3D TV test signals in line with the HDMI 1.4a interface standard

Meeting the new T&M challenges that new 3D technologies create for TV manufacturers

ROHDE&SCHWARZ

Broadcasting/Test&Measurement

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New test scenarios for new 3D TV sets

3D, the runaway hit in cinemas, can now be enjoyed at home. The latest HDMI standard, 1.4a, provides the foundation for 3D video data transmissions to consumer electronic equipment. New or more advanced display technologies convert this data in such a way as to create the three-dimensional effect for viewers. However, these new technologies create new challenges for 3D TV manufacturers, especially in development and quality assurance.

High definition multimedia interface (HDMI)

The introduction of HDMI technology at the end of 2002 brought about a paradigm change in the consumer electronics industry. For the first time, a digital AV interface has found broad support among both equipment manufacturers and content providers: Well over a billion HDMI-ready electronic devices have been produced since 2002. Before this, consumer electronic equipment primarily used analog interfaces to exchange video content – despite the recognized qualitative disadvantages as compared to their digital counterparts. Progress was held back mainly by content providers, such as Hollywood studios, who had reservations: Outputting digital versatile disk (DVD) or digital video broadcasting (DVB) contents directly via external interfaces could provide pirates the opportunity to make copies without loss of quality. HDMI dispelled these reservations. HDMI uses specialized high definition content protection. When this protection mechanism is active on the transmitter side (a Blu-ray player, for example), it verifies that the receiver supports this mode before exchanging the encryption key that allows the transmitted data to be decoded. The interface is also designed for high-quality, low-noise transmission of audio and video content. Data is transported over three high-speed data channels, known as transition minimized differential signaling (TMDS) lines. The latest version, 1.4a, specifies a bandwidth of up to 3.4 Gbit/s.

The well-proven R&S®DVSG digital video signal generator is the instrument of choice for testing 3D TV sets.

HDMI 1.4a – high-level evolution

HDMI 1.4a, released in March 2010, is the latest revision of the interface standard. It offers enhanced functionality, including home networking, 3D, and new maximum resolutions. It also retains backward compatibility with previous versions.

In addition to televisions, modern households also have game consoles, PCs or even surround sound systems. Today, each piece of equipment will have an Ethernet connection for accessing the Internet or exchanging content with the other devices. Since cabling is often used for the connections, entertainment areas become unsightly cable jungles. HDMI 1.4a implements a bidirectional 100 Mbit/s Ethernet connection within the HDMI interface. It provides a common data connection for all the equipment, making separate LAN cables unnecessary.

For broadcast transmissions, compressed audio is transmitted and then decoded by the TV set. Instead of using the built-in speakers, an external surround sound system is frequently used for audio output. This requires an additional S/PDIF connection between the TV and the sound system. HDMI integrates an audio return channel, which is used to transmit the decoded audio and also serves to reduce cabling.

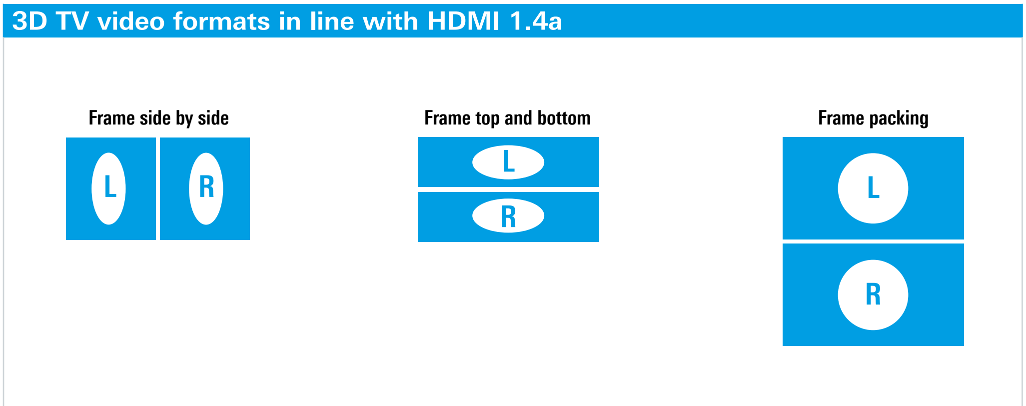
The HDMI Ethernet and audio return channel (HEAC) function in HDMI merges the concepts of the Ethernet channel and the audio return channel. Transmission via HDMI cable is made possible by shielding and twisting the hotplug and utility lines, thus creating a new data channel.

The latest HDMI standard, 1.4a, defines new picture formats and timings that transmit the stereoscopic picture information to TV sets using players or set-top boxes: Frame-compatible formats are based on conventional resolutions that divide the two perspectives horizontally (side by side) or vertically (top and bottom). These picture formats are used primarily for broadcasting 3D content. In this case, the existing infrastructure for high-definition (HD) transmission can be used. The drawback is the lower effective resolution – the individual picture sections are simply scaled up to the entire display area. All current and planned 3D TV transmissions use these frame-compatible formats. Frame-packing formats, i.e. sequential pictures in full resolution, complete the list. These formats are used primarily in combination with Blu-ray disc players and – compared to frame-compatible formats – offer optimum picture quality.

For some years now, digital cinema projectors have been using resolutions beyond full HD, such as 4096 × 2160 pixels. In private homes, these types of resolutions have remained out of reach. However, the demand for higher resolutions has grown right alongside increasing screen widths and the planned introduction of autostereoscopic screens (which make 3D glasses unnecessary). Feature films are typically produced at a reduced refresh rate of 24 Hz or 25 Hz, and so HDMI 1.4a also uses those values. To make these resolutions usable in practice, new driver chipsets are needed that support pixel rates of up to 365 MHz. These drivers are not yet available. The first chipsets that will support this mode are expected around the middle of 2011.

In addition to the main advancements mentioned above, the new standard also includes several refinements: New color ranges to permit video playback from digital cameras, a new micro plug for porting HDMI to mobile phones, and a new automotive connection system to replace analog video in vehicles.

3D TV video formats in line with HDMI 1.4a



Two different perspectives of each image are required for stereoscopic view. For transmission, they can be packed either in a standard frame (side by side or top and bottom), which reduces the effective resolution. Or they can be packed in one extra large frame, keeping the orignal resultion but requiring higher transmisson bandwidth.

3D effect through multiple perspectives

The term 3D TV is used to describe different technologies that make motion pictures or television images appear to be three-dimensional when viewed on TV sets. Multiple perspectives of the same scene are recorded and played back with the correct perspective. Stereoscopic playback, the most common method used today, offsets two perspectives of the same scene by the distance between one's eyes and plays them back on the screen in a defined sequence. The content intended for each eye is delivered synchronously either via active shutter glasses with alternating frame replay or via passive polarization glasses with alternating polarized picture information. The result is a three-dimensional effect.

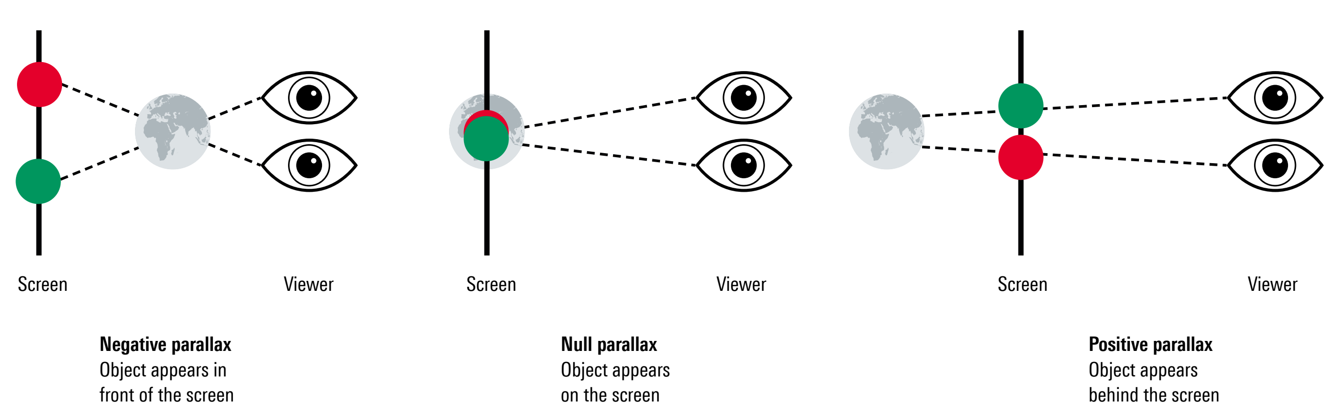
The first 3D TV sets were mainly active systems using shutter glasses. This technology was chosen because of the relatively low effort required to convert existing 2D TV sets. Over the past few years, the image refresh rate has been increased significantly in order to compensate for negative effects of motion artefacts on flat screens. An additional infrared interface permits the frame refresh rate to be synchronized with the exposure time of the glasses. Passive systems that use polarization filters as their synchronization mechanism are more complex and expensive to produce, but their more advanced technology delivers better picture quality.

Autostereoscopic screens are also currently being developed. In contrast to the other systems described here, these screens create three-dimensional effects without the aid of glasses. The total resolution is divided horizontally between the picture information for the left eye and that for the right eye, and then sent to the viewer accordingly via a system of lenses. The main problem is the extreme dependence on viewing angle. At present, a viewer can only see the three-dimensional effect from a specific position. First releases of this screen technology are already available for portable devices which are less dependent on the viewing angle, such as mobile phones.

The goal of 3D TV efforts is to produce holographic systems that provide an almost infinite number of perspectives of the same scene, making a 360° view possible. Research institutes have been working on this idea for a long time, but a practical application is still not in the foreseeable future.

When looking at real objects, depth perception is mainly based on parallax: Each of the viewer's eyes sees a slightly different perspective of the object. This principle is used for 3D TV, where two slightly different perspectives of an object (or scene) are presented to the viewer's eyes.

Depth perception through parallax as the basis of 3D TV



Meeting new T&M challenges

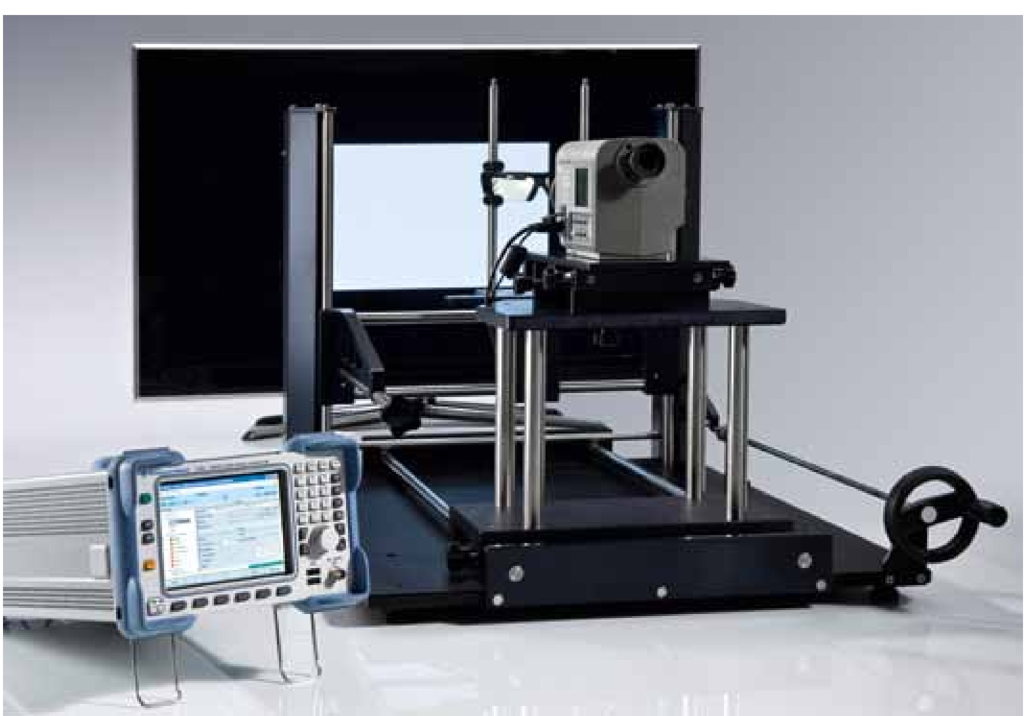
When processing 3D video signals, the software must also be adapted so that it can convert the motion estimation, scaling and deinterlacing to the new formats. The trouble spots in the various 3D TV technologies must also be identified through testing. No uniform test standards are currently available for ensuring the quality of 3D TV displays, primarily because the topic is still so new and the concepts being presented are too varied. This was made clear when sales of the first 3D TVs started in the first quarter of 2010.

In active systems, for example, faulty synchronization mechanisms can cause ghosting effects, i.e. crossover of the information intended for the left eye to the right eye and vice versa. The fault lies with the slow pixel response time of LCD displays. A pixel requires a frequency of 120 Hz to change states. Overshoot and the slowness of liquid crystals cause pixels to change state in reaction to the states of other pixels.

Brightness is frequently reduced drastically in both active and passive systems. Because of the very short exposure times for each eye, often only a fraction of the transmitted light passes through the shutter glasses to the human eye. The polarizing filters in passive systems absorb a significant portion of the light.

Highly accurate T&M instruments are required to provide precise and reproducible test results. When equipped with the R&S®DVSG-K10 AV signal generator option, the R&S®DVSG digital video signal generator is able to create all common primary 2D and 3D video formats in line with HDMI 1.4a, uncompressed and without interfering compression artifacts. Using the R&S®DVSG-B10 AV signal generator extension (hardware expansion), users can also output long 3D sequences: The video memory is expanded to 4 Gbyte allowing, for example, sequences of 387 individual RGB pictures at 1080p and 36 bit color depth to be output. At lower resolutions or lower bit depths, the sequence length increases proportionally. A pattern library for various 2D and 3D picture formats is included as standard. The library contains moving sequences for subjective picture quality assessment as well as test patterns, which, together with a Konica Minolta CS-2000 spectroradiometer, can be used to analyze the luminance, color or crosstalk. The Konica Minolta spectroradiometer sets the industry standard with contrast measurements of 1000.000:1.

A typical setup for testing active and passive glasses systems is shown in the figure below: The spectroradiometer is set up at a measurement angle of 1° and at a distance corresponding to three to four times the screen height. The Konica Minolta CS-2000 is lined up vertically with the test point on the screen. The measurement through the shutter glasses or polarizing glasses is centered in order to simulate the position of a viewer's pupils. A positioning system facilitates the correct and reproducible alignment of the test setup at various test points.

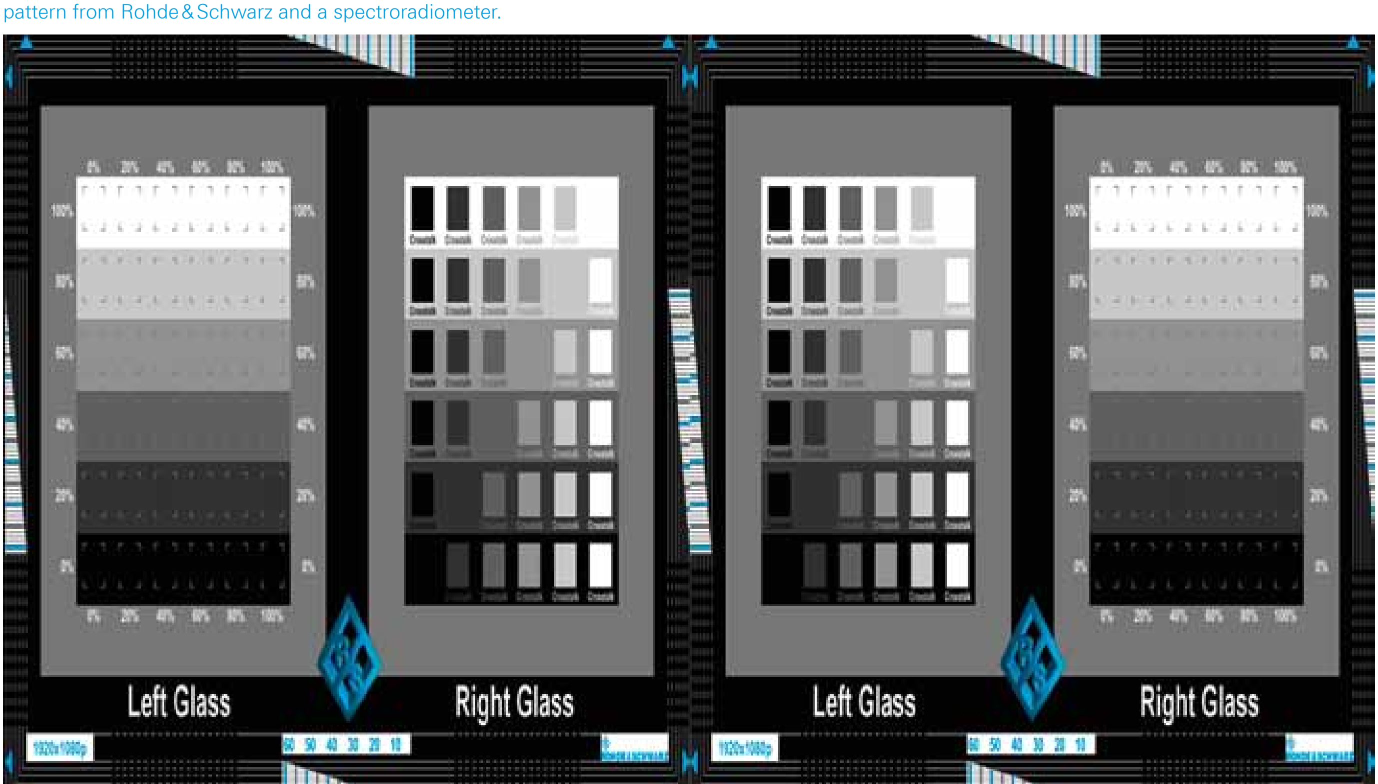


Typical test setup to measure the luminance of 3D TV sets using the R&S®DVSG digital video signal generator (here with an Instrument Systems positioning system and a Konica Minolta spectroradiometer).

3D test patterns for determining the luminance and color information are derived from existing 2D test pattern templates. The test setup used for 2D screens as described above can be used to perform traditional measurements, including contrast, gamma, gamut, white point, homogeneity, and viewing angle dependency. The 2D templates from the EBU TECH 3321/3325 guidelines are suitable as test patterns. The Rohde&Schwarz AVG pattern import software enables users to create their own 3D test scenarios from the uncompressed test patterns defined in the EBU guidelines. The software generates the appropriate 3D AVG files based on picture pairs for the left and right eye. The import function for uncompressed PCM audio files with up to eight channels completes the scope of functions provided by the software. The Windows application can be run on the signal generator or on a separate PC. More information on EBU TECH 3321/3325 can be found in FKT, Issue 8-9/2009.

Special test patterns are needed to identify specific trouble spots in the latest generation of 3D TVs. However, it is possible to obtain an objective and reproducible comparison for crosstalk using the setup described above in combination with the test pattern shown in the figure below. Six gray blocks with a 20% gradation from 0% to 100% white on the one eye are each mapped to a grayscale with a 20% gradation from 0% to 100% white plus detection surface markers on the other eye. Crosstalk can be reproducibly assessed using a spectroradiometer to perform centered measurements on the detection surfaces.

Crosstalk can be measured reliably using the crosstalk test pattern from Rohde&Schwarz and a spectroradiometer.

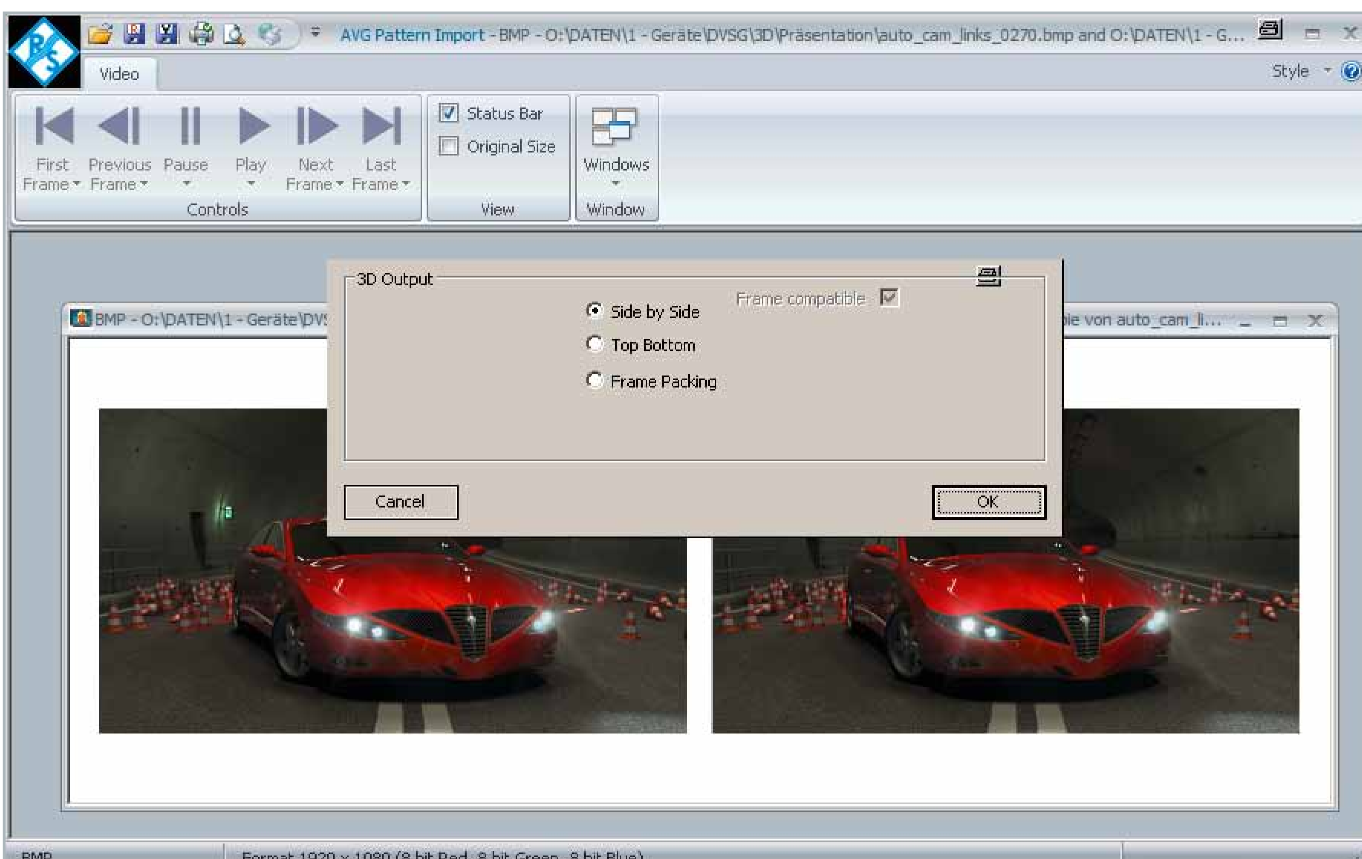


Display tests under real conditions

The R&S®DVSG has a reference decoder option that lets users check how compressed 3D TV signals occurring in typical broadcast transmissions are processed. They can play back live 3D signals containing complex scene cuts and pictures, blocking and other compression artifacts that were recorded anywhere in the world on the basis of MPEG-2 transport streams. The R&S®DVSG supports both MPEG-2-coded video and MPEG-4 advanced video coding (AVC), and is also able to decode all current audio standards. This allows users to optimize the display technology in the lab. Any errors experienced under critical application conditions can be easily reproduced.

The introduction of 3D TV into homes is still in its infancy. Different technical concepts for consumer electronic equipment and the lack of binding test specifications make it difficult for producers of 3D TV equipment to perform a comparative evaluation of the quality of their products. However, new high-performance, highly accurate T&M devices that can be flexibly adapted to new test conditions will make this possible in the near future.

The Rohde & Schwarz AVG pattern import software enables users to conveniently configure specific 3D test patterns on the R&S®DVSG digital video signal generator or on a separate PC.



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