Picture Quality Analysis System

The PQA500 is the latest-generation Picture Quality Analyzer built on the reputation of Tektronix’ Emmy Award-winning PQA200/300. Based on the concepts of the human vision system, the PQA500 provides a suite of repeatable, objective quality measurements that closely correspond with subject human visual assessment. These measurements provide valuable information to engineers working to optimize video compression and recovery, and maintaining a level of common carrier and distribution transmission service to clients and viewers.

Compressed Video Requires New Test Methods

The true measure of any television system is viewer satisfaction. While the quality of analog and full-bandwidth digital video can be characterized indirectly by measuring the distortions of static test signals, compressed television systems pose a far more difficult challenge. Picture quality in a compressed system can change dynamically based on a combination of data rate, picture complexity and the encoding algorithm employed. The static nature of test signals does not provide true characterization of picture quality. A test scene with natural content and motion can be used, with human viewers reporting the results, but this method of evaluating the capabilities of a compressed video system is inefficient and not very objective. Subjective testing with human viewers is impractical for CODEC design and operational quality evaluation. The PQA500 provides a fast, practical, repeatable and objective measurement alternative to subjective evaluation of picture quality.

Human viewer testing has been traditionally conducted as described in ITU-R Rec. BT.500-11. A test scene with natural content and motion is displayed in a tightly controlled environment, with human viewers expressing their opinions of picture quality to create a Differential Mean Opinion Score, or DMOS. Extensive testing using this method can be refined to yield a consistent subjective rating. However, this method of evaluating the capabilities of a compressed video system can be inefficient, taking several weeks to months to perform the experiments. This test methodology can be extremely expensive to complete, and often the results are not repeatable. Thus, subjective DMOS testing with human viewers is impractical for the CODEC design phase and inefficient for ongoing operational quality evaluation. The PQA500 provides a fast, practical, repeatable and objective measurement alternative to the subjective DMOS evaluation of picture quality.
Picture Quality Analysis System

How It Works
The PQA500 takes two video files as inputs: a pristine reference video sequence and a compressed, impaired or processed version of the reference. First the PQA500 performs a spatial and temporal alignment between the two sequences without the need for a calibration stripe embedded within the video sequence. Then the PQA500 analyzes the quality of the test video, using measurements based on human vision system and attention models, and then outputs quality measurements that are highly correlated with subjective assessments. The results include overall quality summary metrics, frame-by-frame measurement metrics and an impairment map for each frame. The PQA500 also provides traditional picture quality measurements such as PSNR (peak signal-to-noise ratio) as an industry benchmark impairment diagnosis tool for measuring typical video impairments and detecting artifacts.

System Evaluation
The PQA500 may be used for installation, verification and troubleshooting of each block of the video system because it is video technology diagnostic: any visible differences between video input and output from processing components in the system chain may be quantified and assessed for video quality degradation. Not only can CODEC technologies be assessed in a system, but any process that has potential for visible differences can also be assessed. For example, digital transmission errors, format conversion (i.e., 1080i to 480p in set-top-box conversions), 3-2 pull-down, analog transmission degradation, data errors, slow display response times, frame rate reduction (for mobile transmission and videophone teleconferencing), and more can all be evaluated, separately or in any combination.

Prediction of Human Vision Perception
PQA500 measurements are developed from the human vision system model, and additional algorithms have been added to improve upon the model used in the PQA200/300. This new extended technology allows legacy PQR measurements for SD while enabling predictions of subjective quality rating of video for a variety of video formats (HD, SD, CIF, etc.). It takes into consideration different display types used to view the video (for example, interlaced or progressive and CRT or LCD) and different viewing conditions (for example, room lighting and viewing distance).
A model of the human vision system has been developed to predict the macro-behavioral response to light stimulus with the following varying parameters:

- Contrast including supra-threshold
- Mean Luminance
- Spatial Frequency
- Temporal Frequency
- Angular Extent
- Temporal Extent
- Surround
- Eccentricity
- Orientation
- Adaptation effects

This model has been calibrated, over the appropriate combinations of ranges for these parameters, with reference stimulus-response data from vision science literature. As a result of this calibration, the model provides a highly accurate prediction.

The graphs above are examples of scientific data regarding human vision characteristics used to calibrate human vision system modeling in the PQA500. Graph (A) shows modulation sensitivity vs. temporal frequency, and graph (B) shows modulation sensitivity vs. spatial frequency. The use of over 1,400 calibration points supports high-accuracy measurement results.

The picture above (C) is a single frame from the reference sequence of a moving sequence, and picture (D) is the perceptual contrast map calculated by the PQA500. The perceptual contrast map shows how the viewer perceives the reference sequence. The blurring on the background is caused by temporal masking due to camera panning, and the black area around the jogger shows the masking effect by the high contrast between the background and the jogger. The PQA500 creates the perceptual map for both reference and test sequences, then makes a perceptual difference map from them.
Comparison of Predicted DMOS with PSNR

In the example above, Reference (E) is a scene from one of the VClips™ library files. The image Test (F), has been passed through a compression system which has degraded the resultant image. In this case, the background of the jogger in Test (F) is blurred compared to the Reference image (E). A PSNR measurement is made on the PQA500 of the difference between the Reference and Test clip and the highlighted white areas of PSNR Map (G) shows the areas of greatest difference between the original and degraded image. Another measurement is then made by the PQA500, this time using the Predicted DMOS algorithm, and the resultant Perceptual Difference Map for DMOS (H) image is shown. It shows the greater perceptual difference with the highlighted white area. Using the human vision model of the PQA500 you can observe the areas of the image which the eye will observe as degraded. In this case the jogger in the image is not as noticeably degraded as the PSNR would have indicated.

Attention Model

The PQA500 also incorporates a new Attention Model to support the predicted human focus of attention. This model considers:

- The motion of objects
- Identifies people by skin detection
- Location
- Contrast
- Shape
- Size
- The distraction of noticeable artifacts

These attention parameters can be customized to give greater or less importance to each function. This allows each measurement using the attention model to be user-configurable. The model is especially useful to evaluate the video process tuned to the specific application. For example, if the content is sports programming, the viewer is expected to have higher attention in limited regional areas of the scene. Highlighted areas within the attention image map will show the areas of the image drawing the attention of the eye.
Artifact Detection

Artifact Detection reports a variety of different changes to the edges of the image:
- Loss of edges or blurring
- Addition of edges or ringing/mosquito noise
- Rotation of edges to vertical and horizontal or edge blockiness
- Loss of edges within an image block or DC blockiness

They work as weighting parameters for subjective and objective measurements with any combination. The results of these different measurement combinations can help to improve picture quality through the system.

For example, artifact detection can help answer questions such as "will the DMOS be improved with more de-blocking filtering?" or "should less pre-filtering be used?"

If edge blocking weighted DMOS is much greater than blurring weighted DMOS, the edge blocking is the dominant artifact, and perhaps more de-blocking filtering should be considered.

In some applications, it may be known that added edges, such as ringing and mosquito noise, are more objectionable than the other artifacts. These weightings can be customized by the user and configured for the application to reflect this viewer’s preference, thus improving DMOS prediction.

Likewise, PSNR can be measured with these artifact weightings to determine how much of the error contributing to the PSNR measurement comes from each artifact.

Comprehensive Picture Quality Analysis

The PQA500 provides full-reference (FR) comparison between test and reference quality measurements and no-reference (NR) measurements on the luminance signal. Reduced reference (RR) measurements can be made manually from differences in no-reference measurements.

The suite of measurements includes:
- Critical Viewing (human vision system model-based, full-reference) picture quality
- Casual Viewing (attention weighted, full-reference or no-reference) picture quality
- Peak Signal-to-Noise Ratio (PSNR, full-reference)
- Focus of Attention (applied to both full-reference and no-reference measurements)
- Artifact Detection (full-reference, except for DC Blockiness)
- DC Blockiness (full-reference and no-reference)
Easy-to-Use Interface

PQA500 has two modes: measurement and review. The measurement mode is used to execute the measurement selected in the Configure Dialog. During measurement execution, the summary data and map results are displayed on screen and saved to the system hard disk. The review mode is used to view previously saved summary results and maps created either with the measurement mode or XML script execution. The user can choose multiple results in this mode and compare each result side by side using the synchronous display in Tile Mode. Comparing multiple results maps made with the different CODEC parameters and/or different measurement configurations enables easy investigation of the root cause of any difference.

Multiple Result Display

Resultant maps may be displayed synchronously with the reference and test video in a tiled or overlaid display. Individual videos can also be viewed at full resolution, one at a time, to accommodate resolutions greater than what the tiled display can accommodate. In Overlay Display, the user can control the mixing ratio with the fader bar, enabling co-location of difference map, reference and impairments in test video sequences.

Summary measures of standard parameters and perceptual summation metrics for each frame and over all frames are provided. Summary measure results are displayed as data lists, maps or graphs with a bar chart during video playback.

Error logging and alarms are available to help users efficiently track down the cause of video quality problems. The logging parameters are:

- Registration information found in automatic temporal and spatial alignment: cropping, scale, shift in horizontal and vertical, Y gain and DC offset
- Alignment confidence (cross-correlation coefficient): (1.0 is perfect match)
- Logs of when measurement values per frame exceed either warning or error levels (configurable by user via the summary node)

All results, data and graphs can be recalled to the display for critical examination.

Automatic Temporal/Spatial Alignment

The PQA500 supports automatic temporal and spatial alignment, as well as manual alignment.

The automatic spatial alignment can measure the cropping, scale and shift in each dimension, even across different resolutions (for example, by aligning SD to HD video). If extra blanking is present within the standard active region, it is measured as cropping when this function is enabled.

The automatic spatial and temporal alignment allows the picture quality measurement to be made among different resolutions and frame rates.
operation by allowing the user to write a series of measurement sequences within an XML script. Measurement results of the script operation can be viewed by using either the PQA500 user interface or via any spreadsheet application that is able to read the created .csv file format as a summary.

Optional SD/HD SDI Interface
The PQA500 analyzes video content handled as computer files, and an optional SD/HD SDI interface enables capturing SDI video signals. The SDI interface is especially useful to professional video equipment manufacturers and broadcasters.

Supported Format by SD/HD/SDI Interface
- SD-SDI: 525i/59.94, 625i/50

Supported File Formats
All formats support 8-bit only:
- .yuv (4:2:2, 4:4:4, 4:2:0 planer)
- .avi (uncompressed) (up to 2 GB)
- .rgb
- ARIB ITE format (4:2:0 planer with 3 separate files (.yyy, .bbb, .rrr))
- .vcap (made by SDI operation)

Pre-Installed Video Sequences
<table>
<thead>
<tr>
<th>Clips</th>
<th>1920x1080</th>
<th>V031202_Eigh_Ave, V031251_Stripy_jogger, V031255_TimeSquare</th>
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<tbody>
<tr>
<td></td>
<td>1280x720</td>
<td>V031002_Eigh_Ave, V031051_Stripy_jogger, V031055_TimeSquare, V031051_Stripy_jogger with 3/10/26 Mbps</td>
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<td>864x486</td>
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<tr>
<td></td>
<td>320x180</td>
<td>Converted V031051_Stripy_jogger Converted V031051_Stripy_jogger with 1000/1780/2850 kbps</td>
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<tr>
<td>PQA300 without Trigger</td>
<td>525</td>
<td>720x486 CbYCrY (601-422) Cheer, Ferris, Flower, Tennis, Cheer_2 Mbps 25 fps</td>
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<tr>
<td></td>
<td>625</td>
<td>720x576 CbYCrY (601-422) Auto, BBC, Ski, Soccer</td>
</tr>
<tr>
<td>PQA300 with Trigger</td>
<td>525</td>
<td>720x486 CbYCrY (601-422) Mobile, Mobile3/6/9 Mbps</td>
</tr>
<tr>
<td></td>
<td>625</td>
<td>720x576 CbYCrY (601-422) Mobile, Mobile3/6/9 Mbps</td>
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</table>
Related Products
Recent updates and more details are available in each data sheet.

MTS4EA Elementary Stream Analysis Software for VC-1, H.264/AVC, MPEG-2, MPEG-4, H.263 and 3GPP Standards

Features and Benefits
► Next-generation (VC-1, H.264/AVC, MPEG-4 and 3GPP) and Legacy (MPEG-2 and H.263) CODEC Support
► Frame-by-frame and block-by-block analysis to allow easy CODEC comparison
► Easy-to-interpret, detailed graphical displays (requires user-installed Microsoft Excel)
► Comprehensive Semantic Trace File Output to determine block-by-block encoder decision making
► AV delay measurement
► Audio decode and analysis
► Synchronized audio and video analysis
► Real-time and non-real-time decoding and analysis of compressed video streams (dependent on PC performance)
► Elementary stream editing
► Batch mode to allow automated testing
► YUV decoded video output for baseband video analysis
► Extraction of elementary stream from transport stream
► Available as single-user local license for PC and Tektronix instruments or server-based floating license

Vclips – for Video Testing and Evaluation

Features and Benefits
Vclips™ is a diverse set of short video clips designed to test video encoders and decoders to the limits of their abilities.
► Video Sizes – Test with many different video sizes; Sub-QCIF, QCIF, CIF, D1, HD (720p and 1080i)
► Difficult subjects – Test with fine detail, nighttime, areas of high contrast, sharp borders, uniform areas, bright and dull colors
► Visual objects – People, buildings, vehicles, trees, landscapes, clouds, water and synthetic objects
► Movement – Fast, slow, uniform, random, multiple moving objects; also pan, zoom and rotate
► Test Card Sequences – Precisely defined motion, bright colors, dull colors, lines, patterns and grids; also strobing and white noise
### Characteristics

#### Pre-Configured Measurement Set

<table>
<thead>
<tr>
<th>Measurement Class</th>
<th>Measurement Name</th>
<th>Display Model</th>
<th>View Model</th>
<th>PSNR</th>
<th>Perceptual Difference</th>
<th>Attention Model</th>
<th>Artifact Detection</th>
<th>Summary Node</th>
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<tbody>
<tr>
<td>Subjective Prediction: Full Reference</td>
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<td>001 SD Broadcast CRT</td>
<td>SD Broadcast CRT</td>
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<td>Attention Biased Subjective Rating Predictions</td>
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<td>Default Weightings</td>
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</table>

Repurposing: Reference and Test are Independent: Use Any Combination Display Model and Viewing Conditions with Each Measurement Above

**Format Conversion:** Reference and Test are Independent: Use Any Combination Display Model and Viewing Conditions with Each Measurement Above

**Format Conversion:**
- Cinema to SD DVD: 015 SD DVD from D-CINEMA DMOS
- SD to CIF: 016 CIF from SD Broadcast DMOS
- HD to SD: 017 SD from HD Broadcast DMOS
- SD to HD: 017A SD Ref: SD Test: HD Broadcast DMOS
- CIF to QCIF: 018 QCIF from CIF and QVGA DMOS

**Format Conversion Details:**
- Cinema to SD DVD: DMD Projector and SD CRT 7 scrn heights, 20 cd/m^2
- SD to CIF: LCD and SD Broadcast CRT (ITU-R BT.500) and 7 scrn heights, 20 cd/m^2
- HD to SD: SD and HD Broadcast CRT (ITU-R BT.500)
- SD to HD: SD and HD Progressive CRT (ITU-R BT.500)
- CIF to QCIF: QCIF and CIF/QVGA LCD 7 scrn heights, 20 cd/m^2

**DMOS Units:**
- Reference: DMOS Units Re: BT.500 Training
- Test: DMOS Units Re: BT.500 Training
## Pre-Configured Measurement Set continued

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<tr>
<th>Class Name</th>
<th>Display Model</th>
<th>View Model</th>
<th>PSNR</th>
<th>Perceptual Difference</th>
<th>Attention</th>
<th>Artifact</th>
<th>Summary Node</th>
<th>Detection</th>
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<td>NA</td>
<td>Default</td>
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### Objective Measurements: Full Reference

#### General Difference

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<th>PSNR</th>
<th>020 PSNR dB</th>
<th>NA</th>
<th>Auto-align spatial</th>
<th>Selected</th>
<th>NA</th>
<th>NA</th>
<th>NA</th>
<th>dB units</th>
</tr>
</thead>
</table>

#### Artifact Measurement

| Removed Edges | 021 Removed edges percent | NA | NA | NA | NA | NA | Blurring | % |
| Added Edges   | 022 Added edges percent   | NA | NA | NA | NA | NA | Ringing/Mosquito Noise | % |
| Rotated Edges | 023 Rotated edges percent | NA | NA | NA | NA | NA | Edge Blockiness | % |
| % of Original Deviation from Block DC | 024 DC blocking percent | NA | NA | NA | NA | NA | DC Blockiness | % |

#### Artifact Classified (Filtered) PSNR

| Removed Edges | 025 Removed edges weighted PSNR dB | NA | NA | Selected | NA | NA | Blurring | dB units |
| Added Edges   | 026 Added edges weighted PSNR dB   | NA | NA | Selected | NA | NA | Ringing/Mosquito Noise | dB units |
| Rotated Edges | 027 Rotated edges weighted PSNR dB | NA | NA | Selected | NA | NA | Edge Blockiness | dB units |
| % of Original Deviation from Block DC | 028 DC blocking weighted PSNR dB | NA | NA | Selected | NA | NA | DC Blockiness | dB units |

#### Artifact Annoyance Weighted (Filtered) PSNR

| 029 Artifact annoyance weighted PSNR | NA | NA | Selected | NA | NA | All artifacts selected | dB units |

### Repurposing: Use View Model to Resample, Shift and Crop Test to Map to Reference

| Format Conversion: Cinema to SD DVD | 030 SD DVD from D-cinema artifact weighted PSNR dB | NA | Auto-align spatial | Selected | NA | NA | All artifacts selected | dB units |
| Format Conversion: SD to CIF | 031 CIF from SD broadcast artifact weighted PSNR dB | NA | Auto-align spatial | Selected | NA | NA | All artifacts selected | dB units |
| Format Conversion: HD to SD | 032 SD from HD broadcast artifact weighted PSNR dB | NA | Auto-align spatial | Selected | NA | NA | All artifacts selected | dB units |
| Format Conversion: CIF to QCIF | 033 QCIF from CIF and QVGA artifact weighted PSNR dB | NA | Auto-align spatial | Selected | NA | NA | All artifacts selected | dB units |

### Attention Weighted Objective Measurements

#### General Difference

| PSNR       | 034 Attention weighted PSNR dB | NA | NA | Selected | NA | Default Weightings | NA | dB units |

### Objective Measurements: No Reference

#### Artifact

| DC Blockiness | 035 No Reference DC Blockiness Percent | NA | NA | NA | NA | NA | No-reference DC Blockiness | % DC Blockiness |
## Ordering Information

**PQA500**

**Picture Quality Analysis System**

**PC Monitor Requirement**

**Note:** PQA500 does not include a PC monitor. A monitor is to be provided by the user.

- Dual-link DVI ports
- Up to 2560x1600 resolution

**Standard Accessories**

- PQA500 Picture Quality Analysis System Quick Start User Manual in English and Simplified Chinese or Japanese Translation If a Language Option was Ordered – 071-2256-XX (English).
- PQA500 Picture Quality Analysis System Release Notes – 071-2259-XX.
- PQA500 Picture Quality Analysis System User Technical Reference – 071-2263-XX.
- PQA500 Picture Quality Analysis System Measurement Declassification and Security Instructions – 071-2266-XX.

**Language Options**

- L0 – English manual.
- L7 – Simplified Chinese manuals.

**Service**

- R3 – Repair service 3 years (including warranty).
- R5 – Repair service 5 years (including warranty).

**Post-sale Upgrade**

- PQA5UP – Field Upgrade Kit for PQA500.
- Option SDI – SD/HD SDI Card for field installation

**Extended Service Offerings**

- CA1 – Single calibration.
- R1PW – Repair Service 1 year (post-warranty).
- R2PW – Repair Service 2 years (post-warranty).
- R3DW – Repair Service 3 years (includes warranty).
- R5DW – Repair Service 5 years (includes warranty).

**Additional Information**

Please contact your local Service Manager for information regarding our products and services, or contact us at: www.tektronix.com/serviceandsupport/contactus
Picture Quality Analysis System

Contact Tektronix:

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Canada  1 (800) 661-5625
Central East Europe, Ukraine and the Baltics  +41 (022) 675 3777
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Denmark  +45 80 88 1401
Finland  +41 (022) 675 3777
France  +33 (01) 69 86 81 81
Germany  +49 (0221) 94 77 420
Hong Kong  +852 2985 6688
India  (91) 11 22275977
Italy  +39 02 258961
Japan  81 (3) 6714-3010
Luxembourg  +44 (0) 1344 392400
Mexico, Central America & Caribbean  +52 (55) 5424700
Middle East, Asia and North Africa  +41 (022) 675 3777
The Netherlands  0900 02 221797
Norway  800 16098
People's Republic of China  86 (10) 6235 1230
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