

**PQA500**  
**Picture Quality Analyzer**  
**Technical Reference**





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**Technical Reference**

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# General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

*Only qualified personnel should perform service procedures.*

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

## To Avoid Fire or Personal Injury

**Use Proper Power Cord.** Use only the power cord specified for this product and certified for the country of use.

**Ground the Product.** This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

**Observe All Terminal Ratings.** To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

**Power Disconnect.** The power cord disconnects the product from the power source. Do not block the power cord; it must remain accessible to the user at all times.

**Do Not Operate Without Covers.** Do not operate this product with covers or panels removed.

**Do Not Operate With Suspected Failures.** If you suspect that there is damage to this product, have it inspected by qualified service personnel.

**Avoid Exposed Circuitry.** Do not touch exposed connections and components when power is present.

**Replace Batteries Properly.** Replace batteries only with the specified type and rating.

**Use Proper Fuse.** Use only the fuse type and rating specified for this product.

**Wear Eye Protection.** Wear eye protection if exposure to high-intensity rays or laser radiation exists.

**Do Not Operate in Wet/Damp Conditions.**

**Do Not Operate in an Explosive Atmosphere.**

**Keep Product Surfaces Clean and Dry.**

**Provide Proper Ventilation.** Refer to the manual's installation instructions for details on installing the product so it has proper ventilation.

## Terms in this Manual

These terms may appear in this manual:



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**WARNING.** Warning statements identify conditions or practices that could result in injury or loss of life.

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**CAUTION.** Caution statements identify conditions or practices that could result in damage to this product or other property.

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## Symbols and Terms on the Product

These terms may appear on the product:

- DANGER indicates an injury hazard immediately accessible as you read the marking.
- WARNING indicates an injury hazard not immediately accessible as you read the marking.
- CAUTION indicates a hazard to property including the product.

The following symbol(s) may appear on the product:



CAUTION  
Refer to Manual



Protective Ground  
(Earth) Terminal



Standby

# Preface

## About This Manual

This manual provides in-depth descriptions of how to use PQA500 Picture Quality Analyzer. This manual discusses advanced configuration of the measurements and how to best use the measurements to address your picture quality analysis needs.



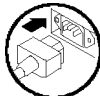
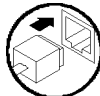



## Documentation

The PQA500 instrument ships with several pieces of documentation. Refer to the following table for descriptions of other documentation for the PQA500.

To read about	Use these documents
Installation and operation (overviews)	<i>PQA500 Picture Quality Analysis Quick Start User Manual</i> . The quick start user manual contains general information about how to put your instrument into service, guides to user interface controls, and application examples.
Measurements (overview)	<i>PQA500 Picture Quality Analysis Measurement Reference</i> . The measurement reference provides a brief description of measurements that are available in the PQA500 instrument.
Server information	Refer to the server documentation for full information on server hardware and software. The server documentation is provided on a CD.

## Conventions Used in This Manual

The following icons are used throughout this manual.

Sequence Step	Front panel power	Connect power	Network	PS2	SVGA	USB
						



# Overview

## How the PQA500 Works

Based on the concepts of the human vision system, the PQA500 provides a suite of repeatable, objective quality measurements that closely correspond with subjective human visual assessment. To provide picture quality measurements, the PQA500 takes two video files as inputs: a 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. The automatic spatial and temporal alignment allows picture quality measurements to be made among different resolutions and frame rates (the alignment can also be performed manually). After spatial and temporal alignment, the PQA500 analyzes the quality of the test video, using measurements based on the human vision system and attention models, and then reports 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 measures such as PSNR (peak signal-to-noise ratio).

A reference video sequence and test sequence can have different resolutions and frame rates. The PQA500 can provide picture quality measurements using any combination of formats, such as HD and SD, or SD and CIF. The PQA500 can also support measurement clips with unlimited sequence duration, allowing a full-length movie to be quantified for picture quality through various conversion processes.

With Option SDI installed, you can use the PQA500 to capture SD or HD video signals in a file for analysis.

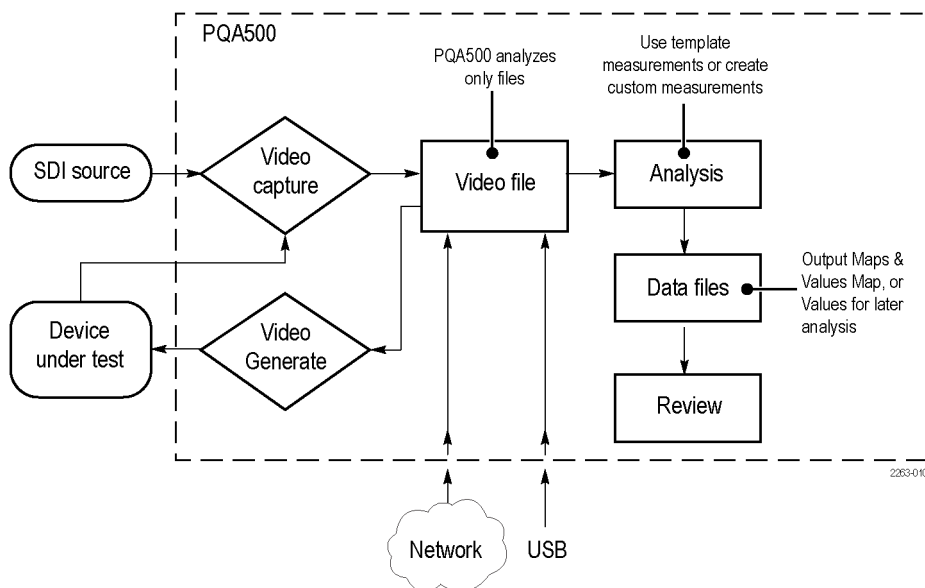


Figure 1: How the PQA500 works

## The Analysis Process

Analyzing picture quality with the PQA500 analyzer occurs in two steps. First, the PQA500 compares the reference and test video sequences. The results can be saved in files if later recall is needed (you can select how results are saved).

In taking a measurement, you select a measurement (either a template measurement or a user-created measurement) from the Configure Measure dialog box. After selecting the measurement, you specify the video file(s) on which the measurement will be taken. Some measurements apply to a single file, though most compare a test file to a reference file. Once you have specified the video files on which to take the measurement, you initiate the measurement.

In the second step, you review the analysis results after the measurement is completed. You can view the results in several ways.

## Template Measurements

The PQA500 application software is configured with 35 template measurements. These measurements are optimized for a variety of uses. You cannot change the parameters of the template measurements, however, you can create new measurements based on a template measurement and save the new measurement under a different name. Measurements are defined through a series of configuration nodes. You change measurement parameters by selecting a configuration node and adjusting its settings to suit your requirements.

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**NOTE.** To accurately simulate the procedure called out in the ITU BT.500 standard, all DMOS predictions require a worst case training. To provide this training, take the selected DMOS measurement once with an example of the worst case video expected for the application according to ITU BT.500 worst case training recommendations. After you have taken the measurement, use the Import function in the Summary Node for the measurement to import the Minkowski value from the measurement results csv file. This sets the training bias for your application as if you were conducting a subjective rating study according to ITU BT.500. Save this new summary setting as your custom measurement for this application with your custom training.

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**Table 1: Template Measurements**

Measurement class	Measurement name
	000 View Video
Subjective Prediction: Full Reference	
Noticeable Differences	
SD Display and Viewing	001 SD Broadcast PQR
HD Display and Viewing	002 HD Broadcast PQR
CIF Display and Viewing	003 CIF and QVGA PQR
D-Cinema Projector and Viewing	004 D-CINEMA PQR
Subjective Rating Predictions	
SD Display and Viewing (with preliminary BT.500 training)	005 SD Broadcast DMOS
HD Display and Viewing (with preliminary BT.500 training)	006 HD Broadcast DMOS
CIF Display and Viewing (with preliminary BT.500 training)	007 CIF and QVGA DMOS
D-Cinema Projector and Viewing (with preliminary BT.500 training)	008 D-CINEMA DMOS
Attention Biased Subjective Rating Predictions	
SD Display and Viewing (with preliminary BT.500 training)	009 SD Broadcast ADMOS

**Table 1: Template Measurements (cont.)**

<b>Measurement class</b>	<b>Measurement name</b>
HD Display and Viewing (with preliminary BT.500 training)	010 HD Broadcast ADMOS
CIF Display and Viewing (with preliminary BT.500 training)	011 CIF and QVGA ADMOS
SD Sports (with preliminary BT.500 training)	012 SD Sports Broadcast ADMOS
HD Sports (with preliminary BT.500 training)	013 HD Sports Broadcast ADMOS
SD Talking Head (with preliminary BT.500 training)	014 SD Talking Head Broadcast ADMOS
Repurposing: Reference and test are independent. Use any combination display model and viewing conditions with each measurement previously listed.	
Format Conversion: Cinema to SD DVD (with preliminary BT.500 training)	015 SD DVD from D-Cinema DMOS
Format Conversion: SD to CIF (with preliminary BT.500 training)	016 CIF from SD Broadcast DMOS
Format Conversion: HD to SD (with preliminary BT.500 training)	017 SD from HD Broadcast DMOS
Format Conversion: SD to HD (with preliminary BT.500 training)	017-A HD from SD Broadcast DMOS
Format Conversion: CIF to QCIF (with preliminary BT.500 training)	018 QCIF from CIF and QVGA DMOS
Attention	
	019 Stand-alone Attention Model
Objective Measurements: Full Reference	
General Difference	
	020 PSNR dB
Artifact Measurement	
Removed Edges	021 Removed Edges Percent
Added Edges	022 Added Edges Percent
Rotated Edges	023 Rotated Edges Percent
% of original deviation from block DC	024 DC Blocking Percent
Artifact Classified (Filtered) PSNR	
Removed Edges	025 Removed Edges Weighted PSNR dB
Added Edges	026 Added Edges Weighted PSNR dB
Rotated Edges	027 Rotated Edges Weighted PSNR dB
% of original deviation from block DC	028 DC Blocking Weighted PSNR dB
Artifact Annoyance Weighted (Filtered) PSNR	
PSNR with default artifact annoyance weights	029 Artifact Annoyance Weighted PSNR dB
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
Format Conversion: SD to CIF	031 CIF from SD Broadcast Artifact Weighted PSNR dB
Format Conversion: HD to SD	032 SD from HD Broadcast Artifact Weighted PSNR dB

**Table 1: Template Measurements (cont.)**

<b>Measurement class</b>	<b>Measurement name</b>
Format Conversion: CIF to QCIF	033 QCIF from CIF and QVGA Artifact Weighted PSNR dB
Attention Weighted Objective Measurements	
General Difference	
PSNR	034 Attention Weighted PSNR dB
Objective Measurements: No Reference	
Artifact	
DC Blockiness	035 No Reference DC Blockiness Percent

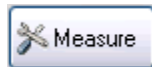
## Creating New Measurements

Most of the time, you will need to create a new measurement to meet your requirements. The Template Measurements have their own settings for parameters and it is likely that your requirements do not precisely match the settings of the Template Measurements.

The easiest way to create a new measurement is by selecting a Template Measurement, modifying the parameters to suite your requirements and saving the new measurement under its own name. Alternatively, you can add a new measurement, add processing nodes as needed, and then adjust the parameters in the processing nodes to meet your requirements.

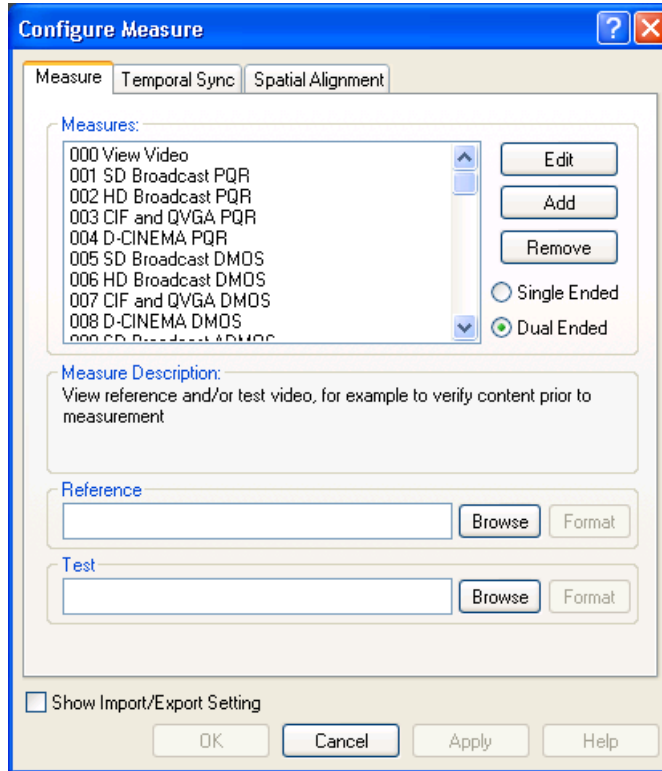
To create a new measurement:

1. Right-click the Measure button.

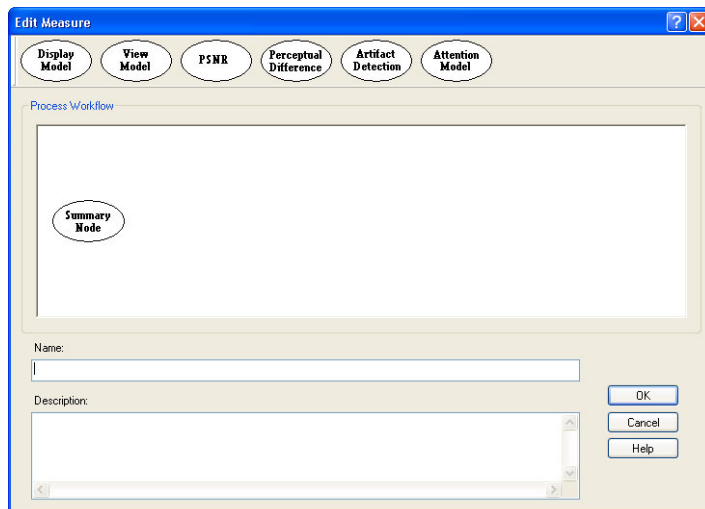




2. To base a new measurement on a template measurement, select a numbered template measurement from the Measures list and click **Edit**.
3. To add a new measurement, click **Add**.



If you click Add to create a new measurement, the PQA500 analyzer displays the **Edit Measure** window with only one configuration node. The measurement has no name or description.



- To change the parameters of your measurement, right-click on a configuration node and select **Configure**. Change the parameters to suit your requirements.

To add a configuration node to your measurement, select the desired node at the top of the window and drag it into the Process Workflow area.

**NOTE.** Once you add a node to a measurement, you can no longer add any of the configuration nodes shown on the left of the selected node to the measurement.

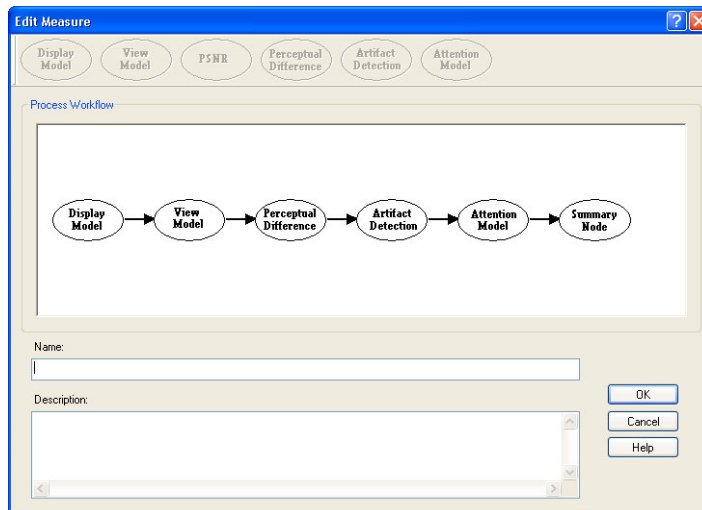
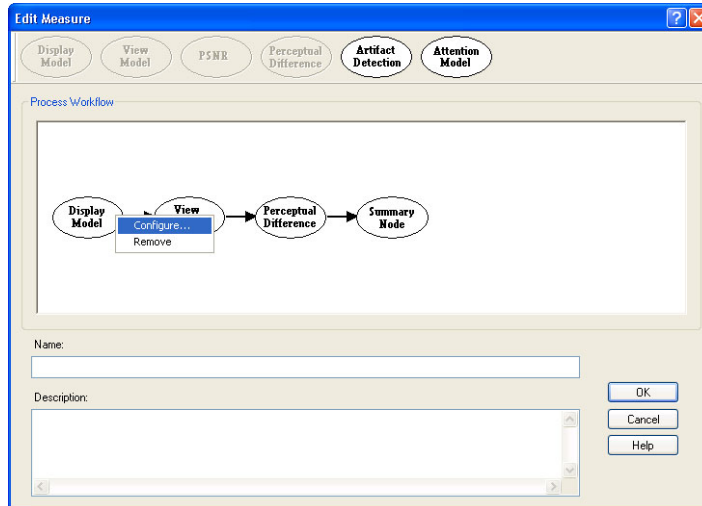
**NOTE.** A measurement cannot contain both the PSNR and Perceptual Difference processing nodes.

To remove a configuration node from your measurement, right-click on the configuration node and select **Remove**.

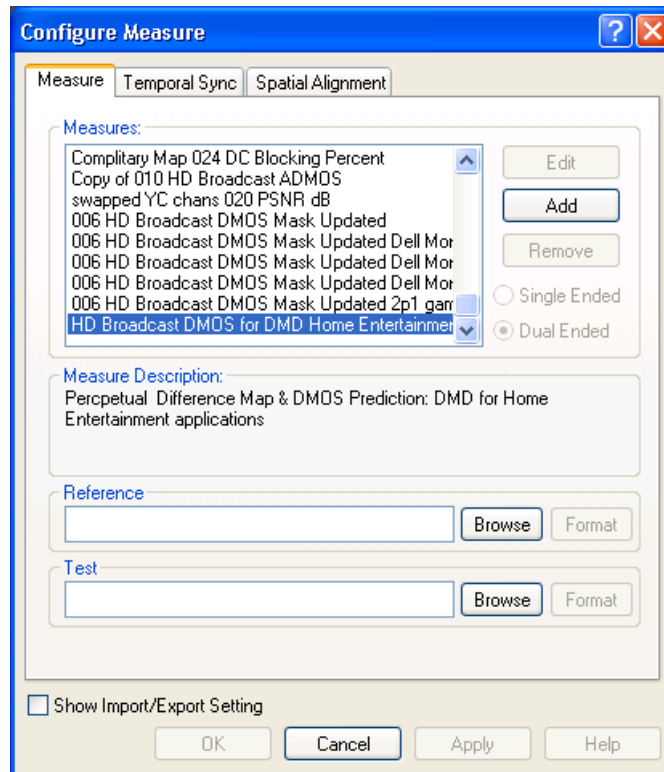
- When you are finished setting the parameters for your new measurement, type a name for the measurement in the **Name** field.

If you based your measurement on a template measurement, the Name field already has a name in it (*Copy of <template measurement name>*). The PQA500 analyzer will not allow you to replace a template measurement.

- You can enter a description for your measurement in the Description field.
- Click **OK** to save your new measurement.



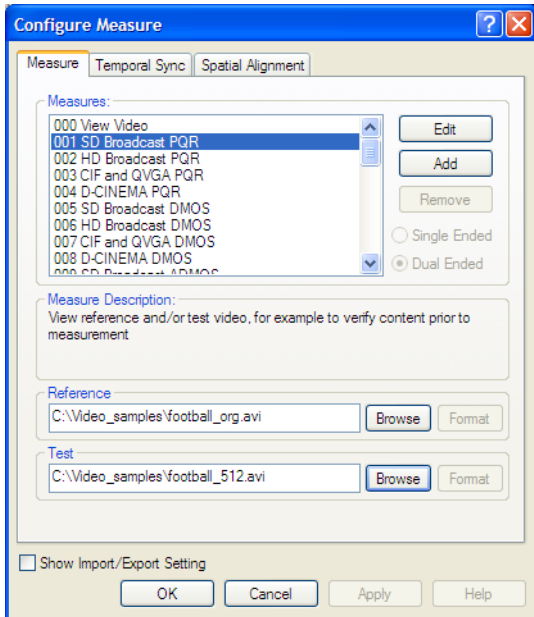
Your new measurement appears at the bottom of the list of measurements in the Configure Measure window.



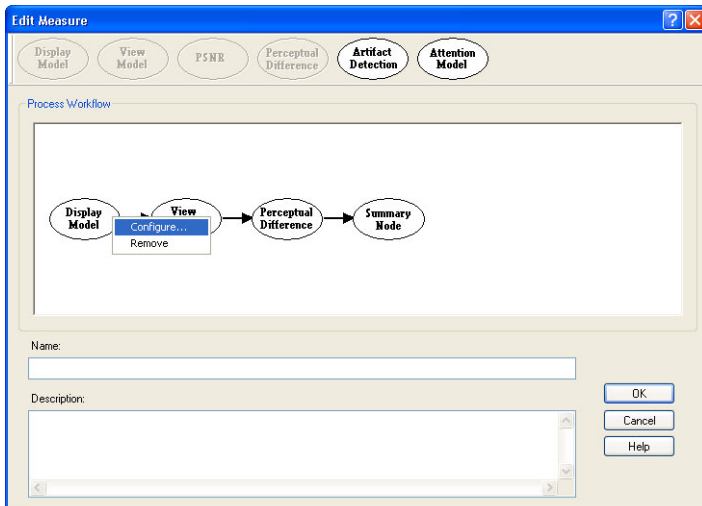
**NOTE.** The Perceptual Difference node uses simulated light units as input, so it always requires the display model to convert the video file to simulated light. Otherwise the measurement results will be invalid. Without a view model, a measurement with a display model and perceptual difference node will have default viewing conditions of 32 pixels per horizontal degree (approximately five screen heights for SD), 0 ambient luminance, and no spatial registration correction. To change these defaults, a view model node is required.

## Configuration Nodes

The parameters that control how a measurement is taken are defined by Configuration Nodes. Measurement parameters are grouped into several configuration nodes. Each configuration node groups related parameters together. You customize a measurement by adding or removing configuration nodes to the measurement and by changing the parameters within the configuration nodes. To access the configuration nodes of a measurement, select **Edit** from the Configure Measure window.



You change the parameters within a configuration node by right-clicking on the configuration node and selecting **Configure** from the pop-up menu.



The following paragraphs list the configuration nodes and the parameters they control. Some of these nodes are not included in every measurement. Two of the nodes (PSNR and Perceptual Difference) are mutually exclusive.

### Display Model

**Parameters Controlled by this Node.** Display technology: CRT, LCD, or DMD. Each technology has user-configurable parameters (Interlace/Progressive, Gamma, Response time, and more). Parameters for the Reference Display and the Test Display can be set independently.

**Usage.** Displays can have a profound effect on perceived video quality. For example, a slow LCD can mask and emphasize different types of distortion. In addition, LCDs can add their unique distortion artifacts. Use this setting to ensure that the viewer response is properly modeled by ensuring the conversion from input video to light is properly modeled.

## View Model

**Parameters Controlled by this Node.** Viewing distance, Ambient Luminance for Reference and Test (can be set independently). Image cropping and registration: automatic or manual control of image cropping and test image contrast (ac gain), brightness (dc offset), horizontal and vertical scale and shift, and speed versus accuracy of the scale and shift correction filters.

**Usage.** The View Model accounts for important aspects of the light that actually reaches the eye, accounting for the environment between the display and the eye. Although ITU BT.500 provides detailed viewing conditions, the actual viewing conditions of your application might not match the BT.500 recommended conditions. This node enables you to adapt the measurement configuration to your viewing conditions, including the addition of ambient light as required by ITU BT.500.

## PSNR

**Parameters Controlled by this Node.** There are no parameters for PSNR. You can only choose whether or not the PSNR result is included as part of the measurement.

**Usage.** Though not nearly as accurate for predicting video quality as measurements that use the human vision model, PSNR is a simple, fast, and objective measurement that can be used for:

- Determining if there is 0 objective difference (bit to bit accuracy) or, if there is a difference.
- A rough guide, in cases where low predicted quality measurement accuracy is OK.

The smaller the display is within the viewer's field of vision, the more accurate PSNR can be. So, for example, for CIF video on a handheld display that is 10 screen heights away, studies show that PSNR can be useful as a quality metric under the right viewing conditions and video content. At the opposite extreme, PSNR generally does a poor job of predicting video quality ratings when compared with the Human Vision Model used by the PQA500 when evaluating an HD, 2K, 4K line video clip viewed at 2 screen heights, especially if the encoder is doing a good job.

## Perceptual Difference

**Parameters Controlled by this Node.** Viewer characteristics (acuity, sensitivity to changes in average brightness, response speed to the moving object, sensitivity to photosensitive epilepsy triggers, and more).

**Usage.** Use the Perceptual Difference node to account for target audience differences in perception. You can use the Perceptual Difference node to model teens watching video on cell phones or football fans watching an HD game on a 58-inch LCD TV. You can also use this node to model for discriminating "expert" users that have different types of higher sensitivities. For example, some expert users may have better acuity or some may be more able to see flashes of (short temporal) distortions. As an example of an expert application, suppose you want to achieve no perceived differences between your test and reference video, but you know the encoder being used can have very short (1 frame) distortions. You could be more conservative than the PQA500 Expert setting by adjusting the temporal sensitivity higher.

Two included user types are typical and expert. The typical viewer included is most appropriate for general population simulation as would be included in a DMOS experiment.

## Attention Model

**Parameters Controlled by this Node.** Overall attention weighting for measures and for each class of attention attractor:

- Temporal (motion).
- Spatial (center, people (skin), foreground, contrast, color, shape, size).
- Distractions (differences between test and reference video, such as artifacts).

**Usage.** Adding the attention model to a measurement improves predicted DMOS accuracy slightly (the amount depends on many things, but, as with PSNR, the degrees of field of view taken by the display is the most important). Unlike PSNR, the larger the display is in the field of view, the more the attention model improves in accuracy. Keep in mind that video quality ratings are statistical and that a video clip with the best mean quality score might not have the best score among the top-most critical portion of the audience. When the attention model is not included in a measurement, the video quality rating is predicted for viewing the video at all portions of the screen evenly (the equivalent of many eyes watching different portions very carefully to see if any portion of the video is different from a reference). However, this is not generally how people watch video. Instead, people tend to look at mostly the same kinds of things, such as people, action and the motion of objects, usually ignoring the background. People are much more sensitive to seeing artifacts if they are looking directly at them than if they are not. The attention model predicts a probability map that indicates where people are most likely to look. For DMOS measurements, this is used to weight the perceptual sensitivities accordingly, thereby improving the DMOS prediction.

The attention model can also be used in conjunction with PSNR and artifact detection: it weights the respective measurement maps with the attention probability to give the portion of distortion that is within the most viewed areas.

The parameters would normally be adjusted to fit the task of a viewer. For examples, for sports, usually people and motion are most important. For a nature show, motion and color might be more important. For a talk show, people and foreground might be most important.

## Artifact Detect

**Parameters Controlled by this Node.** Added Edges (Ringing/Mosquito Noise), Removed Edges (Blurring), Rotated Edges (Jaggies, Edge Blockiness) and DC Blockiness (Removed detail within a block).

**Usage.** This node is used to detect artifacts of different fundamental classes that might be related to particular causes such as encoder filters and excess quantization and analog distortions such as reduced bandwidth of baseband video. For example, DC Blockiness shows up in MPEG-2 video when excess quantization takes place. Including this node in a measurement is especially useful because these types of artifacts are often cited by viewers as features they find especially objectionable. Because some people find one type of artifact less objectionable than another, measuring these artifacts can help engineers make design or configuration trade-offs in a way that optimizes conflicting trade-offs.

Edge measurements are made by comparing the test and reference luminance gradient at each reference pixel. In this way, jaggies are detected as reference diagonal gradients rotated to the vertical or horizontal directions.

## Summary Node

**Parameters Controlled by this Node.** Statistical Units (PSNR, Perceptual Difference, Blockiness). Measure Map settings: Gain, Offset, display as signed data. Worst Case Training for ITU-R BT.500 Training (Default or User application tuned, determined by Worst Case example).

**Usage.** In general, the summary node is used to specify how results are reported. The summary node takes measurement maps and reduces each to a scaler (a single number) of a particular measurement unit. It also takes a sequence of these summary measurement scalars produced over time (one per measurement map per field or frame) and produces a single sequence summary measurement scaler. For example, a predicted DMOS measurement has a perceptual difference map produced per time sample (at the highest rate of field or frame rate) and reduces this map to a DMOS score per time and an overall sequence DMOS score at the end of the measurement. The same processing occurs for measurements such as PSNR, PQR, and Artifact Detection. To reduce the maps to scalars, there are certain choices of units, training and other requirements that are specified in the configuration of the summary node.

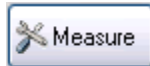
## Changing Configuration Node Settings

### Display Model

The Display Model parameters are used to specify the display technology used by the viewer and the parameters of the display. There are three choices for the type of display used: CRT (cathode ray tube), LCD (liquid crystal display), and DMD (digital micromirror device).

To change the display model parameters:

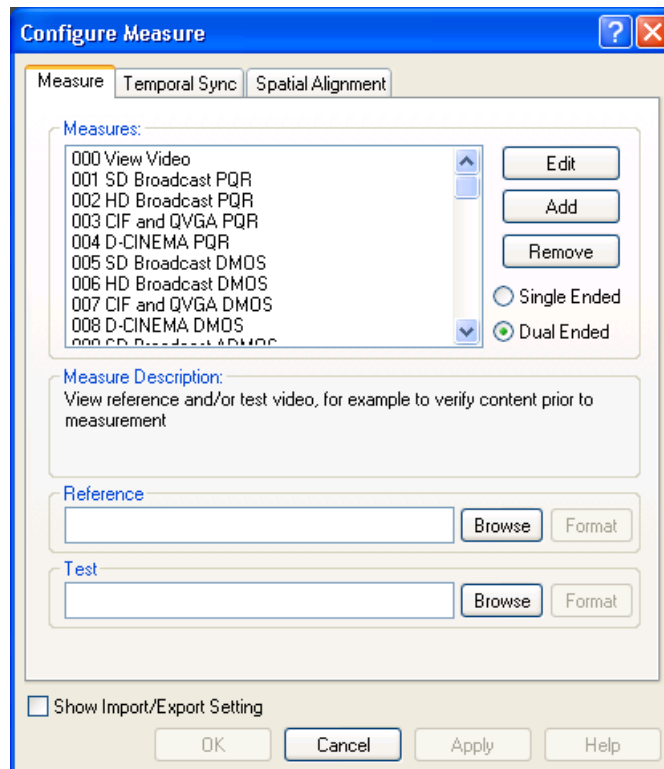
1. Right-click the Measure button.



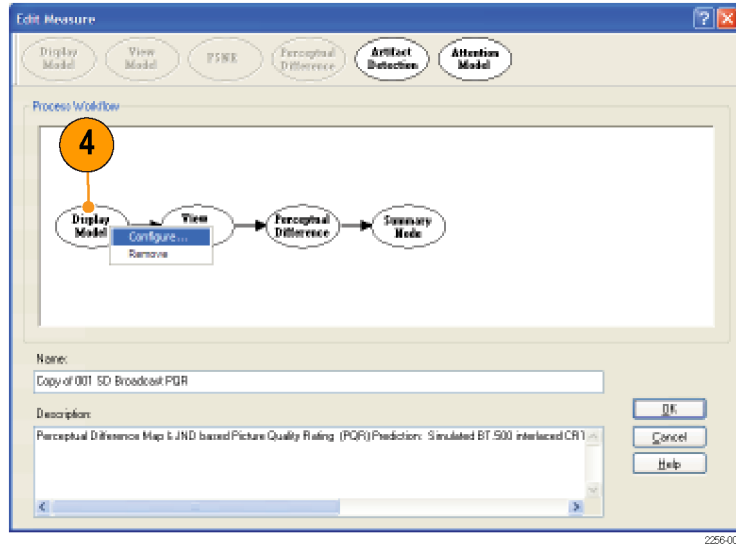
2. Select the desired measurement from the Configure Measure window.

**NOTE.** If you choose a template measurement, you will have to save the changed measurement under a new name.

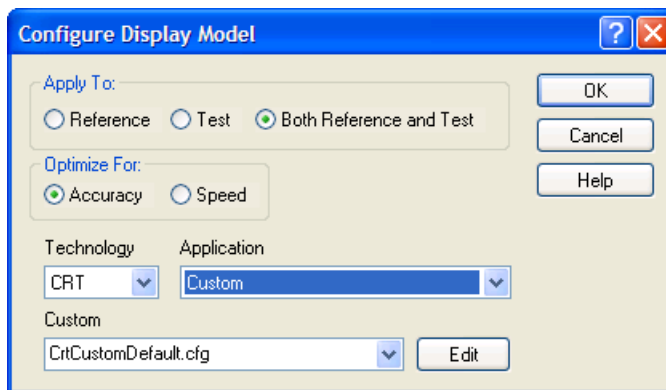
3. Click **Edit**.



- Right-click on **Display Model** and select **Configure**.



- Select the display technology from the **Technology** drop-down list.
- Select **Custom** from the **Application** drop-down list. After you select Custom, the Custom drop-down list is enabled.

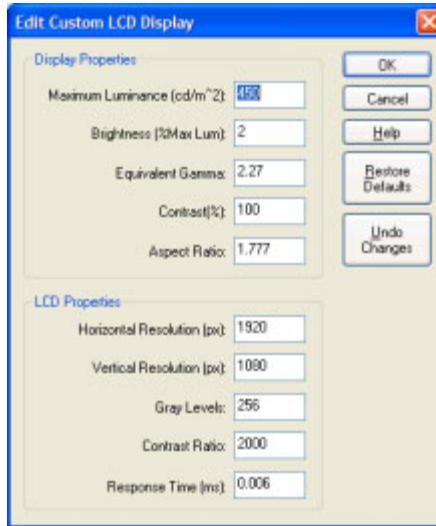




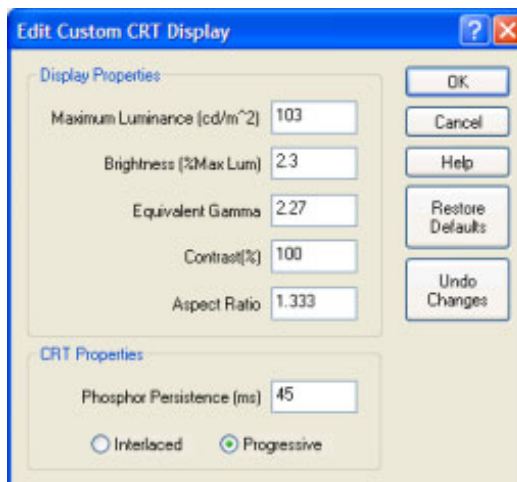
The Edit Custom window contains two groups of settings: Display Properties and CRT/DMD/LCD-specific properties. The parameters in the Display Properties group are the same for every display technology, though the values differ. The parameters in the CRT/DMD/LCD Properties group change depending on the technology. The illustrations to the right show the difference in the properties for an LCD display and a CRT display.

7. Edit the settings as necessary to suit your requirements.
  - Click **Restore Defaults** to return all settings to the initial factory values.
  - Click **Undo Changes** to return all settings to the previously saved values.
8. Click **OK** to save your changes.

**NOTE.** The interlaced CRT setting requires "Top field First" interlaced video content. If "Bottom field First" content is supplied, the display simulation might be inaccurate.



LCD display properties



CRT display properties

The following table lists the parameters that can be set in the Display Model configuration node.

**Table 2: Display model parameters**

Parameter	Setting	Usage
Apply To:	Reference	Select when specifying the settings for the Reference video.
	Test	Select when specifying the settings for the Test video.

**Table 2: Display model parameters (cont.)**

Parameter	Setting	Usage
	Both Reference and Test	Select when specifying the settings to use for both Reference and Test video.
Optimize for	Accuracy	Reserved for future use.
	Speed	Reserved for future use.
Technology	CRT / DMD / LCD	Select the appropriate display.
CRT	Broadcast Monitor, Consumer TV, Computer Monitor	Select for the display application.
LCD	LCD TV, Computer LCD Monitor, Mobile Device	Select for the display application.
DMD	Digital Cinema, Business Boardroom, Home Entertainment	Select for the display application.

The following tables list the default values for the Display Model parameters. If the display you want to test for has different parameters than the default values shown in these tables, you must create a custom configuration file that sets the display parameters as required.

**Table 3: Predefined CRT display parameters**

Display Properties	Broadcast Monitor	Consumer TV	Computer Monitor	Custom Default	HD Default
Maximum Luminance	103	450	103	103	103
Brightness	2.27	2.27	2.27	2.27	2.27
Equivalent Gamma	2.3	2.3	2.3	2.3	2.3
Contrast	100	100	100	100	100
Aspect ratio	1.33	1.33	1.33	1.33	1.77
CRT Properties					
Phosphor Persistence (ms)	10.0	10.0	10.0	45	10
Interlaced	1	1	0	1	0
Progressive	0	0	1	0	1

**Table 4: Predefined LCD parameters**

Display Properties	LCD TV	Computer Monitor	Mobile Device	Custom Default
Maximum Luminance	450	250	450	450
Brightness	2.27	2.27	2.27	2.27
Equivalent Gamma	2.0	2.0	2.0	2.0
Contrast	100	100	100	100
Aspect ratio	1.77	1.33	1.33	1.33
LCD Properties				
Horizontal Resolution	1920	1600	320	1920
Vertical Resolution	1080	1200	240	1080
Gray Levels	256	256	64	256
Contrast Ratio	2000	500	100	2000

**Table 4: Predefined LCD parameters (cont.)**

Response Time (ms)	6	20	80	6
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**Table 5: Predefined DMD parameters**

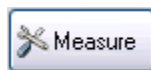
Display Properties	Digital Cinema	Business Boardroom	Home Entertainment	Custom Default
Maximum Luminance	50	30	30	100
Brightness	2.6	2.27	2.27	2.2
Equivalent Gamma	2.3	2.3	2.3	2.3
Contrast	100	100	100	100
Aspect ratio	1.77	1.33	1.77	1.33
<b>DMD Properties</b>				
Horizontal Resolution	2048	1280	1280	1280
Vertical Resolution	1080	720	720	720
Gray Levels	4096	255	255	1024

**View Model**

The View Model specifies the conditions under which the display is viewed and, optionally, performs spatial alignment, cropping, gain, and DC offset adjustment to match the test video to the reference video. You can set values such as the viewing distance and ambient luminance level.

To change the view model parameters:

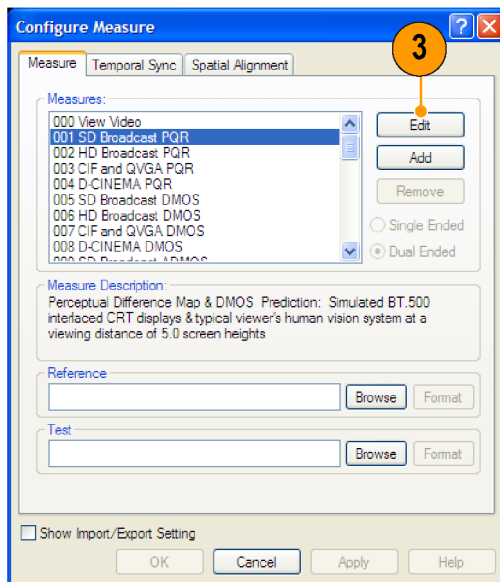
1. Right-click the **Measure** button.



2. Select the desired measurement from the Configure Measure window.

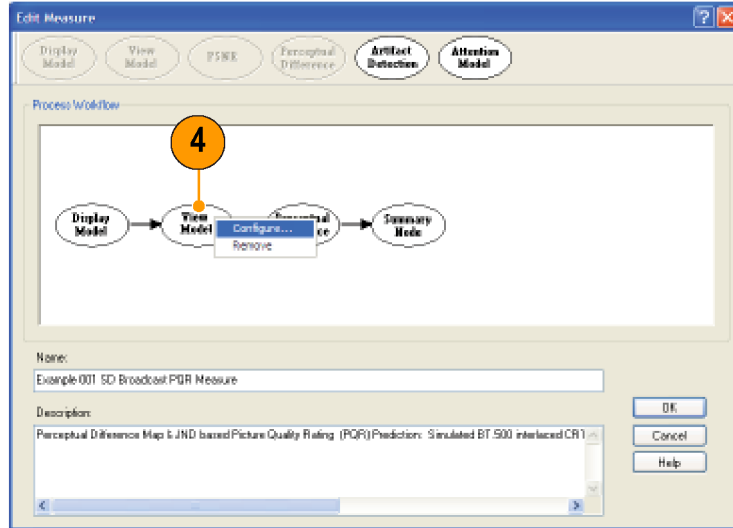
**NOTE.** If you choose a template measurement, you will have to save the changed measurement under a new name.

3. Click **Edit**.



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- Right-click on **View Model** and select **Configure**.

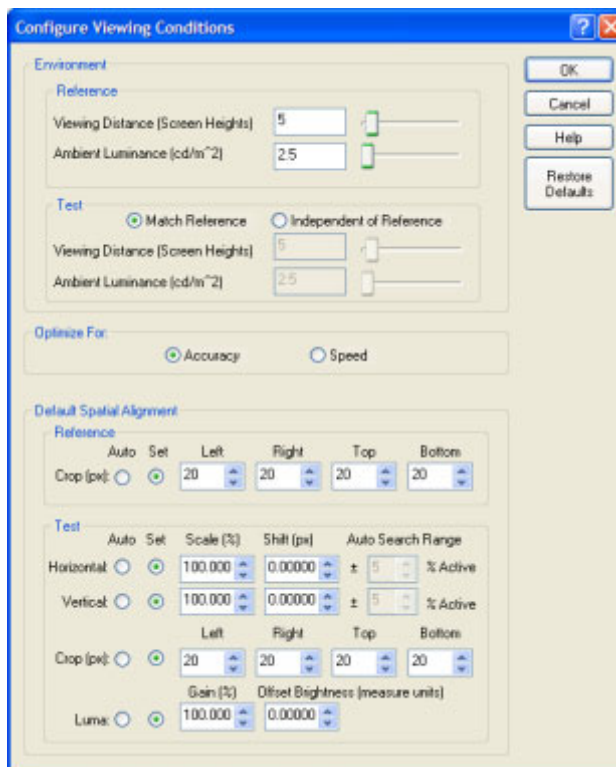


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- Edit the settings as necessary to suit your requirements. All cropping and shift values of the test are in reference pixel units (use post scale values). Offset brightness is in the units used for the view model. For example, if the output of a display model is input, the units are nits (candelas per square meter). But, if video is directly input, the units are LSBs.

Click **Restore Defaults** if you want to return all settings to the initial factory values.

- Click **OK** to save your changes.



The following table lists the parameters that can be set in the View Model configuration node.

**Table 6: View model parameters**

Parameter	Setting	Usage
Environment		

Table 6: View model parameters (cont.)

Parameter	Setting	Usage
Reference	Viewing Distance (Screen Heights)	Specify the distance between the display and the viewer in screen heights.  For compliance with BT.500 recommendations, use 5 screen heights for SD source material. For compliance with BT.710-4, use 3 screen heights. The PQA500 supports values up to 100.
	Ambient Luminance (cd/m <sup>2</sup> )	Specify the light level in the viewing area. Use 0 for a dark room, use 1–3 for moderate lighting, and use a setting >100 for sunny conditions.
Test	Match Reference	Select to set the viewing distance and ambient luminance values to the values used by the reference environment.
	Independent of Reference	Select to set the test environment to different values than those used for the reference environment.
	Viewing Distance (Screen Heights)	Specify the distance between the display and the viewer in screen heights.  For compliance with BT.500 recommendations, use 5 screen heights for SD source material. For compliance with BT.710-4, use 3 screen heights. The PQA500 supports values up to 100.
	Ambient Luminance (cd/m <sup>2</sup> )	Specify the light level in the viewing area. Use 0 for a dark room, use 1–3 for moderate lighting, and use a setting >100 for sunny conditions.
Optimize For:		
Accuracy		Select to use a significantly better reconstruction filter that keeps reconstruction artifacts below 11 bits. Selecting this setting effectively doubles the required time for video alignment (if it is used).
Speed		Select to use a simpler reconstruction filter that almost doubles alignment speed. Selecting this setting results in worst case resample artifacts that are about 60% accurate relative to the values achieved by the Accuracy setting (approximately 10-bit accuracy).
Default Spatial Alignment		
Reference	Crop (pixels and lines)	Use to ignore border pixels, VITS, or other edge components not of interest for measurement, or pixels and lines not included in the test video clip.
Test	Horizontal Scale and Shift	Use to manually or automatically set the test video horizontal spatial registration to match the reference video. <sup>1</sup>
	Vertical Scale and Shift	Use to manually or automatically set the test video vertical spatial registration to match the reference video. <sup>1</sup>
	Crop (pixels)	Use to ignore border pixels, VITS, or other edge components not of interest for measurement, or pixels and lines not included in the reference video clip.

**Table 6: View model parameters (cont.)**

Parameter	Setting	Usage
	Luma Gain and Offset	Select Auto to discount the differences in brightness and contrast between video and displays in quality measurements.

<sup>1</sup> Speed of alignment measurement: The time required to perform an automatic spatial alignment is an exponential function of the Auto Search Range. For video sequences that are already spatially aligned, but need luminance gain and/or DC Offset correction, set the Auto Search Range to 1% (the minimum allowable range) for both dimensions. For small offsets relative to each respective non-active edge, small values can be used for the auto search range that will result in substantial improvements in the time required to perform automatic spatial alignments.

**Changing the Spatial Alignment.** You might need to change the spatial alignment between your test and reference video files to accommodate changes in the test file due to processing. Video files must be spatially aligned to get meaningful results.

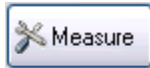
To save time in successive measurements, auto-correction may be run once and then the measured values (cropping, horizontal and vertical scale, horizontal and vertical shift, luma gain, and offset brightness) can be saved as manual settings. This allows the measurement of alignment correction values to be skipped with subsequent measurements, saving substantial processing time.

### Perceptual Difference

The Perceptual Difference node includes the human vision model for quantifying perceptual sensitivities to the tested video, including differences (such as artifacts from codecs, noise or any visible difference of any kind) optionally relative to a reference, changes in perception due to changes in displays, viewing distances, and more. The output of this node is a Perceptual Difference Map in units of percent perceptual contrast. The Perceptual Difference node allows you to adjust parameters for viewer characteristics (such as acuity, sensitivity to changes in average brightness, response speed to changing over time, scene changes, sensitivity to photosensitive epilepsy triggers, and more).

To change the Perceptual Difference parameters:

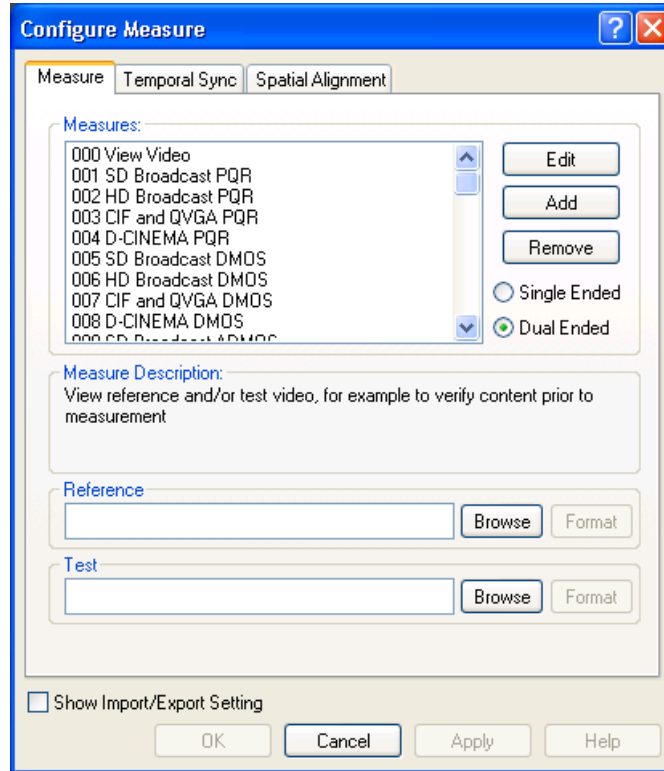
1. Right-click the Measure button.



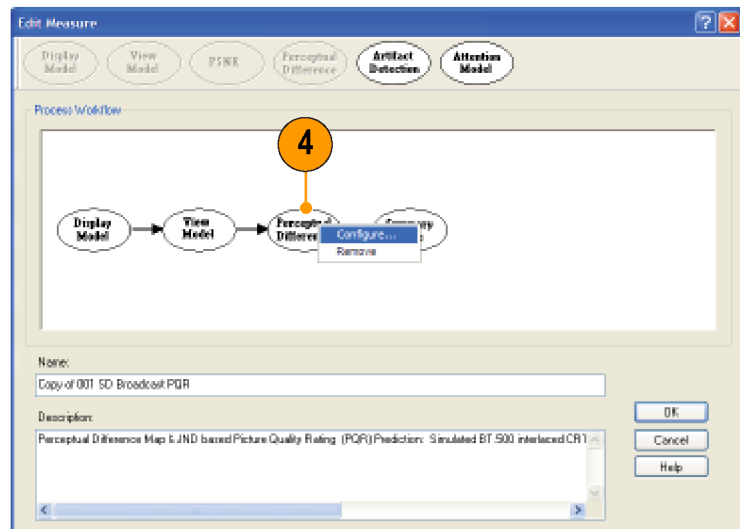
2. Select the desired measurement from the **Configure Measure** window.

**NOTE.** If you choose a template measurement, you will have to save the changed measurement under a new name.

3. Click **Edit**.

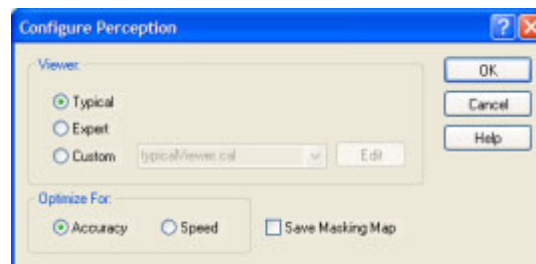


4. Right-click on **Perceptual Difference** and select **Configure**.

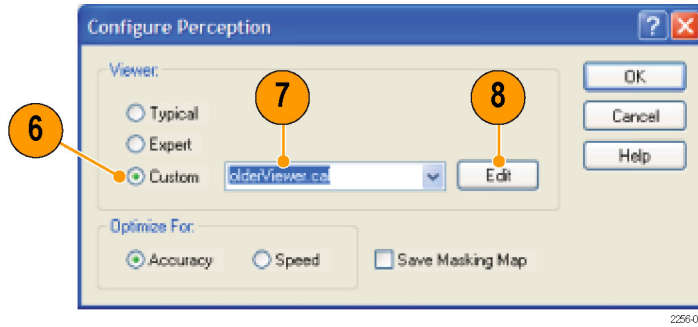


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5. Edit the settings as necessary to suit your requirements.  
If the Typical or Expert viewer does not meet your needs, you can specify the parameters for a custom viewer.



6. Click **Custom**.
7. Type a name for the custom viewer parameters in the Custom field or select a previously created configuration file from the drop-down list.
8. Click **Edit** to display the **Edit Perception Viewer** window.



9. Edit the settings as necessary to suit your requirements.
  - Click **Restore Defaults** to return all settings to the initial factory values.
  - Click **Undo Changes** to return all settings to the previously saved values.
10. When you have completed making your changes, click **OK** to save your changes.



The following table describes the parameters that can be set in the Perceptual Difference configuration node.

**NOTE.** These are all expert user controls. To ensure accurate results, you should not change these settings unless you are familiar with human vision science and have read the white paper “An Adaptable Human Vision Model for Subjective Video Quality Rating Prediction Among CIF, SD, HD, and E-Cinema” (located on the Documentation CD), which explains these parameters as controls for various portions of the model.

**Table 7: Perceptual difference parameters**

Parameter	Setting	Usage
Acuity	Minimum Acuity: 0 (legally blind) to 1 (perfect, super-human acuity). This parameter controls the acuity (center spatial frequency response) in the darkest areas of the image.	The default value is 0.38, which is appropriate for “average” viewers. Use 0.45 for expert viewers. This parameter controls the Tektronix Human Vision Model. Start with the default value and move toward the extreme values to suit your requirements.
	Lum. Sensitivity: 0 (no adaptation) to 1.0 (hyper-sensitive). This parameter controls how the local acuity increases with increases in local average luminance.	The default value is 0.003. Start with the default value and move toward the extreme values to suit your requirements.



Table 7: Perceptual difference parameters (cont.)

Parameter	Setting	Usage
	Area Adaptation: 0 (the entire visible area) to 1.0 (smallest resolved area). This parameter controls (surround spatial frequency) how large an area is integrated to determine the local luminance used for the local luminance sensitivity adaptation. Larger values make adaptation to luminance more localized.	The default value is 0.115, which is for “average” viewers. Use 0.2 for expert viewers. Start with the default value and move toward the extreme values to suit your requirements.
	Adapt. Lum. Sens. : 0 (no adaptation) to 1.0 (hyper-sensitive). This parameter controls the (surround spatial frequency) luminance sensitivity to the area integration adaptation. Large values accelerate the localization of the acuity adaptation to luminance.	The default value is 0.003. Start with the default value and move toward the extreme values to suit your requirements.
	Variance Sens.: 0 (no adaptation) to 1.0 (hyper-sensitive). This parameter controls how the acuity changes from a stimulus of threshold contrast to supra-threshold contrast. Higher values correspond to bigger differences in acuity for low contrast versus high contrast stimuli.	The default value is 0.6. Start with the default value and move toward the extreme values to suit your requirements.
<b>Speed</b>		
	Minimum Speed: 0 (extremely slow) to 1.0 (instant response / zero response time). This parameter controls the speed of visual response in darkness.	The default value is 0.5. Start with the default value and move toward the extreme values to suit your requirements.
	Lum. Sensitivity: 0 (always as slow as in darkness) to 1.0 (fast even for slightly lighter than darkness). This parameter controls how much response time decreases with increase in average local luminance.	The default value is 0. Start with the default value and move toward the extreme value to suit your requirements.
	Adaptation Speed: 0 (virtually no speed adaptation to local luminance) to 1.0 (instantaneous speed adaptation to local luminance). This parameter controls how quickly response time changes to local luminance.	The default value is 0.25. Start with the default value and move toward the extreme values to suit your requirements.
	Adapt. Lum. Sens.: This parameter controls temporal integration used for determining the local luminance value to which speed adapts. Use 0 for static and 1.0 for extreme photosensitive epilepsy.	The default value is 0.0001. Start with the default value and move toward the extreme values to suit your requirements.

**Table 7: Perceptual difference parameters (cont.)**

Parameter	Setting	Usage
	Variance Sens.: 0 (no adaptation) to 1.0 (hyper-sensitive). This parameter controls how the response speed changes from a stimulus of threshold contrast to supra-threshold contrast. Higher values correspond to bigger differences in response speed for low contrast versus high contrast stimuli.	The default value is 0. Start with the default value and move toward the extreme value to suit your requirements.
<b>Masking</b>		
	Noise Masking: This parameter sets the baseline threshold of perception (1 JND) for the highest sensitivities.	The default value is 0.025, which is appropriate for “average” viewers. Use 0.0126 for expert viewers. Start with the default value and move toward the extreme values to suit your requirements.
	Local Lum. Sensitivity: This parameter sets sensitivity to changes in luminance (for example, between reference and test).	The default value is 0.1. Start with the default value and move toward the extreme values to suit your requirements.
	Local Lum. Mask: This parameter controls how much luminance masks (or simple Weber’s Law) compared to other masking.	The default value is 0.1. Start with the default value and move toward the extreme values to suit your requirements.
	Local Similarity: This parameter controls how much masking is due to local image pattern similarities.	The default value is 9000. Start with the default value and move toward the extreme values to suit your requirements.
	Sim Localization: This parameter specifies the localization of similarity masking. For example, 0 is used for no localization and 1 is used for 100% localization of masking due to local similarity.	The default value is 0.9. Start with the default value and move toward the extreme values to suit your requirements.
	Variance Masking: This is a local complexity masking control.	The default value is 0.003. Start with the default value and move toward the extreme values to suit your requirements.
	Area Threshold: This parameter controls the support region area for variance masking by clipping regions below a threshold.	The default value is 0.000075. Start with the default value and move toward the extreme values to suit your requirements.
	Area Integration: This parameter controls the localization of variance masking: use 0 for no localization and use 1 for 100% localization.	The default value is 0.04. Start with the default value and move toward the extreme values to suit your requirements.
Overall Sensitivity	Gain: This parameter sets the overall sensitivity.	The default value is 50. Start with the default value and move toward the extreme values to suit your requirements.

## PSNR

The PSNR configuration node does not contain any parameters. The node is present so that the PSNR result can be added to a measurement. A measurement can include either PSNR or Perceptual Difference, but not both.

PSNR is calculated on a frame-by-frame basis using the following equation from the ATIS Technical Report T1.TR.74–2001.

$$PSNR(t_n) = 20 \log_{10} \left[ \frac{Y_{peak}}{\sqrt{\frac{1}{N_h N_v} \sum_{j=O_h}^{O_h+N_h-1} \sum_{j=O_v}^{O_v+N_v-1} [Y_{ref}(i, j, t_n - d) - \hat{Y}_{proc}(i, j, t_n)]^2}} \right]$$

PSNR is calculated on a sequence basis using the following equation from the ATIS Technical Report T1.TR.74–2001.

$$PSNR = 20 \log_{10} \left[ \frac{Y_{peak}}{\sqrt{\frac{1}{M N_h N_v} \sum_{n=0}^{M-1} \sum_{j=O_h}^{O_h+N_h-1} \sum_{i=O_v}^{O_v+N_v-1} [Y_{ref}(i, j, t_n - d) - \hat{Y}_{proc}(i, j, t_n)]^2}} \right]$$

## Artifact Detection

The Artifact Detection configuration node allows you to specify parameters that control the measurement of spatial artifacts. There are two mutually exclusive artifact detection measurements that can be performed at any one time:

- Spatial Gradient Artifacts
- DC Blockiness Artifacts

The chosen measurement can be used to weight any upstream measurement result by using a cross-fade between the input result map and a 100% artifact weighted result using the "Overall Artifact Weighting" control. A setting of 0 is equivalent to eliminating artifact detection (as if the node did not exist in the processing chain), and a setting of 100% gives full artifact weighting. Full artifact weighting filters the previous map, for example PSNR or perceptual contrast such that areas with no artifact are 0 and areas with 100% artifact are passed unchanged.

**Spatial Gradient Artifacts.** The three classes of spatial gradient-related artifacts measured are:

- Reduction in gradient magnitude at each point (% Lost Edges, usually associated with blurring).
- Increase in gradient magnitude at each point (% added edges, usually associated with ringing, mosquito noise, and similar artifacts).
- Rotated gradient orientations (% rotated edges, usually associated with blocking).

Gradients are measured by applying vertical, horizontal, and diagonal 3 x 3 edge filters and classifying outputs according to the largest magnitude and corresponding sign. Thus, edges are classified into one of eight possible gradient directions: up, down, right, left, 45°, 135°, -45°, and -135°. If the direction changes from diagonal to vertical or horizontal, a rotated edge artifact associated with jaggies is detected.

The weighting for Lost, Added Edges and Rotated Edges is relative: the total is internally normalized to 100%. Note however, that measurement values for added and lost edges are complimentary; if 100% lost edges are measured, zero added measures will be measured.

The Produce complimentary data setting produces a one's compliment of the normalized-to-one result map before being applied to the input result map, if any. Use this setting to measure, for example, DMOS due to artifacts other than those selected. If this setting is chosen, areas without the enabled artifacts are bright in the results map and a perfect (no detected artifact) result is 100% when no upstream node is present, or there is no change for PNSR. For DMOS, artifact weighting is treated as an annoyance weighting. For example, rotated edges of jaggies can be treated as more annoying than blurring by giving the corresponding weights to each.

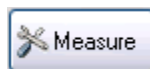
**DC Blockiness Artifacts.** This measurement attempts to find a blocking grid structure and then, for full reference (dual ended) measurements, measures the difference between each pixel and the mean value within the block in which the pixel resides, normalized by the corresponding difference in the reference video. If all pixel values are equal to the block mean in the test, but corresponding pixels in the reference are not equal to the block mean, the measurement result is 100% DC Blockiness.

The denominator can be zero, in which case, the contributing pixel term is zero. Thus, images formed of only DC blocks might have less than 100% results. For example, flat (no detail) areas of the reference and test image that occupy a block will all be zero. However, for detailed areas of the reference video, DC blocked test video will measure very close to 100% DC Blockiness.

In addition to these measurements, when used in conjunction with other measurements such as DMOS, selecting all edge artifacts and "produce complimentary data" gives weight to perceptible differences not due to edge differences. This includes perceptible differences due to noise and other types of artifacts that are not included in these three edge difference classes.

To configure the Artifact Detection parameters:

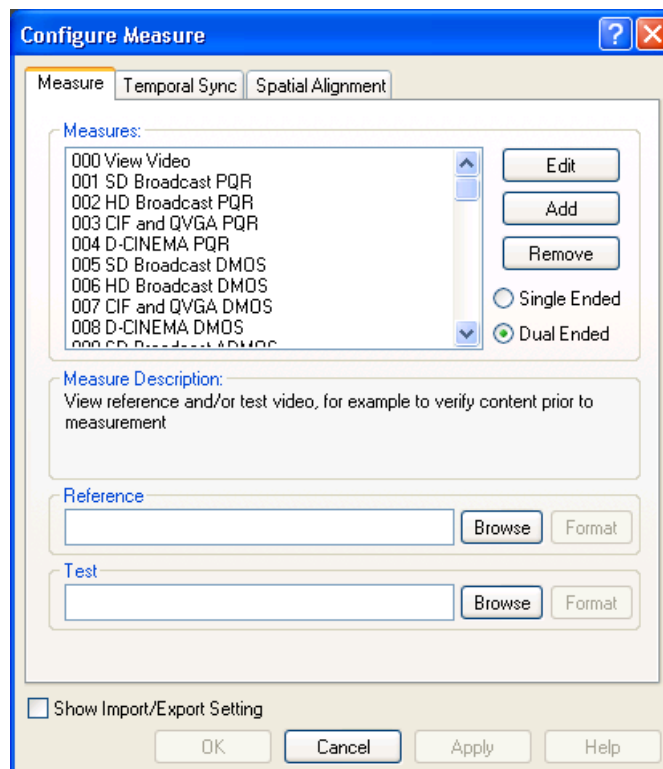
1. Right-click the Measure button.



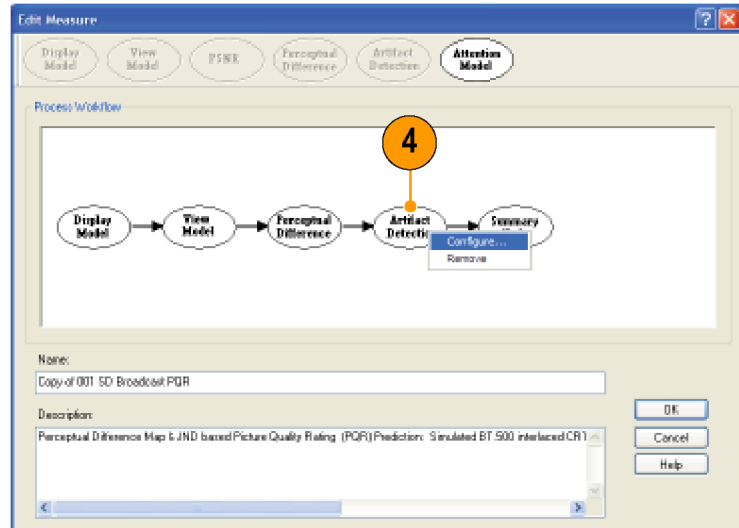
2. Select the desired measurement from the **Configure Measure** window.

***NOTE.** If you choose a template measurement, you will have to save the changed measurement under a new name.*

3. Click **Edit**.

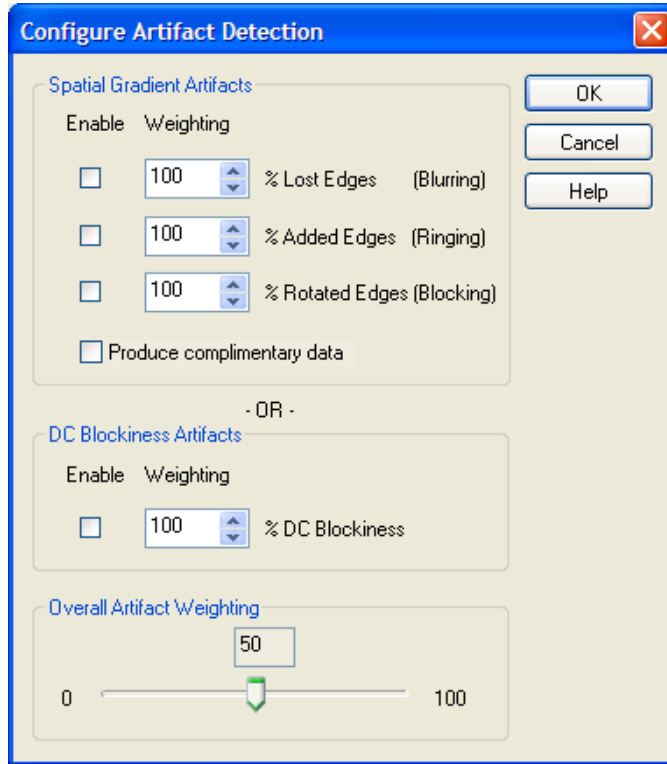


- Right-click on **Artifact Detection** in the Process Workflow area and select **Configure**.



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5. Edit the settings as necessary to suit your requirements.
  - Select or deselect the **Enable** checkbox to determine whether the associated artifact is detected in the measurement.
  - Adjust the value next to each artifact type to specify how much importance is given to the associated artifact.
6. Click **OK** to save your changes.



The following table lists the parameters that can be set in the Attention Model configuration node.

**Table 8: Artifact detection parameters**

Parameter	Setting	Usage
Spatial Gradient Artifacts	% Lost Edges (Blurring)	Lost Edges refers to a transition (an edge) that occurs over a greater distance (or disappears). Lost Edges occur when the brightness difference from pixel to pixel is less than expected from the reference. Enable this setting to weight the importance of Lost Edges in your measurement.
	% Added Edges (Ringing)	Added Edges refers to a transition (an edge) that appears where there wasn't an edge before. Added Edges appear when the brightness difference from pixel to pixel is greater than expected from the reference. Enable this setting to weight the importance of Added Edges in your measurement.

Table 8: Artifact detection parameters (cont.)

Parameter	Setting	Usage
	% Rotated Edges (Blocking)	An example of a rotated edge is a diagonal edge in a reference image that becomes a "jaggy" staircase of horizontal and vertical edges in the test image. In this case, the diagonal edges have been rotated to horizontal and vertical edges. In more complex images, the net effect is that the image has rectangular or block-like artifacts. Enable this setting to weight the importance of Rotated Edges in your measurement.
	Produce complimentary data	In a sense, this setting inverts the results of artifact weighting. For example, if you want to know how much of the difference between the test and reference is not attributed to edge changes (noise is an example), select all three edge artifacts and then select this setting.
DC Blockiness Artifacts	% DC Blockiness	This measurement scans for loss of variance (detail of all kinds, not just edges) within each image block. 100% DC blockiness means that the image only has the "DC" or average value and has lost all other information. 0% means it has lost nothing. This measurement is useful for MPEG-2 codec testing where lowering bit rates eventually results in 100% DC blockiness.

**Table 8: Artifact detection parameters (cont.)**

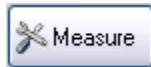
Parameter	Setting	Usage
Overall Artifact Weighting	Range: 0–100	This setting is used in conjunction with other measurements as a cross-fade weighting. In other words, if 100% is used here, it serves as a hard filter to mask the measurement map upstream (perceptual difference or PSNR objective difference) where there are no artifacts detected (unless complimentary data is selected, in which case it does the opposite). Thus, the resulting measurement represents the portion of the relative PQR, DMOS or PSNR that is due to the selected artifacts. However, if 50% is used, it allows 50% of the non-artifact weighted map to go through. This is useful when annoyance weighting is desired in a measurement.

### Attention Model

The Attention Model configuration node allows you to specify how attention (attraction) is measured and specify the weighting for selected characteristics.

To configure the Attention parameters:

1. Right-click the Measure button.

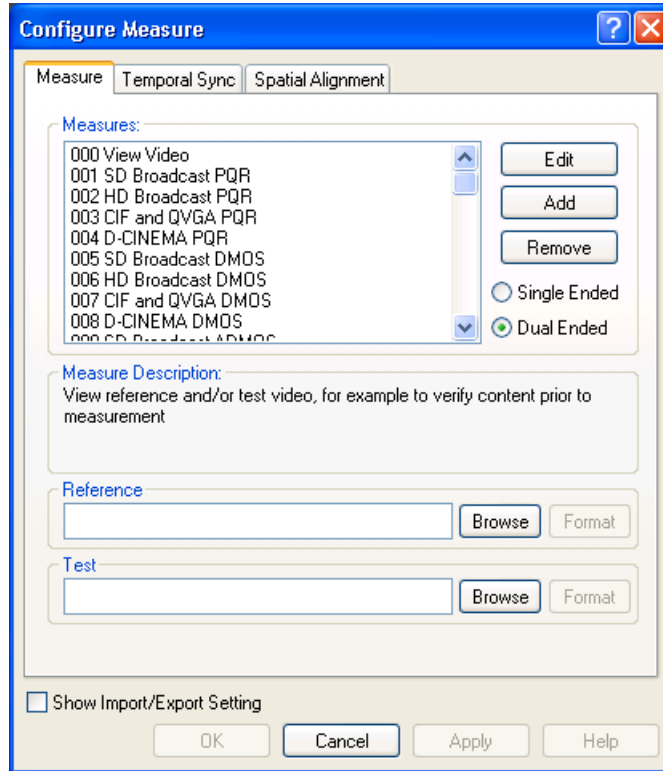




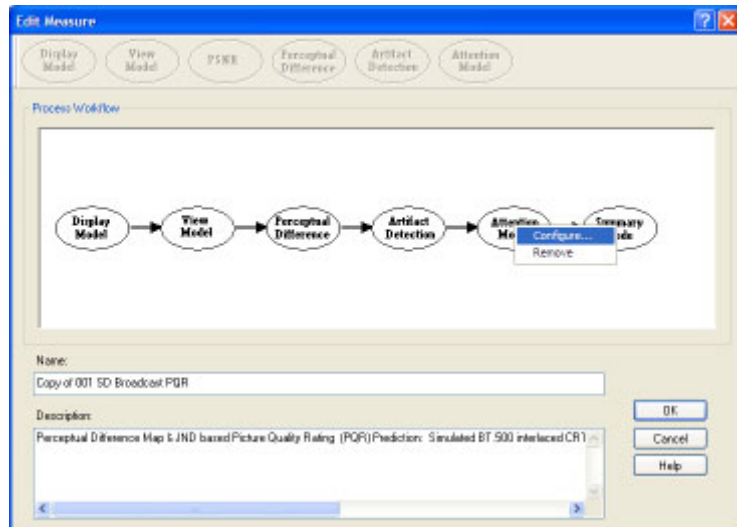
2. Select the desired measurement from the **Configure Measure** window.

**NOTE.** If you choose a template measurement, you will have to save the changed measurement under a new name.

3. Click **Edit**.



4. Right-click on **Attention Model** and select **Configure**.

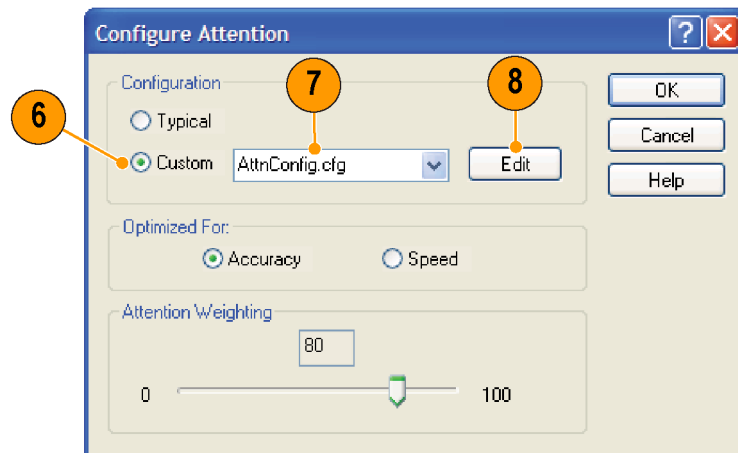


5. Edit the settings as necessary to suit your requirements.



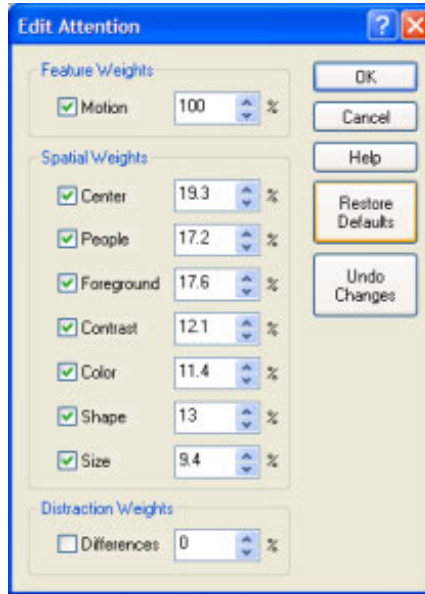
If the Typical configuration does not meet your needs, you can specify the parameters to create a custom attention model.

6. Click **Custom**.
7. Type a name for the custom attention model parameters in the Custom field or select a previously created configuration file from the drop-down list.
8. Click **Edit** to display the **Edit Attention** window.



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9. Edit the settings as necessary to suit your requirements.
  - Select or deselect the checkbox next to a setting to determine whether not the setting is included in the measurement.
  - Click **Restore Defaults** if you want to return all settings to the initial factory values.
  - Click **Undo Changes** if you want to return all settings to the previously saved values.
10. Click **OK** to save your changes.



### How Attention Weighting is Used

Attention Weighting controls the cross fade between the attention probability weighted upstream map and the unweighted upstream map. Measurements that include the perceptual difference node, such as Predicted DMOS, apply attention weighting differently than objective measurements such as PSNR or Artifact Detection. For Artifact Detection and PSNR, the attention probability density map is used directly to attenuate the resulting upstream map. For DMOS, the attention map is normalized such that the perceptual difference map may be both increased and attenuated according to attention probability.

For objective measurements, attention weighting produces the portion of objective measurement where people are most likely to look. For DMOS, the attention weighting effectively excludes areas where people do not look from the measurement, giving a measurement of predicted DMOS primarily using the areas of interest. This means that ADMOS with 100% Attention Weighting will have lower results than those set at 0%, if the areas of highest attention are less distorted than areas where people do not look and vice versa; ADMOS with 100% attention weighting will have higher results than those set at 0% if areas of highest attention are more distorted than areas where people don't look.

The following table lists the parameters that can be set in the Attention Model configuration node.

**Table 9: Attention model parameters**

Parameter	Setting	Usage
Feature Weights	Motion	This parameter accounts for the viewer's interest in motion. Higher values correlate with a greater interest in moving objects. If this parameter is not enabled, object motion is ignored.
Spatial Weights	Center	This setting specifies the importance of the center of the screen.
	People	This parameter signifies the importance of people in the video. People are detected through skin and object shape detection.

**Table 9: Attention model parameters (cont.)**

Parameter	Setting	Usage
	Foreground	In the Tektronix Attention Model, objects are associated with the center and with the edges. The objects that are not associated with the center are considered background.
	Contrast	This setting specifies how important contrast is. If a heavily airbrushed, faded image is placed next to a high-contrast image, people tend to look at the high-contrast image. This setting controls how much this is expected to happen in a particular application.
	Color	This setting sets the importance of color in the image. A higher value for this setting represents greater attention to highly saturated colors over the generally more dull grays.
	Shape	When this setting is emphasized, simple, long and thin shapes are tracked more than complex blobs.
	Size	This setting considers the presence of large objects in the image, because large objects tend to draw more attention in an image.
Distraction Weights	Differences: Weights distractions outside the probable focus of attention. Distractions include artifacts, large differences between reference and test, or other things that might make someone look at an area normally not of interest in program material.	The focus of attention is the point in an image where viewers place their center of vision. Distraction weighting allows the upstream measurement maps (such as perceptual difference, PSNR, and artifact detection) to be used to define additional attention sources. The settings for the parameters in the upstream measurement maps are controlled in the configuration nodes of the associated measurement maps.

The default values for the Attention Model parameters are shown in the following table.

**Table 10: Attention model default parameters**

Parameter	Setting	Default value
Feature Weights	Motion	66.66
Spatial Weights	Center	19.3
	People	17.2
	Foreground	17.6
	Contrast	12.1
	Color	11.4
	Shape	11.4
	Size	9.4

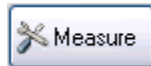
**Table 10: Attention model default parameters (cont.)**

Parameter	Setting	Default value
Distraction Weights	Differences	100

### Summary Node

The Summary Node specifies how results are reported. You can specify statistical units for measurements, whether results are saved and how they are saved, display characteristics of the map, and levels for warnings and errors.

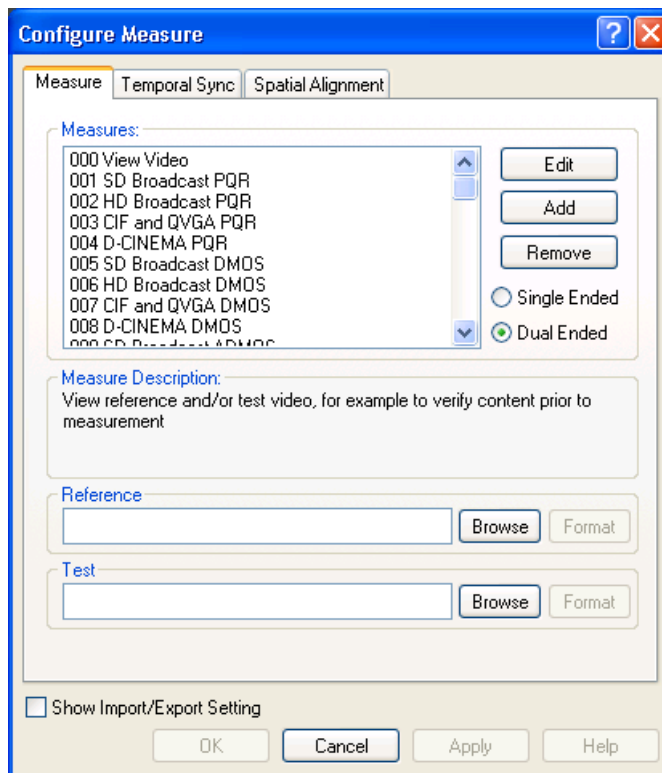
1. Right-click the Measure button.



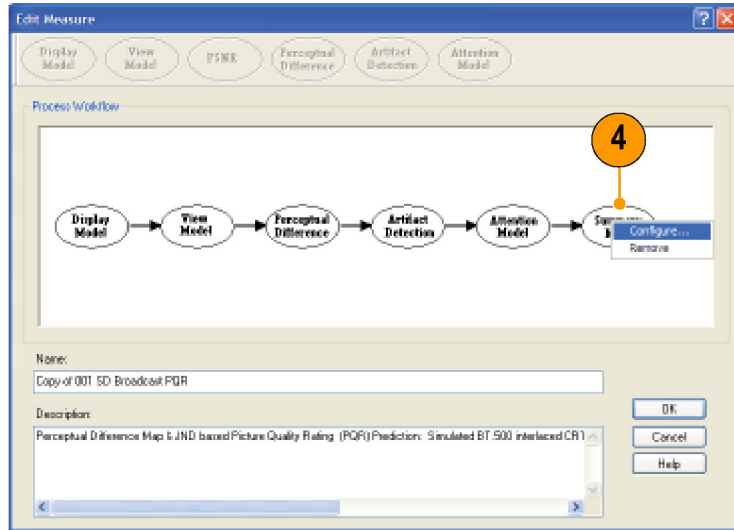
2. Select the desired measurement from the **Configure Measure** window.

**NOTE.** If you choose a template measurement, you will have to save the changed measurement under a new name.

3. Click **Edit**.



- Right-click on **Summary Node** and select **Configure**.

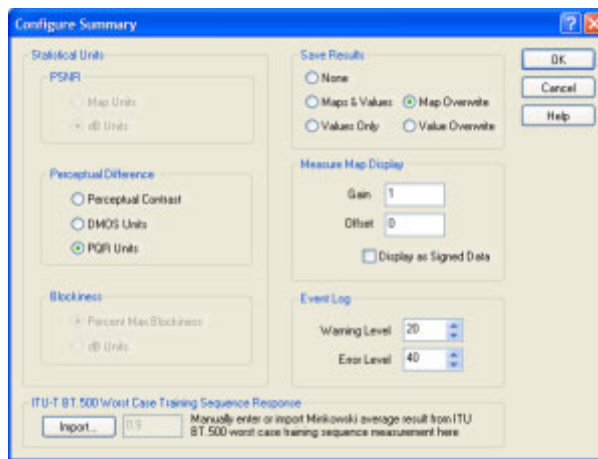


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- Edit the settings as necessary to suit your requirements.

The **PSNR** and **Perceptual Difference** settings are mutually exclusive. Only one setting will be accessible at a time, as determined by the core measurement node.

- Click **OK** to save your changes.



The following table describes the parameters that can be set in the Summary Node configuration node.

**Table 11: Summary node parameters**

Parameter	Setting	Description	Usage
<b>Statistical Units</b>			
PSNR Units	Mean Absolute LSBs	Sets PSNR results units to map units. Only selectable when measuring PSNR. This is a non-standard PSNR measurement, but is useful for some diagnostics. For example, map units would be useful where small differences between large results are of interest.	Selecting this setting might be of interest to some encoder designers and evaluators or other engineers interested in detailed mechanics of distortions.

Table 11: Summary node parameters (cont.)

Parameter	Setting	Description	Usage
	dB Units	Sets PSNR results units to dB. Only selectable when measuring PSNR. This is the standard unit of measurement for PSNR and is equivalent to the RMS difference of reference-test pixels in LSB units. Measured in dB referenced to peak white (also in LSB units).	This is the standard unit for PSNR.
Perceptual Difference	% Perceptual Contrast	Sets the units used in the graph display to % Perceptual Contrast when the Perceptual Difference node is part of the measurement. Percent perceptual contrast is the unit of the perceptual difference map. Percent perceptual contrast of 100% is the maximum possible (except under transient conditions) and 0.1% corresponds to nominal threshold.	Perceptual contrast units can be useful in: <ul style="list-style-type: none"> <li>■ Making reduced reference measurements to compare total perceptual contrast of a reference (one number) to the test (which is measured in single-ended mode, remotely).</li> <li>■ Determining legibility against viewing distance.</li> </ul>
	DMOS Units	Sets the units used in the graph display to DMOS Units when the Perceptual Difference node is part of the measurement. Predicted DMOS quantifies video differences above one JND (Just Noticeable Difference) consistent with human ratings (see ITU-T BT.500 Worst Case Training Sequence Response later in this table).	DMOS units would be an appropriate choice for units when a low to relatively high quality range is expected and you are interested in average quality ratings because the test video is expected to be noticeably different than the reference.
	PQR Units	Sets the units used in the graph display to PQR Units when the Perceptual Difference node is part of the measurement. PQR stands for Picture Quality Rating. One PQR unit corresponds to one JND (Just Noticeable Difference).	PQR units would be an appropriate choice for units when: <ul style="list-style-type: none"> <li>■ An excellent quality level is expected and you are interested in determining if any difference can be seen between the test and reference. Values above 1 are not as valid as DMOS for quantifying this difference.</li> <li>■ You want to compare results with legacy Tektronix measurements.</li> </ul>

Table 11: Summary node parameters (cont.)

Parameter	Setting	Description	Usage
Artifact Units	Percent Maximum Artifact	Sets the units used in the graph display to Percent Max Artifact when Artifact Detection is the measurement. For example, if the artifact detection selected is DC Blockiness, an output of 100% corresponds to the entire image block being a constant ("DC") value, whereas 0% corresponds to no change from the reference.	Percent Maximum Artifact is often more useful if distortion is larger, for example, more than 5% .
	dB Units	Sets the units used in the graph display to dB Units when the Artifact Detection node is part of the measurement.	dB is usually useful under conditions of moderate distortion (less than 5%).
Save Results			
	None	When selected, no measure map or measurement values are saved to disk when the measurement is completed.	Use this setting to conserve disk space and time managing results. If you saved results of previous tests for comparison, selecting this setting enables you to quickly run tests and make comparisons without filling the disk with temporary results that will have to be manually deleted at some point.
	Maps & Values	When selected, both the measure map and measurement values are saved to disk when the measurement is completed. The map and results filenames are incremented by one (file1, file2, file3), for each subsequent run of the measurement.	Select this setting to maintain a full history of tests.
	Map Overwrite	When selected, both the measure map and measurement values are saved to disk when the measurement is completed. The map and results files are overwritten for all subsequent runs of the measurement.	Use this setting to conserve disk space and time managing results. Also, when you are using scripts, you can run a set of tests, check results, adjust the video or measurement settings and rerun the same test with the intent of throwing out the first results. This saves time in managing file storage.
	Values Only	When selected, only measurement values are saved to disk when the measurement is completed. The results filename is incremented by one (file1, file2, file3), for each subsequent run of the measurement.	Use this setting if you want to load measurement results into your own spreadsheet for analysis or into the Graph View for later analysis. Results maps are not saved, thereby significantly reducing use of disk space.



Table 11: Summary node parameters (cont.)

Parameter	Setting	Description	Usage
	Value Overwrite	When selected, only measurement values are saved to disk when the measurement is completed. The results file is overwritten for all subsequent runs of the measurement.	This setting is useful when you are using scripts; you can run a set of tests, check results, adjust the video or measurement settings, and rerun the same test with the intent of throwing out the first results. This saves time in managing file storage.
<b>Measure Map Display <sup>1</sup></b>			
	Gain	Change to adjust the brightness level of the results map. This is useful when optimum contrast for the test and reference video is different from that of the results map.	Use this setting to adjust the contrast in the results map. This does not affect measurement results (such as graphs and summary numbers), only the results map display.
	Offset	Change to shift the baseline of the results map. This parameter can be used in combination with Gain to enhance relatively minor differences in the measure map. This is useful when the optimum reference and test video brightness setting on the display are different from the optimum brightness setting for the results map.	Use this setting to control the brightness in the results map. This setting does not affect measurement results (such as graphs and summary numbers), only the results map display.
	Display as Signed Data	When this option is not selected, results map pixels have intensity proportional to the absolute value of the measurement being made. So for example, for PSNR, brighter pixels correspond to larger differences, both positive and negative differences, between the test and reference. However, when this option is selected, the sign is retained at each pixel so that when a positive offset (see Measure Map Display Offset above) is added, no difference is gray, with positive differences being brighter and negative differences being darker.	In normal use, the results map displays the magnitude of difference between the reference and test. Use this setting to make the measure map show the difference between positive and negative values.
<b>Event Log</b>			
	Warning Level	Sets the green-to-yellow transition point on the indicator bar in the Graph portion of the display.	Adjust this value to shift the warning transition point.
	Error Level	Sets the yellow-to-red transition point on the indicator bar in the Graph portion of the display.	Adjust this value to shift the warning transition point.

**Table 11: Summary node parameters (cont.)**

Parameter	Setting	Description	Usage
ITU-T BT.500 Worst Case Training Sequence Response	Import	Used to import the % Perceptual Contrast Difference Minkowski result from a previously run test. This corresponds to the ITU BT.500 worst case training procedure.	This button is selected to calibrate a given DMOS measurement. First, the DMOS measurement is run using a worst case video sequence. Then the measurement is edited, this "Import" button is pressed, and the DMOS results are selected, thereby importing the Minkowski metric of the perceptual contrast difference (which represents the training result).

<sup>1</sup> These settings are saved with the test results, and are used during the measurement and during the review of saved results. (See page 39, *Adjusting the Display of the Measure Map.*)

# Measure Map

## What is the Measure Map?

The Measure Map is an image frame that uses differences in brightness to indicate reference video pixel co-located differences between the reference and test sequences or the magnitude of a measure, depending on the selected Measure. The brighter the area on the impairment map, the greater the difference between the reference and test sequence or, for no reference measurements, the magnitude of the result. The measure map file has the same name as the executed measurement except for a “map” file extension (for example, 013 HD Sports Broadcast ADMOS.map). The measure map file is located in the same folder as the measurement results files. Measurement results are saved in the folder that contains the test file. The results files are saved in a folder named after the test file with “-Results” appended to the file name (for example, V031051\_Stripy\_jogger\_1280x720p\_3mbs-Results).

The measure map file has no header information and each pixel data is in 32-bit floating point format. For example, the file size for a measure file with 1920x1080 video has  $1920 \times 1080 \times 4 = 829,440$  Bytes/frame. If the measurement has the Display Model node properties set to interlaced, the measurement creates one measure map for each field.

### Measure map units

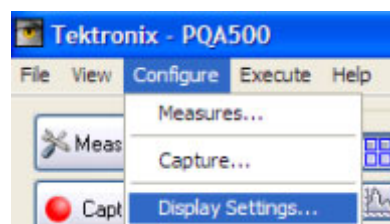
Map type	Units
PSNR	601 8-bit LSBs
Display Model	Nits
Perceptual Difference (including PQR and DMOS measurements)	% Perceptual contrast difference
Perceptual Response (single-ended perceptual response node outputs — perceptual response measurements)	% Perceptual contrast
Artifact Detection	% of maximum possible
Attention Model	Un-normalized probability density

## Adjusting the Display of the Measure Map

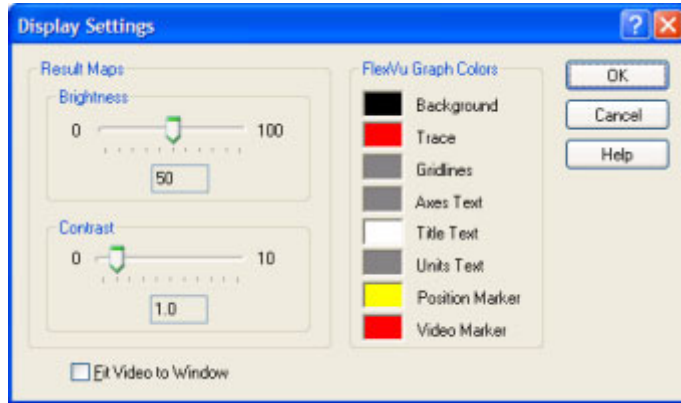
There are times when the difference between a reference and test sequence is not significant and the impairment map will not display a large difference in brightness. You can adjust the impairment map settings to enhance the display of differences. Use the Configure > Display Settings dialog box to adjust the display.

To adjust the display of the Measure map:

1. Select **Configure > Display Settings**.



2. Use the sliders for Brightness and Contrast to suit your needs.
3. Click **OK** to save your changes.



# Using XML Scripting

## XML Scripting Commands

The PQA500 analyzer contains two Dual-Core Intel® Xeon® processors. In normal operation, PQA500 application software utilizes only one core at a time. However, using the PQA500 analyzer XML scripting capability, you can run a measurement sequence on each of the four cores simultaneously. You do this by running the software from a command line. When run in this way, the normal Windows application interface is not launched, but you will get a status readout in the command prompt while the measurement is running. Using the XML scripting capability maximizes system performance when you need to perform multiple measurements. You can run up to four measurements at once.

To use XML scripting, you edit an XML script file to specify the measurement to be made, the reference and test files, and any other parameters necessary to execute the test. To run a script, you open a command prompt window, change directories to the PQA500 application directory, and type "PQxml filename". The measurement will begin and the results will be saved in the same location as they would be if the measurement were run through the regular PQA500 Windows application. There is an example script file provided with the PQA500. The name of the example file is ExampleListOfMeasurementsToMake.xml. It is located in the PQA500 application folder.

The following table describes the XML scripting commands.

**Table 12: XML scripting commands**

Command	Type	Parameter	Description
<b>Log File Commands</b>			
LOG filename	char		Sets the log file name. The log file is saved in the PQA500 application folder.
		Example: LOG filename= "TheReportFile.csv"	
LOG status	char		Sets the log file status.
		start	Start logging.
		stop	Stop logging.
		close	Close the log file.
		Example: LOG status="start"	
<b>Nest Commands</b>			
XMLFILE filename	char		XML file to call from this file.
		Example: XMLFILE file= "ExampleListOfMeasurementsToMake.xml"	
<b>Measurement Commands</b>			
MEASURE name	char		Set the measurement that is shown on the Measure config dialog.
		Example: MEASURE name="001 SD Broadcast PQR"	
startRefFrame	float		Start frame for reference sequence. Copy the number that is shown on the temporal alignment tab in the Config Measure dialog window. Resolution is 1.0.
		Example: startRefFrame="1.0"	

Table 12: XML scripting commands (cont.)

Command	Type	Parameter	Description
endRefFrame	float		End frame for reference sequence. Copy the number that is shown on the temporal alignment tab in the Config Measure dialog window. Resolution is 1.0.
		Example: endRefFrame="149.0"	
startImpFrame	float		Start frame for test (impaired) sequence. Copy the number that is shown on the temporal alignment tab in the Config Measure dialog window. Resolution is 1.0.
		Example: startImpFrame="1.0"	
endImpFrame	float		End frame for test (impaired) sequence. Copy the number that is shown on the temporal alignment tab in the Config Measure dialog window. Resolution is 1.0.
		Example: endImpFrame="149.0"	
dualended	char		Selects the measurement mode.
		false	Specifies single-ended measurement.
		Example: dualended="true"	
reference	char		Specifies the file name for the reference sequence. When an avi or vcap file type is selected, the system ignores the refWidth, refHeight, refRate, refInterlace and refSampleFormat commands.
		Example: reference="F:\PreInstalled_Sequences\PQA500 with Trigger\525\ Mobile+.601-525.yuv"	
refWidth	int		Width of the reference sequence.
		Example: refWidth="720"	
refHeight	int		Height of the reference sequence.
		Example: refHeight="486"	
refRate	float		Frame rate of the reference sequence.
		Example: refRate="30.0"	
refInterlace	char		File format for reference sequence. Please refer to the <i>Supported Video Formats</i> in the Quick Start User Manual
		noInterlace	Progressive video or deinterlaced video.
		planar	Planar format.
		inverted	Top and bottom reversed video.
		fieldOneFirst	A line belonging to field 1 comes first, then a line for field 2, then a line for field 1, and so forth.

Table 12: XML scripting commands (cont.)

Command	Type	Parameter	Description
		fieldTwoFirst	A line belonging to field 2 comes first, then a line for field 1, then a line for field 2, and so forth.
		Example: refInterlace="noInterlace"	
refSampleFormat	char		Color sample format for reference sequence.
		BGR_8_8_8	BGR 24 bits/pixel.
		GBR_8_8_8	GBR 24 bits/pixel.
		YUV_8_8_8	YUV 24 bits/pixel.
		YCbYCr_8_8	YUY2 16 bits/pixel.
		CbYCrY_8_8	UYVY 16 bits/pixel.
		YCbCr_420	YUV420 planar 12 bits/pixel (also use refInterlace to specify noInterlace when using this format).
		Example: refSampleFormat="CbYCrY_8_8"	
refLeftCrop	int		The pixel where the reference sequence is cropped on the left side.
		Example: refLeftCrop="1" refRightCrop="1" refTopCrop="1" refBottomCrop="1"	
refRightCrop	int		The pixel where the reference sequence is cropped on the right side.
		Example: refRightCrop="1"	
refTopCrop	int		The pixel where the reference sequence is cropped on the top edge.
		Example: refTopCrop="1"	
refBottomCrop	int		The pixel where the reference sequence is cropped on the bottom edge.
		Example: refBottomCrop="1"	
autoRefHorizCrop	char		Enables the automatic horizontal crop function to align the reference sequence with the test sequence.
		Example: autoRefHorizCrop="true"	
autoRefVertCrop	char		Enables the automatic vertical crop function to align the reference sequence with the test sequence.
		Example: autoRefVertCrop="true"	
impaired	char		Specifies the file name for the test sequence. When an avi or vcap format file is selected, the system ignores the impWidth, impHeight, impRate, impInterlace and impSampleFormat commands.
		Example: impaired="F:\PreInstalled_Sequences\PQA300 with Trigger\525\ Mobile3mbs+.601-525.yuv"	

**Table 12: XML scripting commands (cont.)**

Command	Type	Parameter	Description
impWidth	int		Width of the test sequence.
		Example: impWidth="720"	
impHeight	int		Height of the test sequence.
		Example: impHeight="486"	
impRate	float		Frame rate of the test sequence.
		Example: impRate="30.0"	
impInterlace	char		The file format of the test sequence. Please refer to <i>Supported Video Formats</i> in the Quick Start User Manual.
		noInterlace	Progressive video or deinterlaced video.
		planar	Planar format.
		inverted	Top bottom reversed video.
		fieldOneFirst	A line belonging to field 1 comes first, then a line for field 2, then a line for field 1, and so forth.
		fieldTwoFirst	A line belonging to field 2 comes first, then a line for field 1, then a line for field 2, and so forth.
		Example: refInterlace="noInterlace"	
impSampleFormat	char		Color sample format for the test sequence.
		BGR_8_8_8	BGR 24 bits/pixel.
		GBR_8_8_8	GBR 24 bits/pixel.
		YUV_8_8_8	YUV 24 bits/pixel.
		YCbYCr_8_8	YUY2 16 bits/pixel.
		CbYCrY_8_8	UYVY 16 bits/pixel.
		YCbCr_420	YUV420 planar 12 bits/pixel (also use impInterlace to specify noInterlace when using this format).
		Example: impSampleFormat="CbYCrY_8_8"	
impHorizScale	int		The percentage value that the test sequence is scaled horizontally to match the reference sequence.
		Example: impHorizScale="100"	
impHorizShift	int		The number of pixels that the test sequence is shifted horizontally to align with the reference sequence.
		Example: impHorizShift="0"	
impVertScale	int		The percentage value that the test sequence is scaled vertically to match the reference sequence.
		Example: impVertScale="100"	



**Table 12: XML scripting commands (cont.)**

<b>Command</b>	<b>Type</b>	<b>Parameter</b>	<b>Description</b>
impVertShift	int		The number of pixels that the test sequence is shifted vertically to align with the reference sequence.
		Example: impVertShift="0"	
impLeftCrop	int		The horizontal pixel to which the test sequence is cropped on the left side.
		Example: impLeftCrop="1"	
impRightCrop	int		The horizontal pixel to which the test sequence is cropped on the right side.
		Example: impRightCrop="1"	
impTopCrop	int		The vertical pixel to which the test sequence is cropped on the top side.
		Example: impTopCrop="1"	
impBottomCrop	int		The vertical pixel to which the test sequence is cropped on the bottom side.
		Example: impBottomCrop="1"	

**Table 12: XML scripting commands (cont.)**

<b>Command</b>	<b>Type</b>	<b>Parameter</b>	<b>Description</b>
autoImpHorizCrop	char		Enables the automatic horizontal crop function to align the test sequence with the reference sequence.
		Example: autoImpHorizCrop = "true"	
autoImpVertCrop	char		Enables the automatic vertical crop function to align the test sequence with the reference sequence.
		Example: autoImpVertCrop = "true"	
autoImpHorizScale	char		Enables the automatic horizontal scale function to match the resolution of the test sequence with the reference sequence.
		Example: autoImpHorizScale = "true"	
autoImpVertScale	char		Enables the automatic vertical scale function to match the resolution of the test sequence with the reference sequence.
		Example: autoImpVertScale = "true"	
autoImpHorizShift	char		Enables the automatic horizontal shift function to align the test sequence with the reference sequence.
		Example: autoImpHorizShift = "true"	
autoImpVertShift	char		Enables the automatic vertical shift function to align the test sequence with the reference sequence.
		Example: autoImpVertShift = "true"	

## FAQs

### Frequently Asked Questions

**Q** What's new in the PQA500 compared to the PQA300?

**A** The PQA500 is the next-generation picture quality analyzer, which builds on the technology and the success of the PQA300. New features in the PQA500 include:

1. Faster analysis than the PQA200 and PQA300
2. Measure any length clip you want (limited only by hard drive capacity and processing time).
3. DMOS prediction measurements, which provide a wider range of picture quality scores than PQR, and which map more closely to subjective human testing than PSNR does. DMOS is more appropriate for quantifying noticeable differences than PSNR or PQR.
4. Support for video resolutions ranging from QCIF to HD to D-Cinema.
5. Support for any video frame rate.
6. The ability to measure cross-resolution and cross-frame-rate material, which allows the PQA500 to evaluate the video quality of format converters.
7. Simulation of human attention to identify which regions of the image are most likely to be focused on by a typical viewer and the option to weight measurement scores based on this information.
8. Artifact detection to measure quality loss due to specific known sources of image artifacts such as blockiness, blurring or ringing.
9. Single-ended measurements for blockiness and attention.
10. Fully configurable measurements that allow the user to specify almost every aspect of the simulated test audience including viewing distance, ambient luminance, type of display used, acuity of the test subjects and much more.
11. Batch-mode processing by an XML script engine that allows automated tests to be run at regular intervals without human interaction. Up to four scripts can be run in parallel without an appreciable reduction in execution speed for each script. This enables substantial throughput improvements over running a single measurement at a time. Scripts run the same measurements as the graphical interface, but run much faster because they do not interact with the graphical interface.
12. Composite results reports (in CSV format—compatible with spreadsheets) of the ensemble of measurements made within an XML script or scripts, because each script can be nested within another script.
13. No stripe is required on video for temporal and spatial registration/alignment.

**Q.** Does the PQA500 come with reference clips?

**A.** Yes. The PQA500 comes with a selection of reference video clips including samples from our Vclips product as well as some video clips that were part of the PQA200 and PQA300 products. You do not need to use the provided clips in order to make measurements.

**Q. Can the PQA500 be used to detect watermarking or subliminal images?**

**A.** The PQA500 does not have any built-in tools to specifically address watermarking or subliminal images. However, a comparison between PSNR and the human vision model can provide some valuable insights when measuring such video sequences. For example, if you compare a PSNR measurement of a video clip with no watermark or subliminal images to the same clip after adding these items to the video clip but having no other visual impairments, the resultant difference map will show the absolute impairment introduced by the marking. The impairment will generally show up as a dark gray region in the PSNR difference map. If you then run a PQR or DMOS comparison between the same two video clips, the resultant difference map shows those portions of the watermark or subliminal image that are visible to the average viewer. This comparison provides an indication of how subtle the marking is and ideally, will be zero or close to zero for completely unobtrusive watermarks. Furthermore, different display technologies can unmask some watermark methods more than others. If you need to keep a watermark below the threshold of perception, you might have to test many different displays and viewing distances to guarantee that the watermark is below the threshold of perception.

**Q. Does the PQA500 run in real-time?**

**A.** No. The PQA500 is designed to be an offline measurement and analysis tool, not a real-time picture quality monitor. However, a QCIF PSNR measurement run four at a time (using XML scripting) runs faster than real time. Additionally, up to four XML scripts can be run simultaneously without significant speed reduction in script execution, thereby substantially increasing throughput.

**Q. Does the PQA500 have any single-ended measurements?**

**A.** Yes. The PQA500 supports single-ended DC blockiness measurements as well as stand-alone simulation of human attention to determine which regions of the video are most likely to draw the eye. These measurements can be run with or without the human perceptual model to estimate either a MOS or objective measures. In addition, single-ended % Perceptual Contrast, added edges, and blockiness measurements can be made at the transmission and receiver ends to make reduced reference measurements by comparison of test and reference results.

**Q. What measurements does the PQA500 perform?**

**A.** The PQA500 can perform PSNR, PQR (same as the PQA300 JND), predicted DMOS (similar to test audience MOS score differences), and artifact and simulated human attention-weighted versions of the above measurements. These measurements can be made between video clips of any resolution and any frame rate and even between different resolution or frame-rate source and impaired content. The artifact and attention measurements can also run separately to give artifact and attention probability measurements, respectively.

**Q. How long does it take to run a measurement on the PQA500?**

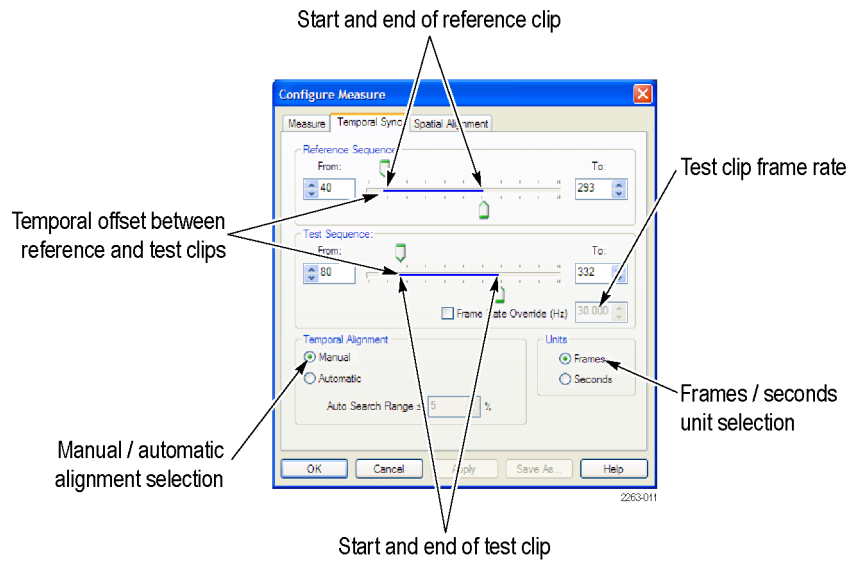
**A.** The amount of time it takes to make a measurement on the PQA500 varies a great deal depending on what type of measurement is being run and what type of content the measurement is being run against. For example, PQR on SD formats runs considerably faster than on the PQA300. The best way to estimate how fast the tool will perform a measurement is to benchmark it on a sample of similar video material with the desired test. If multiple measurements are to be made, XML scripts can be run in parallel for more than a 4X improvement in speed. Each script runs a given measurement faster than when run through the graphical user interface, because the graphical user interface updates the screen for each time interval of the input video.

**Q. How do you account for temporal and spatial alignment between clips in the PQA500?**

**A.** The PQA500 supports both manual and automatic alignment of reference and test clips by adjusting the following items:

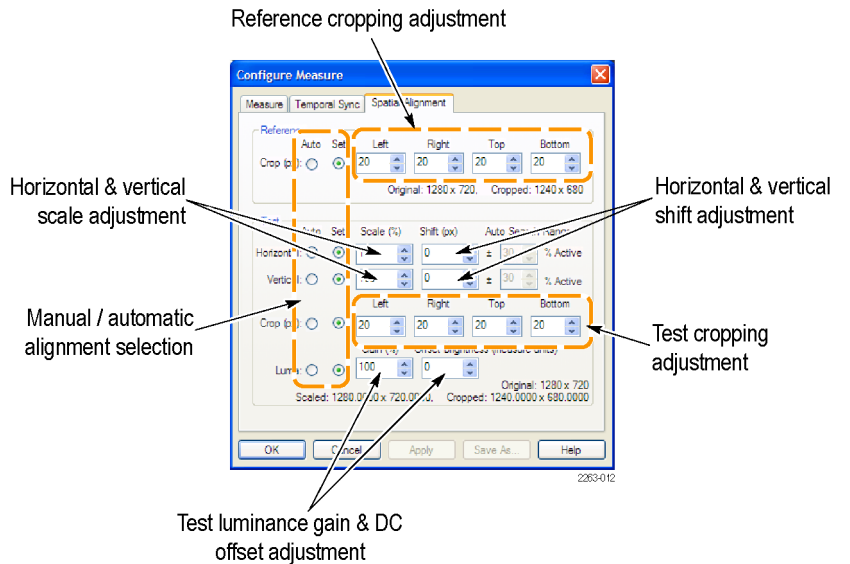
**Temporal Sync**

- Start and end frame or time for reference clip
- Start and end frame or time for test clip
- Temporal offset (shift) between reference and test clips
- Test clip frame rate



**Spatial Alignment**

- Horizontal and/or vertical shift between reference and test clips
- Horizontal and/or vertical scaling or stretching between reference and test clips
- Horizontal and/or vertical cropping between reference and test clips (letterboxing, zoom and so forth)
- Overall luminance gain and/or DC offset between reference and test clips



You can manually adjust each of these parameters while you watch a live-running PSNR until you achieve temporal and spatial alignment between the clips or you can run an automatic alignment that scans a portion of the video clips looking for similarities and automatically determines the best temporal and spatial alignment.

For systems with fixed spatial shift, scale and cropping, run the system spatial alignment once and save the measurements in the View model mode for subsequent measurements to save time taking measurements in the future. Also, note that the Auto Search Range can affect alignment measurement time exponentially. If you know that the Shift, Scale, and Crop settings are very close, reduce the Auto Search Range for much faster performance.

**Q. Is there any limit to the length of clip that can be analyzed by the PQA500?**

**A.** No. The only limiting factors to how long a clip you can analyze are the capacity of the hard-drive and the amount of time required to perform the measurement.

**Q. With subjective testing ratings being the benchmark in the market, how does the PQA300/PQA500 correlate to those results?**

**A.** The PQA300 has the only independently verified objective and repeatable score (PQR) that strongly correlates to subjective testing ratings (up to 90% correlation). As the first to market with a picture quality analysis system with a repeatable objective score, it has been recognized in the market as the de facto standard, which includes winning the Emmy Award for Technical Excellence in 2000.

The predicted DMOS of the PQA500 goes further to actually predict the DMOS values directly rather than simply correlate to DMOS in another scale. The ITU BT.500 training simulation makes this possible, as well as significant development of both threshold and suprathreshold perceptual contrast prediction accuracy of the new human vision model.

**Q. What is considered a “good” PQR score?**

**A.** A “good” picture quality score depends greatly on the system being tested. Ideally, a PQR score of 0 is perfect, but you would only see a score that low with a very high-quality SDI loop through. Any composite video will likely see a score of 3 to 4 on a high-quality loop through from the NTSC/PAL conversion alone. As a general rule of thumb, a PQR score of 1 is considered to show little or no perceived impairment. A score of 3 would show some impairment, but it would not be very noticeable. For PQR values above 1, DMOS is a more appropriate measurement for quantification of video quality. A PQR score of 10 or more would show clearly observable impairment. For a high-quality MPEG encoder/decoder system, you might see PQR values ranging from 3 to 14, roughly corresponding to bit rates of 12 Mbps to 3 Mbps. For more information on PQR scores, see the Tektronix application note *Measuring and Interpreting Picture Quality in MPEG Compressed Video Content* (available for download on [www.tektronix.com](http://www.tektronix.com)).

**Q. What is considered a “good” DMOS score?**

**A.** DMOS is the difference between two MOS (Mean Objective Score) values. The 100 point scale used in the PQA500 corresponds to the 100 point range usually used in the analysis of DMOS. A MOS generally uses a 5 point scale, with each integer assigned to a subjective quality adjective such as “excellent” for 5 and “poor” for 1. Thus, on a 5-point scale with an excellent reference, a DMOS of  $\leq 1$  is considered “good.” On the 100-point scale, this corresponds to a DMOS of  $\leq 20$ . The scale also depends on training. (See Table 11 on page 34.)

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