.4.48 Send path - Color uniformity R/G @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.11.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: 0,90 ≤ ratio(R/G)≤ 1,2

2.4.49 Send path - Color uniformity R/G @300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.11.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: 0,90 ≤ ratio(R/G)≤ 1,3

2.4.50 Send path - Color uniformity B/G 0 @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.11.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: 0,90 ≤ ratio(B/G)≤ 1,2

2.4.51 Send path - Color uniformity B/G @300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.11.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: 0,90 ≤ ratio(B/G)≤ 1,2

2.4.52 Send path - Frame rate @7lux3000K

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 7lux
Color temperature: 3000K

Output: f ≥ 15fps

2.4.53 Send path - Frame rate @ 30lux3000K

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 30lux
Color temperature: 3000K

Output: f ≥ 15fps

2.4.54 Send path - Frame rate @ 30lux5000K

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 30lux
Color temperature: 5000K

Output: f ≥ 15fps

2.4.55 Send path - Frame rate @ 160lux4000K

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 160lux
Color temperature: 4000K

Output: f ≥ 24fps

2.4.56 Send path - Frame rate @ 300lux3000K

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 300lux
Color temperature: 3000K

Output: f ≥ 24fps

2.4.57 Send path - Frame rate @ 300lux5000K

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 300lux
Color temperature: 5000K

Output: f ≥ 24fps

2.4.58 Send path - Frame rate @ 200kbps

For the detailed description of the test please refer to abovechapter 2.1.12.

Conditions: Light intensity: 300lux
Color temperature: 3000K
Network conditions: during the call in perfect network the bandwidth is suddenly limited to 200kbps for Skype call.
Wait 15 seconds.

Output: $f \geq 5fps$
The call does not drop
Packet loss is below 5% on both sides

2.4.59 Send path – Delay

For the detailed description of the test please refer to abovechapter 2.1.13.

Conditions: Light intensity: >800 lux (the scene must be bright enough to ensure that the maximum frame rate is used)

Output: $d_{send} \leq 300ms$

2.4.60 Send path - Depth of field

For the detailed description of the test please refer to abovechapter 2.1.14.

Conditions: Light intensity: 1000lux
Color temperature: 5000K

Output: $MTF50_{min} \geq 0,30$ cycles/pixel

2.4.61 Send path - Field of view

The requirement is not applicable from test specification version 4.0.2. Kept as placeholder for consideration in future.
The result is provided for informational purpose.

2.4.62 Send path - Field of view consistency

For the detailed description of the test please refer to abovechapter 2.1.15.

Conditions: Light intensity: 300lux
Color temperature: 5000K
Overload receive PC CPU.

Output: $\Delta\alpha < 13\%$

2.4.63 Receive path – Delay*

For the detailed description of the test please refer to abovechapter 2.1.13.

Conditions: Light intensity: >800 lux (the scene must be bright enough to ensure that the maximum frame rate is used)

Output: $d_{receive}$≤300ms

**Not applicable to PC accessories that are only input devices.*

2.4.64 Receive path – Artifacts*

For the detailed description of the test please refer to abovechapter 2.1.16.

Conditions: Maximum receive resolution

Output: No significant problems during subjective evaluation.
In case of a failure detailed description and sample video is provided.

**Not applicable to PC accessories that are only input devices.*

2.4.65 Preview path – Delay

For the detailed description of the test please refer to abovechapter 2.1.13.

Conditions: Light intensity: >800 lux (the scene must be bright enough to ensure that the maximum frame rate is used)

Output: $d_{preview}$≤300ms

2.4.66 Preview path – Acuity

For the detailed description of the test please refer to abovechapter 2.1.2.

Conditions: Screen capture is made with good still image camera.
The local preview window is scaled to VGA.

Output: MTF50 ≥ 0,02 cycles/pixel

3 Test setup and test environment details

3.1.1 Objective video test setup

All standalone video devices are tested over a Skype to Skype two way video call. Skype call is made in the ideal network conditions.

If device allows both the LAN and Wi-Fi connection then LAN connection is used as a first preference and Wi-Fi verified as secondary. If only Wi-Fi is supported then Wi-Fi connection will be used.

Video resolutions (send and receive) and frame rates are the highest defaults which the device enables in ideal conditions, unless otherwise stated in the test case.

A call is made between the DUT and the Reference Skype PC. The Reference PC is configured for 1280x720 resolution and one of the two output DVI cables is connected to the DVI capture card in Test Management PC.

Majority of the tests are conducted by using the DVI capture card to capture the DUT camera send video and extracting the frames for image processing/analysis. The DVI video is captured at constant 30 frames per second.

If the device supports VGA, or QVGA and not the 1280x720 resolution for send video, then the test management tool still captures the video at 1280x720 @ 30fps, but the images for analysis are extracted at the original native resolution (VGA or QVGA respectively).

The following test cases use a different method for image capture. The image for analysis is captured by making a "Snapshot" in windows Skype client UI button or through Skype Call menu -> Video -> Video Snapshot command.

- Acuity
- Depth of field
- Field of view consistency

> NB! – the "Video Snapshot" is always at 1:1 resolution respective to the current send video resolution from DUT camera. Thus a snapshot function could be used for all objective single frame video test cases if the DVI capture setup is not available.

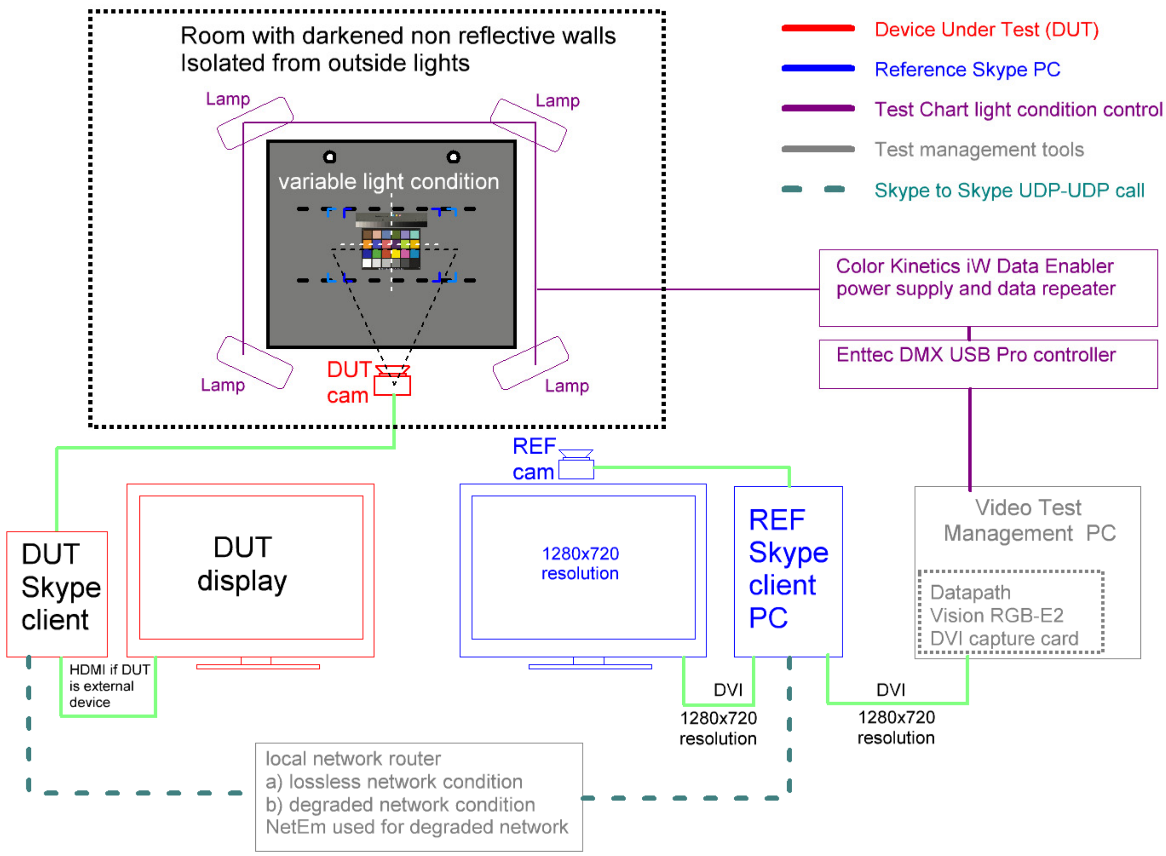


Figure 33. Logical schema to describe the test setup.

3.1.2 Initialization and test settings

On the reference Skype PC it is possible to open the call technical information window to verify the DUT send video parameters and network parameters. Go to Skype -> Call menu -> Technical Call Info (visible only if a call is ongoing).

Verify the following parameters from Call Technical Info prior to testing

- The call is UDP – UDP
- Relays = 0
- Video receive - resolution, frame rate, bit rate - make sure these parameters have reached the maximum supported before starting the testing (these are the DUT camera send video parameters!)

3.1.2.1 *Call Technical Info during Skype calls*

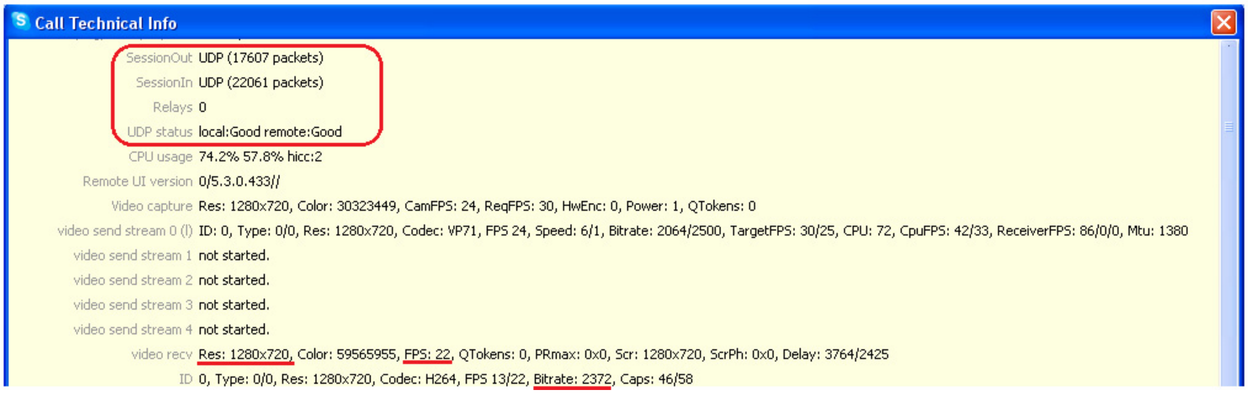


Figure 34. Snapshot of the call technical info displayed in Skype UI on reference PC.

Much more detailed description about the various info presented in the Call Technical Info window, please refer to http://developer.skype.com/skypekit/development-guide/audio-video-integration/technical-call-info

3.1.3 Lighting conditions

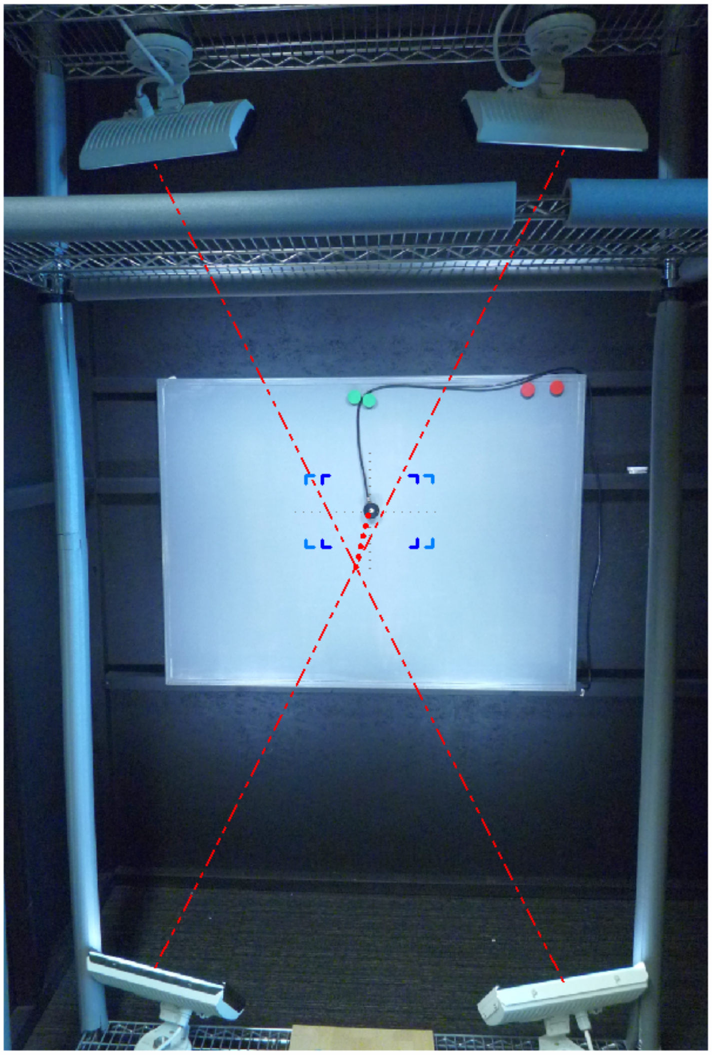
In order to control the lighting conditions a dedicated test room that is separated from the uncontrollable light sources should be used. The walls and objects in the room should be matt black or dark gray and not produce any disturbing reflections.

The lights for objective testing enable us to independently alter the color temperature and illuminance on the test target in given boundaries.

Color temperatures and illuminances of particular interest are:

- 7lux – very low light
- 30 lux, 3000 K – low tungsten light
- 30 lux, 5000 K – low daylight
- 300 lux, 3000 K – standard tungsten light
- 300 lux, 5000 K – standard daylight
- 1000 lux, 5000 K – bright daylight (used to testing overexposure)
- 160 lux, 4000 K – medium fluorescent light (used for testing frame rate)

On the flat test charts we provide as uniform illuminance as possible. Over the chart, illuminance can vary no more than 10%.
Lighting intensity and color temperature are calibrated at the test targets center position with Gigahertz Optik HTC-99D.



The picture shows

- Mechanical fixture for lights – mounting stands of lights positioned 0.74 meters from test board surface
- four of Color Kinetics iW Blast 12 Powercore lights
- Gigahertz Optik HTC-99D sensor shown in center position of test targets. This is the position used for illuminance and color temperature calibrations of the lights for each light condition.

Figure 35. Description of the light conditions in the video lab.

3.1.4 Test charts

List of all test charts used to measure objective image and video quality parameters:

3.1.4.1 DUT initial alignment test chart

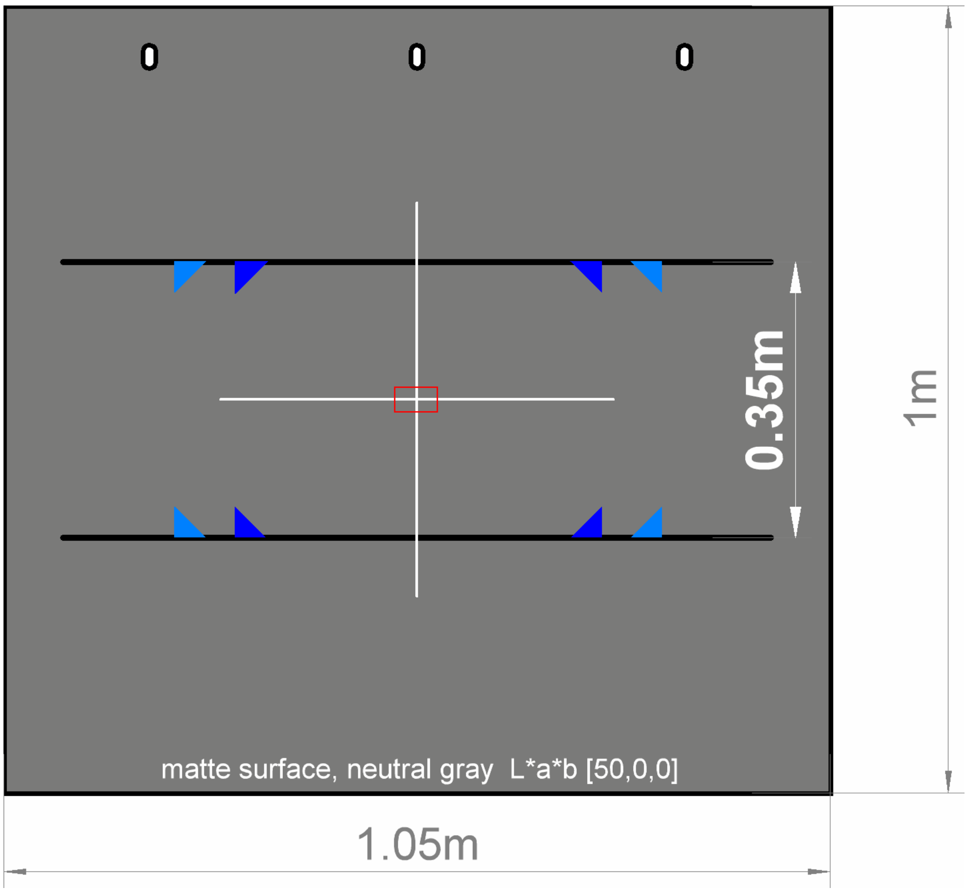


Figure 36. Position 1 for the DUT.

The following alignment markers are printed on the alignment test chart:

- black lines – define the vertical FOV. Both lines should be just visible in camera capture image
- Dark blue corners represent the field of view for 4:3 aspect ratio
- Light blue corners represent the field of view for 16:9 aspect ratio
- White cross indicates the center point of test targets (main position where light illumination and color temperature have been carried out)
- Red rectangle – position for the laser distance meter used for camera alignment process

The same legend is valid on the following figures describing other test charts.

3.1.4.2 *GretagMacbeth ColorChecker together with Kodak Q-14 Gray Scale test charts*

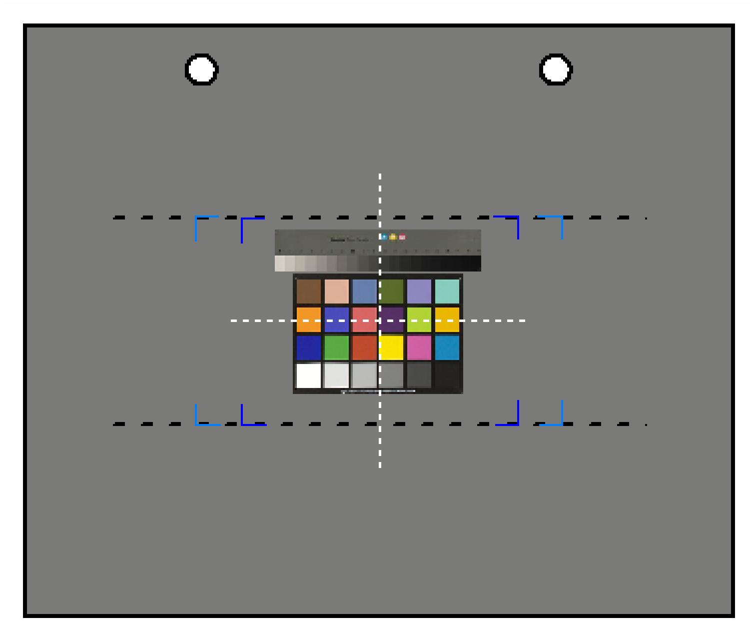


Figure 37. Test chart with ColorChecker and Gray Scale.

The ColorChecker test chart is used for the following tests:

- Spatial noise deviation
- Temporal SNR
- Color accuracy and Saturation
- Light falloff and Color uniformity
- Field of view consistency

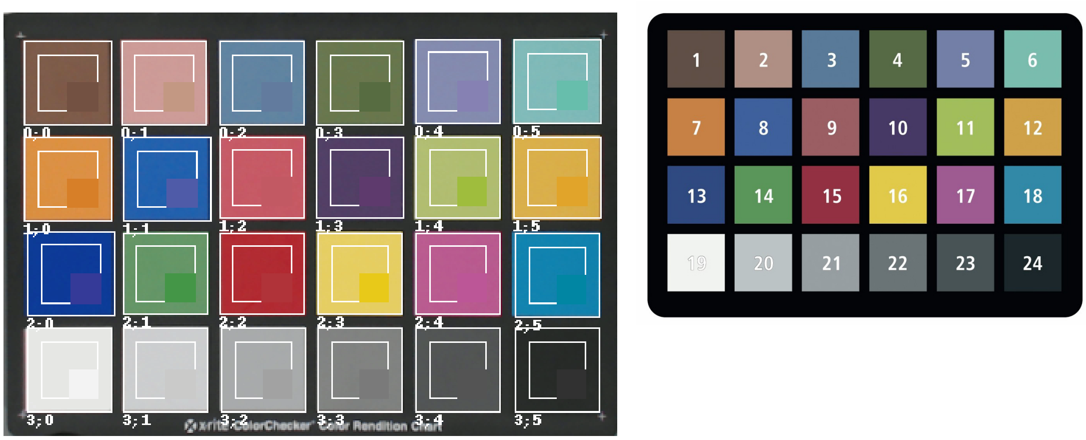


Figure 37. ROI and patch numbers on the ColorChecker.

The datasheet for the ColorChecker can be found here:
http://xritephoto.com/documents/literature/en/ColorData-1p_EN.pdf

The Gray Scale is used for Dynamic range testing only

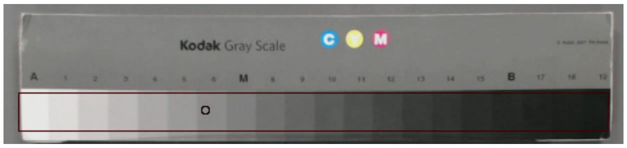


Figure 38. ROI on the Gray Scale.

3.1.4.3 GretagMacbeth ColorChecker for SMIA and stretch distortion

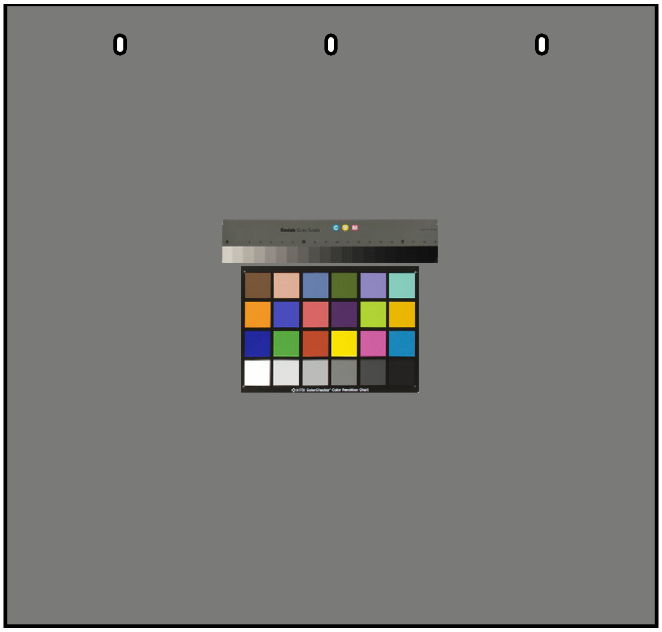


Figure 39. Position 2 for DUT.

3.1.4.4 Small Imatest SFR Plus 5x7 chart for Acuity test (full chart area of approximately 22 X 33 inches)

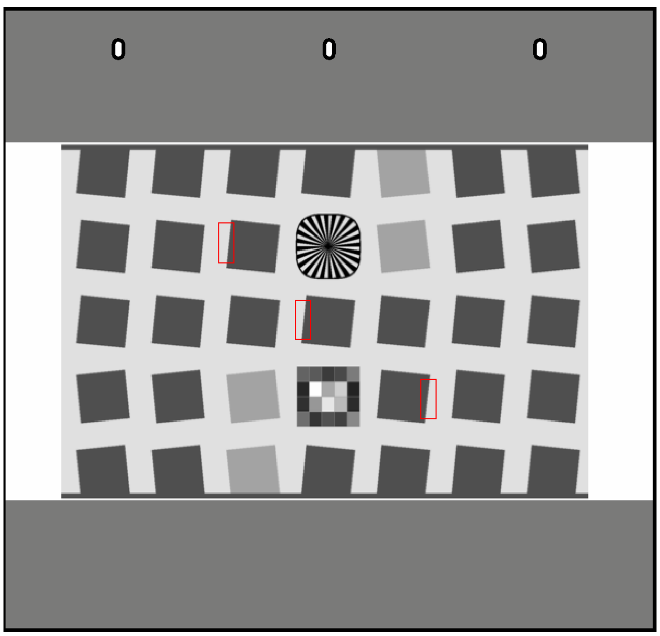


Figure 40. SFR Plus 5x7 chart.

- Imatest order information - SFRplus test chart, 24X40", 5X7, semi-gloss, black&white, 2-tone

3.1.4.5 Gray Board – for light falloff, color uniformity and framerate tests

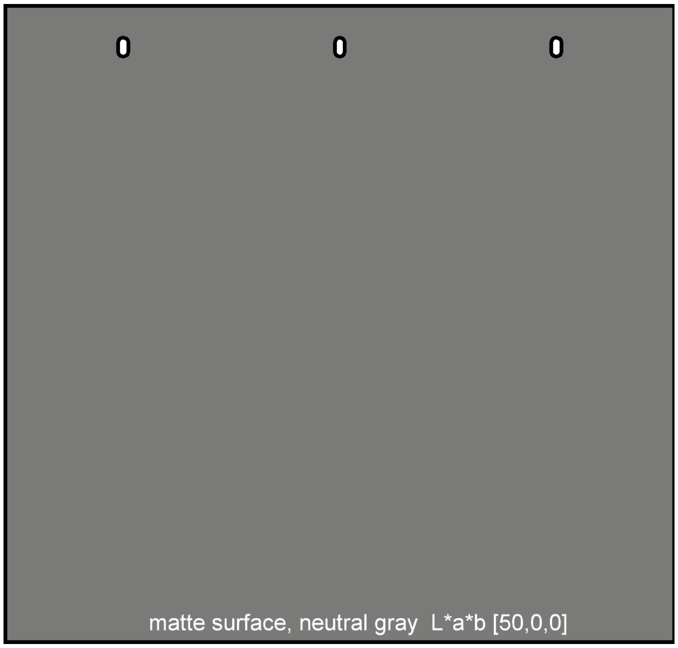


Figure 41. Gray board test chart.

3.1.4.6 Large Imatest SFR Plus 5x7 chart – for >1.5m depth of field test (full chart area of approximately 40 X 56 inches)

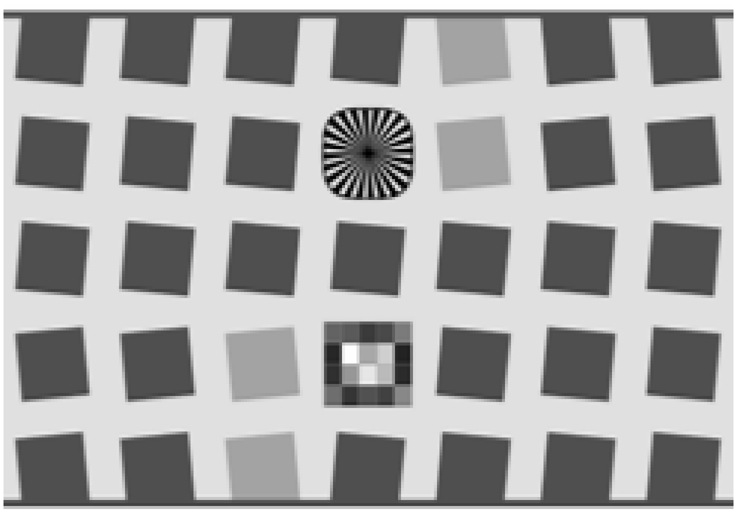


Figure 42. Large SFR Plus test chart.

- Imatest order information - SFRplus test chart, 40X60", 5X7, semi-gloss, black&white, 2-tone

3.1.5 Other inventory

Besides the charts, Skype uses the following equipment when performing the certification tests:

- Lights with power supply and controller
  - four of Color Kinetics iW Blast 12 Powercore lights
    - color temperature adjustable in the region of $-3000K - 6500K$
    - luminous intensity controllable
    - average power consumption is $\overline{P} = 4 \times 50W = 200W$
    - AC/DC converter built into the lights
    - light controlling data path: PC → DMX USB Pro → Data Enabler → Lights
  - controlled by Enttec DMX USB Pro controller
  - Color Kinetics iW Data Enabler- power supply and data repeater
- Camera holder mechanism
- Laser distance meter
  - Bosch DLE 50 Professional
  - minimum measuring distance: 5 cm
- Reference PC
  - operating system: Microsoft Windows XP SP3
  - CPU Type Core 2 Duo, 2,666 GHz
  - system memory: 2010 MB
  - video adapter : NVIDIA GeForce 8500 GT (512 MB)
- Color and lux-meter
  - Gigahertz Optik HCT-99D (measures both – color temperature and illuminance)
- Datapath VisionRGB-E2 Dual DVI capture card
- Video test management PC (hosts the above DVI capture card and runs the automated test scripts)

4 Appendix

4.1 Using a "Snapshot" function to capture image

- Make sure the camera is sending the required resolution.
- Make sure the light condition on test chart is correct.
- Make sure the camera has achieved the best focus (in case of auto focus).
- Take a "Video Snapshot" in windows Skype client UI button or through Skype Call menu -> Video -> Video Snapshot command.
- Post process the captured image according to applicable test case.

NB! – the "Video Snapshot" are always at 1:1 resolution respective to the current send video resolution from DUT camera. Thus a snapshot function could be used for all objective video test cases if the DVI capture setup is not available.

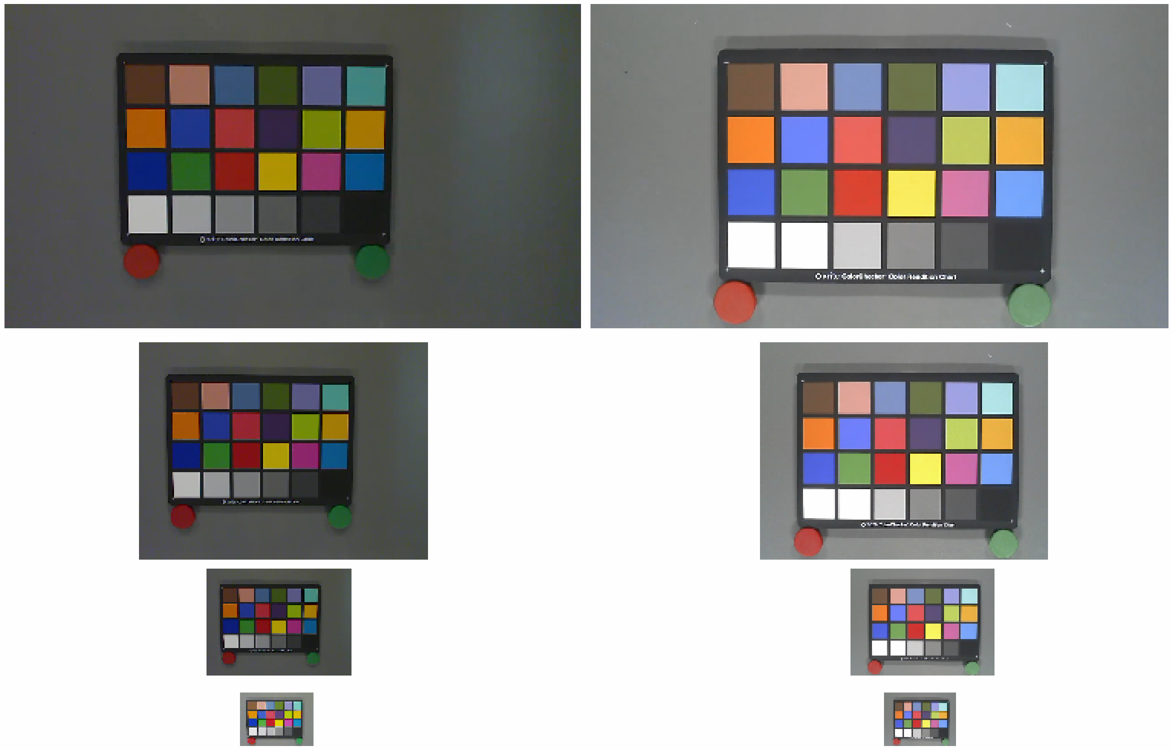
4.2 Testing the Field of view consistency

In order to test the Field of view consistency it is necessary to capture a send video image in all of the supported video send resolutions.

One way to achieve the video resolution changes in DUT send video is the following

- Use a CPU loading software on the Reference Skype PC. For example CPUgrab or CPUkiller.
- Load the CPU to >90% processor load (can be checked from Call Technical Info during a Skype call).
- After 20..40 seconds the DUT send video resolution starts to decrease as a Reference PC CPU overload induces a Skype client to send a command to DUT to lower the video resolution.
- Make a Video Snapshot after each resolution change (resolution change can be checked from Call Technical Info during a Skype call)
- Analyze each of the captured Snapshots for Field of View consistency.

Example



Bad sample　　　Good Sample

4.3 Delay test – Arduino based LED blinker sw code

Extract from the Arduino LED blinker code

```
int ledPin;    // LED connected to digital pin 9

unsigned int a; //register

void setup()  {

  // m-sequence registers

  // let's try to generate z^8 + z^6 + z^5 + z^4 + 1

  a = 1;

  ledPin = 9;

  Serial.begin(9600);

}

void loop()  {

  //unsigned int z_pow_0 = a & 1;

  //unsigned int z_pow_2 = (a & 4) >> 2;

  unsigned int z_sum = ( (a & 1) ^ ((a & 16) >> 4) ^

                        ((a & 32) >> 5) ^ ((a & 64) >> 6)  ^ ((a & 256) >> 8)) <<
```

4.4 References

[1] Public Safety Statement of Requirements by The SAFECOM Program, Department of Homeland Security, Norman Koren August 18, 2006

[2] ANSI T1.801.02

[3] Video Quality Research Home Page

1) Temporal Edge Noise Measured with the Added Edge Energy Frequencies Parameter
2) Jerkiness Measured with Lost Motion Energy Parameter and Percent Repeated Frames
3) Noise Measured with Average Motion Energy Difference Parameter
4) Block Distortion (Tiling) Measured with the HV to non-HV Edge Energy Difference Parameter
5) Error Blocks Measured with Added Motion Energy Parameter
6) Blurring Measured with the Lost Edge Energy Parameter

[4] Imatest: the world's leading software package for testing digital image quality
[5] Wikipedia: CPU Time
[6] Wikipedia: Depth of Field
[7] Wikipedia: Frame Rate/Frame Frequency