



White Paper: Video Testing for Display Manufacturers

*Bill Reckwerdt, CTO
Video Clarity, Inc.*



Ten years ago the Cathode Ray Tube (CRT) was the single prevalent display technology. Today CRT, Liquid Crystal Display (LCD), Thin Film Transistor (TFT), Plasma, Digital Light Processing (DLP), Liquid Crystal on Silicon (LCOS), and Organic Light-emitting Diode (OLED) are mature and mainstream technologies. Understanding and testing both current and up-and-coming technologies has opened Pandora's Box. Fortunately, evolving standards and test equipment make the job easier.

It is ironic that Televisions, one of the more personal purchases a person or family can make, is the focus of governmental regulations. Governments are deciding when analog terrestrial broadcast signals will be shutoff. This is causing Digital TV manufacturers to unite. To meet the growing demands of digital display testing, engineers must choose a test system that provides the maximum flexibility. In this way, a complete display test process can be created that easily adapts as the manufacturing requirements change.

Many factors affect the perceived video quality, and can be summarized as

- Scaling artifacts caused by the incoming video being a lesser resolution than the display itself.
- The Luminance & Resolution of the display itself irrespective of the incoming video.

Scaling

Most new televisions have a native resolution of 1920x1080, 1368x768, or 1280x720. Standard definition television is 720x480 (576 for PAL). Standard definition signals are upscaled using display graphic technology within the television. The quality of the scaling affects the perceived video quality.

The display manufacturers must choose a display graphic technology. To do this, they need to provide input to the processor and then read its output. The input is normally DVI or HDMI, and the output is LVDS. An LVDS capture device records the LVDS signal and either creates an RGB file or converts it to DVI.

The simple test scenario is

- Source DVI/HDMI to the display adapter up to 1080P/120Hz

- Capture from DVI or from File
- Store the video sequences as frames so that they can be played at any rate.
- Allow multiple playing modes such as play, shuttle, jog, pause, zoom and pan.
- Apply objective metrics to the video sequences to score the video frame-by-frame, and log/graph the results for easy analysis.
- Export pieces of video sequences to further analyze off-line.

Luminance

According to Wikipedia, Luminance is a photometric measure of the density of luminous intensity in a given direction. It describes the amount of light that passes through or is emitted from a particular area, and falls within a given solid angle.

Luminance is often used to characterize emission or reflection from flat, diffuse surfaces. The luminance indicates how much luminous power will be perceived by an eye looking at the surface from a particular angle of view. Luminance is thus an indicator of how bright the surface will appear. In this case, the solid angle of interest is the solid angle subtended by the eye's pupil. Luminance is used in the video industry to characterize the brightness of displays. In this industry, one candela per square meter is commonly called a "nit". A typical computer display emits between 50 and 300 nits.

Luminous testing includes measuring black-level, color temperature, peak brightness, dynamic range, and display contrast. To test Luminous, 2 pieces of equipment are needed:

- Digital I/O device to generate Test Patterns
- Data Acquisition Hardware - Photometer

The Digital I/O Device must be able to generate fully uncompressed test patterns at any resolution, bit-depth, and for moving pictures, any frame rate. Based on current technology, this means an HD-1080P device - i.e. 1920x1080, 32-bit color (with an upgrade path to 48-bit deep color), and 120Hz. The device should provide DVI and Component HD signals at the very least.



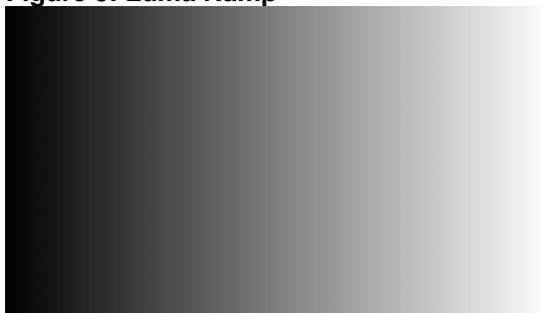
Figure 1: 75% Color Bars



Figure 2: 100% Color Bars



Figure 3: Luma Ramp



The Data Acquisition Hardware must be able to read the luminous values from the Display or the Display Adapter. This is normally referred to as a photometry or a spectroradiometer.

The results from the data acquisition hardware must be quantitatively, compared to the original test pattern. If the results are the same +/- a small variance due to non-linearity of geometry, then the test has succeeded.

Resolution

Resolution in its most general sense is a display's ability to produce fine detail. In TV video, it is generally defined as TV lines. In the computer video, "addressable pixels" are used. A 1280 x 768 pixel display may address that many pixels, but the real visual performance, or

"resolvable pixels", of the display may be, for example, only 720 x 486 (NTSC). "Resolvable pixels" is therefore the more accurate term.

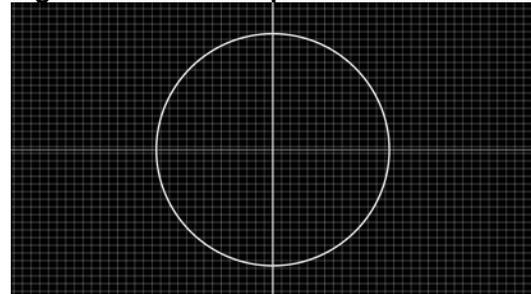
To test Resolution, the same 2 pieces of test equipment described above are needed.

The Digital I/O Device must be able to generate 1-pixel wide lines in both the horizontal and vertical space.

Figure 4: Line Sharpness Test Patterns



Figure 5: Circle Sharpness Test Patterns



The Data Acquisition Hardware must be able to read lines to 1/2 pixel accuracy from the Display or the Display Adapter.

The results from the data acquisition hardware must be quantitatively, compared to the original test pattern. If the results are the same +/- a small variance due to non-linearity of geometry, then the test has succeeded.

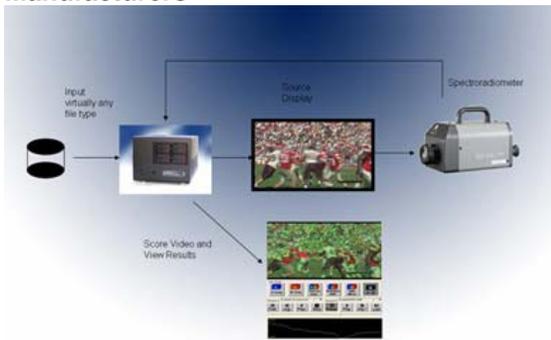
Case Examples

- A Graphic or Display chip manufacture needs to Play out "Source" video sequences at various resolutions and rates to their graphic or display chip through DVI, HDMI, or VGA.
- Capture the output of their unit (LVDS to DVI converter).
- Visually inspect the output of their algorithm compared to the original Source.



- Generate a Score for repeatability.
- A Display manufacture needs to
- Play out “Source” video sequences at various resolutions and rates to test their display through DVI, HDMI, or VGA.
 - Visually inspect the performance of their Display.
 - Generate a count of dropped frames if any occurred.

Figure 6: Video Testing for Display Manufacturers



The Author

Bill Reckwerdt has been involved in digital video since the early 90's from digital compression, video on demand, to streaming servers. He received his MS specializing in Behavioral Modeling and Design Automation from the University of Illinois Urbana-Champaign.

He is currently the VP of Marketing and the CTO for Video Clarity, which makes quantitative, repeatable video quality testing tools. For more information about Video Clarity, please visit their website at <http://www.videoclarity.com>.