A Video Quality
Test & Measurements Collection

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VideoQ, Inc.

VideoQ is a California-based company, focused on video test & measurement and video enhancement technologies, products and services.

More than 50 man-years of award-winning experience in the field of Broadcast, Consumer Electronics, Transcoding and Video Data Compression.

Critical Picture Quality Technologies for Broadcast, Consumer Electronics, Transcoding, Video Data Compression, SDTV, HDTV, Digital Cinema, Mobile TV, IPTV.
VideoQ Mission - Picture Quality Assurance

In a world of increasing video formats and resolutions and where the continued use of legacy standards such as analogue and interlace, there is a need to maintain quality through multiple de-interlacers, compression codecs, scalers etc.

It is VideoQ's mission to assist the development of quality-preserving system chains by highlighting the effects of concatenated filters of every type.

Comprehensive system analysis allows to investigate the most complicated issues, including modern multi-format, multi-resolution workflows with concatenated codecs/processors.
VideoQ = IP + Technologies

Test Patterns Generation

Unique set of tools generating extremely accurate deterministic and pseudo-random test components in YUV and RGB formats with precise sub-pixel positioning and sub-pixel motion profiles.

Video Quality Subjective Evaluation

Guides, Tutorials, Scoring & Benchmarking Procedures

Video Data Path Objective Measurements

Algorithms and Programs, including Automated Analysis Tools
Who needs VQL?

- **Video professionals:**
  
  VQL is the same as X-Ray/MRI for medical practice – complicated or hidden video processing problems become instantly visible at glance.

- **Content providers and aggregators:**
  
  Buying QC/QA products from VQL family you are buying peace of mind.

- **Technology developers:**
  
  VQL drastically reduces development and/or QA time and money – thanks to VQL days of tedious analysis became seconds.
VQL for Software and Hardware Applications

VQL Collection Families
- ScalTracker
- ZonTracker
- GradTracker
- StresTracker
- SD Digital & Analog
- Line-based Tests
- Audio Tests

Software Coders, Transcoders, Players, Analyzers

VQL Compatible Hardware Players/Generators
- 3Genie by NuMedia
- VQS & VQTS by VideoQ

Other (3rd party) players
VideoQ Approach to VQL

VideoQ approach to VQL combines “classic” and “digital” methodologies, sharing same test patterns and covering all 3 levels of video quality control:

1. Instant visual-aural Quality Estimation

2. Objective Measurements of video and audio performance

3. Fully automated (robotic) Quality Control
VQL Key Features

- VQL files are designed to be compatible with all commonly used software or hardware codecs and media players.

- Static and dynamic video test patterns are available in a variety of resolutions, interlace modes, aspect ratios and frame rates from QCIF up to 1080p60.

- All test patterns remain suitable for accurate measurements even after low bitrate coding, heavy scaling and/or cropping, e.g. after down-conversion for mobile devices.

- Full custom compressed and uncompressed test files and application-specific live video clips are available on request.
Available File Formats

Video

Default video format is .YUV, available in multiple resolutions.
List of available resolutions may vary within subsets

.YUV, Uncompressed 4:2:2 UYVY raw video – single frame for static test charts or multiple frames for dynamic test patterns

Typical custom video formats:

1. .AVI, Uncompressed or compressed (lossless or Xvid compression) 4:2:2 UYVY, progressive, with specified frame rate

2. .M2TS, .TS, 4:2:2 or 4:2:0, MPEG2 or H264/AVC compression, MPEG transport stream wrapper with specified bitrate, frame rate and interlace mode

Full Video Format and Test Patterns customization is also possible on request.
Available File Formats

Still Images

.BMP, Uncompressed RGB, 24 bit/pixel

Audio

Default audio format is:

.WAV, Uncompressed PCM, L&R Stereo, 16bits@48kHz

Typical custom audio formats:

1. .MP3, MPA1L3, Stereo, CBR, 128 kbps, 16bits@44.1 kHz
2. .WAV, LPCM, 5.1 Surround Sound
3. .AAC, 5.1 surround sound
4. .AC3, 5.1 surround sound

*Full Audio Format and Test Patterns customization is also possible on request.*
VQL Structure

1. Static Basic Tests
   Aimed at testing YUV/RGB levels and YUV/RGB frequency response

2. Static Advanced Tests
   Aimed at checking display gamma, color space conversion (matrixing) and gradations linearity

3. Visual ScalTracker Test
   Dynamic test aimed at testing cascaded scalers, aspect ratio convertors, and frame rate convertors

4. ZonTracker Test
   Multi-purpose universal dynamic test to check overall video performance thru scalers, codecs, etc.

5. Dynamic Contrast Tests
   Allows at glance assessment of luminance gradations rendition - static and dynamic, global and local

6. Color Space Explorer Test
   Visualize color space transformations - smoothly going thru all 16 millions colors in 8 bit YUV space

7. Audio Tests

8. Tests for Automatic Analyzers, 3D Video and Compression
1. Static Basic Test Patterns

Resolutions: 720x480, 720x576, 1280x720, and 1920x1080

1.1. Color Bars 100/0/100/0
1.2. Color Bars 100/0/75/0
1.3. SMPTE Bars
1.4. Grayscale, 10steps with PLUGE
1.5. Y Ramp with PLUGE
1.6. Pulses and Bars
1.7. Y Sweep
1.8. Y Multiburst Digital
1.9. Blue-Yellow Sweep
1.10. UV Sweep
1.11. UV Multiburst Digital
1.12. Valid Ramps
Static Basic Test Patterns (1)

1.1. Color Bars
100/0/100/0

1.2. Color Bars
100/0/75/0

1.3 SMPTE Bars
RGB range: 16-235
RGB range: 16-235
RGB range: 16-235
Static Basic Test Patterns (2)

1.4. Grayscale-10 with PLUGE

1.5. Y Ramp with PLUGE

1.6. Pulses and Bars

Y range: 16-235
Static Basic Test Patterns (3)

1.7. Y Sweep

Min Period: 2.5 Y pixels
(Max Frequency 0.4*FY)

1.8. Y Multiburst Digital

Periods: 2, 2.5, 4 Y pixels

1.9 Blue-Yellow Sweep

Min Period: 5 Y pixels
(Max Frequency 0.2*FY)
Static Basic Test Patterns (4)

1.10. UV Sweep

Min Period: 5 Y pixels
(Max Frequency 0.2*FY)

1.11. UV Multiburst Digital

Periods: 4, 5, 8 Y pixels

1.12. Valid Ramps

RGB range: 16-235
2. Static Advanced Tests

Resolution 1920x1080:

2.1. Split Color Bars, 4 Bands
RGB-to-YUV Matrices 709 and 601, levels schemes 16-235 and 0-255

2.2 Display Gamma Test
Visual Check Test, Gamma Range: 1 to 3.8, Y ranges: 0-50% and 0-75%

2.3 Luminance Linearity Test
Visual check of clipping & banding in three ranges: 215-255, 0-255 and 0-32

2.4 YRGB Gradations Test
Visual check of clipping & banding, separately for Y, R, G, and B
2.1. Split Color Bars 75/0/75/0, 4 Bands

Band #1: 709 to 709, 0-255
Band #2: 709 to 709, 16-235
Band #3: 709 to 601, 0-255
Band #4: 709 to 601, 16-235

RGB-to-YUV Matrices 709 & 601, levels schemes 16-235 and 0-255
Two multi-strip textured bands allow visual assessment of picture display gamma. These bands test gamma values for two corresponding critical sub-ranges of screen brightness: 0%-75% and 0%-50%.

Black and white PLUGE components and vertical luminance ramp facilitate proper display set-up prior to actual gamma assessment.
2.3. LIN – Luminance Linearity Test

- HD static pattern suitable for Luminance Levels and Linearity Accuracy assessment.
- Featuring full luminance range (0-255) ramp and shallow luminance ramps for two sub-ranges near nominal black (16) and nominal white (235) video levels
LIN - Details Of Full Range Ramp with PLUGEs
LIN - Details Of Shallow Luminance Ramps
2.4. LINYRGB – 4 Channels Gradation Test

- HD static pattern suitable for Y, R, G and B Levels and Linearity Accuracy assessment
- Featuring 4 full range (0-255) ramps, 2x4 PLUGEES and 2x4 2D (conical) shallow ramps
3. VST – Visual ScalTracker

VST – *Visual ScalTracker*: Scaling, Cropping, De-interlacing Test

480i60, 480p60,
576i50, 576p50,
720p50, 720p60,
1080p24, 1080p30, 1080i50, 1080i60, 1080p50, 1080p60

Family of HD and SD, 16:9 and 4:3 dynamic patterns suitable for visual picture quality assessment; sub-patterns revealing critical image scaling problems at glance:

- H & V Pixel Mapping
- Pixel Phase
- Centering & Cropping
- Motion Adaptive De-interlacing artifacts
- Linear and Non-Linear Aspect Ratio Conversion
- Frame Rate Conversion artifacts
- Static and Dynamic Y Sharpness and 2D Frequency Response
VST Test Pattern Composition

- Radial Plates, Y & UV
- Vertical Frequency Bursts Area
- Large 0.8"H Circle and Diamond Lines aimed at testing picture geometry
- Single white pixel Edge Markers on top of 5% Safe Area Markers (dark gray rectangles)
- 5% Safe Area Border Lines
- Moving Sprite with Radial Plate and Central Star
- ScalTracker
- Visual
- Aspect Ratio
- Crop Markers

UST720 50p
1280x720
2.35:1
4:3
14:9
5%
VST Functional Components’ Example
Tri-band Frequency Burst Patterns

Tri-band Frequency Burst Patterns consist of two groups of bursts with frequencies proportional to luma pixels rate FY: full width horizontal and full height vertical bursts bands, each consisting of maximum luminance frequency of 0.5 FY in the middle with slightly oblique bands of 0.4 FY surrounding the middle burst.

The central 0.5 FY bands are especially sensitive to any errors in pixel clock, mapping or scaling. Two other bands allow differentiation between horizontal and vertical distortions thru the whole picture area – from left picture edge to the right picture edge and from top to bottom.

Vertical and almost vertical burst lines test horizontal frequencies, whilst horizontal and almost horizontal lines test vertical frequencies.

These large bursts are also used as background for moving sprite, thus allowing “at glance” detection of adaptive de-interlacing static and dynamic artifacts.
VST Components Showing Scaling Problems

- Highly noticeable Beating Artifacts shows the slightest V scaling, e.g. 5% overscan
- Moving Sprite jerkiness reveals Frame Rate Conversion problems
- Radial Plates show Y & UV 2D Frequency Response
- Missing Edge Markers reveal side cropping
- Full Width and Full Height Tri-band Frequency Bursts allows local scaling detection
VST Frame Format Markers

2.35:1 height crop, 4:3 or 14:9 width crop

VST 720 and VST 1080 patterns are designed for measurement in 16:9 frame format, as well as in 4:3, 14:9 and 2.35:1 frame formats. Cross-shaped Frame Format Markers indicates precise area for each corresponding Aspect Ratio.

These are the most popular scale and crop modes:

- **4:3 crop is used to display 16:9 content on legacy standard definition TV sets,**
- **14:9 is a compromise (non-letterboxed) mode used in simulcast broadcasting to present 16:9 content on 4:3 and 16:9 screens,**
- **2.35:1 is used to show letterboxed “cinemascope” movies on 16:9 screens.**
4. ZT – ZonTracker

ZT – ZonTracker: Universal Multi-purpose Test

720p50, 720p60,
1080i24, 1080i30, 1080i50, 1080i60, 1080p50, 1080p60

Family of HD 16:9 dynamic patterns, featuring moving multi-colored sprite with Y and UV zone plates, suitable for visual picture quality assessment; sub-patterns revealing critical image spatial and temporal scaling problems at glance:

- Static and Dynamic Y and UV Sharpness and 2D Frequency Response
- Frame Rate Conversion artifacts
- Timeline problems
- Y and UV Motion Adaptive De-interlacing artifacts
- Y Levels Conversion artifacts (Banding)
- Black & White Clipping
- Color Space Conversion (Matrixing) errors
- H & V Cropping
- Analog and Digital Noise and Interferences
ZT Test Pattern Composition

- Tri-band White PLUGE 100% Color Bars
- Vertical & Horizontal Frequency
  Luminance Bursts, fractions of Y rate
- V Crop Markers
- Tri-band Black PLUGE
- Grayscale 0-255
- Moving Sprite with Y & UV Zone Plates,
  Noise Reducer Tests
- Y & UV Texts (BlackX & RedX)
- Timing Indicator
- H Frequency Wedge,
  Markers in equivalent H sizes
- Green-Magenta Zone Plate
- Interlace Wedge
- 0.9 H Circle
- Horizontal & Vertical Frequency
  Chrominance Bursts, fractions of Y rate
- 75% Color Bars
- Blue-Yellow Zone Plate
- H Crop Markers, in pixels

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ZT Test Pattern Components

1. **Background** – 50% Gray (126d) with black 16:9 Grid Pattern, central area allocated for Moving Sprite

2. **Moving Sprite** – Luminance / Green-Magenta Zone Plate with variable contrast wedges, triangles, luminance and chrominance letters:
   - Estimates Y and UV 2D static and dynamic frequency response
   - Circular motion, two speeds with pauses

3. **Large Circle** – 0.9 Height Diameter in the center - Geometry and smoothness of curved lines indicator

4. **Timing Indicator** – clockwise handle rotation indicates frame rate:
   - One small increment (black to white strip) equals to 1 frame
   - Green flashes indicate one second increments.

5. **Crop Markers** on vertical & horizontal edges - estimation in pixels of horizontal and vertical cropping

6. **Color Bars** – 100% and 75% saturated strips at the top and bottom - Correct color indicators

7. **Tri-band PLUGE(s)** – Black (0, 16, 31) and White (224, 235, 255) levels clipping estimation

8. **Colored Zone Plates** – Green-Magenta and Yellow-Blue - 4:2:0 detection and Y/UV discrepancies

9. **Horizontal & Vertical Frequency Luminance Bursts** - Luminance H and V frequency response

10. **Horizontal & Vertical Frequency Chrominance Bursts** - Chrominance H and V frequency response

11. **Interlace Wedge** - Interlace and vertical scaling problems indications
5. Dynamic Contrast Tests

5.1. **APL** – Average Picture Level Test: Y Levels, Black & White Clipping
1080p30

5.2. **DP** – Dynamic 2D PLUGE & APL Test: Dynamic Y Levels Consistency
1080p24

5.3. **DBL** – Dynamic Backlight Test: Local & Global Luminance Uniformity
1080p24
5.1. APL – Average Picture Level Test

- Near-Black Shallow 2D Ramp
- Near-White Shallow 2D Ramp
- Full Contrast Photo
- Variable Level (0%, 10%, 20%, ..100%) Window
- Full Range Ramp with PLUGE
5.2. DP – Dynamic PLUGE Test

Dynamic PLUGE (DP) Pattern View at Start Moment

Variable & Flashing APL Background

Range: 0d - 255d

Large Near-Black 2D Ramp

Moving Full Range 2D Ramp

Range: 16d - 34d = 0 - 8%
DP Pattern View at 50% APL Segment

Full Range 2D Ramps – moved out of screen

Large Near-Black 2D Ramp

APL = 50%

Full Range 2D Ramps – moved out of screen
5.3. DBL – Dynamic Backlight Test

- Dark Gray / White Background
- Possible Halo Artifacts Areas – near the sprite
- Moving Sprite changing colors:
  - White on Black,
  - Black on White,
  - White on Black with Black in the center
6. CSX – Color Space Explorer

**CSX** – Unique test aimed at visualization of color space conversion artifacts

1080i60

In 20 seconds this test going three times thru all 256x256x256 = 16 millions colors with accurate digital read-out of Y, U and V Levels.

Featuring large dynamic YUV palette and current Y level indicator.

Four-quadrant dynamic indication of RGB legal space boundaries for two level schemes (16-235 and 0-255) and two color matrixing schemes (601 and 709)

Black and white PLUGE components and vertical luminance ramp allow to check set-up prior to actual test.
CSX Pattern View Example: Y=36d

Variable Y Level affects all colors in the UV Palette Window.
7. Audio Tests

7.1. AUD1 Combination Test: WAV, MP3, L+R Stereo

7.2. AUD2 Combination Test: WAV, MP3, L+R Stereo

7.3. Surround Sound 5.1 Channel Names: AAC-ADTS, AC3, Multi-channel WAV

7.4. Blank Audio: MP3, L+R Stereo

7.5. White Noise: 0 dBFs, WAV (not filtered) and MP3 (20-20000 bandpass)

7.6 Pink Noise: 0 dBFs, WAV (not filtered) and MP3 (20-20000 bandpass)

7.7. Brown Noise: 0 dBFs, WAV (not filtered) and MP3 (20-20000 bandpass)
7.1. AUD1 Sound Test

LR Stereo Test for Level Calibration, Frequency Response Measurement, Pulse Response Measurement, Dolby Low Level Noise & Distortion Check

AUD1 Test Components Sequence (total length = 20 sec):

- 1 sec mute
- 5 sec of 1,000 Hz, -12 dBFS Tone
- 1 sec mute
- 0.02 sec of 1,000 Hz, -12 dBFS (Modulated Pulse = 1 TV frame in 50p)
- 1 sec mute
- 5 sec of Logarithmic Sweep: 2 octaves/sec, 10 octaves, 20-20,000 Hz, -12 dBFS
- 1 sec mute
- 5 sec 1kHz, -40 dBFS Tone
- 1 sec mute
7.2. AUD2 Sound Test

LR Stereo Test for Level Calibration, Channel Swap Check, Channel Polarity Check, Overload and Dynamic Range Test, including L-R difference channel

AUD2 Test Components Sequence (total length = 20 sec):

- 0.4 sec mute
- 4 sec of L & R 1,000 Hz, 18 steps Raiser from -18 dBFs to 0 dBFs
  - 0.6 sec mute
  - 4.4 sec of L only (R=mute) 1,000 Hz, 18 steps Raiser from -18 dBFs to 0 dBFs:
    - 0.6 sec mute
    - 4.4 sec of R only (L=mute) 1,000 Hz, 18 steps Raiser from -18 dBFs to 0 dBFs:
      - 0.6 sec mute
      - 4.4 sec of Inverted L & R 1,000 Hz, 18 steps Raiser from -18 dBFs to 0 dBFs
        - 0.13 sec mute
8. Tests for Analyzers, 3D and Compression

8.1. VQMA Matrix Tests
Mature VideoQ product used by many customers of VQMA2 – automatic software analyzer

8.2. Robotic ScalTracker
Aimed at testing cascaded scalers, aspect ratio convertors and frame rate convertors of all sorts. For visual evaluation, instrumental measurements and fully automated (robotic) processing

8.3. 3D Static and Dynamic Video Tests
3D tests with calibrated parallaxes and moving Zone Plate, side-by-side and line-by-line formats

8.4. StresTracker
Advanced Dynamic Test for visual evaluation and instrumental estimation of compression codecs performance, including PSNR calculation
# 8.1. VQMA Test Pattern

**All-In-One:**
Single pattern allows automatically measure multiple video signal parameters using VideoQ VQMA Analyzer Program

<table>
<thead>
<tr>
<th>Test Signal:</th>
<th>Parameters:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour Bars</td>
<td>Chroma Vectors</td>
</tr>
<tr>
<td>Multi-Burst</td>
<td>Color Matrix Check</td>
</tr>
<tr>
<td>Grey-scale</td>
<td>Frequency Response</td>
</tr>
<tr>
<td>2T, 20T pulses</td>
<td>Nonlinearity, Y Levels</td>
</tr>
<tr>
<td>Modulated Ramp</td>
<td>2T pulse K-rating, Y vs. C Gain &amp; Delay</td>
</tr>
<tr>
<td></td>
<td>Differential Gain, Differential Phase</td>
</tr>
<tr>
<td></td>
<td>YUV2RGB conversion Detection (Illegal Colors)</td>
</tr>
</tbody>
</table>

Noise & Interferences accurately measured by analysis of frame differences of mainly static video test.
VQMA – Multi-resolution Test Pattern Family

1080i & 1080p

PAL

Web & Mobile

NTSC
8.2. RST – Robotic ScalTracker Test Pattern for VQMA3 Analyzer

Y Levels Test Area.

Scale & Position Test Area.

UV & RGB Levels Test Area.

Timing Indicator

Interlace Detector

Cadence, Skip & Freeze Test Area

Frequency Response Test Bursts

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RST - Test Pattern Features

Automated Measurement of:

1. Geometry: H & V positions and scaling factors
2. Levels: Y Black & White Levels, U & V Shift and Gain
3. Colorimetry: RGB-YUV Color Matrix Detection (1 bit Flag)
4. Frequency Response: on multiple H frequencies selected to match common Horizontal sizes
5. Letterbox and Pillar box Detection and Measurement:
6. Interlace Errors Detection: Field Swap/Field Pairing
7. Temporal Profile Detection: Frame Freeze/Frame Drop/Field Cadences
8.3. ZonTracker-3D

3D (Stereo) version of ZonTracker Test Pattern

**ZT-3D** – Similar to normal (2D) ZT Test with extra components aimed at visualization and calibration of positive and negative parallaxes (Left-Right disparities)

1080p60

Available in two formats:
- Side-by-side (half horizontal resolution)
- Line-by-line (half vertical resolution)

Variants with L-R images swapped to match the parallax polarity of the target 3D display
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Zero parallax Background

Moving Sprite changing parallax:
Goes in front and behind the background plane

Negative parallax
– out-of-screen components

Positive parallax
– behind-the-screen components

Zero parallax Background

ZT-3D Test Pattern - side-by-side format
ZT-3D Test Pattern - line-by-line format

Negative parallax
– out-of-screen components

Moving Sprite changing parallax:
Goes in front and behind the background plane

Positive parallax
– behind-the-screen components

Background plane parallax: 0 psh

psh = percent of screen height

Victor Steinberg

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8.4. CST – StresTracker Test for Compression Engines

Time-line Continuity Indicator

Stress Level Indicators

Moving Sprite

“Clean area “ for visual artifacts evaluation

Stress Area of variable size and contrast

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Other VQL-related VideoQ Products
VQS-200 – Reference HDMI/SPDIF Source

- Ultra-compact AV Test Source
- SD and HD playback, user selectable HDMI output format:
  - 480p@60, 576p@50, 720p@50, 720p@60
  - 1080i@50, 1080i@60, 1080p@24, 1080p50, 1080p@60
- Slide-show with adjustable speed:
  BMP images, including Static Test Patterns
- HDMI 1.3 output: 16-235 and 0-255 level schemes switchable by test file selection
- Flexible pixels mapping and scaling:
  - No scaling (dot-by-dot), if file resolution matches HDMI resolution
  - Up- and down- scaling to match the HDMI resolution, if AutoScaling=On
- Easy expansion with any external USB storage device
  (live clips, user content, etc.)
- Codecs & Formats: MP2, MP4, H264/AVC; AVI, MP4, VOB, TS, M2TS
- Easy Navigation: thru straight forward folders and files with Remote Control
- SPDIF 5.1. and Analog Audio (L+R ) out, AC3 & MP3
- Auxiliary CVBS output (NTSC/PAL)
VQTS – PC-based Generator-Analyzer

- **Target Applications:**
  - R&D Labs Development, Verification & QA
  - Factory Automation & QA/QC

- **Modular architecture, containing:**
  - VQL Test Files Library
  - VQMA Family of SW Analyzers

- **Multi-standard, multi-format VQL test library playout:**
  - HDMI/DVI, VGA, YPrPb, CVBS
  - HDSDI - option

- **Multi-standard, multi-format video capture:**
  - HDMI/DVI, VGA, YPrPb, CVBS
  - HDSDI - option

- **Full Custom SW Automation Shell**
VQMA2 – The software tool to measure video processors
VQB – Video Quality Benchmarking Tool

VQB is a sophisticated video benchmarking tool for multiple segments of IPTV, PC and CE industries. It is targeted at:

- Industry analysts
- Computers, video servers and related hardware manufacturers
- GPU and CPU suppliers
- Software developers
- System integrators
- PC-based home theatre installers and customers
- PC users interested in getting top video performance