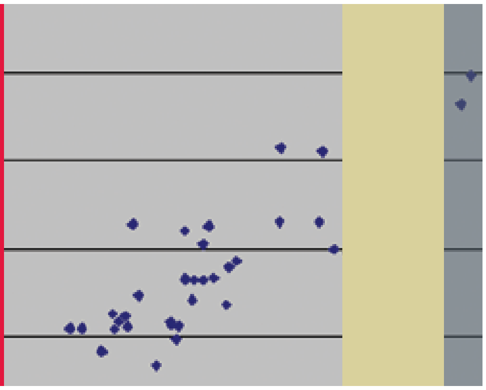

Objective Measurements and Subjective Assessments

Application Note

Introduction

As digital video technology matures, and more types of video media become available in an increasing number of formats, there is a need to compress large volumes of video material in various formats for TV, the Internet (including IP), Mobile Video Devices, Digital Cinema and the like.

HDTV program broadcasting has expanded into the global marketplace. The increased number of wireless devices available with video capability and high-quality package media (e.g. Blu-ray) has gained a strong foothold. This deployment has heightened consumer awareness of picture quality which raises the bar of expected picture quality for developers, manufactures and broadcasters.

To respond to the end user's expectation of higher picture quality in diverse programs, video equipment manufacturers must use more productive development processes to deliver new products to market faster, and with lower manufacturing costs. Television broadcasters and network operators must deliver more content at higher quality over increasingly congested networks. Finally, video content producers must create and re-purpose higher quality video content for a growing range of applications, formats and delivery media.

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In this environment, picture quality assessment techniques are playing a larger role in video product design, video system deployment and content quality assurance. Many organizations assess picture quality using a subjective, informal approach—one that asks people in the organization to compare test video sequences to reference video sequences. Over time, one person or a small group of people will demonstrate an ability to detect video quality impairments. These are the organization's "golden eyes."

A "golden eyes" subjective rating may match the end consumer's video experience or these discerning evaluators may see artifacts that the average viewer might miss. But, many typical organizations cannot afford a large staff of "golden eyes." Conflicts in scheduling these limited resources for picture quality assessments can delay work. Alternatively, expenses for hiring a "golden eyes" evaluator from outside the organization can be costly. Subjective evaluations can easily take several hours, making evaluator error from fatigue, a factor in the evaluation.

Some organizations use formal subjective assessment to replace or augment informal subjective assessments using "golden eyes." The ITU-R BT.500 recommendation describes various methods of conducting formal subjective picture quality assessments, along with requirements for selecting and configuring displays, determining reference and test video sequences, and selecting subjects for the viewer test audiences.

Specifying the desired tests, gathering the required video content, recruiting and selecting the viewing audience, conducting the tests and analyzing the results generally requires several weeks. Typically, independent laboratories perform this subjective testing, although a few organizations may have internal resources that can conduct these formal subjective assessments. When conducted by an independent laboratory, overall costs for these subjective picture quality assessments must include significant time and thousand of dollars. Given this commitment of time, resources and expenses, typical organizations will conduct a very limited amount of formal subjective picture quality assessments. If they use these methods at all, teams will generally perform this testing at very few critical milestones in the project or deployment.

Whether they use informal or formal approaches, video equipment manufacturers, television broadcasters, network operators and video content producers are finding it impractical to use subjective picture quality assessment to fully address the challenges described above. Engineering and quality assurance teams in these companies need to optimize picture quality vs. various constraints. For example:

- On a tight development schedule, a product development team needs to determine the best picture quality they can achieve at a specific product manufacturing cost.
- A cable network operator needs to find the system configuration that produces the best picture quality at a specific bandwidth allocation.
- A post-product company needs to find the best down-conversion algorithm to use in repurposing digital cinema content on DVDs.

These optimization processes require repeated picture quality assessments as the engineering or quality assurance team tries different approaches or configurations and tests the results. Conducting subjective assessments for each trial using actual viewers is too time-consuming and costly. Delivering video products, systems and content with optimal picture quality in today's environment requires instruments that can make accurate, reliable, repeatable objective picture quality measurement faster than subjective assessments.

To serve as an adequate replacement for "golden eyes" and formal subjective assessment, objective picture quality measurements on video content must produce results that match subjective ratings on the same video content. Peak-Signal-to-Noise Ratio (PSNR) measurements are not sufficient to meet this criteria. Simple examples can produce PSNR measurement results that completely disagree with subjective ratings of picture quality. Any method for objective picture quality assessment must prove its merit by verifying its ability to match the results of subjective assessment. However, comparing objective picture quality measurements and a subjective picture quality assessment requires careful planning, execution and analysis. Many factors affect the comparison and may include:

- Video content selected for the comparison
- Method, configuration and subjects used in the subjective assessments
- Quality and characteristics of the subjective assessment data
- Objective measurements used in the comparison and their configuration
- Results analysis

Insufficient attention to these factors can lead to misleading conclusions about the merits of a particular objective picture quality measurement method.

This paper describes a comparison of PQA500 objective picture quality measurements with subjective assessments performed on HD video content processed with H.264 encoding. It will show that the measurements made by the Tektronix PQA500, properly configured to match the subjective assessment conditions, has a correlation coefficient of 0.935, with an ideal value of 1.0 indicating an exact match between assessment results. Root Mean Square Error deviation (RMSE) of 6.11, with an ideal value of 0.0 indicating no difference between the results, with an example subjective assessment results from H.264 encoded 1080i video with bit rates between 2 Mbps and 70 Mbps.

Video Content

The selection of test material is important for comparing any objective measurement against subjective ratings. The selected video content has to represent scenes from a variety of programs which contain a diversity of contrast, brightness, color, high motion, difficulty to encode/decode and other attributes, which would generally be shown in the TV broadcasting content.

The video material that was selected for testing, as described in this paper, consisted of 24 reference sequences (e.g. unprocessed) in HD 1080i59. The duration of each reference sequence was either 8.3 or 10 seconds. Brief descriptions for each reference video are listed in the Appendix.

The 24 reference sequences were processed with H.264 encoding, using nine variations of bit rate from 2 Mbps to 70 Mbps producing a total of 216 test sequences. The test sequences used for the subjective rating were narrowed down from 216 to 60, with due consideration for keeping the material diverse and to get a uniform distribution of degradation scales from "Excellent" to "Bad."

Figure 1. Example of Subjective Assessment.

Subjective Assessment

Subjective assessments were conducted by the Communications Research Centre (CRC), Canada. Thirty-three viewers (18 males and 15 females) participated in the experiment. One viewer had significant experience with the subjective assessment of picture quality. The remaining viewers were all non-experts. Mean age was 33.9 years. All viewers were screened prior to participation for normal, or corrected to normal, visual acuity and normal color vision.

The viewing room used for the subjective test conformed to ITU-R Rec. BT. 500 guidelines. The video sequences to be evaluated were displayed on a Sony BVM-D24 CRT professional monitor. Viewers saw the video sequences from a distance approximately equal to three times the picture high (e.g. viewing distance 3H). A detailed description of the viewing parameters, including monitor characteristics and viewing environment, was described in a final report from the CRC. (Figure 1)

No more than two viewers were tested simultaneously. A personal computer was used for controlling stimulus delivery and collecting the ratings provided by the viewers. Ratings were collected electronically using a custom input device.

The subjective quality of the video sequences was measured using the Double-Stimulus Continuous Quality-Scale (DSCQS) method (refer to Rec. ITU-R BT 500). The procedure consisted of a series of judgment trials, each announced verbally by number (e.g. Trial # 1, Trial # 2 and so on). In each trial, two versions of the same video clips were presented twice (total of four presentations). The first presentation of a trial was always verbally identified as “A”, and the second as “B.” This pair of presentations was repeated twice, thereby completing a single trial (e.g. AB, AB) as shown in Figure 2.

In each trial, either "A" or "B" was a Reference sequence; the other was a Test sequence. The Reference was always one of the unprocessed (e.g. original) source sequences, whereas the Test sequence was one of the corresponding test sequences obtained by processing the source sequence with one of the test conditions. The order of presentation of the Reference and Test was randomized across trials without informing the viewers. The order of presentation of different test sequences was also randomized across viewers or group of viewers.

Viewers were asked to rate both the “A” and “B” video clips using a continuous vertical scale as depicted in Figure 3.

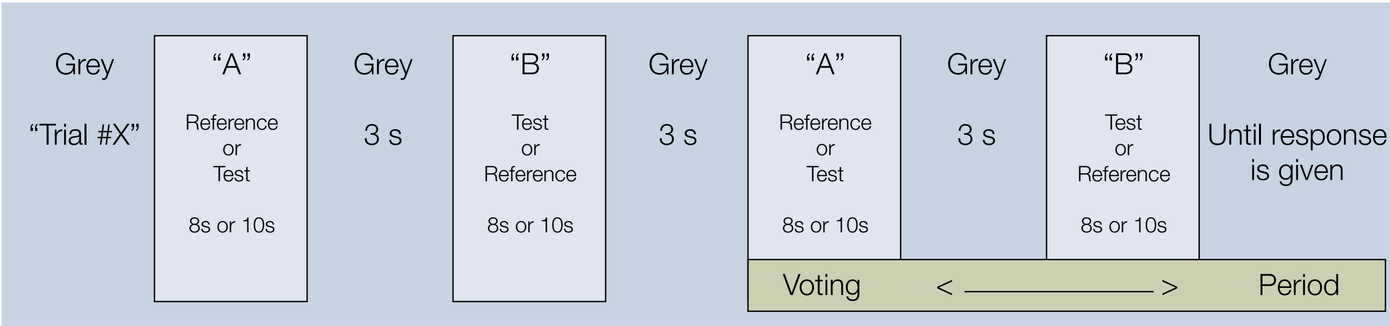


Figure 2. DSCQS Trial Structure.

Figure 3. DSCQS Rating scale.

Figure 4. CRC input device.

To rate the video quality, the viewers used an electronic input device, shown in Figure 4. Viewers were asked to position the slider at the point on the scale that best corresponded to their judgment of the video quality of the "A" image and then press the LEFT button; and then repeat the same judgment for the "B" video sequence and press the RIGHT button.

In each case, a "training sequence demonstration" per ITU-R BT. 500 section 2.6, was employed with two sequences processed at three quality levels (H.264 70/6/2 Mbps), for a total of six trials/presentations. The sequences were presented in descending order of quality. Viewers were told that the demo had two purposes: to familiarize them with the task and to show them examples of "Excellent," "Fair" and "Bad" video quality that would be included in the test. Figures 5 through 8 show example pictures from the equivalent samples of reference and worst case (2 Mbps) that were used as "training sequence demonstrations."

Figure 5. Reference Sample1.

Figure 6. Worst case training Sample1.

Figure 7. Reference Sample2.

Figure 8. Worst case training Sample2.

array[n] = K1 * array2[n] + K2
(where K1 and k2 are constant)

Figure 9. The condition of correlation coefficient of 1.

Pooling Subjective Assessment Data

In the DSCQS method, subjective quality is expressed in terms of opinion scores. The Mean Opinion Score (MOS) has been defined as the arithmetic average score of the opinion scores from each viewer. Then, the Differential Mean Opinion Score (DMOS) is the defined as the difference of the average opinion scores. The DMOS is conventionally calculated by subtracting the MOS score for reference sequence from that for test sequence, but in this paper, we have the reversed subtraction for the convenience. Thus, a negative DMOS implies that the Test sequence was judged as having a higher perceived quality than the Reference sequence; a DMOS of zero implies that the Test and Reference sequences were judged as having the same perceived quality; and finally a positive value implies that the Test sequence was judged as having a lower perceived quality than the Reference sequence. Thus a positive DMOS represents the loss of quality, if any, due to processing.

Metrics Showing the Performance of the Objective Measurement Against Subjective Rating

The metrics showing the performance of the objective measurements against subjective ratings have to come from statistical methods, to properly represent the characteristics of the tests, and to be well known/accepted in the industry.

The correlation coefficient is one such metric that meets these criteria. It can describe the degree of similarity between not only the same metrics but also different metrics, enabling us to compare PSNR(dB) with DMOS or PQR with DMOS. The correlation coefficient gives results ranging between -1 to 1. Where the relationship between two data arrays is shown as the formula (Figure 9), and when K1 is positive, the correlation is 1.0. When K1 is negative, the correlation is -1.0 (see Figures 10 and 11).

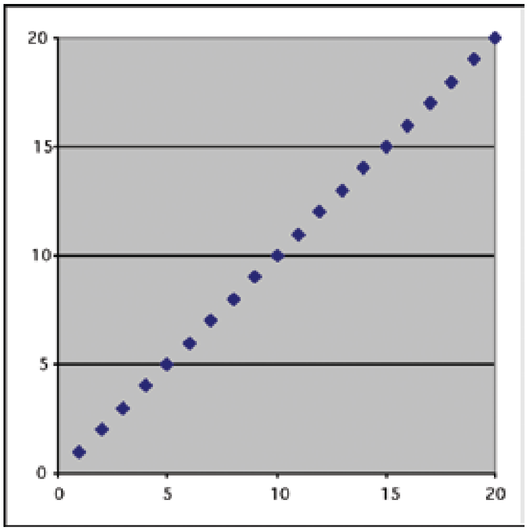


Figure 10. Correlation coefficient: 1.

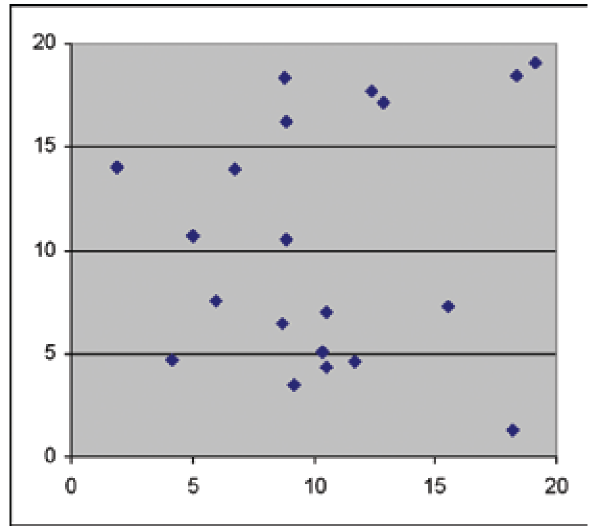


Figure 11. Correlation coefficient: 0.134.

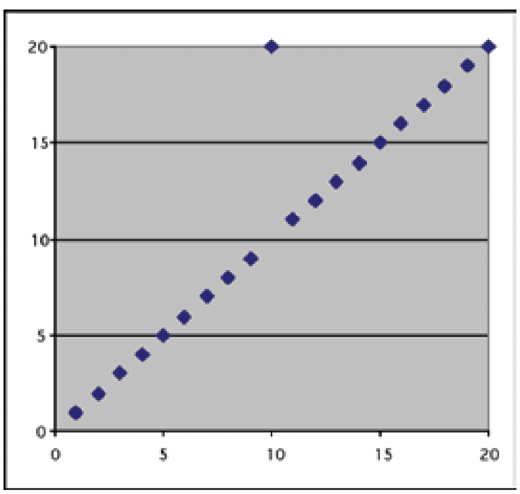


Figure 12. Correlation Coefficient: 0.935, RMSE: 2.179 with error of 10 at center data.

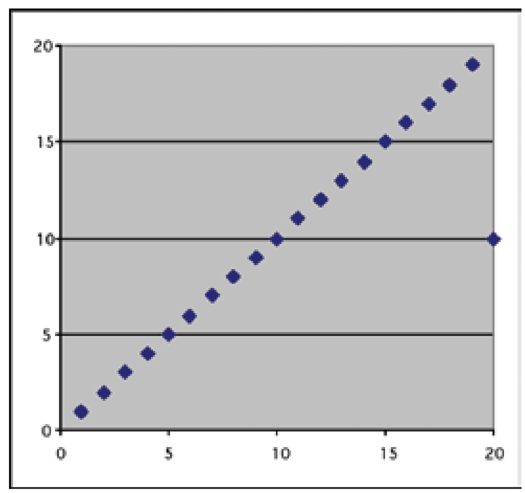


Figure 13. Correlation Coefficient: 0.926, RMSE: 2.179 with error of 10 at last data.

The correlation coefficient is definitely one metric to show a performance attribute. But, heavily relying on that metric alone, when discussing the performance of the objective measurement, could be misleading. For example, the correlation coefficient could be changed by the sample location where the error is included or even where the degree of error is unchanged. The error in Figure 12 is located in the middle sample of the data array and the error in Figure 13 is located on the last sample of data array. Both these errors have same amount of error, but the correlation coefficients have different results.

In this paper, RMSE of Root Mean Square Error (RMSE) will be used—after correcting for mean error—the result is shown to be equal to error standard deviation, as well as correlation coefficient. RMSE can represent the error difference between the two data arrays which has no variance caused by sample location (Figures 12 and 13). However, its use is limited to cases where the variables have identical units and expected results are the same (e.g. Subjective DMOS vs Predicted DMOS).

The ideal model will give a correlation coefficient equal to 1 and RMSE equal to 0. In practice, the high performance model may show a high correlation coefficient of close to 1 and a low RMSE of close to 0.

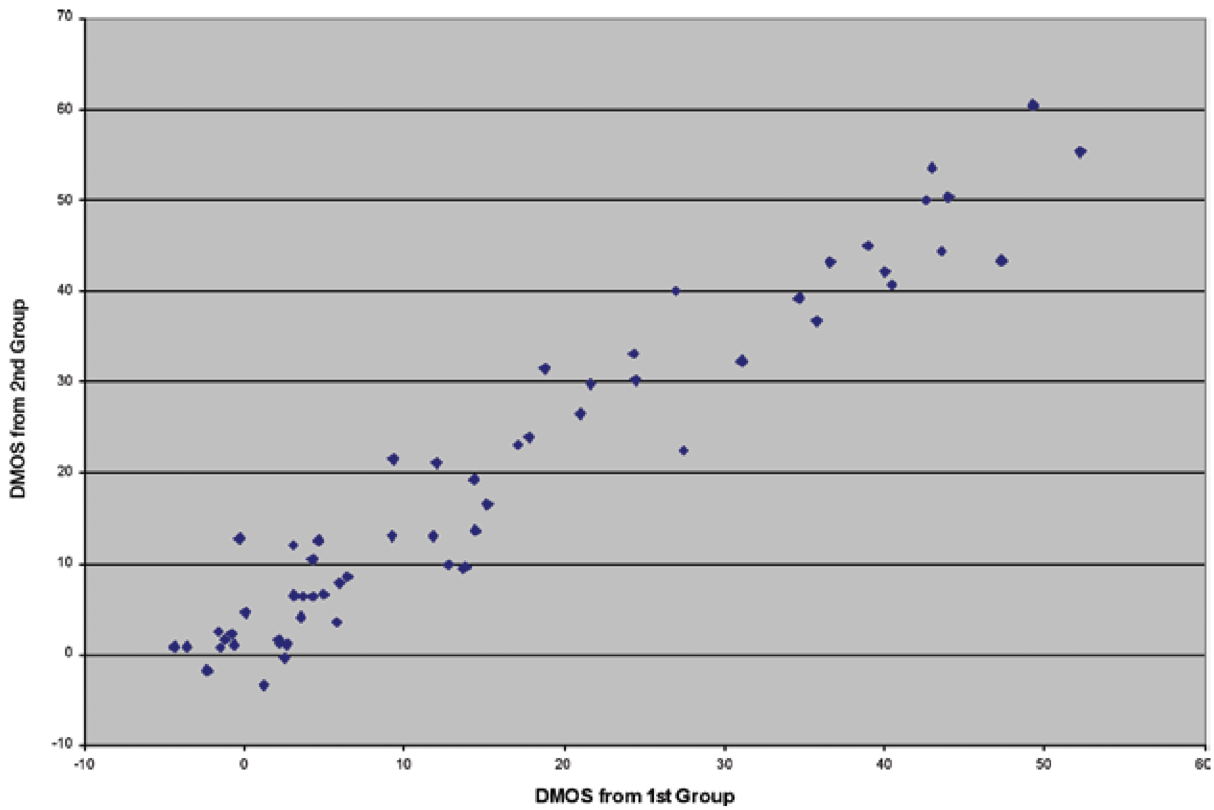


Figure 14. Validity of subjective assessment data.

Validity of Subjective Assessment Data

In this series of tests, a total of 33 subjects participated and about 1980 DOS scores were collected through 60 test video sequences. To further validate the subjective DOS data, the 2 data set were collected from 2 groups randomly, one group of 16 subjects and another group of 17 subjects, and a separate DMOS was calculated for each test sequence from the 2 separate groups. The graph in Figure 14 shows the relationship between the DMOS from the 1st group of 16 subjects (shown on the x-axis) and the DMOS from the 2nd group of 17 subjects (shown on the y-axis). The 60 data points represent each test video, conveyed from the average score of 16 or 17 subjects. The correlation coefficient between them equals 0.966, RMSE is 4.56. This result proves that the subjective experiment was conducted within a well controlled test environment, with randomly/consistently selected test material and subjects, delivering a highly valid data set ranging from 2 to 70 Mbits/sec. The correlation coefficient and RMSE achieved by this validation, 0.966 and 4.56, would be the performance target of the objective measurements.

Objective Picture Quality Measurements

In this paper, the performances of 4 Full-Reference measurements were evaluated. Peak Signal to Noise Ratio (PSNR), Picture Quality Rating (PQR), DMOS and Attention weighted DMOS (ADMOS), were measured by the PQA500 and compared against the subjective picture quality assessments described above.

The PSNR measurement is a Noise-based measurement that computes the noise, or error, in the test video relative to the reference video. This measurement is well known as having less correlation with subjective ratings. However, it is periodically shown in papers and equipment literature since the algorithm is very simple to understand and it historically was more useful for less efficient encoders/decoders and wider ranging quality. It provides intuitive results at debugging stages during development and is commonly used in the industry. This measurement is often picked up as a reference for discussing the performances of other perceptual based measurements.

PQR and DMOS are perceptual-based measurements using human vision system models. They provide more accurate rating results, correlating more closely to human subjective tests than the PSNR measurement alone. The PQR measurement evaluates whether viewers notice a difference between the test and references video content, making PQR very suitable for measuring high quality video (typically broadcast video). The DMOS measurement evaluates how much impairment viewers will perceive in test video content. DMOS is more suitable for measuring the video content differences over a wide quality range (after calibration training for worst case video content).

ADMOS is a DMOS measurement, with the addition of a part of human cognition that accounts for what we are most likely to watch in any given scene. In any video sequence, some elements in the video will draw viewers' attention, while they tend to ignore other elements. Differences will appear more pronounced in areas which "grab" the viewer's attention. Conversely, differences that occur in regions of the video that viewers are more likely to ignore will have less of an impact on test scores. The standard DMOS measurement gives equal weight to every perceptual contrast difference between the reference and test video. ADMOS proves to be a suitable picture quality measurement, providing higher comparison accuracy against human subjective testing, when human cognition is considered.

Please refer to the application note, "Understanding PQR, DMOS and PSNR Measurements (28W-21224-0)" for more information of PSNR, PQR and DMOS metrics.

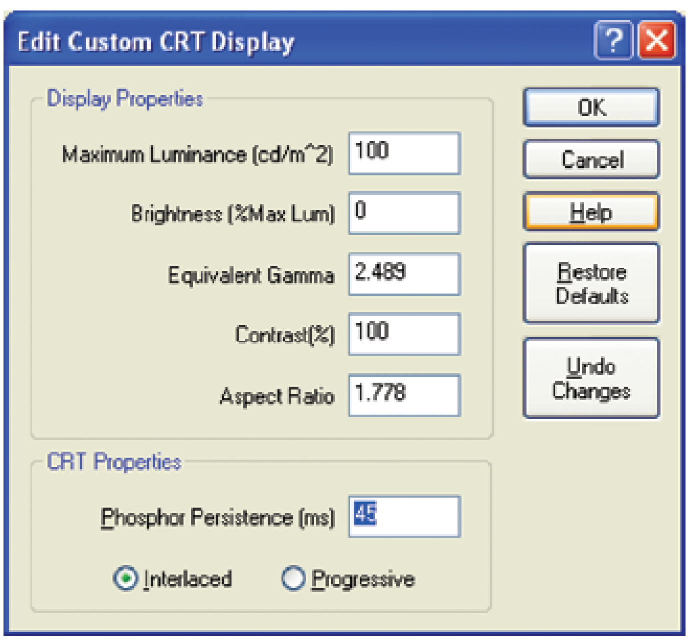
Configuring PQA500 Measurements

The objective measurements provided by PQA500 have extensive user configurability to match the parameters of the measurement model to the conditions employed in the subjective testing—including the display type and the viewing environment.

A Sony BVM-D24EWU picture display monitor was used at the subjective tests conducted by CRC. The PQA500 display parameters were configured for PQR, DMOS and ADMOS measurements in the Display node as follows.

In Display node:

Parameter	Value
Maximum Luminance (candela/meter^2)	100
Brightness (percentage Maximum Luminance)	0
Equivalent Gamma	2.489
Contrast (percentage)	100
Aspect ratio	1.778
Phosphor Persistence (ms)	45
Image Scan	Interlaced

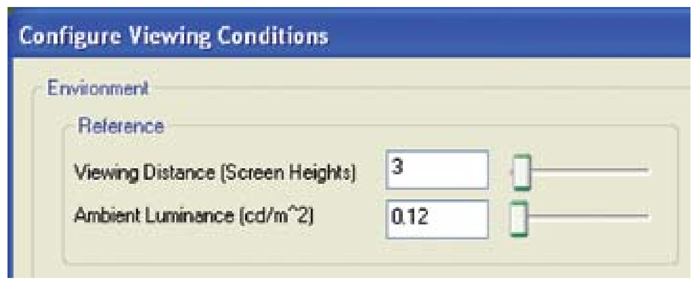


The CRC final report of subjective tests describes viewing environment parameters as well. Those parameters were applied to the PQA500 in the View node.

In View node:

Parameter	Value
Viewing Distance (screen heights)	3
Ambient Luminance (candela/meter^2)	0.12

The ambient luminance value combines the room luminance and the display black level.



"Minimum Acuity" is the parameter that describes how much detail the model "sees," lower values (down to 0) for less detail and higher (up to 1.0 = transparent) for more detail. Preliminary calibration to vision science data related to the DSCQS method resulted in a 'Minimum Acuity' of 0.32. This new value gave a more accurate prediction for this test whereas the default value of 0.38 assumed a typical viewer.

The default numbers of the masking filters, "Similarity Localization" and "Area integration," are chosen under the condition of 5 screen height viewing distance. Since 3 screen height of the viewing distance was deployed in the subjective test conducted by CRC, these parameters were recalculated accordingly.

In Perceptual difference node:

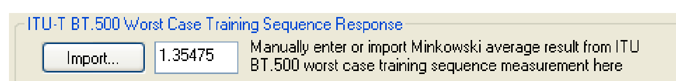
Parameter	Value
Minimum Acuity	0.32
Similarity Localization	0.8
Area Integration	0.02

For DMOS and ADMOS measurements, defining the "worst case training sequence response" in summary node is critical for accurate results that align with subjective assessments. This is the method that used to set the worst case training sequence response.

1. Set the parameters in Display node, View node and perceptual difference node then make the new DMOS-1/ ADMOS-1 measurements.
2. Run DMOS-1/ADMOS-1 measurement with the sequences which were used at "training sequence demonstration" in subjective tests.
3. Copy the Minkowski result in the result file that was created by DMOS-1/ADMOS-1 execution by clicking the "Import button" in summary node in new DMOS-2/ADMOS-2 measurements. Since the worst DMOS in the Subjective rating was 55, the imported Minkowski result was multiplied by 65/55 and re-submitted, where "65" is the DMOS score assumed by the algorithm as the typical worst DMOS score in general subjective evaluations.
4. Now, DMOS-2/ADMOS-2 measurements have been configured to align to the subjective assessment by setting the parameters in Display node, View node, perceptual difference node and summary node.

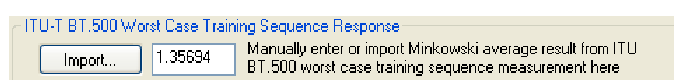
In Summary node of DMOS:

Parameter	Value
Worst case training sequence response	1.35475



In Summary node of ADMOS:

Parameter	Value
Worst case training sequence response	1.35694



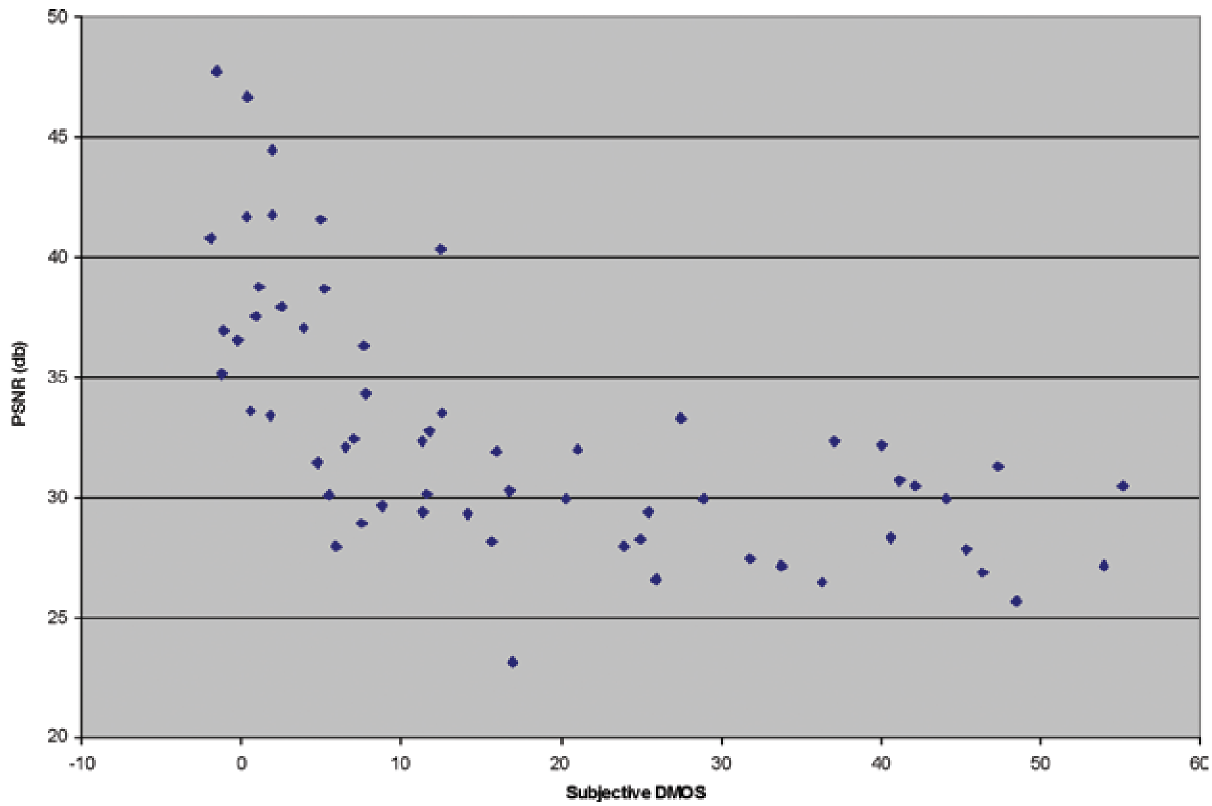


Figure 15. PSNR vs Subjective DMOS.

$$PSNR_{seq} = 20 \log_{10}\left[\frac{235}{\sqrt{\frac{1}{MN_vN_h}\sum_{n=0}^{M-1}\sum_{j=0}^{N_v-1}\sum_{i=0}^{N_h-1}[\,Y_{ref}(i,j,f_n) - Y_{test}(i,j,f_n)\,]^2}}\right]$$

Figure 16. Equation of PSNR.

Comparing PQA500 Measurements and Subjective Assessments

In this section of the paper, the results of PQA500 PSNR, PQR, DMOS and ADMOS measurements are compared to the subjective assessment results. In addition, the pre-configured ADMOS measurement is done without any modification to show the importance of PQA500 user configurability.

PSNR Measurements (Pre-configured)

Peak-Signal-to-Noise Ratio measurements are not perceptual-based measurements. They do not use the PQA500's human vision model. PQA500 makes PSNR measurements in conformance to the T1.TR.74-2001 recommendation titled "Objective Video Quality Measurement Using a Peak-Signal-to-Noise Ratio (PSNR) Full Reference Technique" issued by the Video Quality Expert Group (VQEG). The equation in Figure 16 shows the PSNR measurement result for the overall video sequences as computed by this method.

The graph in Figure 15 shows the relationship between the PQA500 PSNR measurements (shown on the y-axis) and the DMOS values collected from viewers in the subjective assessment (shown on the x-axis). Each point in the plot represents one of the test video sequences. The graph shows that a test video that achieves over 35 dB of PSNR would get less than 20 out of 100 point (the input device in Figure 4 maps to a 100 point scale for fine comparisons) subjective DMOS. However, the test video achieving less than 35 dB of PSNR could get any score of subjective DMOS.

The correlation coefficient between the PQA500's PSNR and the subjective DMOS from the DSCQS assessments equal 0.625.

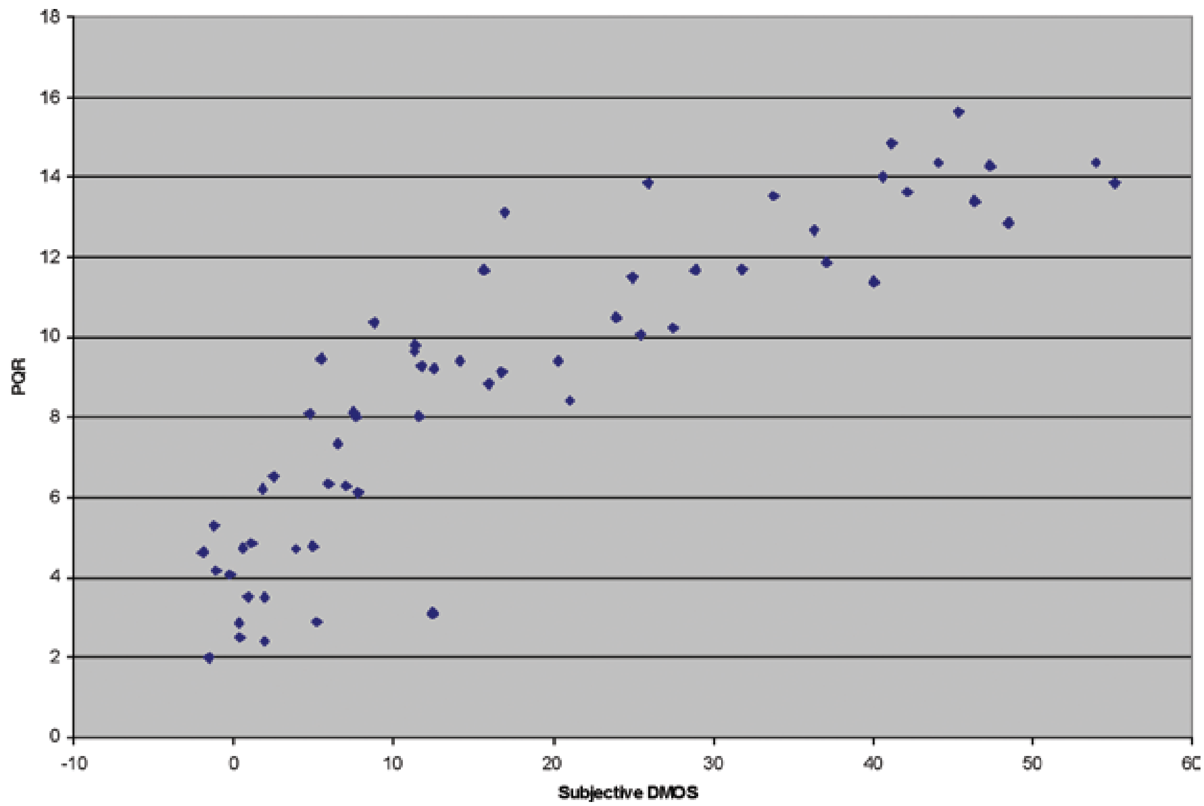


Figure 17. PQR vs Subjective DMOS.

PQR Measurements

As noted above in the discussion on objective picture quality measurements, the PQR measurement evaluates how much viewers notice the differences between the test and references videos. Certainly the more noticeable differences between the test and reference video, the more likely viewers will give the test video a higher DMOS score. Thus PQR scores should track subjective DMOS scores. Unlike the DMOS measurement, however, the PQR measurement is not a prediction of a DSCQS subjective evaluation which evaluates how much impairments viewers perceive between the test and reference video based on the training sequence demonstration.

Figure 17 shows the relationship between the PQA500's PQR measurement (y-axis) and the DMOS values collected from viewers in the subjective assessments (x-axis). Compared to PSNR measurements, the graph clearly shows that changes in the PQA500's PQR measurements correspond to changes in subjective DMOS values. The correlation coefficient between the PQA500's PQR and the subjective DMOS from the DSCQS assessments is equal 0.881.

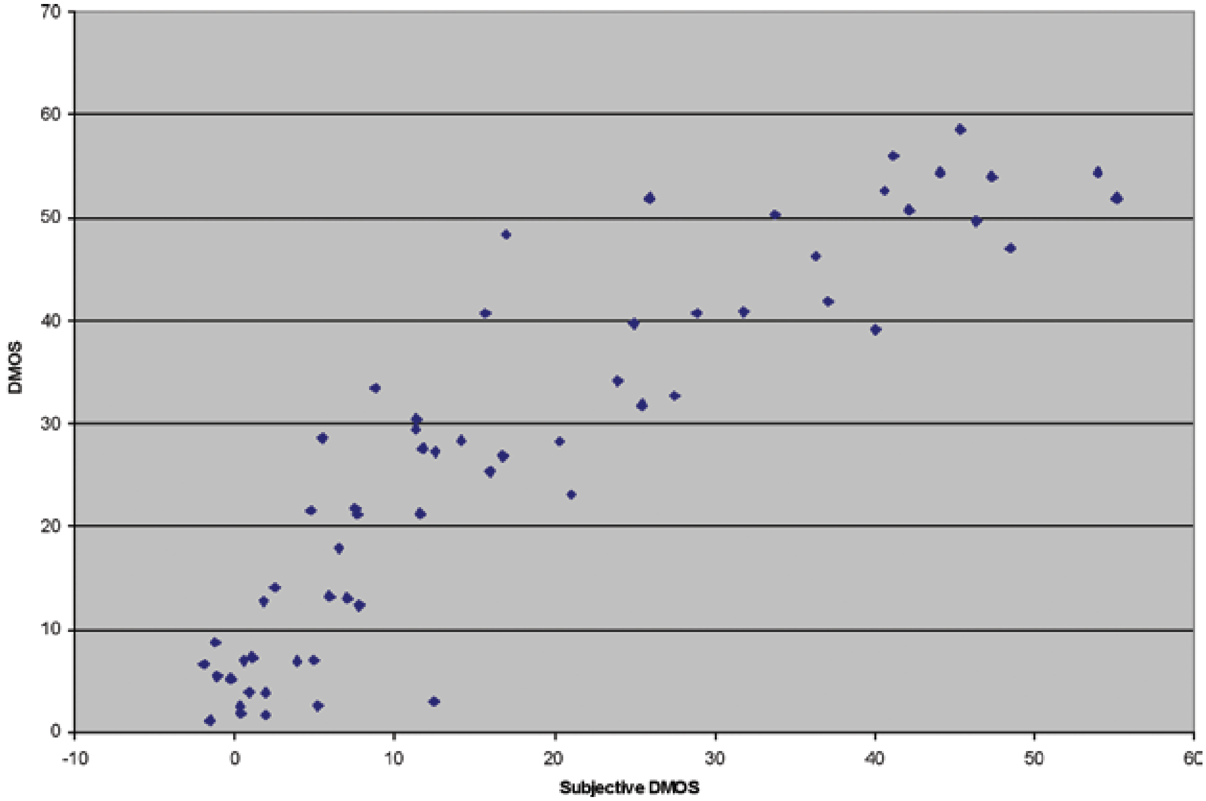


Figure 18. DMOS vs Subjective DMOS.

DMOS Measurements

The PQA500's DMOS measurement is designed to predict the results for formal subjective assessment like the DSCQS procedures that are based on ITU-R BT.500. Figure 18 shows the relationship between the PQA500's DMOS measurement (y-axis) and the DMOS collected from viewers in the subjective assessments (x-axis). The DMOS values show a slightly "tighter" relationship with the subjective DMOS values, producing a correspondingly higher correlation coefficient of 0.903 and RMSE of 7.72.

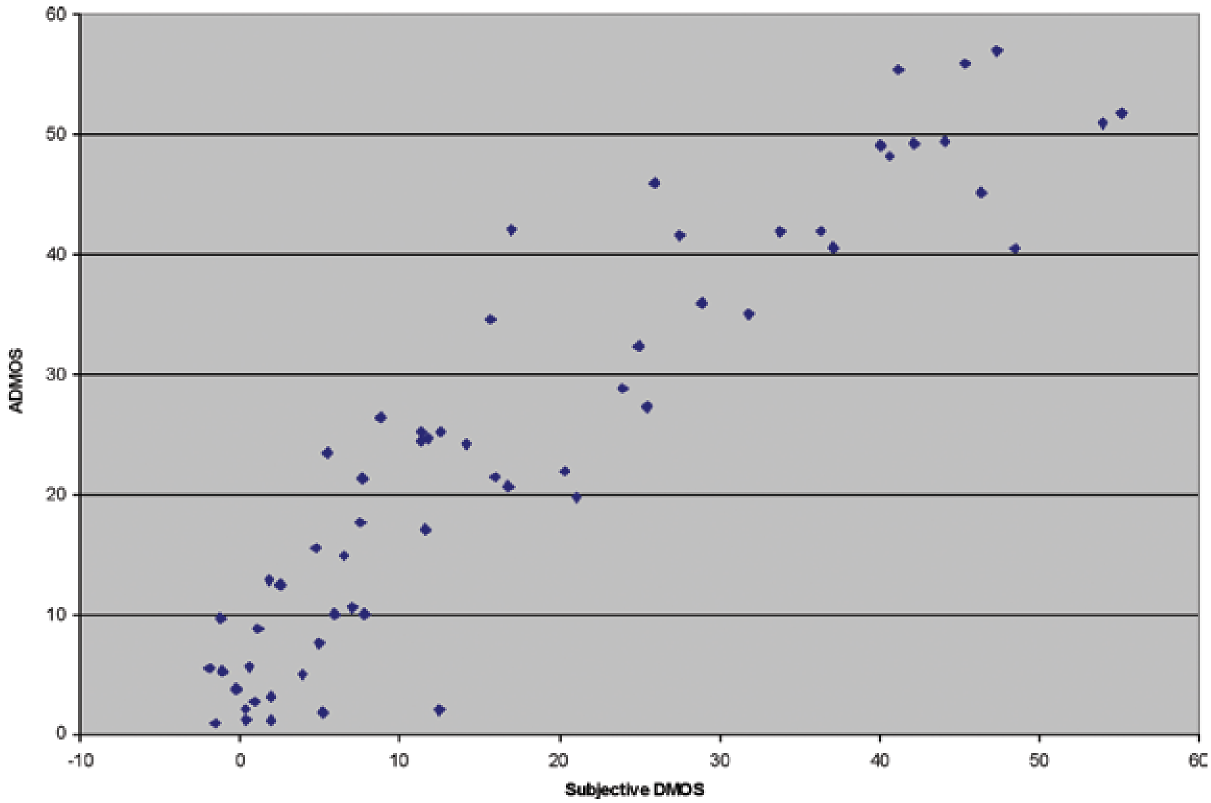


Figure 19. ADMOS vs Subjective DMOS.

Attention-weighted DMOS Measurements

Figure 19 shows the relationship between the PQA500's Attention-weighted DMOS (ADMOS) measurement (y-axis) and the DMOS values collected from viewers in the subjective assessment (x-axis). With attention weighting, the PQA500 more closely models the viewers' actual assessment process. The more tightly clustered points in Figure 18 reflect this improved model as does the higher correlation coefficient of 0.923 and RMSE of 6.67.

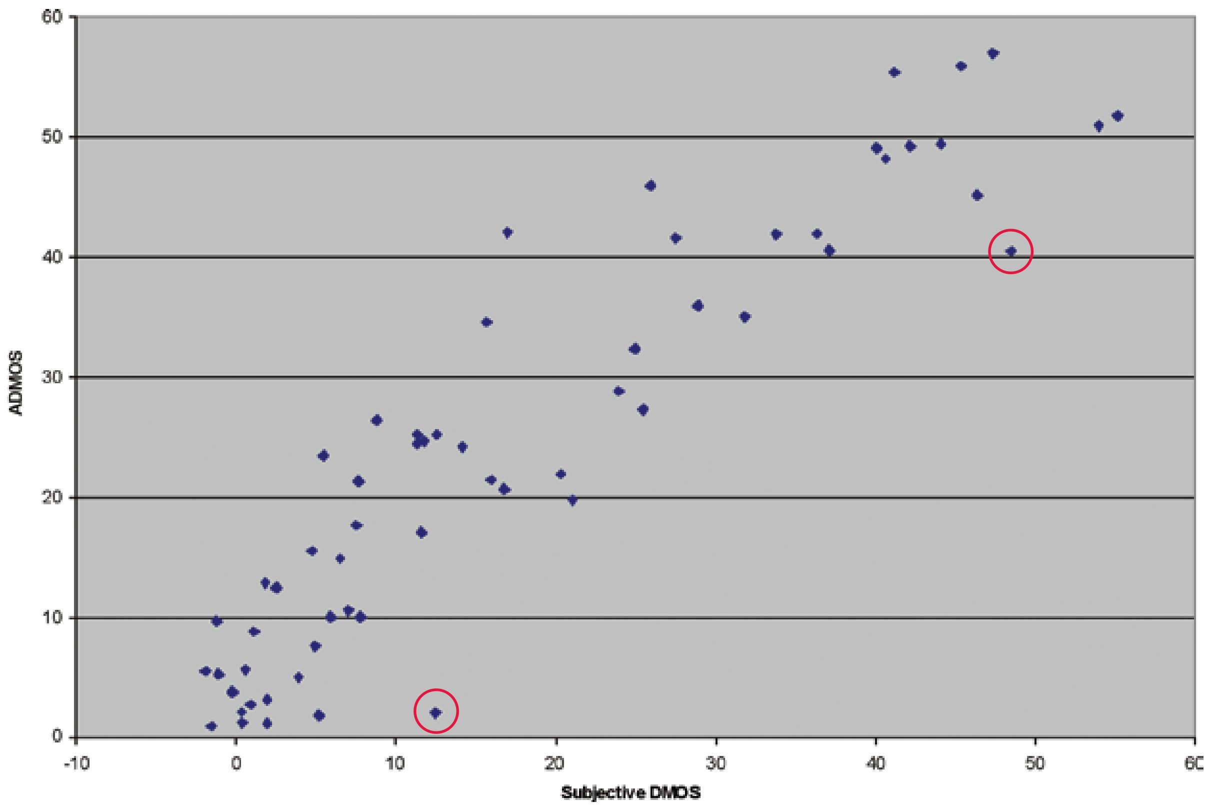


Figure 20. ADMOS without 2 outlier vs Subjective DMOS.

Attention-weighted DMOS Measurements without Outliers

The two ADMOS measurement results red circled in Figure 20 diverged significantly from the other ADMOS measurements. In the video sequences that produced these "outlier" measurements, the primary difference between the reference and test videos appeared in chrominance rather than luminance.

Currently, the PQA500's human vision model does not process chrominance information, which accounts for the divergent results for these two outlier sequence scores.

To estimate the performance of this enhanced PQA500, the outliers were removed from the dataset and the correlation was recalculated. This approach also provides a correlation of the PQA500's current ADMOS measurements for most typical situations where luminance dominates the difference between reference and test video. With this reduced data set, the PQA500's ADMOS measurement had a correlation coefficient of 0.935 and RMSE of 6.11.

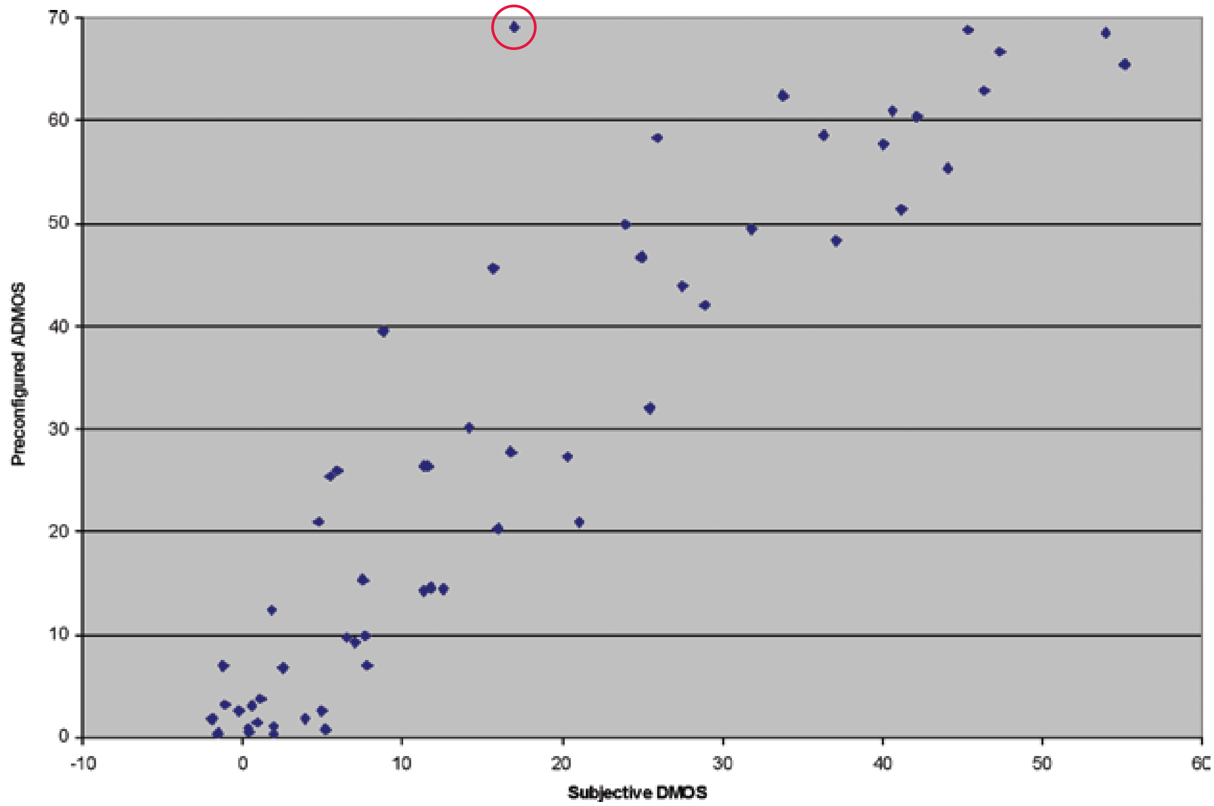


Figure 21. Pre-configured ADMOS vs Subjective DMOS.

Attention-weighted DMOS Measurements (Pre-configured)

The ADMOS measurement described above had parameter modifications based on the preconfigured measurement, “010 HD Broadcast ADMOS measurement.” Here, the original “010 HD Broadcast ADMOS measurement,” was used without any modification and compared with another set of ADMOS measurements with the proper parameter modifications matching the environment that was used for the subjective evaluation.

Figure 21 shows the relationship between the PQA500’s preconfigured Attention-weighted DMOS (ADMOS) measurement (y-axis) and the DMOS values collected from viewers in the subjective assessment (x-axis). It shows correlation coefficient of 0.912 and RMSE of 10.91 without 2 outliners described above. A correlation coefficient difference of 0.02 from the ADMOS without outliners would not usually be considered as a big difference. However, the difference of 4.80 of RMSE couldn't be ignored. The error variation of ADMOS without user configuration was up to 1.8 times bigger than ADMOS with proper configuration. This measurement also created a new outliner red colored in Figure 20 due to the different parameter in the perceptual difference node from one in the ADMOS with proper configuration.

This result shows the importance of setting the parameters in the measurement appropriately in order to get highly accurate objective measurement result that tightly match subjective assessments. PQA500 users are encouraged to set the parameters of an “assumed hypothetical subjective assessment” into the user configuration areas in order to better meet the requirement of the application.

Conclusion

To address the conflicting demands, engineering and quality assurance teams need solutions that help them efficiently and effectively optimize picture quality in their video products and systems. Subjective assessments are too slow and costly. Objective picture quality measurements can offer the needed speed at a reasonable cost. We have shown that the PQA500's perceptual-based picture quality measurements do match subjective viewer assessment. This comparison was performed on 1080-line video processed with H.264 encoding, but the same process can be applied to other video formats and processing. Done properly, these comparisons will show a high correlation between PQA500 measurement results and scores collected in formal subjective assessments.

Properly comparing PQA500 measurement results to subjective assessment involves consideration of several factors:

- Selected video data set and the detail of conducted subjective assessment
- Quality of subjective assessments
- Configuring measurement to account for display and viewing conditions
- Using Attention model

Attention to these factors can lead to correlations with subjective assessment above 0.9.

The PQA provides repeatable objective measurements are shown to correlate well with subjective viewer trials. This means that manufacturer can use the PQA500 during the development of their algorithms to effectively ensure that their design produces the highest possible picture quality.

By using the PQA500 test can be carried our quickly at multiple stages during the design process to validate the picture quality produce by the device.

Consumers today are demand the best possible picture quality and with high resolution display are able to discern more easily picture quality artifacts. Therefore manufacturers and engineers need to ensure that their device produce the best quality picture output to make their product produce a pleasing image to the viewer. The PQA500 provides consumer/professional video manufacturers with a repeatable method of measuring the picture quality and ensuring changes to the design do not degrade the picture quality of their device.

For broadcasters and network operators being able to define delivery specification which give the best picture quality to the viewer will ensure that their program/network will standout from the rest.

Video content providers are now being asked to produce their content in a wider array of formats for a variety of device applications. Within these applications it is important that the picture quality in HD has the same impact as that delivered to the user on a mobile phone. By using the PQA500 video content providers can evaluate the various compression and delivery formats to ensure the best possible picture quality of the program.

Appendix

Reference video description

#1 Driving the car shooting from the flowing car. The background moves fast

#2 European town. Brightly colored

#3 Walking flamingoes. Camera panning following flamingoes

#4 Leafy avenue with camera zoom in

#5 Horse race, panning camera following horse. The background moves fast

#6 Football game, Camera panning with loose shot

#7 Sprinkling water with a lady overlay

#8 A girl walking in the flower garden, Loose shot

#9 Whale show at aquarium. Panning camera following whale

#10 Waterfall, fixed camera

Note: The measurements were edited and run with PQA500 V2.6.2 software. The latest software is available on www.Tektronix.com

#11 Running people at marathon event

#12 Duck taking off from the pond. Close up shot

#13 Waling people waving the colorful flags

#14 Walking people, camera dolly

#15 Airborne, zooming into a tree

#16 A band playing the music at the studio, scene cuts

#17 Coach crossing in front of the fixed camera

#18 New York night view, fixed camera

#19 A man fishing in the river, fish in the water, scene cuts

#20 Camera following astronauts walking

#21 Camera following space shuttle launch

#22 Colorful flowers, rotating trumps

#23 A lady waiving the fan

#24 Still objects with camera dolly

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For Further Information
Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit **www.tektronix.com**

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