

# HD and SD Analog Component Video Spatial Distortion Measurements with the VM6000



## Requirements for Managing Display Formatting in Analog Component HD and SD Video Signals

With many combinations of video displays and signal formats available during the SD/HD transition, the consumer could easily be missing a part of the picture. Important areas in the picture are protected in program production, using safe-action and safe-title guidelines, but these will become less important in the future as a more viewers watch programs in wide-screen, High Definition formats. A partial solution to this issue is aspect ratio conversion to fit the signal to the viewer's chosen display format.

Additional issues remain, including conversion between almost-similar standards, for example the fit of a program converted from the standard definition serial digital 601

format, with 720 samples per line, for transmission in the 704 samples per line ATSC digital broadcast format. Reformatting can require that images are fit into a new aspect ratio, width vs. height, truncating one side or the other of the original picture. This reformatting presents problems for equipment manufacturers, broadcasters, editors, and other video professionals because equipment may be set to incorrect modes or malfunction. The VM6000 Spatial Distortion measurement provides a precise measure of fit, shift, offset, and cropping or missing picture elements, between a converted picture signal and a reference, industry standard display format.

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## VM6000 Spatial Distortion Measurement

The Spatial Distortion measurement provides a point-by-point positional comparison of the incoming signal vs. a stored reference bitmap version of the same signal. From this comparison, the VM6000 determines the horizontal start and end, vertical start and end, horizontal and vertical size and offset, and any spatial offsets within the field or frame. This provides a measurement of any undesirable distortions created by a device under test when an original test signal in one format, for example, is converted to another format.

### The Terms of Spatial Distortion

When a video picture conforms exactly to an electrical video format, it will fit every element of a display designed exactly for that format. The picture will start at the correct location at the top, be positioned correctly left to right, and end as expected at the bottom. The viewer will see the whole picture, with nothing extra. If the display physical format also matches the intended picture format, width vs. height or aspect ratio, picture elements will appear undistorted. Spatial Distortion is a measure of how a picture matches its intended electrical video format, and will be measured in terms of position on an ideal display.

**Video horizontal or vertical positioning or shift:** Picture elements may be shifted up or down, to the left or right. Unwanted blank areas may be introduced where picture would be expected, and the picture may be extended into vertical and/or horizontal blanking areas.

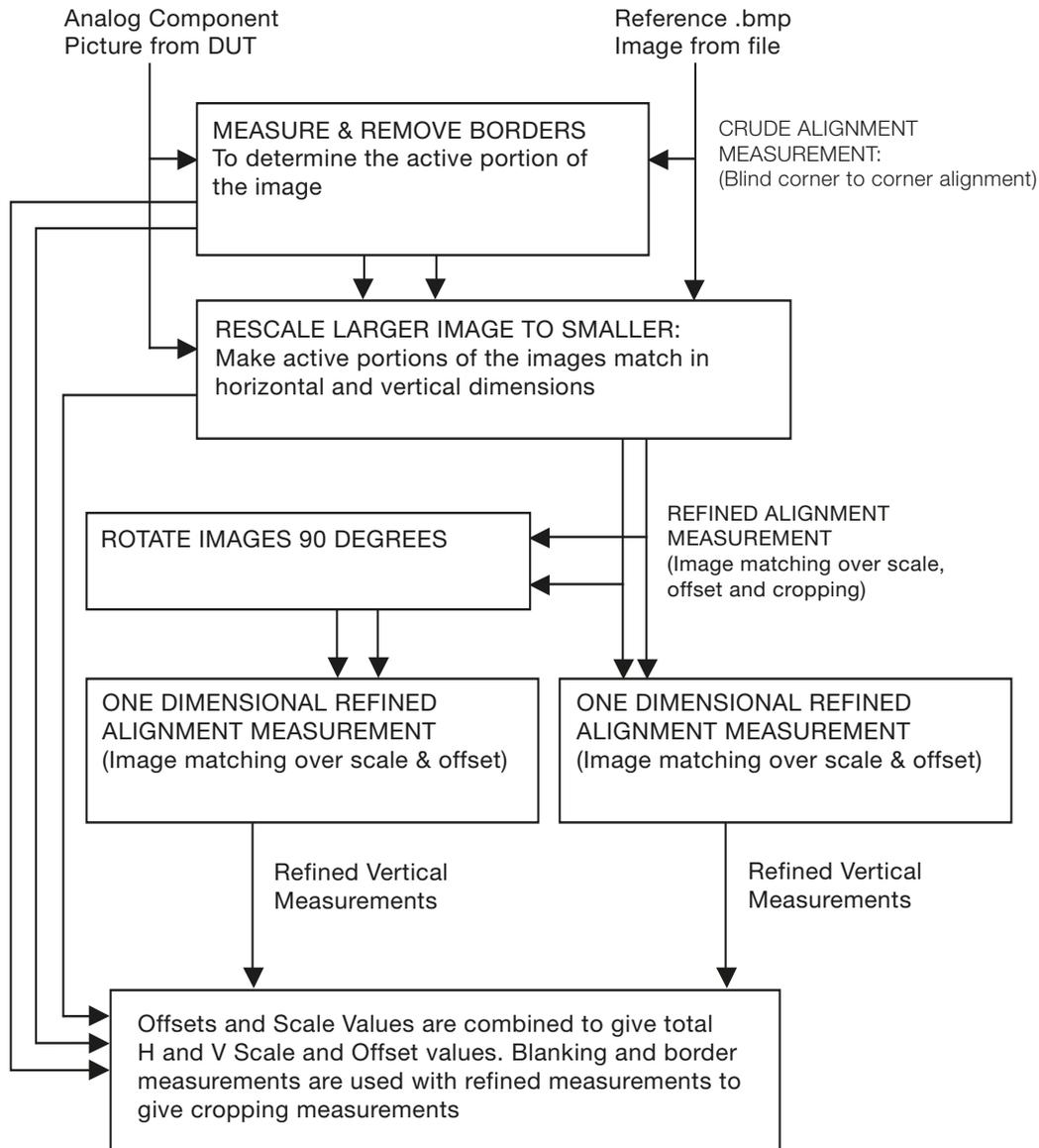
**Picture cropping or missing picture elements near edges:** Picture elements may be missing, cut off and replaced by blanking.

**Size and aspect ratio distortions:** The picture may be reformatted incorrectly for display, i.e., a 4x3 aspect ratio picture filling the full active video line time may appear stretched if a widescreen receiver is set to display a 16x9 picture.

The block diagram in Figure 1 describes the VM6000 Spatial Distortion measurement.

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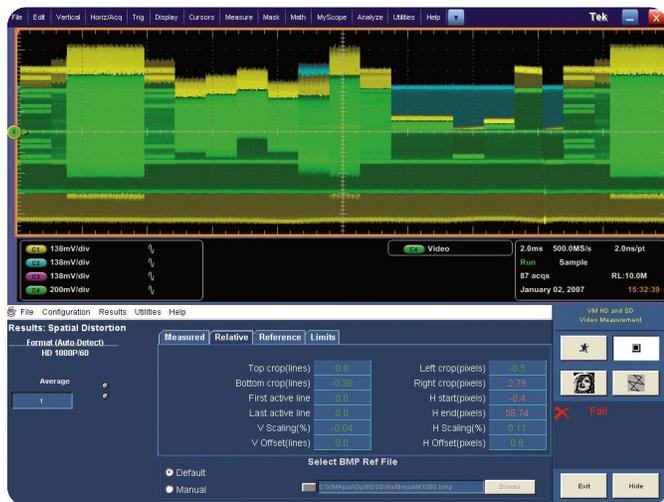
► **Figure 1.** Spatial Distortion measurement block diagram.

Intermediate steps in the measurement include rescaling both the test and reference images. They are both upsampled for better accuracy in the VM6000, though in the horizontal dimension the original acquisition engine sample rate is often already sufficient, in which case the application may not upsample any more. The final results reported are all in terms of the reference; for example the test horizontal scale relative to the reference is the ratio of widths of test and reference mapped images. Mapped images are the portions of test and reference images that have a corresponding pixel in the other.

As an example of how all results are in reference units: if the active part of a test image is 10% greater than it's matching part of the reference, even though the test image was perhaps, for example, cropped to be 87% of the reference width, the "H Scaling (%)" result would be 110.0. In this example, the total cropped test image pixels would be  $(100-87)\% \times 110\% = 14.3\%$ , but the measurement reports the left and right pixels which together would be  $100-87\% = 13\%$  reference pixels... if the reference is 1280 pixels wide, the total cropping (left + right) would be  $13\% \times 1280$  pixels = 166.4 pixels.

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► **Figure 2.** Spatial Distortion relative to a reference bitmap.

## Measuring Spatial Distortion with the VM6000

As with other automatic VM6000 measurements, the Results>Spatial Distortion>Relative tab provides a quick reference for measurement against ideal values.

This report, Figure 2, indicates the picture is positioned correctly at the top of the frame (Top Crop and Vertical Offset), and all lines are visible with about 1/3 extra blank lines at the bottom of the frame. The left of the picture is not cropped, but the active video line starts about 8 pixels to the left of its expected position. The picture is stretched by about 0.11% horizontally extending about 59 pixels into the horizontal front porch. Horizontal blanking crops about 3 pixels at the right of the frame. Limit File values have been exceeded for horizontal position, so the measurement reports FAIL. These deviations could be acceptable for many applications and the Reference and Limits Files could be adjusted as described later in this application note for an appropriate match to expected performance. Consumer equipment, for example often offers a selection of format conversions for display of one signal aspect ratio, perhaps 16x9 on a legacy 4x3 aspect ratio display.

Spatial Distortion is a comparison between a picture from a device under test and a reference .bmp file stored in the VM6000 user directory. The VM6000 automatically detects the format of the signal from the device under test, for example, 1080i60, and compares the incoming picture to a stored .bmp file, in this format example c:\vmapps\OptHDSD\RefBmps\M1080.bmp.

The Spatial Distortion measurement is selected under the Configuration>Measurements tab. Limits and Reference values, and Relative results reported, if enabled under the Configuration>Reference and Limits tab. Press the RUN button to run the measurement.

## Vertical Picture Distortions

**Top Crop (Lines):** This value is a measurement of lines missing or cropped out of the visible picture at the top of a display. A positive value indicates the number of lines cropped; a negative value would indicate a number of extra non-blank lines found in the test image but not found in the reference bitmap image.

**Bottom Crop (Lines):** The number of lines missing at the bottom of the picture. Extra non-blank lines in the test image, not found in the reference image are reported as a negative value.

**First Active Line:** The line number of the first active line of video. This could be different than the first picture line if the picture does not register with the horizontal/vertical blanking window.

**Last Active Line:** The line number of the last active line of video or picture blanking.

**V Scaling (%):** The relative vertical size of the active picture, regardless of position, vs. the stored reference .bmp image.

**V Offset (Lines):** The position of the start of the picture at the top of the display, vs. the corresponding line of the stored .bmp image.

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► **Figure 3.** Spatial Distortion measured values.

## Horizontal Picture Distortions

**Left Crop (Pixels):** This value is a measurement of picture elements (pixels) missing or cropped out of the visible picture at the left of a display. A positive value indicates the number of pixels cropped; a negative value would indicate a number of extra non-blank pixels found in the test image but not found in the reference bitmap image.

**Right Crop (Pixels):** The number of pixels missing at the right edge of the picture. Extra non-blank pixels in the test image, not found in the reference image are reported as a negative value.

**H Start (Pixels):** The indent from the left edge of the picture, in pixels. This could be different than the electrical blanking edge if the picture does not register with the horizontal/vertical blanking window.

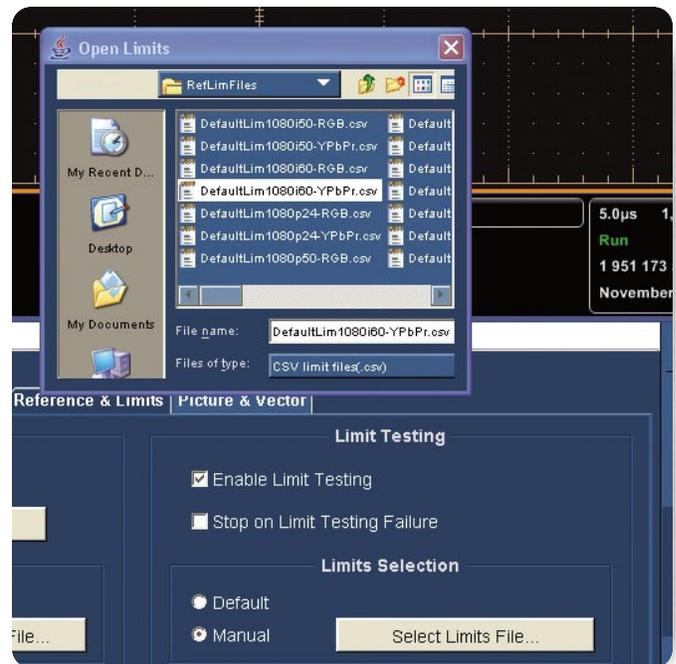
**H End (Pixels):** The pixel number of the last active picture element at the right edge of the display.

**H Scaling (%):** The relative horizontal size of the active picture, regardless of position, vs. the stored reference .bmp image. This is calculated using the standard pixel (sample) clock rate for the given format.

**H Offset (Pixels):** The position of the start of the picture at the left edge of the display, vs. the corresponding pixel of the stored .bmp image.

## Spatial Distortion Reference and Limits Files

Reference and Limits Files are included by default for full-screen video in each of the standard VM6000 formats, and may be custom configured for this measurement to match the expected output of a device under test. Any changes to default values may then be stored for later recall in a .vmset file under the File>Save (or Recall) Setup menu.



► **Figure 4.** Manual selection of a Limits File.

Note that Manual selection of a Reference or Limits File will not automatically select a corresponding Reference Bitmap File. Automatic (default) selection will follow the signal format, and Manual selection breaks away from the format to provide independent selection for each file type.

## Reference and Limits Files

Default Reference and Limits Files for each pre-defined component video format are supplied with the VM6000 for user convenience and may be modified to fit the user's specification application. The appropriate file is automatically determined by default when a format is selected, or a user-created file may be loaded manually under Configuration>Reference & Limits>Limits (or >Reference) Selection. Select Manual, and Select Limits File (or Select Reference File) to see the RefLimFiles directory. To display these files, select file type .csv. Save the default file for possible future reference and modify a copy of the original file. The modified file will become the default file if the original filename is retained. If saved under a new filename, the file may be accessed manually.

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### Default Limit File

This Default Limits File is provided AS IS without warranty of any kind and is intended to be used as a template only. WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE EXPLICITLY DISCLAIMED. Copyright 2006 Tektronix. Permission to use and create derivatives in conjunction with VM600 family products hereby granted. All other rights reserved.

**Format: 1080i/60**

**Color Space: YPbPr**

Spatial Distortion		
Top Cropping (Lines)	-1	-1
Bottom Cropping (Lines)	-1	-1
First Active Line	20	22
Last Active Line	1122	1124
V Scaling (%)	99	101
V Offset (Lines)	-1	1
Left Cropping (Pixels)	-1	1
Right Cropping (Pixels)	-1	1
H Start (Pixels)	191.3075	193.3075
H End (Pixels)	2112.155	2114.155
H Scaling (%)	99	101
H Offset (Pixels)	-1	1

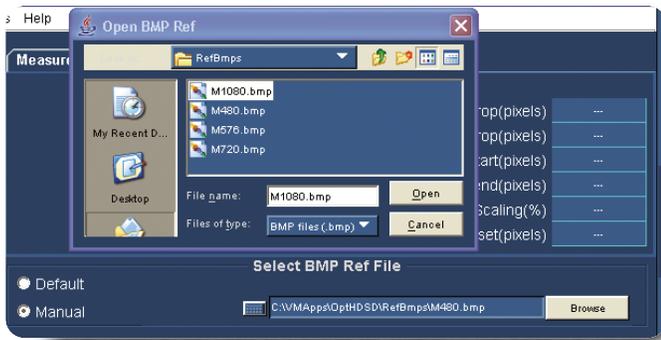
► **Figure 5.** Partial Default Lim1080i60YPbPr example.

To access a Limits File manually, under the Reference & Limits tab, Enable Limit Testing and select Manual. Clicking on Select Limits File brings up a user directory containing RefLimFiles and other user information. Select Files of type: CSV Limit Files (.csv), to see available files. Note that Reference and Limits Files are both in the same user directory, and that Reference Files can similarly be recalled in the Relative Result Display box at the left of the Reference & Limits display.

VM6000 User Reference and Limits Files are located in the C:\VMApps\ directory. The Spatial Distortion section of a typical (DefaultLim1080i60-YPbPr.csv) Limits File opened in Microsoft™ Excel might read as in Figure 5, with the Min Limit in the middle column and Max Limit in the right column.

The user may modify any of the Min or Max values in the Limits File.

Reference Files (i.e. DefaultRef1080i60YPbPr) are similar, but with a single target value for each parameter. The Configuration>Reference & Limits>Relative Result display>, also provides an opportunity to capture actual measurement (Capture Results as Reference) of a device under test, which may then be saved as a Reference File for comparison with future measurements.



► **Figure 6.** Manual selection of a Spatial Distortion Reference File.

## Reference Bitmap Files

Default Tektronix Matrix Signal full screen bitmap (BMP) picture files for each of the VM6000's pre-defined formats are supplied for reference. Versions of these files are also available as compressed ES, DVD, H.264, and ATSC transport streams for use with the Tektronix RTX130 series RF sources.

Customer video signals may also be used, with corresponding .bmp reference formats. The user may change this .bmp file to suit the measurement need, or manually select an appropriate file.

Best results are obtained if the picture has lots of edges and uniquely identifiable portions of the image, with large differences across both horizontal and vertical dimensions.

## Images to avoid are:

- Images with repeating patterns that might give ambiguous shift vs. cropping results, such as typical convergence patterns or full color bars (with every line the same)
- Very low contrast images, or "flat" images in the luminance channel (the luminance channel, or luminance derived from RGB is used for this measurement)
- Images that have a constant vertical column averages (averaging pixels along the vertical for each column gives same result as any other column)
- Likewise along the horizontal: images that have a constant horizontal row average (line average for each line is the same)

Other Reference Picture Files to avoid include synthetic zero mean test signals superimposed (added) to pedestal signals such as full screen sweeps and symmetrical full screen zone plate signals. Typical video scenes do not have any of these problems. Most matrix signals and test signals with both horizontal and vertical changes in mean signal level will work properly.

Spatial Distortion Reference Files may be manually loaded under the Results>Spatial Distortion tab. Select Manual and Browse to bring up the RefBmps directory of stored Reference Bitmaps. You would store any user bitmaps in this directory, C:\VMApps\OptHDSD\RefBmps\ as files of type .bmp.

## Summary

Measurement, evaluation and documentation of Spatial Distortion, through the video production chain, and particularly in the development of consumer format conversion devices is critical.

The Tektronix VM6000 Automated Standard and High Definition Measurement Set provides the tools to evaluate Spatial Distortion as part of a full suite of comprehensive, time-efficient automated measurements through product development and production. Full automation of this otherwise time consuming measurement make it both efficient and practical.

The VM6000, with its automated Spatial Distortion measurement can dramatically reduce development, validation, and production time, while providing a benefit for both the consumer and program provider. It is your unseen contributor to viewer satisfaction.

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