

# V Q M A 3

Video Analyzer and Video Scope  
Software Tool

*Version 3.1.6*

**User Manual**



# VQMA3

## Video Quality Measurement and Analysis Software

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*by VideoQ Inc*

*Software Video Analyzer to measure the quality of captured and streamed video.*

*Ideal tool for development labs, software developers and high volume manufacturing instantly revealing your video camera or other video device performance.*



# VQMA User Manual

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Printed: June 2013 in Santa Clara, California, USA

## Special thanks to:

*All colleagues at VideoQ, who contibuted to this product development*

## Revision History

Revision	Date	Description
3.0.0	2009, December	RC 1
3.1.1	2010, March	Release
3.1.2	2010, October	Release
3.1.3	2010, December	Release
3.1.4	2011, March	Release
3.1.5	2012, October	Release
3.1.6	2013, June	Release

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# 1 Introduction

VQMA3 is a self-contained software solution allowing manual or automated measurement of the performance of video cameras, video processors and/or video capture devices in a PC running **Windows™** OS. Used in cascade with high quality capture device VQMA3 can measure the quality of the incoming video signal, such as 3G-SDI/HD-SDI, DVI/HDMI/DP/LVDS or analog YPrPb.

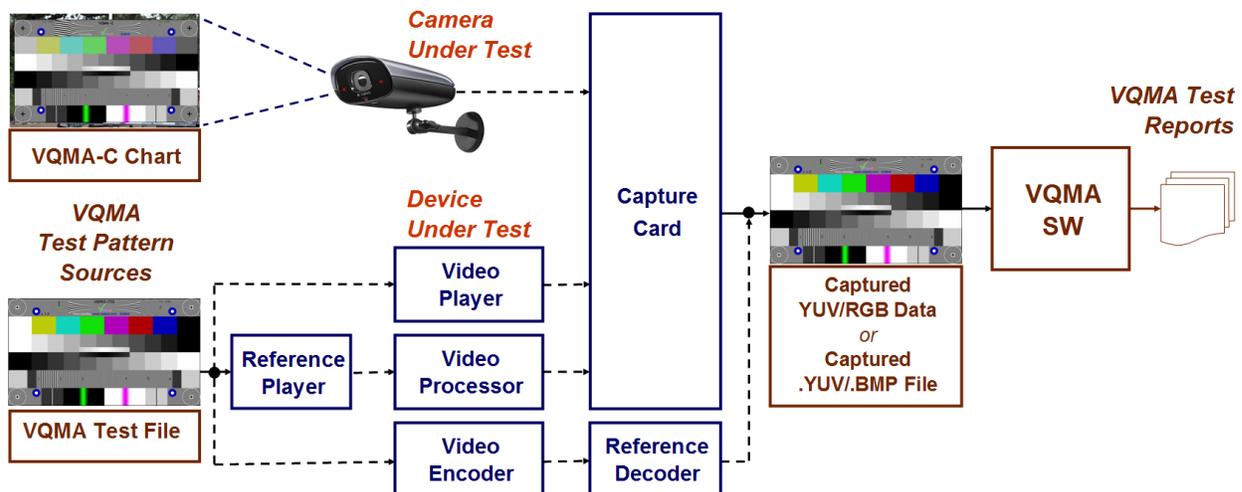
System Requirements:

- Windows XP, Vista, 7 or 8 - 32 bit or 64 bit versions
- About 2 MB of disk space

VQMA3 measures and display the following parameters:

- Picture Geometry (Position, Scale, Rotation, Keystone), 4 Corners Focus, H & V Shading
- Black and White levels, Gamma value and RGB Balance Errors on Grayscale pattern
- YUV and RGB Levels on Color Bars and Errors vs. reference values
- Frequency Response on fixed range of multi-burst frequencies
- K-rating on 2T pulse
- Y vs. UV Gain (Color Saturation) on 20T pulse
- Weighted and Unweighted SNR for Y and UV, Noise Spectrum and Histograms Display
- Total Video and Selected Line YUV/RGB waveform display (Scope) in a variety of formats

A source of special Matrix Test Pattern - VQMA-C Optical Test Chart or VQMA Test Signal Generator/Player - should be presented at the input(s) of camera or any other device under test and the resulting video data should be acquired via decoder and/or capture device as shown on the diagram below.



Captured test pattern video data should be stored on fast access media, e.g. HDD, in a file of suitable format, i.e. \*.YUV file or \*.BMP containing **single video frame or at least 8 consecutive video frames in uncompressed UYVY, YUV2 or RGB format with native 4:2:2 or 4:4:4 resolution** from minimum 640 x 480 to maximum 4096 x 3072.

VQMA analyzes video data stored in this file, and produces detailed test report in printed form and/or short report in machine-readable format.

The program also contains special driver acquiring test pattern data (YUV or RGB) directly from Unigraf capture card - via shared memory, without any intermediate file recording.

Measured values are automatically checked against target values stored in the .INI file. Editable .INI file allows customization of the test requirements to match the performance of particular cameras or devices of multiple types/models.

The accuracy of measurements is typically better than 1/10 of the target tolerance range, e.g. typical errors are about 0.5% for video levels and about +/- 0.1 dB for frequency response.

Analysis of decompressed video, e.g. after MPEG encode-decode, is also possible, but the output must be in 4:2:2 YUV or 4:4:4 RGB format compatible with VQMA software.

Horizontal and vertical test chart position errors and test chart image scaling (zoom ) are automatically compensated within the specified limits. Significant zoom-out (down to 33% ) slightly reduce VQMA results accuracy. On the other hand, scaling-up more than 105% and/or cropping of captured video are not acceptable, therefore they should be avoided.

Partial test procedures result in several partial “pass/fail” flags corresponding to each particular parameter, such as white level, or Y vs. UV gain. These flags are combined together using logical AND function, thus providing a global single bit “pass/fail” flag.

VQMA software can be launched and used in two modes:

- Windows GUI Mode
- Command Line (DOS box) Mode

### Windows GUI Mode

Starting VQMA3.EXE without any command line parameters brings up standard Windows GUI. This mode is intended for laboratory design, adjustments and verification procedures with measurements results presented in graphical format suitable for printing, e.g. creating PDF document. In Windows GUI mode it is possible to produce printed reports with more details, containing all results, including diagrams and screenshots. Short-form .TXT or .CSV machine-readable report files can also be saved as required.

Each time the user successfully opens the .YUV or .BMP test file or save short-form report .TXT or .CSV file, VQMA automatically appends **Log File** with the event date-time information and full path to the file involved.

### Command Line (DOS box) Mode

DOS box mode (under Windows) requires command line parameters and usually means running batch file in the background (unattended) mode.

In this mode **Log File** and short-form **Test Report Files** are created automatically. All important test results are presented in machine readable format, suitable for inclusion in higher level automated QA/QC systems. Test results are presented as a set of comma separated values within a report file of .TXT or .CSV format.

## Using VQMA in multi-screen/multi-resolution environment

Frames smaller or equal to 1920x1080 are analyzed in full size. If frame size exceeds 1920x1080, only central 1920x1080 area (containing HD or sub-HD version of test pattern) is analyzed.

In any case all test chart component positions and spatial frequencies are automatically scaled as needed.

This allows usage of *the same VQMA test pattern* for SD, HD, Ultra HD and Digital Cinema *frame sizes*.

Usage of different *chart sizes* (*within the transmitted or captured frame*), and variety of *aspect ratios*, provides for frequency response measurement within wide range of *spatial frequencies* - from 100 tvl to 3,000 tvl.

For example, captured .YUV video file may contain video data arranged as **4:2:2 UYVY** ("UYVY") or **YUYV** ("YUY2" also known as "YUV2") multiplex of **1920** pixels (2x1920 bytes), by **1080** TV lines. If there was no scaling involved, this particular version of VQMA chart allows frequency response measurement from 100 to 600 tvl.

By default, VQMA uses 8 bit "broadcast" quantization scale: Black\_Y = 16d, White\_Y = 235d, Grey\_UV = 128d, but VQMA analyzer can also automatically detect and process YUV/RGB data in so-called "full-scale" or "high" level scheme with Black = 0d and White = 255d.

VQMA does not support *automatic analysis* of video quality parameters on **any other test pattern**, except the original **VQMA matrix test pattern**.

However, it is possible *to use other test patterns or any other images*, e.g. full field 75% color bars or live camera snapshot, but *with limited functionality*.

In this case only **Noise Measurement** and **YUV/RGB Scope** pages of VQMA display can be used, i.e. VQMA will show measured noise parameters and also the YUV/RGB waveforms related to the selected line of video frame.

*Analysis of video files in lower resolutions SD formats, captured in composite video systems such as NTSC/PAL/SECAM, is also possible with the previous VQMA versions, the latest is VQMA 2v4. Note that VQMA2 and VQMA3 use different test patterns, so they are not directly compatible.*

## 2 Supported file formats

VQMA3.EXE can open any one file of three types:

- \*.**YUV** Single frame of raw YUV data, any pre-selected or specified resolution from 640x480 to 4096x3072 pixels, without any header or wrapper, *suitable for quick video parameters check, also saving HDD space*
- \*.**YUV** Multiple frames of raw YUV data, concatenated in one file, format - as above
- \*.**BMP** Single frame or multiple frames, 24b (RGB) or 32b (RGBA) data, 54 bytes header, any resolution from 640x480 to 4096x3072 pixels (auto-detected)

If the name of opened BMP file ends with "**\*\_0.BMP**", e.g. "FRAME\_0.BMP" and the folder contains files "**\*\_1.BMP**" ... "**\*\_7.BMP**", they are analyzed as 8 frames long video sequence (equivalent of 8 frames long .YUV file). If any one of "**\*\_1.BMP**" ... "**\*\_7.BMP**" files is missing, then "**\*\_0.BMP**" is analyzed as a single frame.

To provide for full and accurate measurement captured video file should contain a number of TV frames containing uncompressed YUV or RGB data of **VQMA-C** test pattern and taken from particular System Under Test Test Point. Total duration of this video sequence should be equal to **1 TV frame** or greater than **8 TV frames**.

VQMA analyzes only **first 8 frames**; input files containing larger number of frames are acceptable, but it does not improve the VQMA measurement accuracy. VQMA *automatically detects* Number Of Frames and switches to the appropriate analysis mode. All video quality parameters can be measured by relatively faster analysis of single-frame files, but with significantly lower accuracy, especially it affects Noise Measurements.

File name **extensions** (.YUV or .BMP) directly control VQMA operation. All **other** file types and extensions are **not supported**.

However, it is possible to use VQMA for video quality analysis with application to systems processing large variety of compressed and uncompressed video file formats, such as .TS, .MXF, .AVI, etc. This requires appropriate front-end *reference decoder*, converting these specific formats to generic YUV or BMP format. Such front-end converter(s) can be supplied on request.

### 3 VQMA Test Pattern: File and/or Reflectance Chart

There are two forms of VQMA3 test pattern supplied as standard (other formats on request):

a) Set of 4:2:2 UYVY **.YUV** and/or 4:4:4 RGB **.BMP** files in different resolutions.

These files provide the reference matrix test pattern as video source on the 3G-SDI, HD-SDI, DVI, HDMI, DP and/or YPrPb outputs of a professional or semi-professional video play-out device, e.g. via media player HDMI connector.

*It is possible to encode and multiplex VQMA bitmaps, thus providing custom transport stream **.TS** or **.M2TS** files (supplied on request).*

*If necessary, VQMA transport stream coming out from play-out server can be further converted into appropriate RF signal via optional external modulator.*

b) Reflectance Chart for camera measurements (VQMA-C order option).

In any case system under test output should be captured by some appropriate high quality device, e.g. Unigraf capture card.

*Note that levels of **Reflectance Chart** itself (and captured video signals from camera) differ significantly from **File Test Pattern** (**.YUV** or **.BMP**), - in particular **Gamma of the Gray Scale is 2.2 instead of 1.0** and **Color Bars Nomenclature is 75/37.5/75/37.5 instead of 100/0/75/0**.*



Test Chart, Gray Scale, Gamma = **2.2**



Test Pattern, Gray Scale, Gamma = **1.0**



Test Chart, Color Bars = **75/37.5/75/37.5**

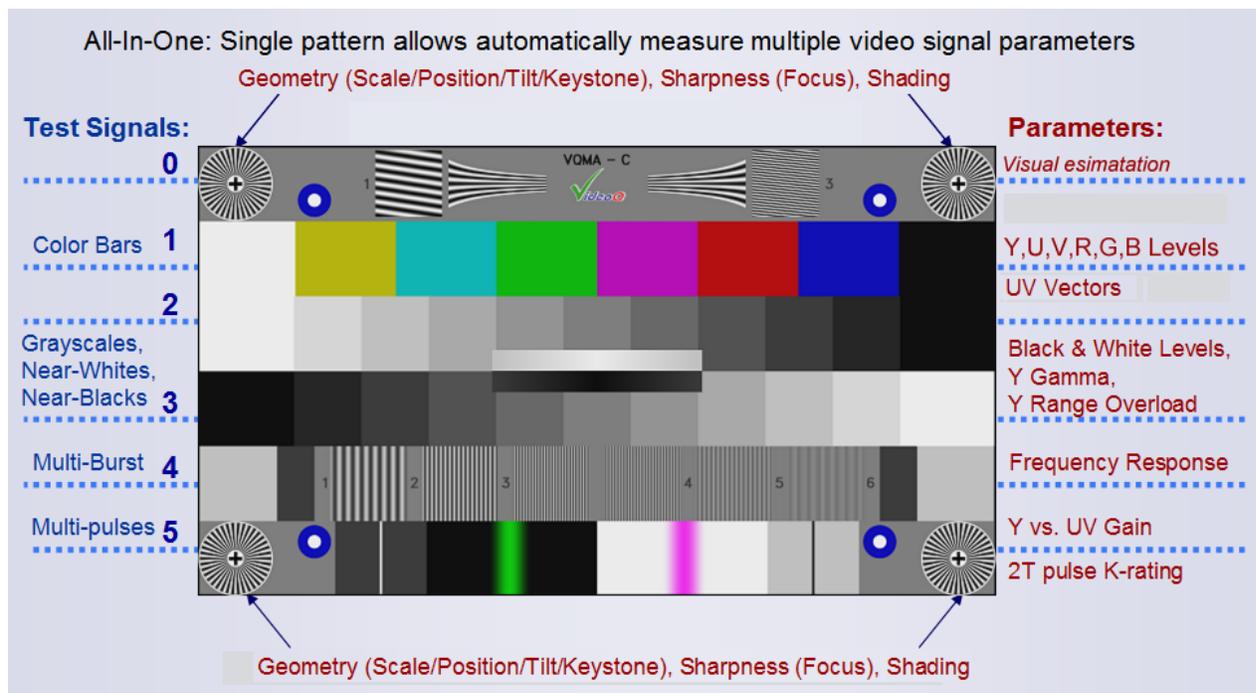


Test Pattern, Color Bars = **100/0/75/0**

Because VQMA is a **static** test pattern, captured video **frame rate** and **interlace ratio** do not affect the analysis results.

Thus, VQMA can handle any frame rate, interlaced or progressive. De-interlacing procedures can be applied at any stage before or after the capture - VQMA results will be the same.

*Video levels are measured as supplied by the actual source. Some media players may output non-calibrated video, with up to 25% errors of black and white levels. This may affect the test results. Higher degree of accuracy can be achieved by using the professional hardware-based well-calibrated test signal generator loaded with VQMA-C test matrix pattern, such as VideoQ VQS-200 or VQS-300.*



VQMA3 matrix consists of 6 horizontal bands (stripes) dedicated for automatic measurements of particular parameters. For convenience these bands are numbered "Band 0" to "Band 5" in VQMA3.EXE menus.

VQMA3 Test Pattern also contains 4 identical Blue-White Circles and 4 Radial Plates with Black Crosses in each corner. These components serve for automatic Geometry (Scale/Position/Tilt/Keystone) measurements as well as for automatic estimation of Sharpness (Focus) and Shading (Vertical and Horizontal Lighting Uniformity)

First (topmost) band of VQMA3 test pattern serves mainly for visual assessment of monochrome vertical details rendition. It is also useful for revealing timebase errors, scalers/deinterlacers/codecs performance, patterned noise, interferences and other artefacts. The appearance of this band may differ in customized versions of VQMA3.

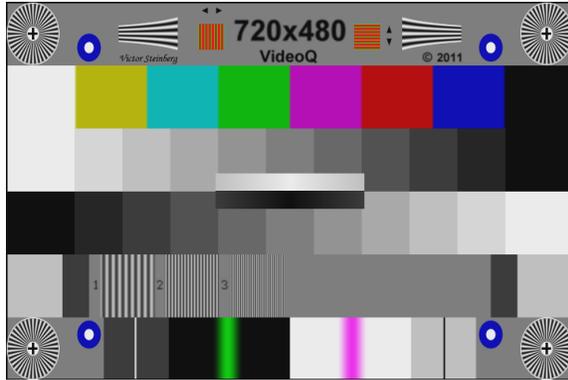
Five lower bands of the matrix serve for simultaneous (parallel) analysis of all parameters describing the performance of the signal transmission chain or the device under test. The diagram above explains the content and purpose of each band.

The central part of VQMA3 matrix pattern contain two additional smaller size components, namely Near-White Grays and Near-Black Grays. Two Shallow Ramps (dark-gray gradients and light-gray gradients) are used for testing extreme Y levels. If these ramps are clipped, then Y Range Overload Errors are detected, measured and displayed. White and black level clipping distortions are also known as White Crash and Black Crash correspondingly.

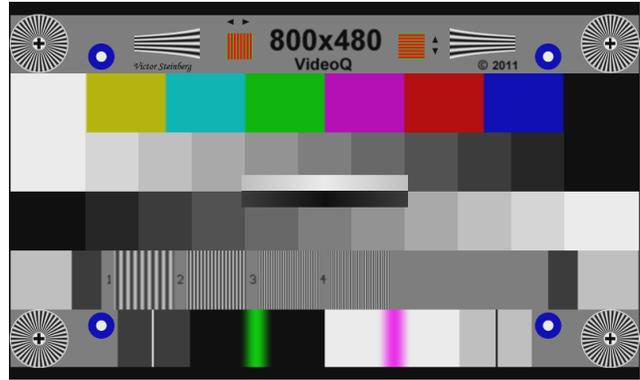
VQMA Test Pattern exists in many resolutions (frame sizes). Test Pattern may occupy full frame area or only central part of the frame.

Below are some examples:

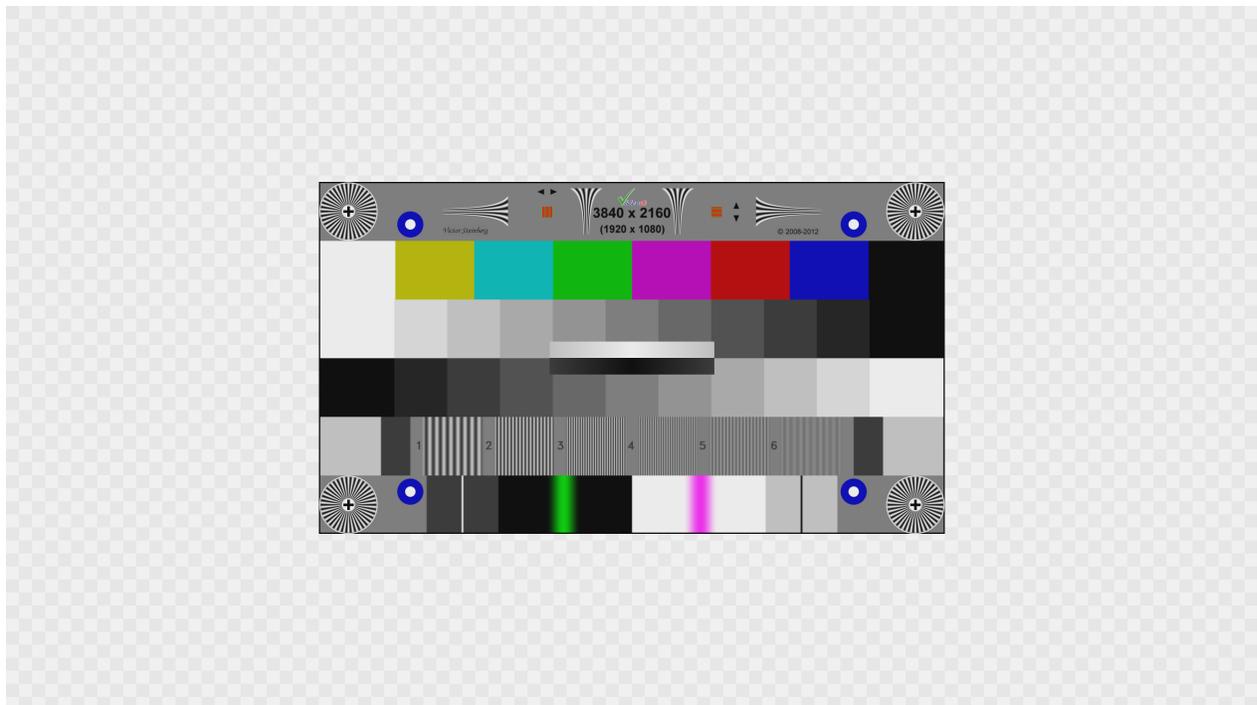
Anamorphic 720x480 chart  
fitting 3:2 720x480 frame



Letterbox 16:9 800x450 chart  
within 10:6 800x480 frame



1920x1080 chart within 3840x2160 frame on light gray checkerboard background



## 4 Software Installation and Test Setup

### 1. Install VQMA software as follows:

Create a folder on the PC hard drive, for example "c:\VQMA3", and copy there the following files:

1. VQMA3.EXE                      Main executable

*Note that in some versions the executable file name can be shortened to VQM.EXE*

2. VQMA3.INI                      Optional customized configuration file

If the .INI file is not found in the program folder, then it will be created automatically by VQMA3.EXE with the default tolerance values. This happens when the video data file of the appropriate standard is opened first time..

VQMA is a copy protected program using uniquely encrypted USB dongle, matched with the copy of your executable as installed. This dongle must be inserted into USB port of the PC where VQMA is installed whenever the VQMA3.EXE is running. In case of loss or damage of this USB dongle, VideoQ reserve the right to revoke the license.



Please note that when the dongle is not connected, the protected application will stop running. If you purchased multiple copies of VQMA please be sure to use the dongle with the same registration number as the copy number on the distribution CD. ***Installation on networked computer system (LAN or WAN) is not possible with this version.***

2. Present **VQMA-C Test Chart** before camera or provide **VQMA-C Test Pattern** as a signal, stream or file to the input of device under test (DUT)

3. Run the appropriate **capture/decode software** to create .YUV or .BMP file(s) containing video data

4. Open this file (or multiple BMP files) in **VQMA program** to measure the performance of the device under test

*Repeat steps 3 and 4 as required.*

**Removing VQMA software** is quite simple. VQMA does not make records in Windows system registry, except the location and resolution of the last opened video data file. Therefore, to remove VQMA from the system it is enough to delete the executable file VQMA3.EXE.

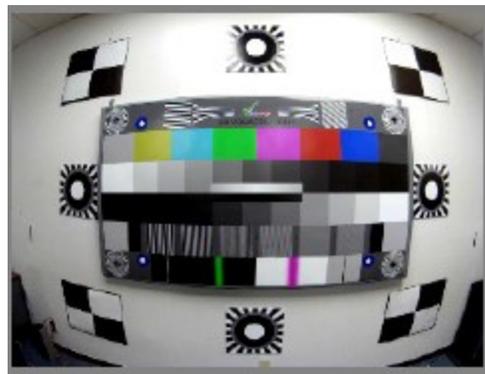
## 5 Testing Cameras with VQMA Reflectance Chart

Ideally, camera should look straight to the center of the chart; lens axis position offset in any direction should not exceed 5%.

Chart illumination uniformity is one of important parameters. Lux meter reading within the chart surface should not vary more than +/- 20%.

Optimal chart-to-camera distance depends on lens specifications; typical range is from 1m to 3m.

Cameras with viewing angles up to +/-30 degrees can be tested using VideoQ standard chart (VQMAC20, diagonal 20"); two plastic brackets attached to tripod front legs provide for good chart fixation and adjustable tilt. Ultra-wide viewing angles ("fish-eye" lenses) require much larger chart; on the right: VQMAC3M chart fixed on the wall (diagonal 3m).



Even small **vibration** of the test chart will be *interpreted* by VQMA as increase of camera noise and drop-down of frequency response, so it is important to fix the chart firmly on something solid. Same applies to camera itself - any vibration during video data capture is highly undesirable. **Fluorescent light sources** are also undesirable. They produce **flickering light**, significantly biasing VQMA noise analysis results.

Optimal chart **illumination level** depends on camera sensitivity. Typically 100 ... 400 lux is enough. For light sources below 200 W the best incidence angle is about 45 degrees. For high power light sources, light reflected from the ceiling or diffused by special filters could be better option. Repeating VQMA SNR measurements for several different illumination levels, e.g. for 20, 100 and 400 lux, helps to reveal camera noise reduction capabilities.

It is highly undesirable to get noticeable **reflections/glare**.

Distance from light sources to the chart should be bigger than camera-to-chart distance. Good lighting can be set up using is *at least two* LED panels of about 400 W, 50cmx50cm each, positioned on the left and on the right at about 45 degrees angle each, preferably *above* camera axis.

Direct light from the LED panels positioned about 50-80 cm above camera axis is reflected by chart surface down to the floor - away from camera lens. Same is true for small (about 10 degrees) chart tilt vs. ideal vertical axis - looking down chart directs reflections downwards.

Glare or reflections may also happen if some bright or reflective objects are **behind or beside the camera**. Good practice is to put dark gray or black curtains behind and next to the camera.

## 6 Capturing Video Data File and running Test Sessions

1. Supply 3G-SDI, HD-SDI, DVI, HDMI, DP or YPrPb signal of the VQMA matrix test pattern via device under test to the appropriate input of capture device or supply compressed stream to the appropriate software/hardware decoder input, e.g. 3G-SDI signal via BNC cable, DVI/HDMI signal via appropriate cable, or just a file in .TS, .YUV or .BMP format.

2. Run any capture software, software driver or Direct Show graph, available on the system, e.g. "YUV File Writer":

2.1. The specified **capture time** should be equal or greater than **8 TV frames**, recommended capture duration is slightly more than **8 frames**, e.g. 500 ms

*Note that capturing video clip of longer duration is acceptable, but it does not improve the accuracy of VQMA results*

2.2. Select output file format, e.g. **uncompressed .YUV** with FOURCC code = UYVY or YUV2, or **.BMP** (RGB)

2.3. Select **native** (full) resolution: preferably (*but not mandatory*) **1920 x 1080** or **1280 x 720**

All this actions should be done by user prior to the measurement and analysis stage, described in the following sections.

The process of capturing new file should be finished and file *closed* before the "open" ("input") function of the VQMA program is performed.

It is possible to give the file any name of user choice and store it in any folder on any *local* or *network* hard drive.

Note than in even in Command Line Mode VQMA3 accepts long file names with spaces, without 8.3 DOS format restrictions.

Usage of *network drives may slow down processing* because of the extra bandwidth required for *copying test file to local folder*.

VQMA remembers the location of the folder with last opened file, so "File Open" dialog defaults to this location.

Manual or automatic update of captured video data and corresponding update of test results are possible at the rate of about 2-5 seconds – this is typical capture-plus-analysis time interval for medium speed PC.

The update of captured data file, renaming, appending and/or overwriting of the relevant files should be done by the user.

VQMA automatically creates and appends the Log File with fixed name:  
**VideoQ\_VQMA\_Log.TXT.**

This log file is *always* located in the same directory as VQMA executable.

It is possible to arrange several folders, each containing separate set of VQMA.EXE, VQMA.INI, and VideoQ\_VQMA\_Log.TXT files.

In such arrangement these folders should be treated as several *completely independent analyzers* with *different* target values and *separate* log files.

Systematic archiving of captured test files, as well as logging of the test results, should be organized by the user, e.g. in form of script or batch file.

If VQMA is integrated with the **Unigraf** capture card, then video data are captured to shared memory and directly processed by VQMA analyzer launched from Unigraf Console Menu via "VideoQ Export" command; there is no need to create/open .YUV or .BMP file.

Note that in case of Unigraf card, there is one important advantage: VQMA can analyze HDCP protected links, but this comes with a restriction - *no provision for saving captured video data*.

VQMA3 tool is capable to process video test patterns *others* than VQMA Chart.

Quite often, for calibration and debugging purposes, user needs just a valid display of YUV/RGB waveform plus UV vector graph.

In such case, it is enough to provide a file containing some standard test pattern, e.g. SMPTE bars or EBU bars.

By special order VideoQ can supply additional software converters to accommodate other file formats, for example - single or multiple .RAW files of appropriate resolutions.

Such converters should be used as interface between the decode/capture device output format and .YUV/.BMP formats supported by VQMA3.

## 7 Running VQMA in Windows GUI mode

Click on the VQMA executable icon, or type VQMA3.EXE (without any other parameters) in the command line, to open GUI with standard Windows menus and dialog boxes.

Multiple instances of VQMA can be opened simultaneously, thus allowing easy comparison of multiple test conditions or multiple devices under tests.

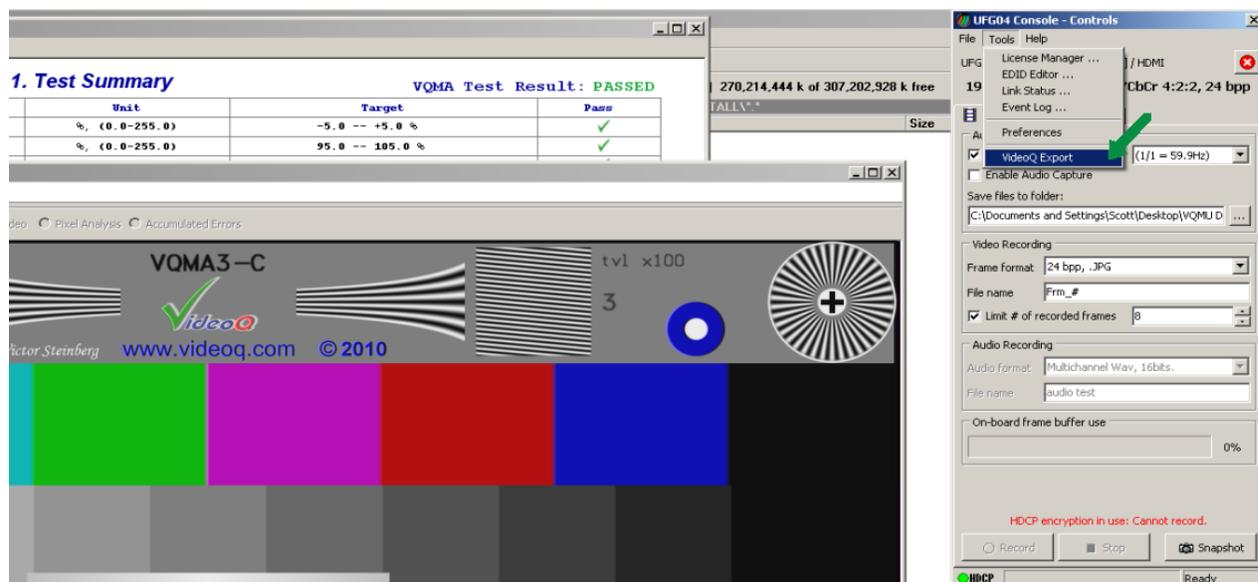
Test Session Results can be saved as **Short Report** as described in the separate section and/or printed out. It is advisable to install a PDF printer, e.g. FinePrint "PDF Factory" to produce **Full Test Report** in .PDF file format - 7 pages with all tables and plots.

VQMA can also be launched from **Unigraf Console Menu** to receive captured test pattern YUV or RGB data directly, via **Unigraf Capture Card** shared memory, without any intermediate file recording.

This data exchange and preview window are active even when normal Unigraf file recording function is disabled due to HDCP restrictions.

It is advisable to print full PDF Report for each test condition - because in this mode captured YUV or RGB data *are not stored and they are not accessible* outside of the analyzer.

Click on "**VideoQ Export**" in the Unigraf Console "Tools" menu:

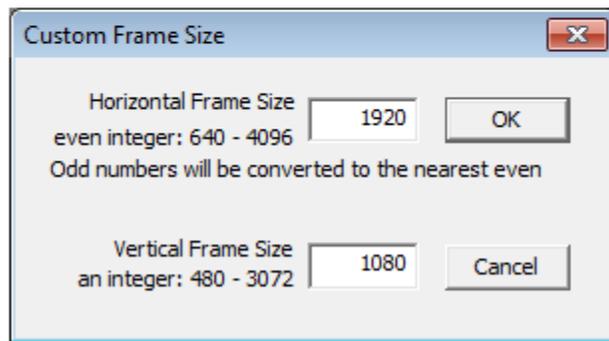
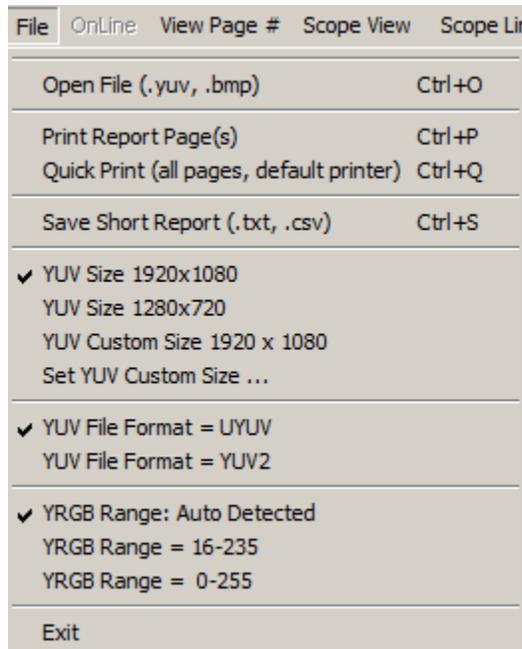


If HDCP restrictions are not present, it is possible to save YUV or BMP data files via Unigraf Console menus - instead or beside of launching VQMA analyzer.

Saved YUV or BMP files can be viewed and analyzed later by launching VQMA3.EXE off-line - in normal Windows GUI mode - separately from Unigraf Console.

## 7.1 Menu - File

This menu should be used first - after launching of VQMA3.EXE in GUI Mode:



User can perform standard Windows functions, - Open File, Print Report Pages, and Exit.

Sub-menu "**Open File**" invokes standard "File/Open" Windows dialog box. User can browse folders to find and open pre-captured video file. Supported file extensions are **.yuv** and **.bmp**.

In "**Print Report**" sub-menu each of seven on-screen pages of VQMA test results can be printed separately or all pages together.

Actual printer name and used page numbers are selected via standard Windows dialog.

It is advisable to use PDF writer, e.g. FinePrint "PDF Factory", to create electronic reports of VQMA test results; paper copies can also be printed if necessary.

If the selected printer is **PDFCreator** (supplied and installed separately under GNU license), then PDF Report with auto-generated file name is created in the folder, where the analyzed YUV/BMP file resides.

Warning: VQMA3.EXE automatically set printer page orientation to "**Landscape**". Manually switching printer into "Portrait" mode **may result in unreadable print-out**.

Selection of "**Quick Print**" instead of "Print Report" allows *bypassing printer selection and page number dialog*; in such case **all pages** will be printed **by the pre-selected printer**.

If the pre-selected printer is **PDFCreator**, then click on "Quick Print" results in PDF Report file creation *without any dialog*.

Menu "File" also includes four VQMA specific functions:

- **"Save Short Report"**

this allows user to browse folders and save short text report in .TXT or .CSV format. Short Report file structure and content are identical to Command Line Mode output, described in the correspondent section of this manual.

- **"YUV Frame Size"**

this allows user to set Custom Frame Size (in Y pixels) and choose either this custom size or one of two standard sizes - **1920x1080** or **1280x720**. The user selected options are stored in Windows Registry, so the choices done within this sub-menu are persistent. Separate pop-up Dialog Box allows entering *even* integers for the *horizontal* size or *any* integer for the *vertical* size; in both cases the permitted ranges are *automatically clipped*. Note that the selected frame size should **exactly match** the .YUV file to be opened. ***It does not affect opening of .BMP files (BMP image resolution is auto-detected)***

- **"Default YUV Format"**

this allows to toggle between two alternative formats of .YUV files to be opened - UYVY and YUV2. ***It does not affect opening of .BMP files (of RGB format)***

- **"YRGB Range"**

this allows user to select (automatically or manually) nominal range of Y, R, G, and B 8 bit values: either 16-235 aka 'Reduced Range', or 0-255 aka 'Full Range'; the selection should be done *before* opening .YUV file, it **does not affect** the analysis results for the **already opened** file - only the analysis of **next** opened file will be affected. ***This selection affects both .YUV and .BMP file formats.***

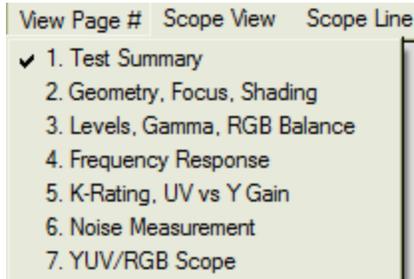
## 7.2 Menu - OnLine

This menu item is reserved for future use - to control video capture devices installed and recognized by Windows.

Current version does not support "Live Capture" mode, so this menu is shown in grey.

### 7.3 Menu - View Page #

This menu allows selection of Test Summary page or partial test result pages as described in the following sub-sections.



Default page selection is "Test Summary".

Test Date and Time are shown at the bottom as well as Video File Name (full path). This information is always presented on all VQMA pages.

Choice of selected page is persistent, same page will be shown after analysis of any new file, until the selection by user of some other page.

It is possible, *though it does not make analysis process faster*, to pre-select any desired page before opening .yuv file, e.g. page # 7 "YUV/RGB Scope". In this case, VQMA opens the selected .yuv file and then goes straight to the selected page display, skipping summary page.

### 7.3.1 Viewing Test Result Pages

VQMA produces several result presentation pages which are displayed one at a time, each page containing detailed report about the particular type of video distortions:

- Test Summary table  
*shows all results, plus partial and global "Pass/Fail" flags*
- Geometry, Focus, Shading  
*also contains auto-positioning markers display*
- Levels, Gamma and RGB Balance  
*shows YRGB Levels Plot on Grayscale, Black and White levels, and more*
- Frequency Response  
*shows YUV multi-burst waveform and Frequency Response Plot*
- K-rating, UV vs Y Gain  
*also contains 2T/20T pulse YUV waveforms display*
- Noise Measurement  
*shows weighted and unweighted SNR for Y, UV and RGB channels ,  
Noise Spectrum Display, Noise Histogram Display and Noise Pattern Display*
- YUV/RGB Scope  
*shows waveforms and levels for YUV and RGB channels, full frame or selected TV line*

User can select any page from "View" menu. At the first run of VQMA3.EXE the "Summary" page is selected; it also can be selected by user at any time later.

At any time moment only one of these pages is displayed. If the user selects another video file, VQMA stays on the previously opened page, allowing fast performance comparison of different devices or even complete systems, e.g. made by different manufacturers.

This feature is also useful for adjustment or comparison of different configurations or modes, e.g. comparing the device performance via HDMI input vs. YPbPr input.

For example, user may open file "Device\_1.YUV", select "Noise Measurement" page, review it, then open another video file, e.g. "Device\_2.YUV".

In this case VQMA stays on "Noise Measurement" page, thus allowing quick (nearly instantaneous) visual comparison of interference levels and noise performances of two capture devices.

All YUV waveform diagrams are shown superimposed over the standard levels vs pixels grid.

Horizontal co-ordinate: Y pixel count from 0 to 1919. In case of 1280x720 frame resolution the display grid still shows 1080 pixels, but signal waveform occupies only central portion of the grid.

On the left side Y level scale is shown in % as well as Reference Black (16d) and Reference White (235d) levels - designated by green dotted lines.

Bipolar UV level scale (in %) is shown on the right side of the grid. There are three UV reference levels: 0% = 128d, nominal minimum -50% = 16d and nominal maximum +50% = 240d. Brown dotted line of the grid designates UV nominal levels.

Important Note: If VQMA-C Test Chart is not detected, e.g. because some other test pattern is used or camera captures VQMA-C chart significantly distorted, then all pages, except Noise Measurement and Scope, will display only *warning message* as shown below:

Frame Size: 1920x1080

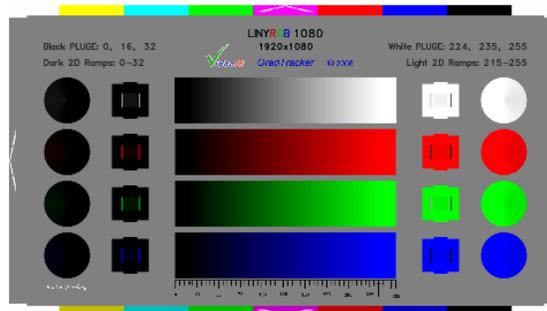
### 1. Test Summary

Valid VQMA Test Pattern Not Detected

Scope and Noise Measurement are still available

To enable VQMA Analyzer re-check:

1. VQMA Reflectance Chart or VQMA Test Pattern is used
2. Correct light level and uniform lighting of the chart
3. Correct chart center position (+/-10%) and tilt (< 2 degrees)
4. Camera zoom (50% -100%) and focus are set properly



### 7.3.2 Test Summary page

The table shows the results of all partial tests, whilst the most important "global" result is displayed in the upper right corner. This is shown as one word, which can be either "Passed" in green or "Failed" in red; it is produced by logical AND function of partial test result flags of the table.

Leftmost column contains the partial test name (name of the measured parameter). Independent on the type of the video data (Test Pattern or Optical Chart) Gamma value is called **Luminance Gamma** with assumed nominal **Display Gamma** value of **2.2**.

Next two columns shows measured value of the particular parameter and unit of measurement.

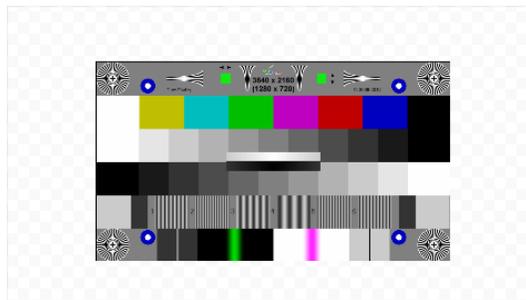
The "Target" column shows actual test tolerance values read from .INI file.

The rightmost column of the table shows partial test results. These are displayed as green ticks, if partial test passed, or red crosses, if partial test failed.

Frame Size: 3840 x 2160, Chart: 1280 x 720 1. Test Summary VQMA Test Result: PASSED

Parameter	Measurement	Unit	Target	Pass
Black Level	0.0 %, (16.0)	%, (0.0-255.0)	-5.0 -- +5.0 %	✓
White Level	100.0 %, (235.0)	%, (0.0-255.0)	95.0 -- 105.0 %	✓
Unfiltered Y SNR	100.0	dB	> 40 dB	✓
K Rating on 2T Pulse	0.0	%	< 3.0 %	✓
UV vs. Y Gain	-0.0	dB	-1.0 -- +1.0 dB	✓
Luminance Gamma	2.2		1.8 -- 2.5	✓
RGB Balance Error	0.0	%	< 10 %	✓
Y Range Black Overload	0.0	%	< 15 %	✓
Y Range White Overload	0.0	%	< 15 %	✓
Frequency Response @F1 = 301 tvl	0.0	dB	-1.0 -- +0.5 dB	✓
Frequency Response @F2 = 600 tvl	-0.0	dB	-2.0 -- +1.0 dB	✓
Frequency Response @F3 = 900 tvl	0.0	dB	-3.0 -- +1.0 dB	✓
Frequency Response @F4 = 1199 tvl	0.0	dB	-4.0 -- +1.0 dB	✓
Frequency Response @F5 = 1499 tvl	-0.1	dB	-5.0 -- +1.0 dB	✓
Frequency Response @F6 = 1798 tvl	-0.3	dB	-6.0 -- +1.0 dB	✓

Automatically selected YRGB Nominal Range: 16-235 VQMA Test Pattern detected



At the bottom of the Summary Table there are two important statements in Brown:

Statement on the left is about the Nominal YRGB Range (Nominal Black and Nominal White values) used to calculate the corresponding percentage values in the Summary Table. This range selection can be Automatic or Manual - as set in the "File" menu.

Statement on the right is about the *automatically detected* test type - Optical Test Chart or Test Pattern.

Picture at the bottom of this page shows *first TV frame*, extracted from the captured video clip under test. It represents the content of opened file in x0.25 reduced scale and serves only for general image identification. **It should not be used for any quality assessment.**

The resolution of opened *frame* and calculated sizes of *chart* within it (which could be equal, smaller or even slightly bigger - if zoomed-up) are displayed in the upper left corner.

Frame Size: 1920x1080 Chart~ 1896 x 1001 **1. Test Summary** VQMA Test Result: **FAILED**

Parameter	Measurement	Unit	Target	Pass
Black Level	2.5 %, (21.5)	%, (0.0-255.0)	-5.0 -- +7.5 %	✓
White Level	82.2 %, (196.1)	%, (0.0-255.0)	90.0 -- 105.0 %	✗
Unfiltered Y SNR	37.8	dB	> 40 dB	✗
K Rating on 2T Pulse	1.7	%	< 3.0 %	✓
UV vs. Y Gain	-3.7	dB	-6.0 -- +1.0 dB	✓

Values after "Chart:" are VQMA chart sizes automatically measured by VQMA3. They may slightly differ (+/-2 pixels) from the exact frame size even in absence of any scaling (scale = 100%). These approximate values serve mainly for indication of zoom (scaling) settings of cameras and signal processors.

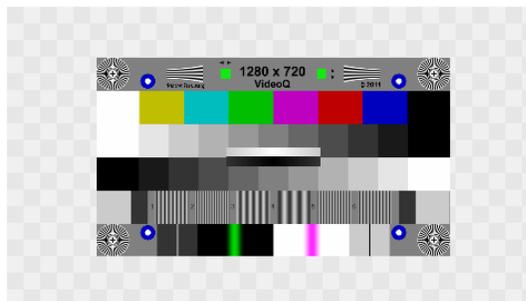
If opened file is of smaller resolution, then it is displayed as centered insert within 1920x1080 checkerboard background picture shown on next diagram:

Frame Size: 1280 x 720 , Chart: 1280 x 720 **1. Test Summary** VQMA Test Result: **PASSED**

Parameter	Measurement	Unit	Target	Pass
Black Level	0.0 %, (16.0)	%, (0.0-255.0)	-5.0 -- +5.0 %	✓
White Level	100.0 %, (235.0)	%, (0.0-255.0)	95.0 -- 105.0 %	✓
Unfiltered Y SNR	100.0	dB	> 40 dB	✓
K Rating on 2T Pulse	0.0	%	< 3.0 %	✓
UV vs. Y Gain	-0.0	dB	-1.0 -- +1.0 dB	✓
Luminance Gamma	2.2		1.8 -- 2.5	✓
RGB Balance Error	0.0	%	< 10 %	✓
Y Range Black Overload	0.0	%	< 15 %	✓
Y Range White Overload	0.0	%	< 15 %	✓
Frequency Response @F1 = 100 tvl	0.0	dB	-1.0 -- +0.5 dB	✓
Frequency Response @F2 = 200 tvl	-0.0	dB	-2.0 -- +1.0 dB	✓
Frequency Response @F3 = 300 tvl	0.0	dB	-3.0 -- +1.0 dB	✓
Frequency Response @F4 = 400 tvl	0.0	dB	-4.0 -- +1.0 dB	✓
Frequency Response @F5 = 500 tvl	-0.1	dB	-5.0 -- +1.0 dB	✓
Frequency Response @F6 = 600 tvl	-0.3	dB	-6.0 -- +1.0 dB	✓

Automatically selected YRGB Nominal Range: 16-235

VQMA Test Pattern detected



Note that Frequency Bursts on the chart are labeled simply "1", "2", ..., "6". In the Summary Table corresponding *spatial frequencies* are marked as "F1" ... "F6". Actual values of these frequencies depend on the test conditions, i.e. frame size and chart size within the frame. For every burst VQMA calculates and displays burst spatial frequency expressed in **tvl** and burst relative level expressed in **dB**. If the frequency exceeds theoretical limit of half pixel rate, then "Frequency Response" words are replaced by "Aliasing Level". For more details - see "Frequency Response Page" section.

### 7.3.3 Geometry, Focus, Shading page

This page displays measured values of major chart geometry parameters as well as parameters related to camera focus and the uniformity of chart illumination.

At the top of the page are messages displaying average Contrast and Focus values based on analysis of 4 corner Radial Plates. High enough values of these parameters are the critical conditions for accurate measurements of other parameters, such as Frequency Response, K-Rating, etc.

Geometry parameters include H & V **Scale** (Zoom), Chart **Position** (H & V **Offsets**), **Tilt** and **Keystone** Distortions.

These values are based on detecting and locating blue-white circular markers in 4 corners of the VQMA-C chart. For purely electronic devices, such as video scalars, only scale and position results are important - Tilt and Keystone values are typically zeroes..

**Contrast** and **Shading** are the parameters related to the uniformity of chart lighting.

Contrast calculation is based on statistics of differences between White and Black levels of all 4 corners. Thus, if some chart corner is affected by glare (pushing Black Level up) or lack of illumination. (reducing White Level), then the overall (average) contrast value will go down.

Shading is calculated as *maximum* non-uniformity of two corresponding sides of the chart. So, if only left chart side is illuminated non-evenly from top to bottom or camera lens "vignetting" is significantly strong, then the displayed Vertical Shading value will go up. Similarly, Horizontal Shading value will go up if only top or only bottom side of the chart shows non-consistent Black and White Levels.

Frame Size: 1920 x 1080, Chart: 875 x 492 Frame Aspect Ratio: 1.778, Chart Aspect Ratio: 1.778

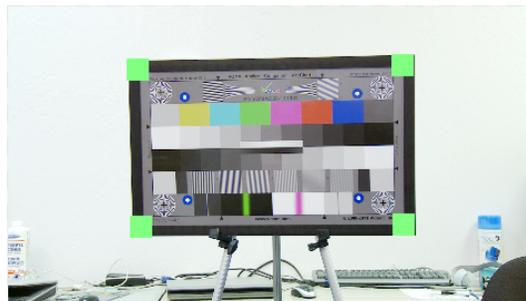
#### 2. Geometry, Focus, Shading

Avrg. Corner Contrast: 83 %  
 Avrg. Corner Focus: 70 %  
 Test Chart Tilt: -1.1 °

	Horizontal	Vertical
Chart to Frame Ratio:	46 %	46 %
Position Offset:	-0.5 %	-2.7 %
Keystone Distortions:	-2.4 %	1.0 %
Black Level Shading:	10.6 %	10.6 %
White Level Shading:	5.2 %	4.5 %

Test Conditions Validated

Contrast 89 %  
Focus 71 %



66 % Contrast  
73 % Focus

Contrast 89 %  
Focus 65 %

87 % Contrast  
68 % Focus

VQMA Chart Detected

VQMA, version 3.1.6 - Wed Jun 26 17:30:52 2013

Green squares mark actual measured positions of the chart edges. They may exactly touch the frame corners, if scale is exactly 100%, inside the frame, if scale is less than 100%, or slightly outside, e.g. for scale = 105%.

If no valid chart is presented, or chart levels and/or geometry parameters are seriously offset, then these square are shown in red and measurement results display is replaced by warning message. Central message "Test Condition Validated" (in green) serves as additional confirmation that chart parameters are good enough for automated analysis.

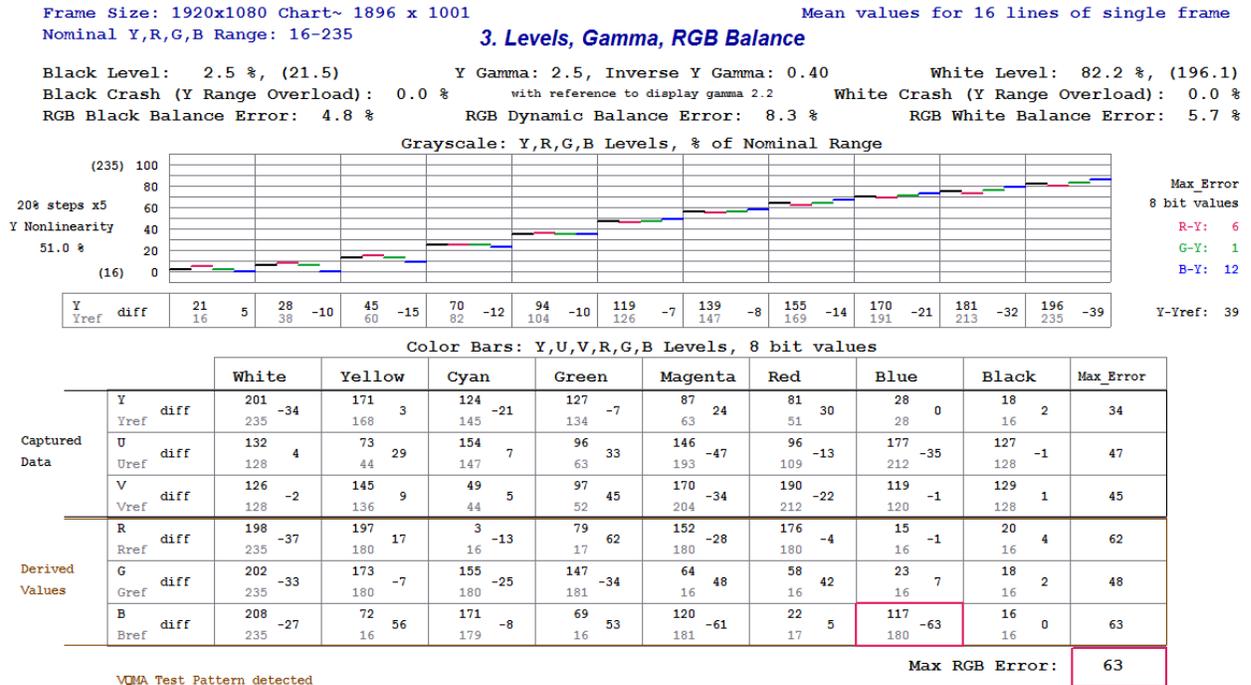
This page also displays **Focus** (Sharpness) estimates separately for 4 corners. It is presented as a percentage of fine details energy with reference to the original (perfect) chart.

Thus, 100% Focus means that measured chart contains in all 4 corners the **same** amount of fine details as electronic original.

Focus value of 150% means **excessive** aperture correction, and 50% Focus value means **lack** of fine details energy, i.e. blurred picture.

### 7.3.4 Levels, Gamma, RGB Balance page

This page displays most important parameters, related to YUV and RGB levels and measured using the best available noise-reducing filter. Grayscale parameters are averaged on two Bands (Band 2 and Band 3). Color Bar parameters are measured on Band 1.



**Black Level** and **White Level** are presented in % of the selected nominal YRGB range and also in D1 8 bit levels.

**Luminance Gamma** is calculated by best fitting method on 9 of 11 staircase porches; two lowest porches are ignored to minimize noise and glare related effects.

Independent on the type of the video data (Test Pattern or Optical Chart) this value is called **Y Gamma** with assumed nominal **Display Gamma** value of **2 .2**.

For user convenience **Inverse Y Gamma (Camera Gamma)** with assumed nominal value of **0.45** is also calculated and displayed. Note that only Luminance Gamma is presented on VQMA Summary Page and in VQMA Short Report file - Inverse Gamma is not shown there.

**RGB Dynamic Balance Error** is a **maximum** of R-G, B-G and R-B magnitudes of all 11 staircase porches. **Black Balance Error** and **White Balance Error** are calculated similarly, but only the lowest (Black) and the highest (White) porches are used.

**Black Crash** and **White Crash (Y Range Overload)** are measured by finding the clipping level of shallow ramps in the central area of the VQMA Test Pattern. The shape of shallow ramp waveforms can be seen on "YUV/RGB Scope" page by selecting "Near Black" or "Near White".

**Grayscale YRGB Levels Plot** displays side-by-side averaged Y, R, G, and B levels of all 11 Grayscale porches expressed in percents of nominal range - from Black on the left to the White on the right. Plotted Y, R, G and B values depend on the selection (manual or automatic) of Nominal YRGB Range.

The **Grayscale Y Levels Table** under the plot shows measured values (in Black), reference values (in Gray) and errors, i.e. differences between them.

On the right there is a display of maximum Y channel error vs. ideal Yref values and RGB errors relative to Y channel, i.e. maximum magnitudes of R-Y, G-Y, and B-Y for all 11 porches. These errors should not be confused with Dynamic Balance Error.

On the left side next to grayscale plot the **Y Nonlinearity** value is shown. It is calculated on 5 even-numbered staircase porches as a ratio  $(\text{Max\_Ystep} - \text{Min\_Ystep})/\text{Max\_Ystep}$  and presented in percents.

The bottom half of the page is occupied by **Color Bars Table**. It contains YUV and RGB levels of VQMA-C test pattern measured on Band #1.

The Table also shows (in Gray) the reference values of 100/0/75/0 Color Bars corresponding to the selected Nominal Range (16-235 or 0-255). The right half of each cell shows calculated Color Bar Errors, i.e. differences between measured and reference values.

Maximal Errors of each row are shown in the rightmost column, and **Maximal RGB Error** of the whole Table is displayed at the bottom right corner.

Maximal RGB Error is highlighted by green or red frame. If the error is **below 3 levels** of 8 bit scale then the **frame color is Green**; it means that there are only minor rounding errors.

If the Max RGB Error is **3 or more** the frame color becomes **Red** and the Table cell(s) containing maximal errors are also highlighted by Red frame(s). This allows easy finding of the most critical combinations of Bar Color and R, G or B component. In the example shown on the previous page, the worst case (Error = -63) is in the Blue channel on Blue bar.

Values within the **"Captured Data"** part of the Table are YUV or RGB data, averaged and rounded to 8 bit values without any mapping or scaling.

Values within the **"Derived Values"** part of the Table are results of application of BT.709 (HD) Color Matrix to the input data, these results are also rounded to 8 bit and compared with the corresponding 8 bit reference values.

"Captured Data" and "Derived Values" markers select top or bottom part of the Table depending on the type of input data (YUV or RGB) .

If captured data are of YUV type, e.g. read from .YUV file, then the YUV (top) rows are marked as "Captured Data" and RGB (bottom) rows of the Table are marked as "Derived Values".

But if captured data are of RGB type, e.g. coming from some RGB source connected via HDMI cable to the Unigraf capture card, then RGB (bottom) rows are marked "Captured Data" and the YUV (top) rows are marked "Derived Values".

Note that calculated Max RGB Error is exactly zero, despite small non-uniformity of RGB values.

This is because the references for "Derived Values" are not taken from pristine RGB Bars (16 and 180), but calculated from YUV Reference Values shown in the upper rows; this is a fundamental feature of YUV-to-RGB 8 bit color matrixing process. In this case RGB References correspond to the ideal player building 24 bit RGB pixels from incoming 24 bit YUV pixels.

Example below shows Color Bars Table for pristine test pattern without any errors in YUV channels.

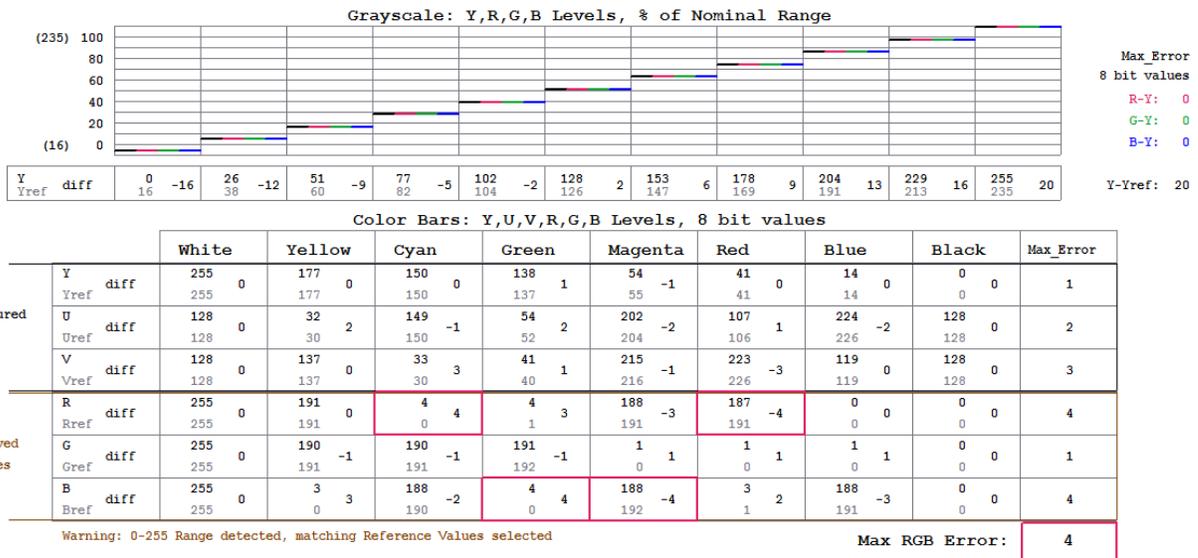
Color Bars: Y,U,V,R,G,B Levels, 8 bit values

		White	Yellow	Cyan	Green	Magenta	Red	Blue	Black	Max_Error
Captured Data	Y	235	168	145	134	63	51	28	16	0
	Yref	235	168	145	134	63	51	28	16	
	diff	0	0	0	0	0	0	0	0	
	U	128	44	147	63	193	109	212	128	
	Uref	128	44	147	63	193	109	212	128	
	diff	0	0	0	0	0	0	0	0	
Derived Values	V	128	136	44	52	204	212	120	128	0
	Vref	128	136	44	52	204	212	120	128	
	diff	0	0	0	0	0	0	0	0	
	R	235	180	16	17	180	180	16	16	
	Rref	235	180	16	17	180	180	16	16	
	diff	0	0	0	0	0	0	0	0	
Derived Values	G	235	180	180	181	16	16	16	16	0
	Gref	235	180	180	181	16	16	16	16	
	diff	0	0	0	0	0	0	0	0	
	B	235	16	179	16	181	17	180	16	
	Bref	235	16	179	16	181	17	180	16	
	diff	0	0	0	0	0	0	0	0	

Max RGB Error: 0

Note that the Color Bars Table always automatically shows appropriate Reference Values - even when the manually selected Nominal Range does not match actual measured values.

In such case, the corresponding Warning Message is displayed (in brown) at the bottom left.



This may happen only in case of manual selection conflicting with the auto-adjustment; the warning message will be never needed if Automatic Range is selected in the "File" menu.

### 7.3.5 Frequency Response page

This page shows the measured *averaged* peak-to-peak amplitudes of six frequency bursts and displays *averaged* luminance waveform of multi-burst band of VQMA matrix pattern (Band 4). Type of averaging filter is selected automatically (best available filter).

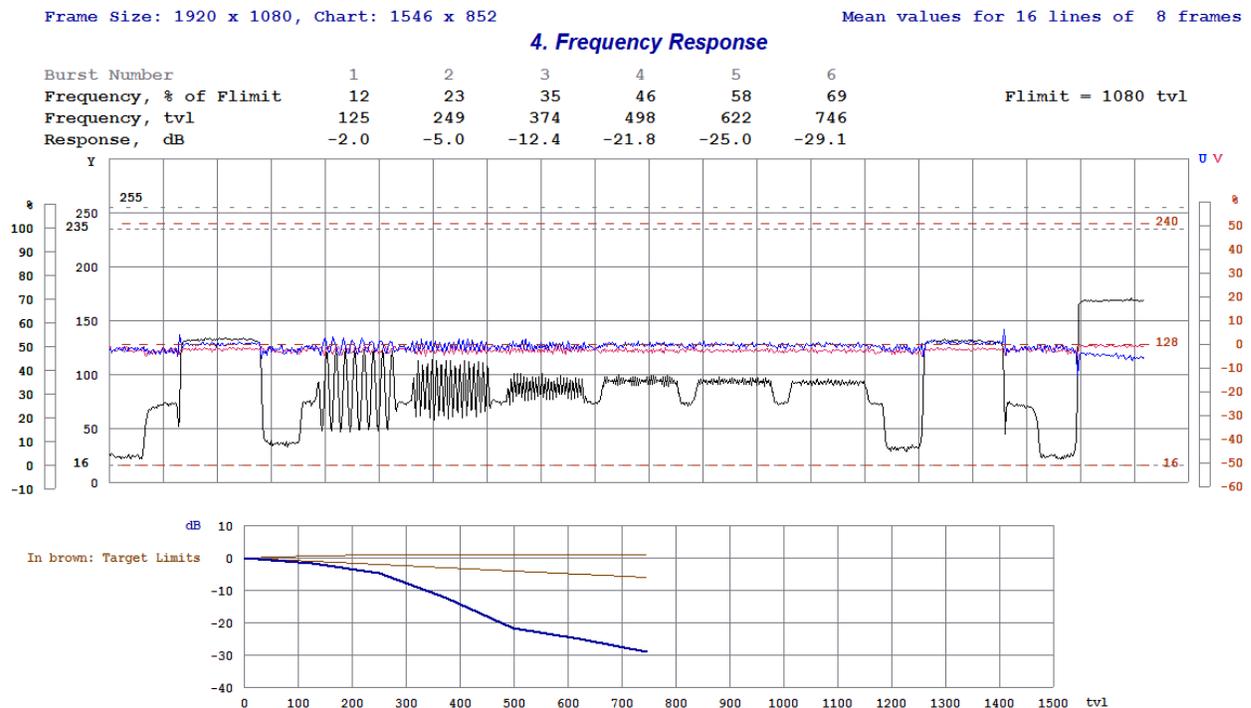
The burst amplitudes are expressed in dB with reference to nominal (undistorted) value.

This band of VQMA test pattern includes special reference bars with levels exactly matching the *nominal* burst amplitude. The measurement algorithm check these bars first, and automatically compensate for any non-standard Black Level and White Level conditions, including Levels Tilt. In other words, VQMA frequency response measurement is always accurate and correct, independent of any lighting, setup or gain errors in Y channel.

Note that spatial frequency value expressed in tvl *does not change* if VQMA Test Pattern is *rendered* in *different resolutions*. For example 400 tvl of burst #4 means that 200 periods occupies full height of 16:9 video frame - *independent* of actual number of pixels per period or V size of the frame: 1080, 720 or 480. On the other hand, any change in the *relative H size* of the test chart *within video frame*, e.g. due to camera zooming, means *change of all frequencies* (and their measured values, expressed in tvl).

Frequencies are shown above the response values in three formats: burst numbers in gray, percents of the limit frequency and actual (captured) tvl values in black.

In the example shown below they significantly differ from original values because of the camera zoom-out ( $1546/1920 = 0.805$ ).



Waveform display on this page includes U (in red) and V (in blue) components useful for visual estimation of "debayering" ("de-mosaicing") algorithm artefacts. Strength of U and V variations appearing on monochrome textures provides an estimate of the debayering filter imperfection.

Significant zooming out or scaling down the chart size, e.g. from 100% to 50%, may also produce in **Y** channel spatial frequencies much higher than original burst frequencies.

Positive side of this transformation is that it allows measurement of Frequency Response in much wider range. For example, 4K camera response can be measured up to 3000 tvl.

Small number of pixels per texture period may also lead to well-known "aliasing" effect. The boundary (limit) frequency of this effect is equal to half of sampling frequency, i.e. it is directly proportional to video frame size in pixels.

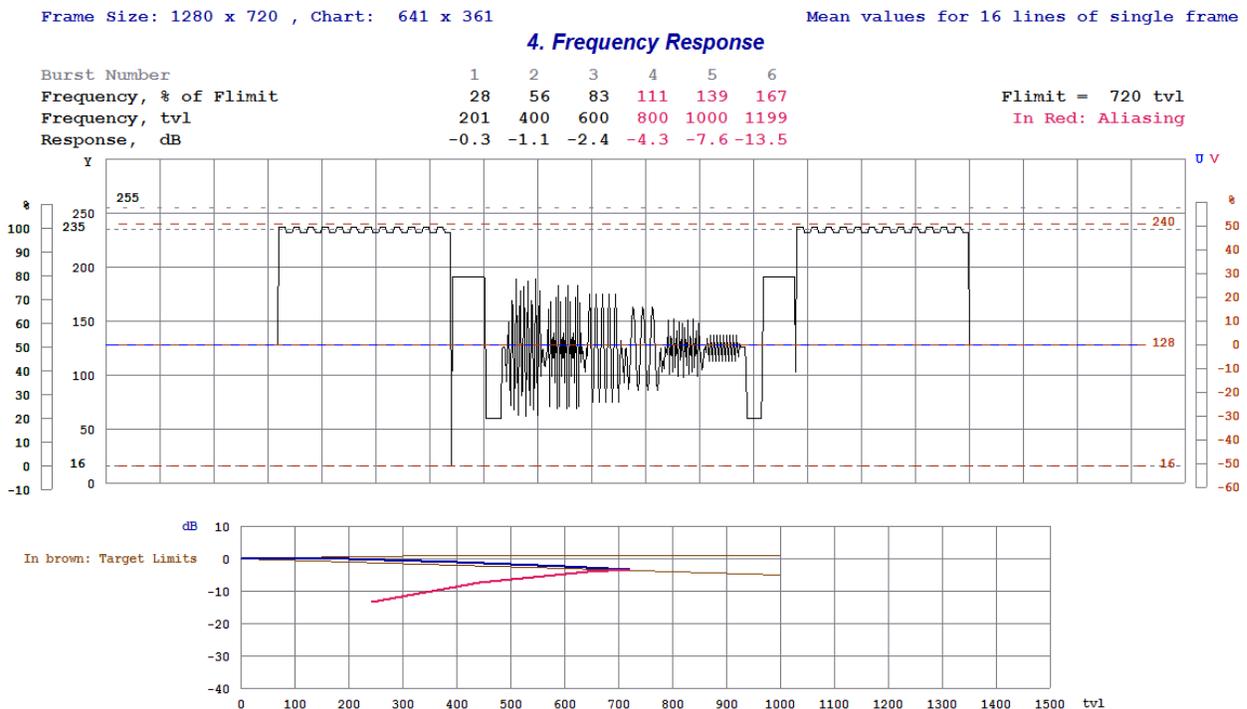
VQMA analyzer automatically calculates this limit and highlights the *aliased frequencies*. Frequencies exceeding the sampling limit are labeled "Aliasing" and shown in red.

Example below shows significant aliasing levels: from -4.3 dB to -13.5 dB for bursts 4, 5 and 6.

In this example 640x360 chart is a product of *down-conversion* from 3840x2160 original to "post-stamp" 640x360 image within 1280x720 frame. This process created relatively high spatial frequencies of 800...1200 tvl - much higher than **720 tvl limit** set by **vertical frame size**.

Sophisticated scaling algorithm could suppress aliasing components much better, but in this example scaling algorithm was quite simple.

The Frequency Response curve is always plotted using actual (captured) frequency values as horizontal positions on the tvl axis. Target limits are re-mapped together with the corresponding frequencies. Aliased frequencies are "mirrored" around the limit frequency and plotted with red pen.



The list of burst frequencies tested by VQMA is rather short; 6 frequencies represent only few points on the frequency response plot. However, in typical test conditions frequency response plot shape is smooth. Thus, VQMA values, measured on few frequency bursts, adequately represent typical frequency response plot in total.

### 7.3.6 K-rating, UV vs Y Gain page

This page displays the measurements results for two key parameters related to the 5th band of VQMA-C matrix test pattern:

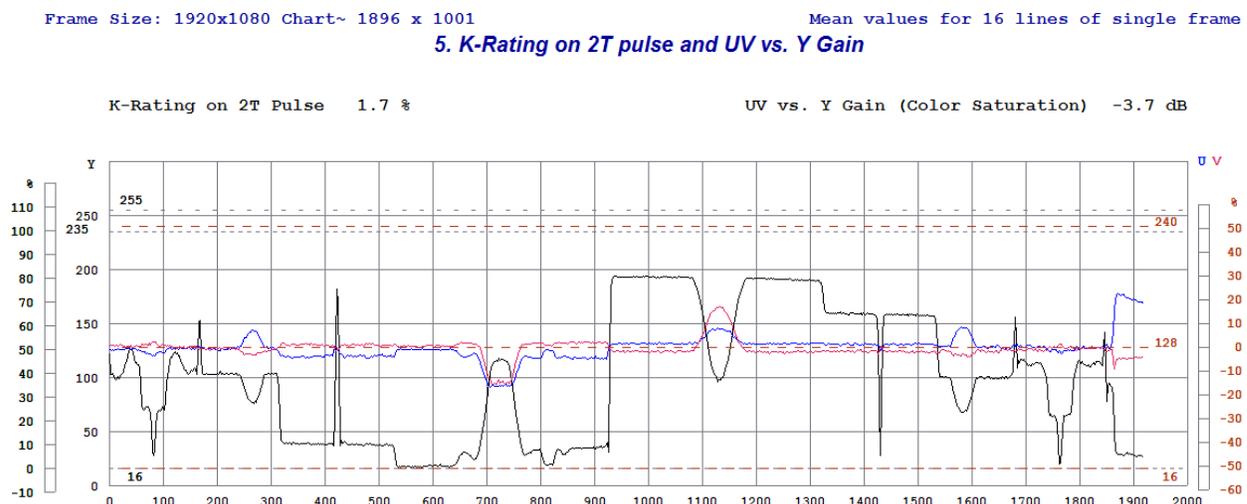
1. **K-rating**, in %, measured on 2T pulse (white needle pulse)
2. **UV vs. Y Gain**, in dB, measured on 20T composite pulse (soft green pulse)

It also shows the overlay of *averaged* waveforms of Y , U and V signals in the band #5.

**K-rating** is a common quality metric using a 2T pulse along with a luminance bar as a reference value. The measurement procedure includes calculation of several partial K-ratings, such as the ratio of the maximum pulse voltage versus the luminance bar voltage, relative 2T pulse width and weighted under-shoots and overshoots levels. Displayed is the overall (worst case) K-rating, which is the maximum of all these partial measurements.

Black (inverted) needle pulse is also present in this band, but its distortions are not included in the K-rating calculation. However, this particular test signal component is useful for estimation of non-linear distortions. If its shape correlates well with the shape of its counterpart of opposite polarity (white needle pulse), then the distortions are rather linear. In case of strong non-linearity, caused, for example, by protective black or white level limiter, the overshoots of two needle pulses will look quite different.

**UV vs. Y Gain** (Color Saturation) is calculated as the relative activity of combined U and V signals (chrominance) of 20T pulse with reference to the activity of Y signal (luminance). Display of Y (in black) U (in blue) and V (in red) components of 20T composite pulses of two opposite polarities (soft green and soft magenta pulses) allows to distinguish between linear and non-linear causes of UV vs. Y gain errors.



### 7.3.7 Noise Measurement page

The most important noise parameter is **RMS** noise level of **Y** channel displayed in the upper left corner of the page using three types of units:

- **% of Nominal White**
- **D1 8 bit levels** (in brackets)
- **Equivalent mV** of analog Y signal (also in brackets)

Other important noise parameter present on this display are:

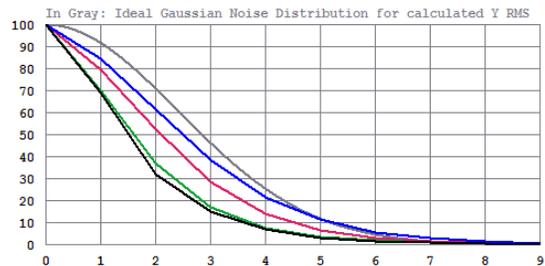
- **Y channel SNR**, calculated in three variants: **unfiltered**, **band-limited** and **weighted**.
  - a) *Y channel low-pass filter bandwidth is set to 80% of the maximal frequency (Flimit = sampling limit), e.g. in 1080i format with 74.25 MHz sampling rate, LPF bandwidth is  $0.8 * 74.25 / 2 = 30$  MHz.*
  - Weighting filter response is also auto-scaled inversely proportional to the frame resolution.*
  - b) *The Y RMS value is derived directly from video data, so it correlates with **unfiltered** Y SNR.*
- **UV SNR**, derived from band-limited unweighted sum of scaled U noise and V noise
- **R, G, B** and "**Dark B**" SNR values, derived from Y and UV SNRs

Note that all SNR values are calculated wrt **nominal** signal range, i.e. assuming video gain = 0 dB.

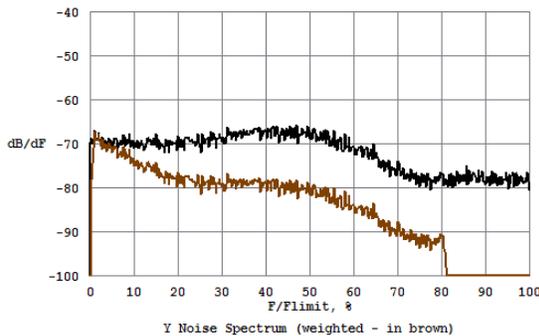
**Y Noise Spectral Density** plots in dB/dF for unlimited and weighted noise spectra allows to see the effect of device under test frequency response and also to distinguish random noise from the contributions by regular textures, e.g. from those caused by RF interference or digital clock pick-up. In the example below Y Noise Spectrum clearly shows "boost" on medium frequencies caused by strong aperture correction in camera video processor.

Frame Size: 1920 x 1080, Chart: 1900 x 1069 **6. Noise Measurement** Noise values calculated from 8 frames  
 Nominal Y,R,G,B Range: 16-235

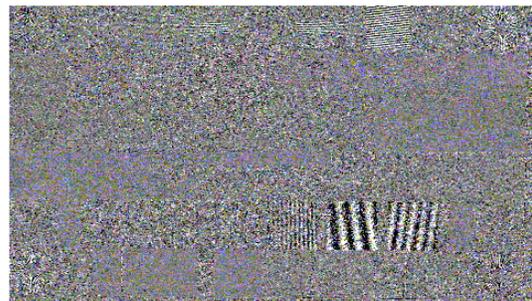
Y RMS unfiltered	1.1 % ( 2.4 8bD1, 8 mV)
Y SNR unfiltered	39.1 dB
Y SNR bandlimited	39.3 dB
Y SNR weighted	47.0 dB
UV SNR bandlimited	48.1 dB
R SNR unfiltered	36.8 dB
G SNR unfiltered	37.7 dB
B SNR unfiltered	35.8 dB
B SNR on dark areas	37.9 dB



Normalized Probabilities of Y,R,G,B Noise Magnitudes (8 bit levels)



Y Noise Spectrum (weighted - in brown)



Noise Image (contrast boosted +24 dB)

"Dark B" SNR value allows differentiate the effects of level dependent noise features. For example, some sophisticated noise reducers target specifically this blue channel noise, but only on dark image areas. The example above illustrates this effect: "Dark B" SNR is about the same as Y SNR, whilst typically (without the special treatment) it should be about 6 dB lower.

The **Noise Image** picture at the bottom right corner of the page shows *boosted* (x16 gain = +24 dB) noise pattern on grey background. It allows visualization of various noise features related to edge enhancement and non-linear noise reduction. This image also helps to differentiate true random noise from other unwanted (but more or less periodic) signals.

In the example shown noise contrast on fine test pattern details, such as frequency bursts and resolution wedges, is noticeably higher than on flat areas. This indicates strong "crispening", i.e. fine details enhancement combined with low levels noise coring.

**Histogram** display in the upper right corner allows differentiation between Gaussian (truly random, i.e. unprocessed) noise from "cored" noise signal produced by noise reducers.

If Y (and G) histogram plots are close to ideal Gaussian curve (shown in gray), then the effect of noise reduction is rather small.

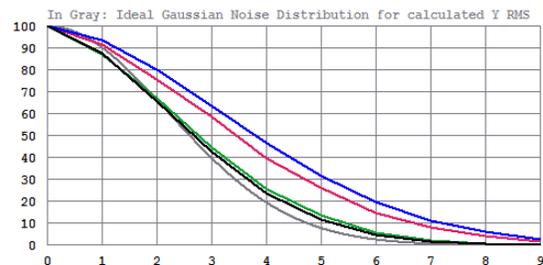
In the example shown above the difference between two curves is very large, which indicates the application of very deep noise reduction boosting the relative probabilities of low noise magnitudes vs. high magnitudes.

In case of BMP or single frame YUV input the analyzed area size is reduced - only the central part of the image is involved in noise calculations - as shown on the following picture.

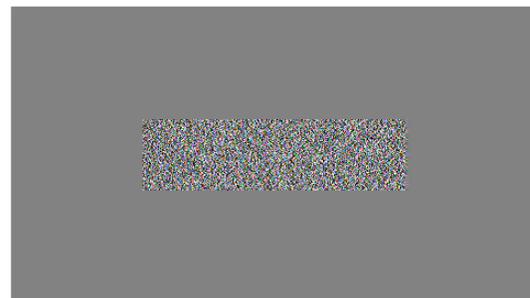
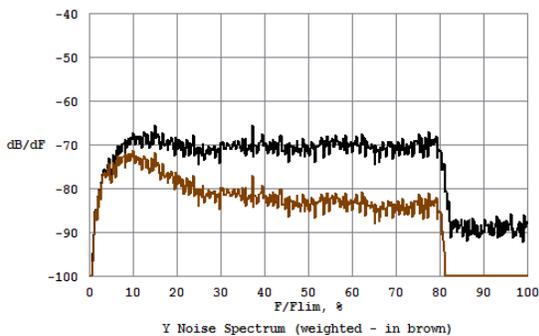
Frame Size: 960 x 540  
Nominal Y,R,G,B Range: 16-235

**6. Noise Measurement** Noise values calculated from single frame

Y RMS unfiltered	1.0 % ( 2.2 8bD1, 7 mV)
Y SNR unfiltered	39.9 dB
Y SNR bandlimited	39.9 dB
Y SNR weighted	48.8 dB
UV SNR bandlimited	46.0 dB
R SNR unfiltered	37.9 dB
G SNR unfiltered	39.7 dB
B SNR unfiltered	37.2 dB
B SNR on dark areas	33.3 dB



Normalized Probabilities of Y,R,G,B Noise Magnitudes (8 bit levels)



Noise Image (contrast boosted +24 dB)

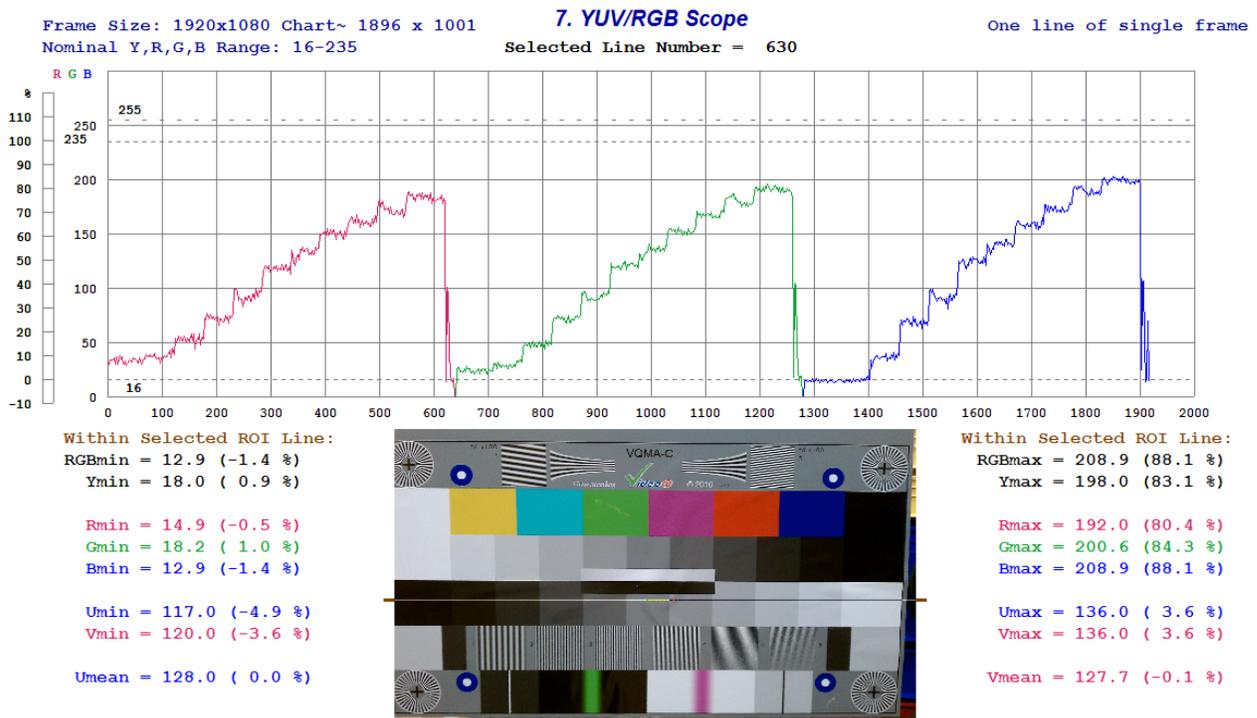
### 7.3.8 YUV/RGB Scope page

This page displays YUV *or* RGB waveforms in a variety of **modes**, selected by three separate **sub-menus**:

- **Scope View** allowing selection of Y, U, V, R, G, B and YUV, UV or RGB combinations
- **Scope Line** allowing selection of display time-base (frame or line) and overlay modes
- **Scope Averaging Filter** allowing selection of temporal and/or spatial noise reduction filters

The waveform displays are very useful, because they allow to estimate actual causes of the distortions.

For example, from the RGB Line Parade plot below it is clear that white balance of the camera under test is biased towards blue colors, whilst extremely low (near nominal black) values of R are in fact much higher than G and B values. Such shape of RGB waveform shows that the camera has serious problems with dynamic color balance.



There is one *special* YUV/RGB Scope display mode shown below. It is dedicated to UV **vectors display** on color bars.

On the left side UV vectors are displayed with unity gain (0 dB), and on the right side same UV vectors are boosted x2 (+ 6 dB) gain.

U and V vector signals are derived from the color bars band of VQMA-C matrix test pattern or any other source of color bars can be used.

U (CR) and V (CB) levels on this display are in % of full UV scale.

Seven target zones (green squares on the left, brown squares on the right) are sized to represent 5% (+/-2.5%) of nominal UV range.

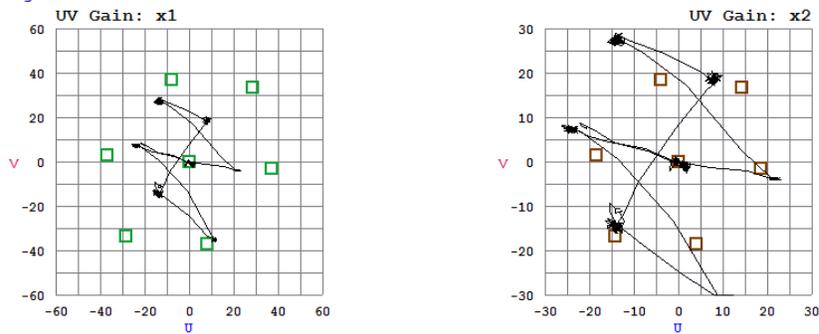
Central points of these squares represents reference 75% Color Bars (left side) and 37.5% Color Bars (right side).

75% Color Bars target boxes are more suitable for testing signal processors, whilst 37.5% targets are more suitable for testing cameras.

Frame Size: 1920x1080 Chart~ 1896 x 1001  
 Nominal Y,R,G,B Range: 16-235  
 Selected Line Number = 302

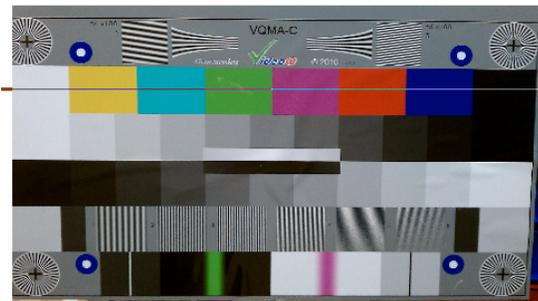
7. YUV/RGB Scope

One line of single frame



UV Vectors in % of full range. Target Boxes = Color Bars: 75% (in Green) and 37.5% (in Brown)

Within Selected ROI Line:  
 RGBmin = 0.4 (-7.1 %)  
 Ymin = 16.0 ( 0.0 %)  
 Rmin = 0.4 (-7.1 %)  
 Gmin = 16.0 ( 0.0 %)  
 Bmin = 13.4 (-1.2 %)  
 Umin = 69.0 (-26.3 %)  
 Vmin = 47.0 (-36.2 %)  
 Umean = 124.8 (-1.4 %)

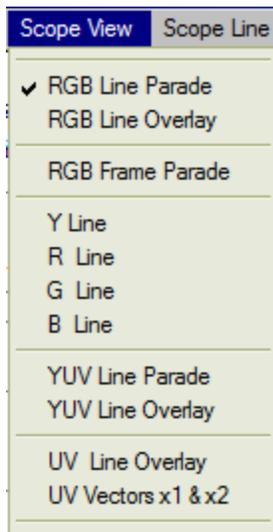


Within Selected ROI Line:  
 RGBmax = 214.9 (90.8 %)  
 Ymax = 205.0 (86.3 %)  
 Rmax = 204.5 (86.1 %)  
 Gmax = 206.2 (86.8 %)  
 Bmax = 214.9 (90.8 %)  
 Umax = 180.0 (23.2 %)  
 Vmax = 193.0 (29.0 %)  
 Vmean = 127.9 (-0.1 %)

### 7.3.8.1 Scope View menu

"Scope View" menu allows selection of desirable signal component (or combination of components) for waveform display.

Default mode is "RGB Line Parade"



The Y, R, G and B "Line" modes are quite simple and display only one selected component of the selected TV line.

There are six modes in which the components are combined:

- RGB Line Parade and YUV Line Parade
- RGB Line Overlay, UV Line Overlay and YUV Line Overlay
- RGB Frame Parade

The difference between Line Parades and Line Overlays is in the time-base.

For Parades the waveforms are down-sampled x3, so less pixels are visible, but each component occupies separate portion of the display, so it is not obscured by other components.

For Overlays signal components are not down-sampled, thus each pixel is displayed, but they are superimposed, and maybe obscured.

The overlays are very useful for comparisons, e.g. to check the RGB balance errors.

RGB Frame Parade differs from all other modes - in this mode only **peaks** and **troughs** of each line are involved.

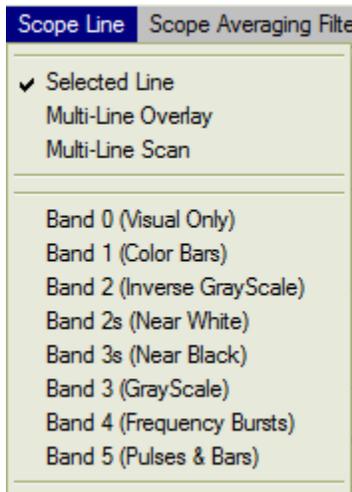
Thus, this display represents top and bottom "envelops" of R,G and B waveforms.

UV Vectors Display Mode is already explained in "YUV/RGB Scope page" section.

### 7.3.8.2 Scope Line menu

"Scope Line" menu allows selection of spatial position of selected line within the test pattern frame.

Selected Line Number is displayed above the waveform display and selected line is highlighted on the thumbnail image at the bottom.



The easiest way to select displayed line is to choose the center of desirable Band by its name or number, for example - Band #1 = Color Bars.

From this starting point the selected line can be shifted up or down via the Line Select Control Panel explained in the following section.

There are two special modes:

- Multi-Line Overlay
- Multi-line Scan

In both cases line number is automatically incremented from top to bottom, so all frame lines are displayed one after another, total duration of the scan is about two-three seconds.

The difference between these two modes is that in "Multi-Line Overlay" all displayed line waveforms are superimposed, i.e. *not cleared*.

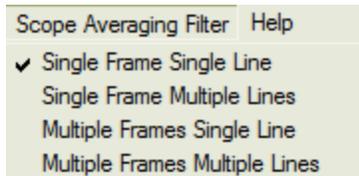
This is useful for example to visualize overall 2D lighting distribution - just by pointing camera to some flat light gray object.

On the other hand, "Multi-line Scan" allows to see all lines *separately* - also in few seconds..

**Important:** Do not interrupt the scan process *until complete finish*. To leave the scan mode click on "Selected Line". This action return the Scope to main "Line Select" mode described above.

### 7.3.8.3 Scope Averaging Filter menu

"Scope Averaging Filter" menu allows selection of spatial/temporal averaging filters used to reduce the harmful effect of noise, which affects the accuracy of measurement and waveform display.



This menu is for advanced users.

Spatio-temporal apertures are:

- a) 1x1 (No filtering, labeled "Single Frame Single Line")
- b) 1x16 (Spatial filtering only, labeled "Single Frame Multiple Lines")
- c) 8x1 (Temporal filtering only, labeled "Multiple Frames Single Line")
- d) 8x16 (Spatial and Temporal filtering, labeled "Multiple Frames Multiple Lines")

Default selection is "Single Frame Single Line"; it allows to see waveform "as is".

Maximum reduction of noise influence over the displayed waveform is achieved by selection of "Multiple Frames Multiple Lines", but this selection is available only for multi-frame inputs.

For single frame inputs significant noise reduction is achieved by selection of "Single Frame Multiple Lines".

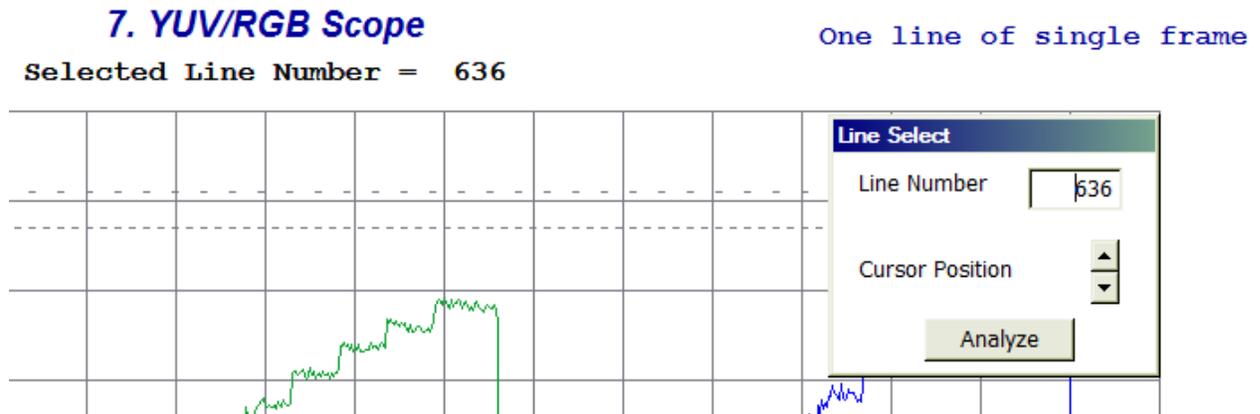
The "Multiple Frames Single Lines" option also allows significant noise reduction without sometimes undesirable involvement of adjacent TV lines.

All listed options are especially useful to compare the behavior and amount of noise, e.g. when viewing the "Staircase Display" bands.

#### 7.3.8.4 Line Select Control Panel

This small separate floating window appears only if the selected page is "YUV/RGB Scope" and can be moved to any convenient place on the screen.

The Line Select Control Panel is hidden if any other page is selected, but is visible again at the same position after the selection of YUV/RGB Scope page.



There are two controls allowing manual selection of the analyzed line number:

- **Dialog Box**, where user can directly type-in the desired line number
- **Cursor Position Arrows** moving up or down highlighted line on the thumbnail image.

Line number can be set only within the available range, defined by input frame vertical size, e.g. from 0 to 1079.

The number displayed in the dialog box automatically follows current position of the cursor. However, typing-in new line number does not change the position of the cursor until "Enter" key or "Analyze" button is pressed.

Thumbnail image is scaled down (zoom x0.25), so the **cursor position** changes only for *one pixel* when **line number** increments *by 4*.

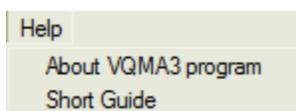
Holding the mouse on arrow of particular direction (up or down) automatically accelerates cursor movement, so going thru all 1080 lines takes only few seconds. When cursor reaches the top or bottom edge of the image line number automatically switches - e.g. if the frame size is 1280x720, then next line after #719 is line #0.

Pressing "Enter" key or "Analyze" button forces the Scope page to reprocess and re-display waveform of a selected line.

*Note that in Multi-line Overlay and Multi-line Scan modes this triggers the process of going thru all video lines again.*

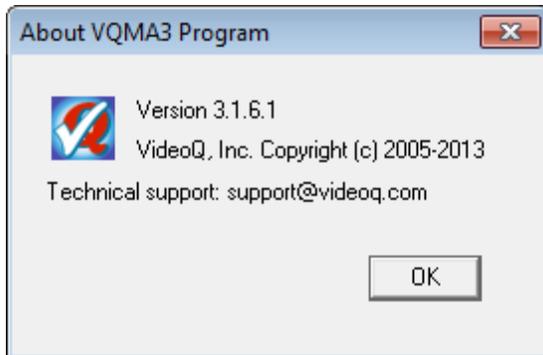
## 7.4 Menu - Help

"Help" menu contains two items:



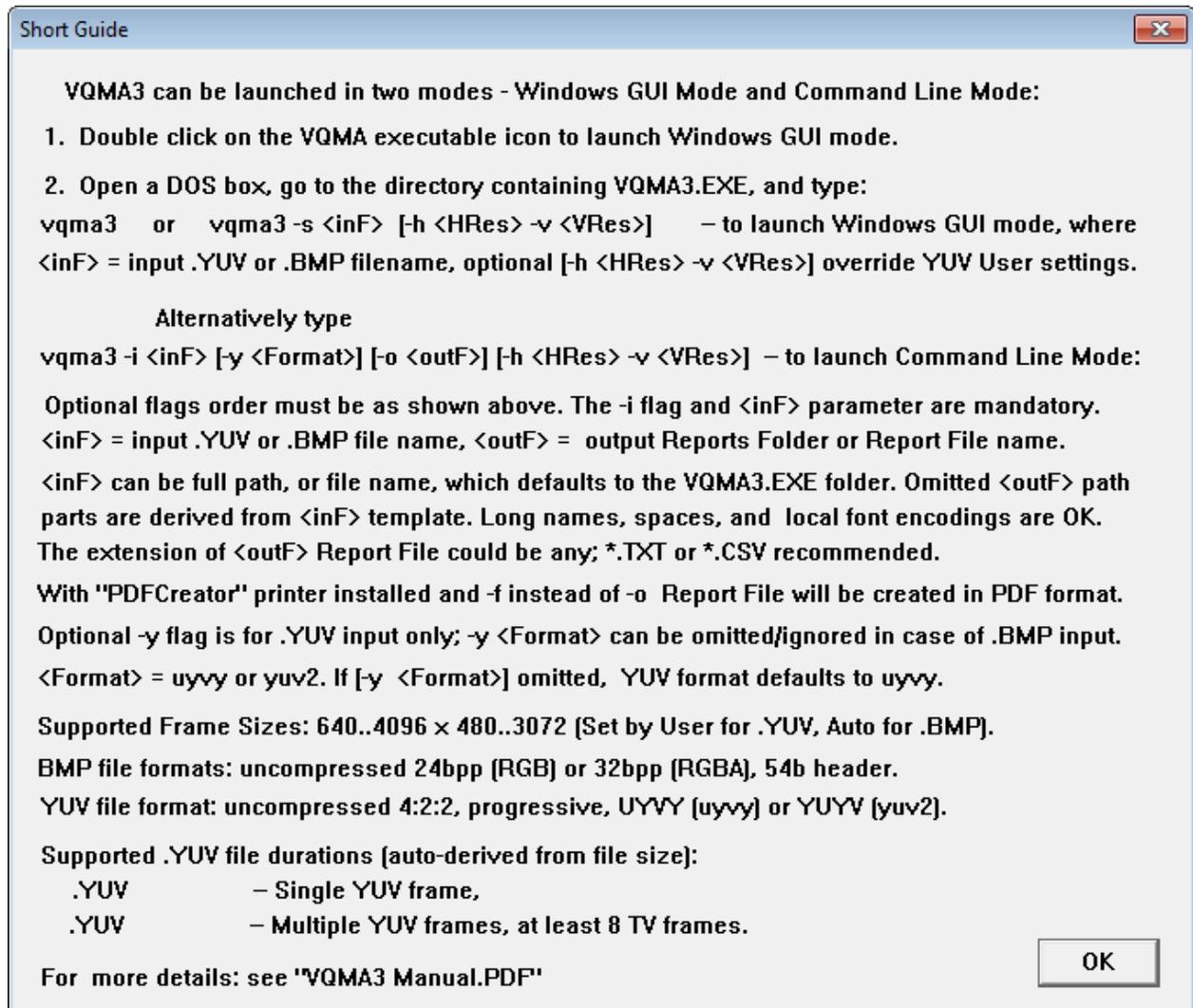
### 7.4.1 About VQMA program

This sub-menu shows program version, copyright and technical support information



## 7.4.2 Short Guide

This sub-menu produces pop-up box with short description of modes of operation and supported video file formats:



## 8 Test results presentation in Short Report

The Short Test Report can be saved from "File" menu or as <OutFile> in Command Line Mode. The results are presented in three sections:

1. VideoQ copyright and VQMA version info (commented out by semicolons), Test Session date and time, full paths to Report File and input Test File
2. Test results in form of comma separated ASCII data
3. Copy of the .INI content (commented out by semicolons)  
*this section allows to log and recall, if necessary, the actual target values used for the test*

The most important is **Section 2**.

It consists of about forty lines containing the results of partial tests, starting with the parameter code in form of reserved codeword - uppercase ASCII characters. After comma there is the measurements result, followed in some cases by another comma and **Success/Failure** codewords.

First few lines are special:

FRAMES\_ANALYZED, shows the total number of processed video frames, typically = 1 or 8.

FRAME\_WIDTH and FRAME\_HEIGHT show the detected YUV file format: e.g. 1920 x 1080.

VQMA\_CHART\_VALIDATION shows Success or Failure of Auto Detection and Validation procedure, i.e. does the YUV file contain VQMA-C chart image with the parameters, such as size, position, tilt and/or contrast suitable for automated measurements. If VQMA\_CHART\_VALIDATION shows Failure then the number of the following report lines will be reduced to just one: SNR. This is necessary because other measurements results depend on the validity of the test pattern.

CHART\_WIDTH, e.g. 1900, and CHART\_HEIGHT, e.g. 1069, are actual (measured) sizes of the test pattern *within* the YUV or BMP frame.

YRGB\_RANGE\_SELECTION shows the User selection between two possible modes: Auto or Manual.

SELECTED\_YRGB\_RANGE shows the selected (automatically or manually) range: 16-235 or 0-255.

For all parameters specified in the VQMA.INI file, the corresponding lines of Test Report also show special “Success” or “Failure” codewords.

For each such line Success/Failure flag means that the measured value is within/outside of the specified target limits. In other words Success/Failure flag shows the compliance of the system under test with the particular target value(s) set in the .INI file.

For example, *minimal* SNR value is *specified* in the VQMA.INI as 46 dB and actual *measured* SNR value is 43 dB.

In such case SNR line of the Test Report will end with the codeword "Failure".

The **global** “Success” flag is typically derived as simple logical AND function of **all partial** “Success” flags

Note that results starting with FREQUENCY\_RESPONSE\_1, FREQUENCY\_RESPONSE\_2, etc are the frequency response reading in dB for the burst of corresponding *number*.

These dB values and Success/Failure flags are calculated for *automatically scaled spatial frequencies* as described in "Frequency Response page" section.

If the scaled frequency exceeds the sampling limit defined by Frame Vertical Size, then corresponding dB values should be interpreted by the database handler as *aliasing level*. For this purpose after 6 lines of FREQUENCY RESPONSE section of the Report File there are 6 additional info lines (without Success/Failure flags). These 6 lines contain actual bursts spatial frequencies and optional ALIASED flag, followed by aliased frequency value in tvl.

For example, if Frame Vertical Resolution = 720 and F4 = 800 tvl, then aliased frequency =  $2*720-800 = 640$  tvl.

Next page contains a sample of VQMA Test Report showing test results presentation:

```
; VideoQ Inc. Copyright [c] 2005-2013
; VQMA v3.1.6.1 Test Report
TEST_DATE_TIME_YEAR, Thu Jun 27 19:40:48 2013
;
REPORT_FILE, "C:\VQMA3 Demo 2012\VQMB3840x2160dwnto1280x720_20130627_194041.CSV"
TEST_FILE, "C:\VQMA3 Demo 2012\VQMB3840x2160dwnto1280x720.bmp"
;
FRAMES_ANALYZED, 1
FRAME_WIDTH, 1280
FRAME_HEIGHT, 720
VQMA_CHART_VALIDATION, Success
CHART_WIDTH, 641
CHART_HEIGHT, 361
YRGB_RANGE_SELECTION, Auto
SELECTED_YRGB_RANGE, 16-235
;
Y_BLACK, 0.0, %, Success
Y_WHITE, 100.0, %, Success
SNR, 100.0, dB, Success
K_RATING, 2.2, %, Success
UV_Y_GAIN, -0.0, dB, Success
Y_GAMMA, 2.2, , Success
RGB_BALANCE_ERROR, 0.0, %, Success
Y_BLACK_RANGE_ERROR, 0.0, %, Success
Y_WHITE_RANGE_ERROR, 0.0, %, Success
FREQUENCY_RESPONSE_1, -0.3, dB, Success
FREQUENCY_RESPONSE_2, -1.1, dB, Success
FREQUENCY_RESPONSE_3, -2.4, dB, Success
FREQUENCY_RESPONSE_4, -4.3, dB, Failure
FREQUENCY_RESPONSE_5, -7.6, dB, Failure
FREQUENCY_RESPONSE_6, -13.5, dB, Failure
;
;BURSTS_SPATIAL_FREQUENCIES_tvI:
F1, 201
F2, 400
F3, 600
F4, 800, ALIASED, 640
F5, 1000, ALIASED, 440
F6, 1199, ALIASED, 241
;
;BARS, R, G, B, 8 bit values
WHITE, 235, 235, 235
YELLOW, 180, 180, 16
CYAN, 16, 180, 179
GREEN, 17, 181, 16
MAGENTA, 180, 16, 181
RED, 180, 16, 17
BLUE, 16, 16, 180
BLACK, 16, 16, 16
;
; Success-Failure flags shown above are derived
; using the following target values:
```

*Next section after the text shown above is a just a copy of VQMA3.INI values used for this Test Report.*

## 9 Customization and editing of INI Files

**VQMA3.EXE** checks the captured (input) video data, read from \*.BMP or \*.YUV file, against the tolerance values contained within the **VQMA3.INI** file, residing in the VQMA3.EXE executable folder. The .INI file *must be present* in the **program folder**, it is editable, so the users can input their customized *tolerance values* for any parameter. If the .INI file is not found in the program folder, then it is created automatically by VQMA3.EXE with the default tolerance values.

**VQMA3.INI** file name is *reserved and cannot be modified*.

The *content* of the .INI files can be edited using any text editor (e.g. Notepad). This allows application of different sets of tolerance values appropriate for the particular device under test or test conditions. Editing should be done with caution because the **list of parameters** and **units of measurement** codes *should not be modified*.

Next is a sample of target values presentation within VQMA3.INI file. It contains a simple list of target values for all parameters. For each parameter the target values are defined by three or four consecutive lines:

1. Parameter Code [in square brackets]
2. Unit Of Measurement Name
3. Lower Limit (Minimum Value)
4. Upper Limit (Maximum Value)

For example:

```
:[Y_BLACK_LEVEL_]
;Y_BLACK_LEVEL_UNIT=%
;Y_BLACK_LEVEL_MIN=-5.00
;Y_BLACK_LEVEL_MAX=5.00
```

For some parameter MIN value is not applicable, so it is omitted, for example:

```
:[RGB_BALANCE_ERROR_]
;RGB_BALANCE_ERROR_UNIT=%
;RGB_BALANCE_ERROR_MAX=10.00
```

Only **numerical values** of MIN and MAX limits can be edited. For example, RGB\_BALANCE\_ERROR\_MAX=10.00 can be changed from 10.00 (default) to 5.00.

It is recommended to store customized .INI files under the names which are different from the reserved ones, e.g. MY\_1080p30.INI. To use these customized .INI file simply rename a copy of the selected MY\_1080p30.INI file to **VQMA3.INI**, overwriting the default file.

It is also advisable to keep a backup copies of the edited .INI files, thus allowing to revert to the desired values if necessary. The process of replacement of the .INI files can be automated by usage of conventional batch files or scripts.

Example of complete .INI file (default values):

```
; VideoQ VQMA v3.1.6.1, file VQMA3.INI created Thu Jun 27 21:52:47 2013
[Y_BLACK_LEVEL_]
Y_BLACK_LEVEL_UNIT=%
Y_BLACK_LEVEL_MIN=-5.00
Y_BLACK_LEVEL_MAX=5.00
[Y_WHITE_LEVEL_]
Y_WHITE_LEVEL_UNIT=%
Y_WHITE_LEVEL_MIN=95.00
Y_WHITE_LEVEL_MAX=105.00
[Y_SNR_]
Y_SNR_UNIT=dB
Y_SNR_MIN=40.00
[K_RATING_]
K_RATING_UNIT=%
K_RATING_MAX=3.00
[UV_Y_GAIN_]
UV_Y_GAIN_UNIT=dB
UV_Y_GAIN_MIN=-1.00
UV_Y_GAIN_MAX=1.00
[Y_GAMMA_]
Y_GAMMA_UNIT=
Y_GAMMA_MIN=1.80
Y_GAMMA_MAX=2.50
[RGB_BALANCE_ERROR_]
RGB_BALANCE_ERROR_UNIT=%
RGB_BALANCE_ERROR_MAX=10.00
[Y_RANGE_BLACK_ERROR_]
Y_RANGE_BLACK_ERROR_UNIT=%
Y_RANGE_BLACK_ERROR_MAX=15.00
[Y_RANGE_WHITE_ERROR_]
Y_RANGE_WHITE_ERROR_UNIT=%
Y_RANGE_WHITE_ERROR_MAX=15.00
[FREQUENCY_RESPONSE_1_]
FREQUENCY_RESPONSE_1_UNIT=dB
FREQUENCY_RESPONSE_1_MIN=-1.00
FREQUENCY_RESPONSE_1_MAX=0.50
[FREQUENCY_RESPONSE_2_]
FREQUENCY_RESPONSE_2_UNIT=dB
FREQUENCY_RESPONSE_2_MIN=-2.00
FREQUENCY_RESPONSE_2_MAX=1.00
[FREQUENCY_RESPONSE_3_]
FREQUENCY_RESPONSE_3_UNIT=dB
FREQUENCY_RESPONSE_3_MIN=-3.00
FREQUENCY_RESPONSE_3_MAX=1.00
[FREQUENCY_RESPONSE_4_]
FREQUENCY_RESPONSE_4_UNIT=dB
FREQUENCY_RESPONSE_4_MIN=-4.00
FREQUENCY_RESPONSE_4_MAX=1.00
[FREQUENCY_RESPONSE_5_]
FREQUENCY_RESPONSE_5_UNIT=dB
FREQUENCY_RESPONSE_5_MIN=-5.00
FREQUENCY_RESPONSE_5_MAX=1.00
[FREQUENCY_RESPONSE_6_]
FREQUENCY_RESPONSE_6_UNIT=dB
FREQUENCY_RESPONSE_6_MIN=-6.00
FREQUENCY_RESPONSE_6_MAX=1.00
```

## 10 Running VQMA in Command Line Mode

VQMA.EXE can be used in DOS window under Windows in unattended (robotic) mode.

```
c:\IT>rem vqma3 test batch
c:\IT>vqma3 -i example.yuv -o example.txt -h 1920 -v 1080
```

### 10.1 Command line parameters

There are two different ways to launch VQMA - GUI Mode and Command Line Mode:

a) To launch VQMA3.EXE from Windows DOS box **in GUI Mode** use the following command line:

**VQMA3.exe** or **VQMA3.exe -s <InFileName> [-y <Format> ] [-h <HSize> -v <VSize>]**

where <InFileName> can be full absolute path, relative path, or just a file name (.YUV or .BMP), which defaults to the same directory where the VQMA executable resides. Long file and folder names with spaces and localized font encodings are supported.

For example, "VQMA3 -s \*.YUV" command line format is used by VideoQ **VQTS** series workstations for automatic transfer of captured YUV data to VQMA executable.

Optional [-h <HSize> -v <VSize>] parameters will not only override user-defined default values stored in Windows Registry, but the stored values will be updated as well.

b) To run the VQMA3.EXE **unattended within Windows DOS box** use the following command line:

**VQMA3.exe -i <InFileName> [-y <Format>] [-o <OutFileName>] [-h <HSize> -v <VSize>]**

Optional <OutFileName> can be absolute path, folder name (*without extension*) or just a file name. If the whole -o <OutFileName> component or some of its parts are omitted, they are created automatically - using <InFileName> as a template with the addition of current date and time.

For example:

<InFileName> = c:\Test\current.yuv

<OutFileName> = c:\MyTests\Report1.txt.

Short Report file will be saved exactly as specified by <OutFileName> full path.

But if <OutFileName> = MyTests (*not full path*), then it will be *interpreted* as a sub-folder name under the source file folder and special unique output file name will be created, adding date and time to the name of input file and changing its extension to the default .TXT extension.

In such case *new* MyTests folder will be *created* and Short Report will be automatically saved as

c:\Test\MyTests\current\_YYYYMMDD\_HHMMSS.txt

**Optional -y** flag and following <Format> parameter allow to switch between two alternative multiplexing formats of YUV data: UYVY and YUV2 (YUYV).

Four characters long <Format> string should be either *uyvy* or *yuv2*. If **-y** flag is not present VQMA defaults to UYVY format.

The **-i**, **-y**, **-o**, **-h** and **-v** option flags should be entered as is. Only **-i** flag is **mandatory**. All command line *flags* are in *lower case with no gap between dash and flag letter*.

The extension of <OutFileName> could be any; recommended formats are: **.txt** and **.csv**. Note that <OutFileName> *without extension* means *folder name*, not file name.

VQMA uses Windows Registry to detect the presence of **PDFCreator** printer program (supplied and installed separately under GNU license).

PDFCreator printer driver is called by special **-f** flag replacing **-o** flag in the command line. Then Test Report is created in PDF format by unattended background printing.

Rules for Report folder and Report file name designation are as in **-o** mode, but full multi-page PDF document is produced instead of TXT/CSV Short Report.

If **-f** flag is used but PDFCreator driver is not detected, then VQMA defaults to **-o** mode, resulting in TXT/CSV Short Report file creation.

Note that in some systems the total command line string length or full path string length could be restricted , e.g. not more than 256 bytes.

Also note that VQMA always uses *local* VQMA3.INI, i.e in the examples above *the target values* are taken from VQMA3.INI residing in the folder where VQMA executable resides. Same applies to optional batch file invoking VQMA with different command line parameters.

However, *another* folder containing *copy* of VQMA3.EXE executable may contain *another* VQMA3.INI file with *different* settings.

If necessary, multiple run instances, successive or variable commands can be organized using standard Windows batch files or scripts.

## 11 Terms and Abbreviations

<b>Term</b>	<b>Explanation</b>
3G-SDI	3 Gbps Serial Digital Interface (short name 3G)
CSV	Comma Separated Values (File Format)
CVBS	Color, Video, Blanking and Sync (Composite Video Signal)
DVI	Digital Visual Interface (Video interface for digital displays)
HDMI	High-Definition Multimedia Interface (also Video interface for digital displays)
NTSC	National Television Systems Committee (also a TV Standard name)
PAL	Phase Alternate Lines (TV Standard)
RMS	Root Mean Square (Value - noise strength estimate)
SDI	Serial Digital Interface (HD version known as HD-SDI)
SNR	Signal To Noise Ratio
SMPTE	Society of Motion Pictures and Television Engineers
TXT	Text (File Format, for VQMA software purposes - same as CSV)
UV	Color Difference Video Signals: U (CB) & V (CR)
Y	Luminance Video Signal
YPrPb	Analog Video Interface Format (also called YUV)
YUV	Digital Component 4:2:2 Multiplex (also a File Format)

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