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General Specification For Virtual Reality Head Mounted Display

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Contents

Foreword

This specification is drafted in accordance with rules in GB/T 1.1—2009.

This specification is issued and administered by the Industry of Virtual Reality Alliance Standard Committee.

The drafting groups: Beijing Institute of Technology, China Electronics Standardization Institute, Shanghai Lexiang Technology Co., Ltd, Shenzhen Virtual Reality Technology Co., Ltd, Goertek Co., Ltd, Beijing Pico Technology Co., Ltd, HTC Communication Co., Ltd, Beijing Xiaomi Technology Co., Ltd, Beijing iQIYI Science & Technology Co., Ltd, Shenzhen Inlife-Handnet Co., Ltd, Beijing Baofeng Mojing Technology Co., Ltd, etc.

The main drafters: Wang Yongtian, Liu Yue, Wang Cong, Weng Dongdong, Cheng Dewen, Guo Mei, Liang Yong, He Zheng'an, Lv Tiehan, Dang Shaojun, Zhao Dachuan, Chi Xiaoyu, Cui Shanshan, Li Fang, Zhou Juejia, Wang Xiying, Sun Qimin, etc.

General Specification for Virtual Reality Head Mounted Display

1 Scope

This specification defines the categorization, performance requirements and test methods for Virtual Reality (VR) Head Mounted Displays (HMD).

This specification is applicable to all types of VR HMDs.

2 Normative References

The following documents are indispensable to the application of this document. For dated references, only the editions with dates are applicable to this document. For undated applicable documents, the latest version (including all amendments) is applicable to this standard.

GB/T 10987-2009 Optical systems. Determination of parameters

GB/T 11460 Information Technology. Requirements and test method of the Chinese ideograms font

GB 13000 Information Technology. Universal Multiple-octet Coded Character Set（UCS）

GB 15934-2008 Electrical accessories. Cord sets and interconnection cord sets

GB/T 17117-2008 Binoculars

GB 18030 Information technology. Chinese coded character set

GB/T 18312-2001 The inspection rule for binoculars

GB/T 26125 Electrical and electronic products - Determination of six regulated substances (lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, polybrominated diphenyl ethers)

GB/T 26572 Requirements of concentration limits for certain restricted substances in electrical and electronic products

GJB 6368 Approval test procedure for military observation and sight instruments,

SJ/T 11281-2007 Measure methods of light emitting diode (LED) panels

SJ/T 11348-2006 Methods of measurement for digital television flat panel displays

3 Terminology

The following terms and definitions are applicable to this document.

3.1 Virtual reality (VR)

A digital artificial environment with multiple realistic senses (sight, hearing, touch, smell, taste, etc.) generated with computer-centered modern high tech, where the users interact with the objects in the virtual world in a natural manner with input and output devices, thus experiencing immersion.

3.2 Head mounted display (HMD)

A computer system display device worn on the user's head, which augments the image on the micro screen with the visual optical system placed in front of the user's eyes, and thus provides immersive or see-through display effects.

3.3 Resolution

The volume of information displayed on the screen, measured in terms of horizontal and vertical pixels.

3.4 Field of view

The angle between the lines through observable bounds and the viewpoint (the center of pupils), including horizontal field of view, vertical field of view, diagonal field of view; unless otherwise specified, it refers to the horizontal field of view, i.e. the angle between the left and right periphery and the single viewpoint.

Note: by default, it is the monocular field of view.

3.5 Screen refresh rate

The number of image refreshes per second on a screen.

3.6 Inter-pupillary distance

The distance between the centers of the eyes' entrance pupils.

3.7 Eye relief

The distance between the last surface of the optical system to the intersection of the exit pupil plane and the optical axis, which is also the distance between the person's eyes and the lens when the whole field of view is seen.

3.8 Distortion

The deformation of the image pixels relative to the reference system, including squash, stretch, shift, twist, etc., which alters the geometric position, size, shape and location.

3.9 Motion-to-photo latency

The time from the user's motion to the corresponding image changes and projection on to the user's eyes through the HMD.

3.10 Virtual image distance

The distance between the virtual image plane of the HMD to the exit pupil (the pupil of the person's eye).

3.11 Pixels per degree

With a given direction in the user's field of view, the number of pixels outputted by the display device as observable from each angular unit.

3.12 Chromatic aberration

The phenomenon of color divergence and distortion while observing the image through an HMD optical system.

3.13 Brightness

The ratio between the luminescence intensity of the surface in a given direction and the surface area perpendicular to the said direction, it is the overall brightness of the HMD measured at the designed exit pupil position outside of the eyepiece. In the display device, the brightest white level is the maximum brightness, and the darkest black level is the minimum brightness.

3.14 Brightness range

The brightness range between the absolute black image (minimum brightness) and absolute white image (maximum brightness) displayed by the device in darkroom environment.

3.15 Diopter

The reciprocal of the distance between the virtual image and the exit pupil axial.

3.16 Image undistortion

To digitally pre-process the output displayed image, so that the image distortion observed through the HMD optical system is minimized.

4 Abbreviations

VR: virtual reality
HMD: head mounted display
FOV: field of view
IPD: inter-pupillary distance
PPD: pixel per degree
VID: virtual image distance
LCD: liquid crystal display
LED: light emitting diode
OLED: organic light emitting diode
EPR: effective pixel ratio
DOF: degree of freedom
USB: universal serial bus
D: diopter
kg: kilogram
mm: millimeter
Hz: hertz
m: meter
ms: millisecond
min: minute
mAh: milliampere hour
V: volt
kPa: kilopascal
g: gram

5 Chinese Information Processing

5.1 Character set

The product shall use the character set specified by national standards in the following scope:

a） A mapping relationship must be established between the compulsory part of GB 18030 or the corresponding part of GB 13000 and GB 18030;

b） The compulsory part of GB 18030 and its optional part on Chinese characters, or the corresponding part of GB 13000 (must have a mapping relationship with GB 18030).

5.2 Chinese font

The requirements of Chinese font use are as follows:

a） Dot matrix font

The bitmap font used by the product shall be selected from the dot matrix series regulated by GB/T 11460. No products shall use a dot matrix of less than 11×12.

b） non-bitmap font

The products shall use a non-bitmap font in accordance with the following requirements:

1） The generated dot matrix shall use standardized pencil, appropriate structure, consistent style, so that it is artistically pleasing and practical for use.

2） The strokes for low dot matrices (24 dot matrix and below) shall be in accordance with the corresponding low dot matrix standard.

3） There is no overlap between adjacent strokes (excluding intersecting strokes).

c） Decorative and instructional characters

The decorative and instructional character pencils shall comply with the national language and characters.

6 Categorization of VR HMDs

6.1 External VR HMDs

The HMD only contains the display system and the sensor system, without any computational capability. It needs to connect to an external main unit.

6.2 Integrated VR HMD

An HMD with integrated display, sensing and computing systems. The computational unit and the sensing unit can be connected with the display part placed on the head, instead of being placed on the head.

6.3 Shell VR HMD

A head mounted device with optical system and optional sensing system and no display or computing system, which provides complete HMD functionalities by combining with a smart terminal such as a smart mobile communication terminal (MCT).

7 Performance Requirements of External VR HMD

7.1 Basic requirements

7.1.1 The concentration limitation of restricted substances

When applicable, the concentration limitation of the hazardous and noxious substances shall conform to the provisions in GB/T 26572.

7.1.2 The weight of the head mounted part

The part of the VR HMD to be worn on the user‘s head for extended duration shall be lighter than or equal to 0.8 kg, this weight does not include the connection cords and separating parts. This weight shall be specified in the product manual.

7.1.3 The dimensions of the head mounted part

The dimensions of the part of the VR HMD to be worn on the user‘s head for extended duration includes width, height, and thickness; the direction of width is parallel to the line through the eyes, the vertical direction is the direction of height; the width shall be less than or equal to 215 mm, the thickness shall be less than or equal to 125 mm, the height shall be less than 160 mm. The dimensions shall be specified in the product manual.

7.2 Optical requirements

7.2.1 Field of view

The angle between the lines through the user's eye and the bounds of the virtual image generated by the HMD; unless otherwise specified, it refers to the horizontal field of view; first-level indicator: shall be greater than or equal to 100°; second-level indicator: shall be greater than or equal to 80°. The field of view shall be specified in the product manual.

7.2.2 Effective pixel ratio

The ratio of the number of pixels visible to the human eye in the VR HMD to that of overall pixels shall be greater than or equal to 65%.

7.2.3 The range of inter-pupillary distance

The adjustable range of the entrance pupils' center distance of the HMD optical system. For adults, the inter-pupillary distance should be between 50 mm and 75 mm; for children, the inter-pupillary distance should be between 50 mm and 65 mm; the distance should be adjustable. The range of inter-pupillary distance shall be specified in the product manual.

7.2.4 Eye relief

The distance between the lens of the HMD closest to the user's eyes and the intersection of the exit pupil plane and the optical axis, shall be greater than or equal to 10 mm.

7.2.5 Exit pupil diameter

The diameter of the circular range in the exit pupil plane where the human eye can see the entire image clearly; this diameter shall be greater than or equal to 4 mm.

7.2.6 Distortion

The image distortion in the HMD is the deformation of the image pixels relative to the reference system, including squash, stretch, shift, twist, etc., which alters the geometric position, size, shape and location. After software algorithm correction, with 30° half-field of view, the distortion in the HMD shall be less than or equal to 3%. The percentage is defined as the number of the deviated pixels divided by the total number of pixels in the same direction.

7.2.7 Adjustable range of diopter

The range of human eye diopter supported by the HMD. The adjustable range for devices supporting diopter adjustments should be greater than or equal to 6D, and it shall be specified in the product manual.

7.2.8 Diopter adjustment

The HMD supports adjustment of the diopters. For devices supporting diopter adjustments, it should be adjusted for both eyes simultaneously or separately for each eye. It shall be specified in the product manual.

7.2.9 Chromatic aberration

The phenomenon of color divergence and distortion while observing the image through an HMD optical system. With 30 °half field of view, distortion shall be less than or equal to 3%. The percentage is defined as the number of the deviated pixels divided by the total number of pixels in the same direction.

7.2.10 The parallel deviation of the binocular optical axis

The angle between the main optical axis of the HMD binocular optical system, including horizontal angle and vertical angle. Horizontally, divergence angle shall be less than or equal to 1 °; horizontally, convergence angle shall be less than or equal to 0.5 °; vertically, intersection angle shall less than or equal to 1 °.

7.3 Display requirements

7.3.1 Display resolution

The resolution of the output image from a display element in the HMD, the number of units used should be specified as well. First-level indicator: shall be greater than 1200×1080; second-level indicator: shall be greater than 960×1080. This shall be specified in the product manual.

7.3.2 Screen refresh rate

The display refresh rate of the HMD. First-level indicator: shall be greater than or equal to 90 Hz; second-level indicator: shall be greater than or equal to 60 Hz. The screen refresh rate shall be specified in the product manual.

7.3.3 Brightness and contract

The ratio of the brightness of display element's center of HMD against the white screen (maximum gray level) to that against the black screen (minimum gray level). First-level indicator: LCD contrast shall be greater than or equal to 500:1; OLED contrast shall be greater than or equal to 5000:1; second-level indicator: LCD contrast shall be greater than or equal to 300:1; OLED contrast shall be greater than or equal to 1000:1.

7.4 Overall performance requirements

7.4.1 Virtual image distance

The distance between the virtual image plane of the HMD to the exit pupil (the human eye pupil) shall be greater than or equal to 0.3 m.

7.4.2 Angular resolution

The number of pixels that per angle unit observable through an HMD. It shall be greater than or equal to 9 PPD in both horizontal and vertical directions, and it shall be specified in the product manual.

7.4.3 System motion-to-photo latency

During a standard test with a virtual scenario, the time lapse between the user's head movement to the optical signal's projection on to the user's eyes via the HMD. First-level indicator: should be less than or equal to 33 ms; second-level indicator: should be less than or equal to 45 ms, or as defined in product standards. The system motion-to-photo latency shall be specified in the product manual.

7.4.4 Opacity

The degree of light leakage measured when the HMD is worn, rated by scores.

7.4.5 Cooling property

To test the cooling property of the HMD, under the standard testing scenario, measure the surface temperature of the device after 15 min of use. The highest temperature of the device surface shall be less than or equal to 55 ℃ (when the environment temperature is 25 ℃).

7.5 Tracking requirement

7.5.1 Tracking Mode

The degree of freedom that can be tracked in an HMD, it includes three modes: no tracking, tracking with three degrees of freedom, tracking with six degrees of freedom. For the HMD that supports tracking, it shall support at least 3DOF; it is recommended for the device to support 6DOF. The tracking mode shall be specified in the product manual.

7.5.2 Angle drift

The average angle drift of the HMD in the horizontal direction after it is idle for 30 minutes shall be less than or equal to 18 °.

7.5.3 Angular sampling rate

The sampling rate for angular sensing device shall be greater than or equal to 60 Hz.

7.5.4 Mobile tracking range

The area that can be tracked when the HMD is placed at a mobile location, which is described with the length and the width. A tracking range less than 3m × 3m is desktop-scaled tracking; a tracking range greater than or equal to 3m × 3m is room-scaled tracking (or otherwise referred to as large-scaled tracking). The mobile tracking range shall be specified in the product manual.

7.5.5 Mobile tracking errors

When an HMD system is placed at a mobile location, the deviation between the moving distance identified by the tracking system and the actual moving distance. The error shall be less than or equal to 15 mm.

7.5.6 Position sampling rate

The sampling rate of the position tracking system shall be greater than or equal to 60 Hz.

7.5.7 Tracking stability

When the HMD is fixed at a position, the range of tracking data jitter, including angular tracking jittering range and position tracking jittering range. First-level indicator: the angular tracking jittering range shall be less than or equal to 1 °, the position tracking jittering range shall be less than or equal to 5 mm. Second-level indicator: the angular tracking jittering range shall be less than or equal to 2 °, the position tracking jittering range shall be less than or equal to 10 mm.

7.5.8 Tracking sensitivity

The minimum turning angle or moving distance that can be identified by the tracking system when the HMD tracking device is turning or moving. First-level indicator: the minimum angle shall be less than or equal to 1°, and the moving distance shall be less than or equal to 5 mm; second-level indicator: the minimum angle shall be less than or equal to 2°, and the moving distance shall be less than or equal to 10 mm. The tracking sensitivity shall be specified in the product manual.

8 Performance Requirements for The Integrated VR HMD

8.1 Basic requirements

See 7.1.

8.2 Optical requirements

See 7.2.

8.3 Requirements of the display device

8.3.1 Display resolution

See 7.3.1.

8.3.2 Screen refresh rate

The screen refresh rate of the integrated VR HMD shall be greater than or equal to 60 Hz. The screen refresh rate shall be specified in the product manual.

8.3.3 Brightness and contract

See 7.3.3.

8.4 Overall performance requirements

8.4.1 Virtual image distance

See 7.4.1.

8.4.2 Angular resolution

See 7.4.2.

8.4.3 System motion-to-photo latency

During a standard VR environment test, the time lapse between the user's head movement to the optical signal's reflection into the user's eyes in the integrated VR HMD, should not be greater than 45 ms unless otherwise provided by the product standard. The system motion-to-photo latency shall be specified in the product manual.

8.4.4 Opacity

See 7.4.4.

8.4.5 Cooling property

See 7.4.5.

8.4.6 Adaptability to power supply

Products with alternating current power supply shall operate normally at 220 V±22 V and 50 Hz±1 Hz. Products with direct current power supply shall operate normally at a nominal voltage of (100±5)%. The nominal value of the direct current voltage shall be specified in the product standard. Units with special power source requirements shall be specified in the product standard. Requirements for sets of cables shall comply with the provisions of GB 15934-2008.

8.4.7 Battery capacity

The capacity of the built-in battery of the equipment. First-level indicator: greater than or equal to 3500 mAh; second-level indicator: greater than or equal to 2200 mAh. The battery capacity shall be specified in the product manual.

8.4.8 Power consumption

The standard power consumption of the device shall be specified in the product manual.

8.4.9 Endurance

When the head-mounted device is operating using the battery, the time lasting from full battery power to automatic turn-off when only using the battery under prescribed settings. first-level indicator: when in movie mode, it shall be greater than 180 min, whereas, in game mode, it shall be greater than 90 min; second-level indicator: when in movie mode, it shall be greater than 120 min, whereas in game mode, it shall be greater than 60 min. The endurance shall be specified in the product manual.

8.5 Tracking requirement

See 7.5.

9 Performance Requirements for Shell VR HMD

9.1 Basic requirements

9.1.1 The concentration limitation of restricted substances

See 7.1.1.

9.1.2 The weight of the head mounted part

The mass of the part of the VR HMD worn on the user's head for a long time, excluding the mass of intelligent devices, wires, and other separate parts, shall be less than or equal to 0.5 kg and shall be specified in the product manual.

9.1.3 The dimensions of the head mounted part

The dimension of the part of the VR HMD worn on the user's head for a long time, including width, height, and thickness; among which, the direction of width is parallel to the line connecting both eyes, the direction of thickness is the horizontal vision direction, and the direction of height is the vertical direction. The width shall be less than or equal to 215 mm, the thickness shall be less than or equal to 110 mm, and the height shall be less than or equal to 160 mm. The dimensions of the head mounted part shall be specified in the product manual.

9.1.4 Types of adaptable MCTs

The model number of the adaptable MCT or supporting specification requirements of the adaptable MCT of the shell VR HMD, such as the interface type, screen size, and boundary dimension of the MCT, shall comply with hardware structural and optical adaptability requirements, and shall be specified in the product manual.

9.2 Optical requirements

9.2.1 Field of view

See 7.2.1.

9.2.2 Effective pixel ratio

The ratio of the number of pixels visible to the human eye in the shell VR HMD to that of overall pixels, shall be greater than or equal to 60%.

9.2.3 The range of inter-pupillary distance

See 7.2.3.

9.2.4 Eye relief

See 7.2.4.

9.2.5 Exit pupil diameter

See 7.2.5.

9.2.6 Distortion

See 7.2.6.

9.2.7 Adjustable range of diopter

See 7.2.7.

9.2.8 Diopter adjustment

See 7.2.8.

9.2.9 Chromatic aberration

See 7.2.9.

9.2.10 The parallel deviation of the binocular optical axis

See 7.2.10.

9.3 Requirements for external sensor devices

The performance requirements for additional sensor devices, such as the gyroscope that the shell VR HMD is equipped with, shall comply with the adaptability requirements and shall be specified in the product manual.

10 Test Methods for VR HMD

10. 1 Ambient conditions of the test

Other than climate environmental test, reliability test, and battery endurance test, all other tests in this standard should be performed under the atmospheric conditions as follows.

Temperature: 15 ℃ - 35 ℃.

Relative humidity: 25% - 75%.

Barometric pressure: 86 kPa - 106 kPa.

10. 2 Chinese information processing

Check the font-conforming level of Chinese characters in the product and in related standard using the method prescribed in GB/T 11460. Character set shall also be checked.

10. 3 Test method for limitation requirements of restricted materials

Conduct in accordance with provisions prescribed in GB/T 26125.

10. 4 Test method for mass of head-mounted parts of the device

10. 4. 1 Test equipment

Electronic Scale: Range: 3 kg, accuracy: 0.1 g.

10. 4. 2 Test procedure

Verify and confirm the zero position and sensitivity of the electronic scale, place the main device and head strap of the HMD (except external connecting wire) on the electronic scale, and read and record the reading indicated on the scale after it stabilizes.

10. 5 Test method for the dimensions of the head-mounted parts of the device

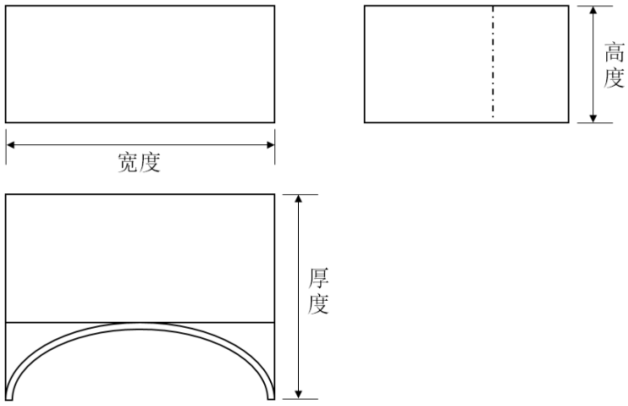
10. 5. 1 Test equipment

Caliper (accuracy is 0.1 mm).

10. 5. 2 Test procedure

As indicated in Fig. 1, the product's direction of vision is deemed to be the positive direction. The direction of width is parallel to the line connecting both eyes, the direction of thickness is the horizontal vision direction, and the direction of height is the vertical direction. Use a caliper to measure the product's width, thickness, and the widest part of the height, and record the readings.

Conduct tests only on the main device, excluding the head strap.



(Note: 宽度: Width; 高度: Height; 厚度: Thickness)

Fig. 1: Definition of the measuring direction for the dimensions of the head-mounted parts of the device

10.6 Test method for field of view

10.6.1 Test equipment

a) spectrometer;
b) image detecting device;
c) optical table.

10.6.2 Test procedure

Place the HMD on the platform of the spectrometer while ensuring the center of the exit pupil of the eyepiece is placed at the center of the rotating platform of the spectrometer, use software to control the HMD to show the ruler in full screen, point the telescope installed on the spectrometer to the maximum ruler reading observed (either by naked eye or captured by the image testing device), and record the scale shown on the dial of the spectrometer. The difference in scale on the dial between the left and the right side is the full field of view.

A slit must be installed in front of the telescope of the spectrometer to ensure the conditions for image formation in low light. This test method refers to 3.2.1 of GB/T 10987-2009.

10.7 Test method for effective pixel ratio

10.7.1 Test equipment

a) video camera (as long as the field of view is greater than the angle between the eyes and the display element in operation and the resolution is greater than that of the display element);
b) main frame of computer.

10.7.2 Test procedure

Used to test the ratio of the number of pixels visible to the eye to the number of overall pixels on the display element.

The resolution of the known display element and the total number of pixels (P).

Firstly, display on the display element in accordance with the following requirements:

Separate pixels on the screen into m sub-blocks, each sub-block is divided into n×n pixel grids (n = 3 in the figure). Light up one cell among all of the sub-blocks each time, indicated by a green light. Light up one cell at a time in every pixel sub-block so that after n2 times of lighting up, every pixel was lit up once, which completes one display cycle. Then light up the entire screen to synchronize.

For instance: as shown in Fig. 2, the screen is divided into m sub-blocks of 3×3 pixel grids, and m pixels are lit up each time. After 9 times of lighting up, every position in the 3×3 pixel grids is lit up once; i.e. each pixel on the screen will have been lit up once.

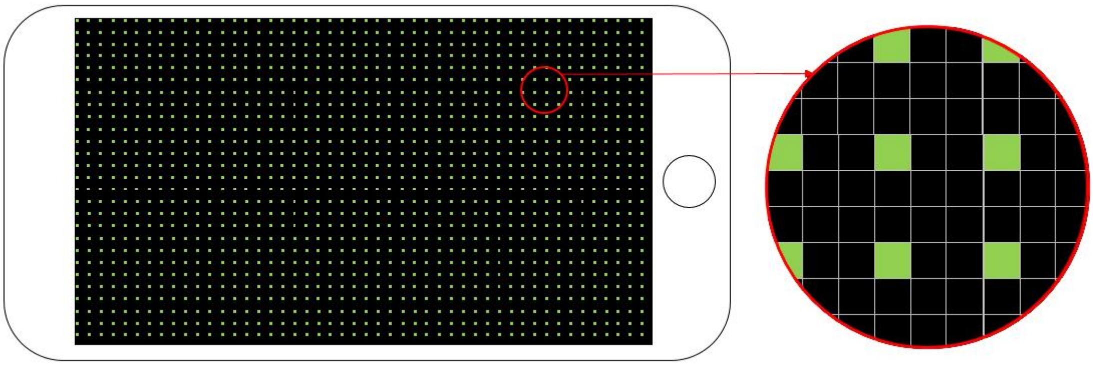


Fig. 2: Pixels on the screen in lighting up order

Place the video camera, HMD, and display element in a dark room, place the display element inside the HMD, and place the video camera on the exit pupil position of the display device. Connect the video camera to the computer, run the test procedure on the display element, and observe it on a computer.

Within one scanning cycle, record the number of green light-spots that appeared in the field of view, tally the amount (record the maximum brightness value of a single pixel before the experiment, and any brightness value greater than 50% of the maximum value can be recorded as a pixel), add up the number of green light-spots observed each time to obtain the number of effective pixels (P') seen by a single eye.

Therefore, the effective pixel ratio is:

$$\mathrm{EPR} = \frac{2P'}{P} \times 100\% \quad (1)$$

Where:

EPR -effective pixel ratio;

P' - the number of effective pixels seen by a single eye;

P -the total number of pixels.

If peripheral distortion becomes serious and causes two neighboring pixel cells to coincide, it is appropriate to increase the n value.

10.8 Test method for range of inter-pupillary distance

10.8.1 Test equipment

Ruler for inter-pupillary distance (can be replaced by a regular ruler with precision of 1 mm).

10.8.2 Test procedure

As shown in Fig. 3, to determine the optical center of two eyepieces, the ruler for interpupillary distance can be used to measure the distance between the two points, which is the central distance of the entrance pupil of both eyes with HMD optical system (*PD*).

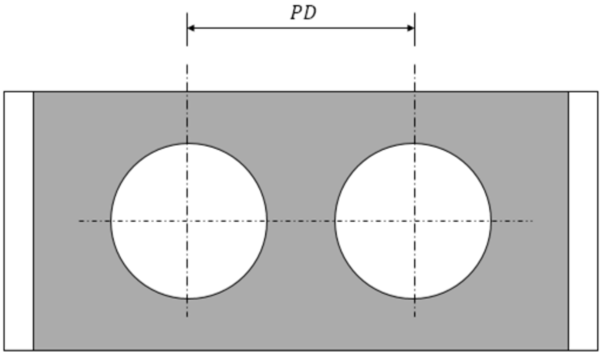


Fig. 3 Measurement of inter-pupillary distance

Adjust PD of the device to the widest and narrowest value, and PD_{Max} and PD_{Min} of the device can be measured by the aforementioned method.

The adjustable range for the central distance of the entrance pupil of both eyes of the optical system of the device is:

$$\Delta PD = PD_{Max} - PD_{Min} \quad (2)$$

Where:

ΔPD - The adjustable range for the central distance of the entrance pupil of both eyes;

PD_{Max}-the widest inter-pupillary distance of the device;

PD_{Min}-the narrowest inter-pupillary distance of the device.

10.9 Test method for the eye relief

10.9.1 Test equipment

a) dynameter;
b) optical table;
c) collimator.

10.9.2 Test procedure

When testing the exit pupil diameter, read and record the numerical value A on the distance scale of the dynameter at the same time; move the inner cylinder forward against the external cylinder until the rear surface of the product's optical system can be clearly seen, then read and record the value B of the distance scale. The absolute value between reading A and reading B is the eye relief of the product.

As the lens of the optical system is extremely clean, a small marker needs to be placed or a dot needs to be drawn on the surface for determination. This test method refers to 6.1.4 of GJB 6368—2008.

10.10 Test method for exit pupil diameter

10.10.1 Test equipment

a) dynameter;
b) optical table;
c) collimator.

10.10.2 Test procedure

Use the dynameter to measure, set the diopter of the product to zero, place the dynameter on the rear side of the eyepiece tube, move the internal cylinder of the dynameter until the image formation of the aperture diaphragm becomes the clearest, read and record the scale value on the reticle, which is the value of the exit pupil diameter.

This test method refers to 3.2.3 of GB/T 18312—2001.

10.11 Test method for distortion and chromatic aberration

10.11.1 Test equipment

a) high-definition monochromatic gray-scale video camera;
b) image testing device (electronic eyepiece, etc.);
c) optical table;
d) 16*16 printing calibration board.

10.11.2 Test procedure

Used to test the distortion result of the whole device after adjustment by the software of the HMD, and can also be used to test the compensation effect of chromatic aberration on the whole unit.

10.11.2.1 Distortion test

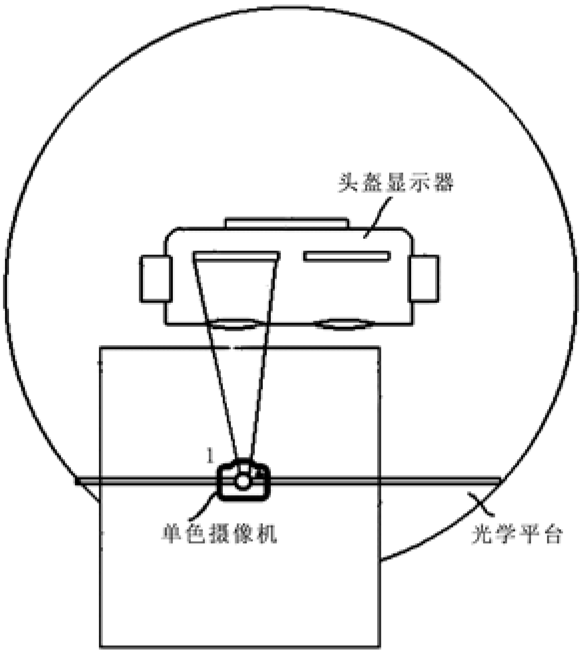
As shown in Fig. 4, place the HMD on the optical table. The resolution of video camera shall be higher than the display resolution of the HMD, and the field of view of the video camera shall be greater than that of the HMD. Firstly, place the high-definition video camera on the center of the eyepiece's exit pupil of the HMD (as shown in position 1 of the figure), videotape images displayed on the screen's calibration board in the HMD device (the image of calibration board is formed by 16*16 grid dots that take up the whole screen, and the image cannot be stretched when in display) to obtain film image 1. Then, use the video camera to film the real calibration board. When filming, the image center of the camera and the center of the calibration board need to overlap, and the optical axis of the camera and the surface of the calibration board should be perpendicular. Adjust the distance between the calibration board and the camera so that the boundary position of the board in the image being filmed is consistent with the boundary in the image displayed by the HMD, from which image 2 is obtained. The distance between the dots corresponding to Image 1 and Image 2 is the offset for each point, indicated as offset $\Delta\omega_i$. Take the maximum offset value within the vision-interested scope as the distortion value, and the result of image undistortion is equal to:

$$\text{Dist} = \max(\Delta\omega_i) \quad \text{(3)}$$

Where:

Dist: result of system's image undistortion;

$\Delta\omega_i$: the deviation from the ideal image undistortion correction.



(Note: 头盔显示器: HMD; 单色摄像机: Monochromatic video camera; 光学平台: Optical table)

Fig. 4 Structure diagram of distortion test

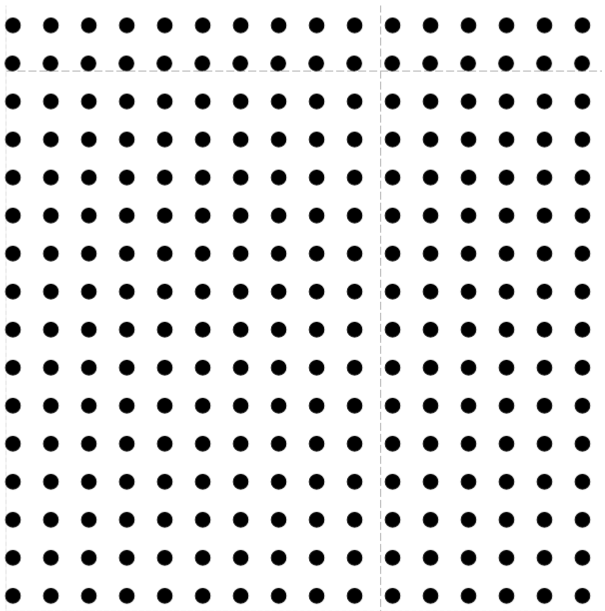


Fig. 5 16*16 calibration board

10.11.2.2 Chromatic aberration test

Same procedure as the distortion test: place the high-definition video camera on the center of the HMD eyepiece's exit pupil (as shown in position 1 of the figure), and videotape images displayed on screen's calibration board in the HMD device. The image of the calibration board is formed by 16×16 grid dots, which occupy the entire screen. When on display, the image cannot be stretched. The HMD shows images in three colors respectively, which are blue, green, and red, resulting in image 1, 2, and 3. The maximum value difference between two corresponding points with a different color is the chromatic aberration value in the scope that is attractive to the field of vision. Record the position of each color dot respectively: blue ωb_i, green ωg_i, and red ωr_i, so the system's chromatic aberration is:

$$\text{dispered} = \max\{|\omega b_i - \omega g_i|, |\omega b_i - \omega r_i|, |\omega g_i - \omega r_i|\} \quad \cdots\cdots\cdots\cdots (4)$$

Where:

ωb_i - indicates the position of image dots when displaying blue image;

ωg_i - indicates the position of image dots when displaying green image;

ωr_i - indicates the position of image dots when displaying red image.

10.12 Test method for diopter and adjustment range

10.12.1 Test equipment

a) diopter tube;

b) optical table;

c) collimator.

10.12.2 Test procedure

To test using the diopter tube and collimator, place a transparent reticle or resolution chart in front of an objective lens of the collimator, place the optical system exactly against the reticle, place the diopter tube in front of the optical system, near the exit pupil position, set the diopter tube to zero position, and adjust the position of the optical system back and forth. When the image of the graduated scale line of the collimator and the graduated scale line of the diopter tube can both be seen clearly, the value is the zero value of the optical system. Adjust the optical system to the maximum value of both positive and negative diopter; if the image of the graduated scale line of the collimator and the graduated scale line of the diopter tube can both be seen clearly through the diopter tube, then the diopter range complies with the nominal value of the product.

This test method refers to 5.1 of GB/T 17117—2008 and 3.2.3 of GB/T 18312—2001.

10.13 Test method for parallel deviation of optical axis between the eyes

10.13.1 Test equipment

a) optical axis instrument;

b) optical table;

c) collimator.

10.13.2 Test procedure

Conduct testing with optical axis instrument. Before the test, set the diopter value of the left and right eyepieces of the HMD to zero, and place it between the collimator and the binocular lens. Adjust the holder of the HMD so that the image formed by the crossover point of the cross-line graduated scale line of the collimator through the left channel optical system of the HMD overlaps with the crossover point of the cross-line graduated scale line of the left channel optical system of the lens. Measure the deviation between the image of the crossover point of the cross-line graduated scale line of the collimator through the left channel optical system of the product and the crossover point of the cross-line graduated scale line of the right channel optical system of lens, and the measured value is the optical axis' parallelism for the HMD.

This test method refers to 3.2.6 of GB/T 18312—2001.

10. 14 **Test method for resolution**

10. 14. 1 **Test equipment**

HMD under test.

10. 14. 2 **Test procedure**

Preset the composite test diagram (Fig. 6) into the HMD, and adjust the display device to the standard work mode.

Run the test and record the shown number of physical horizontal pixels and the number of physical vertical pixels of the display device. The test result is indicated by multiplying the number of horizontal pixels by the number of vertical pixels, which is the resolution of the device. This test method refers to 4.4.2 and 5.14 of SJ/T 11348—2006.

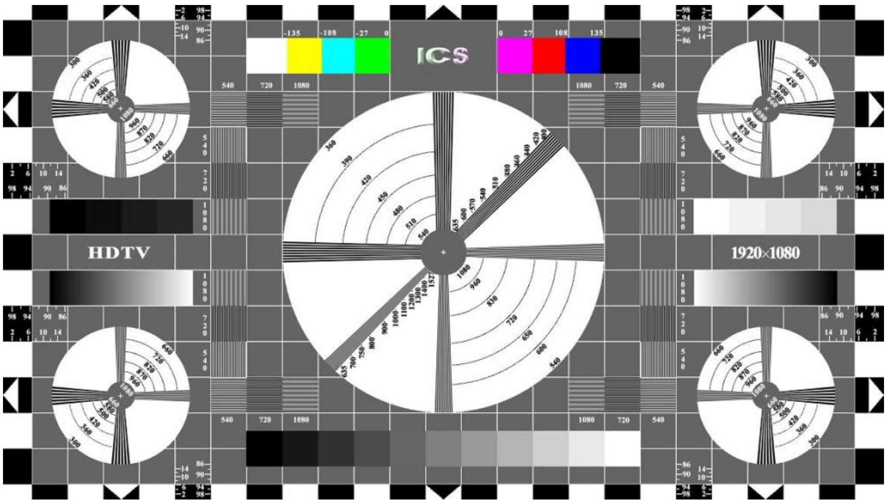


Fig. 6: Composite test diagram

10. 15 **Test method for the screen refresh rate**

10. 15. 1 **Test equipment**

Oscilloscope.

10. 15. 2 **Test procedure**

By applying a preset procedure, the displayed part of the HMD device can be displayed in accordance with the requirements: set the brightness level of the screen to maximum, set the gray-scale level to level 1 on the changing scale, and the display color is white. Observe the waveform of the LED drive current of a color of any pixel by using an oscilloscope, and measure the cycle of a set of waveforms of the drive current T; the screen refresh rate is:

$$FC=1/T \qquad (5)$$

Where:

FC-screen refresh rate;

T-cycle.

This test method refers to 4.3.2 of SJ/T 11281—2007.

10.16 Test method for brightness contrast

10.16.1 Test equipment

Brightness meter.

10.16.2 Test procedure

To test the ratio of the brightness of the HMD element's center against the white screen (maximum gray level) to that against the black screen (minimum gray level).

Place the HMD and the brightness meter in a dark room. Put the meter on the exit pupil position of the HMD. By putting something under the HMD or the meter, place the meter in the optical center of the HMD's imaging system.

Start the HMD, display pure white screen, adjust the brightness to a minimum, and record the brightness values at that moment $L_{min\,1}$; adjust the brightness to a maximum, and record the brightness values at that moment $L_{max\,1}$. Repeat three times before taking a mean value:

$$\overline{L_{min}} = \frac{L_{min\,1} + L_{min\,2} + L_{min\,3}}{3} \quad (6)$$

Where:

$\overline{L_{min}}$: The mean value of minimum brightness;

$L_{min\,1}$: The minimum brightness at the first measurement;

$L_{min\,2}$: The minimum brightness at the second measurement;

$L_{min\,3}$: The minimum brightness at the third measurement.

$$\overline{L_{max}} = \frac{L_{max\,1} + L_{max\,2} + L_{max\,3}}{3} \quad (7)$$

Where:

$\overline{L_{max}}$: The mean value of maximum brightness;

$L_{max\,1}$: The maximum brightness at the first measurement;

$L_{max\,2}$: The maximum brightness at the second measurement;

$L_{max\,3}$: The maximum brightness at the third measurement.

Brightness contrast can be calculated against a white screen:

$$C_{白} = \frac{\overline{L_{min}}}{\overline{L_{max}}} \quad (8)$$

Where:

$C_{白}$: Brightness contrast against the white screen;

$\overline{L_{min}}$: The mean value of minimum brightness;

$\overline{L_{max}}$: The mean value of maximum brightness.

Change the white screen to a pure black one. Following the white screen test procedures, repeat the brightness tests. Then get the brightness contrast C黑 against the black screen.

10. 17 Test method for virtual image distance

10. 17. 1 Test equipment

The special equipment consists of objective lenses, image sensors, linear motion mechanisms, position sensors, computers and software applications.

10. 17. 2 Test procedure

The virtual image is formed through the objective lens. The image sensor receives the images. Find the best image-plane position with the automatic focusing algorithm and the position sensor. This best position that corresponds to a unique virtual image distance can be calculated.

Connect the test equipment to the products being tested. Ensure that the optical axis of the two coincide. Ensure that the exit pupil of the products under test coincide with the test equipment's entrance pupil. Receive the virtual image under test with the test equipment's detector. Via automatic focusing algorithm, determine the best imaging position, which is l' after calculation. Then put it into the following equation to get the virtual image distance.

Virtual image distance:

$$l = \frac{f'^2}{l'} + f' \qquad (9)$$

Where:

l: Virtual image distance;

f': Test equipment focus;

l': The distance between the test equipment's detector and the back focal plane.

Specify the test equipment focus f' beforehand.

During the test, the HMD's diopter is 0.

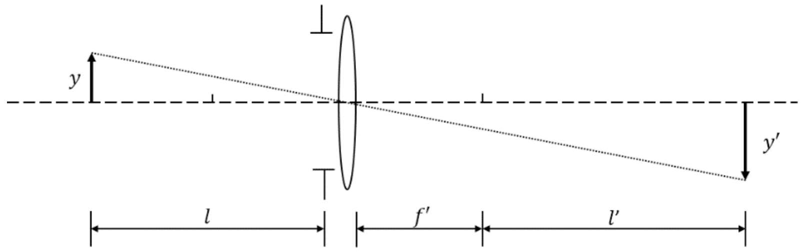


Fig. 7 The diagram of virtual image distance

10.18 Test method for angular resolution

10.18.1 Test equipment

a) video camera (as long as the field of view is greater than the angle of the display element to the eye and the resolution is greater than the display element);

b) main frame of computer.

10.18.2 Test procedure

To know the number of pixels that per unit of angle can see when the user under test wears an HMD.

The resolution of known display element.

First, implement trial procedures on the display element, whose contents are as follows:

Number the pixel location coordinates (according to the Cartesian coordinate system), and scan them row by row. First, scan the y coordinate top-down. Each time, only one row of pixels is white, with the rest being black and the illuminating time being 0.5 s until the whole screen has been scanned; The whole screen illuminates white for 1 s; Then, scan the x coordinate from left to right. Each time, only one column of pixels is white with the rest being black and the illuminating time being 0.5 s until the whole screen has been scanned. After one cycle ends, the whole screen illuminates white for 2 s, which is used as a sync signal. At this point, trial procedures on display element have been fully implemented.

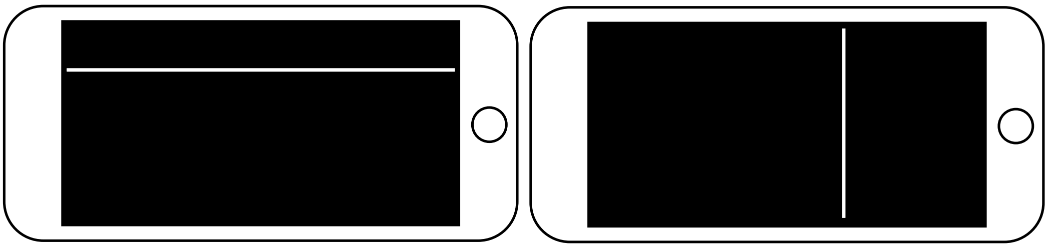


Fig. 8 Scan the y coordinate top-down (left); Scan the x coordinate from left to right (left)

Place the video camera, HMD, and display element in a dark room, place the display element inside the HMD, and place the video camera on the exit pupil position of the display device. Connect the video camera to the computer, run the test procedure on the display element, and observe it on a computer.

Within one cycle of scanning, there is a top-down scan and a left-right scan. During the top-down scan, record the upper boundary's position and length of the white pixels each time, namely, a one-dimensional horizontal line, and after the scan, record the data for one set of lines; During the left-right scan, record the left and the right boundary's position and length of the white pixels each time, namely, a one-dimensional horizontal line, and after the scan, record the data for one set of lines; Combining two sets of data, the viewing area can be divided into *P* ' grids.

From grids, we can get the maximum numbers of pixels seen horizontally P_x and vertically P_y.

With the known width of one pixel and the eye relief L, we can get the equipment's angular resolution based on the geometrical relationship:

$$\alpha_x = \frac{P_x}{2\arctan\frac{P_x \cdot a}{2L}} \quad (10)$$

Where:

α_x: The angular resolution in x direction;

Px: The maximum pixels seen horizontally;

a: One pixel's width;

L: Eye relief.

$$\alpha_y = \frac{P_y}{2\arctan\frac{P_y \cdot a}{2L}} \quad \text{（11）}$$

Where:

α_y: The angular resolution in the y direction;

Py: The maximum pixels seen vertically;

a: One pixel's width;

L: Eye relief.

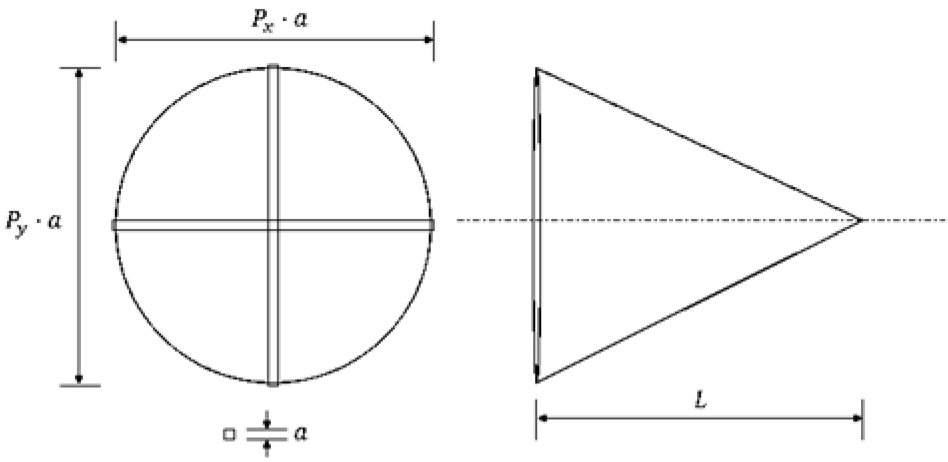


Fig. 9 Test figure of angular resolution

10.19 Test method for system motion-to-photo latency

10.19.1 Test equipment

a) High-speed cameras (appropriate frame rate should be over 1000 frames);

b) High-precision ruler;

c) Controllable motion table;

d) Laser-firing device.

10.19.2 Test system description

No light requirements for test environment.

The system set-up and pre-heating condition of the device under test (DUT): keep normal operation mode and preheat.

Precision requirements for high-precision ruler: the precision is not less than 0.0001 m.

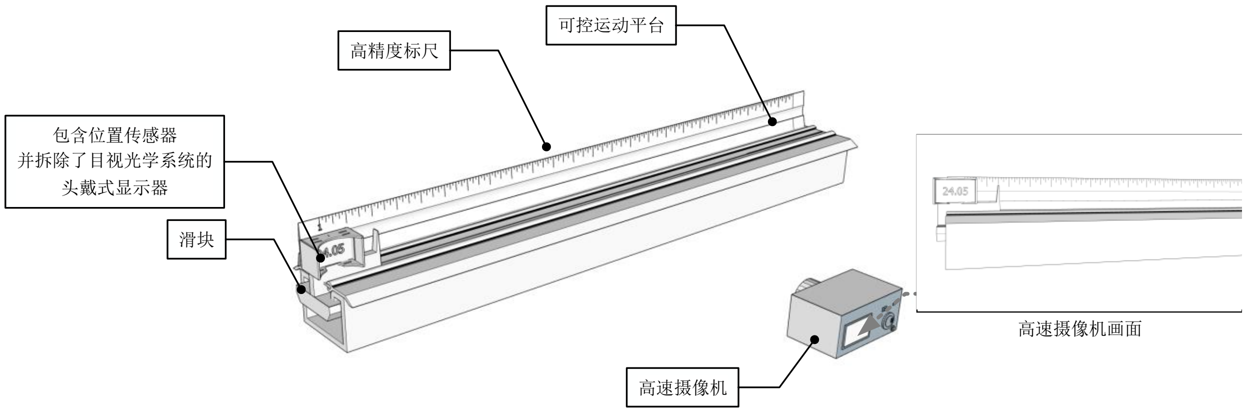
Specification for the high-speed camera: frame rate is not less than 1000 frames.

10. 19. 2. 1 Test equipment for mobile motion-to-photo latency

As is shown in Fig. 10, test equipment for mobile motion-to-photo latency consists of the following parts: a high-speed camera, a controllable motion table that can move along a linear path, a high-precision ruler installed on the table and the HMD with a position sensor.

The high-speed camera is fixedly installed relative to the motion table. The HMD with a position sensor is installed on the slider of the controllable motion table. The high-precision ruler is fixedly installed behind the slider. With this, the high-speed camera can clearly capture the entire ruler and the value that the slider pointer corresponds to on the ruler. The HMD's visual optical system shall be removed so that the high-speed camera can clearly capture the contents on the display elements of the HMD. A pointer installed on the slider can indicate the slider's location accurately.

Implement a trial procedure on the computing unit connected to the HMD. Through the data of position sensor on the HMD, the slider pointer's corresponding ruler readings in digital forms at any time will be shown on the HMD's screen.



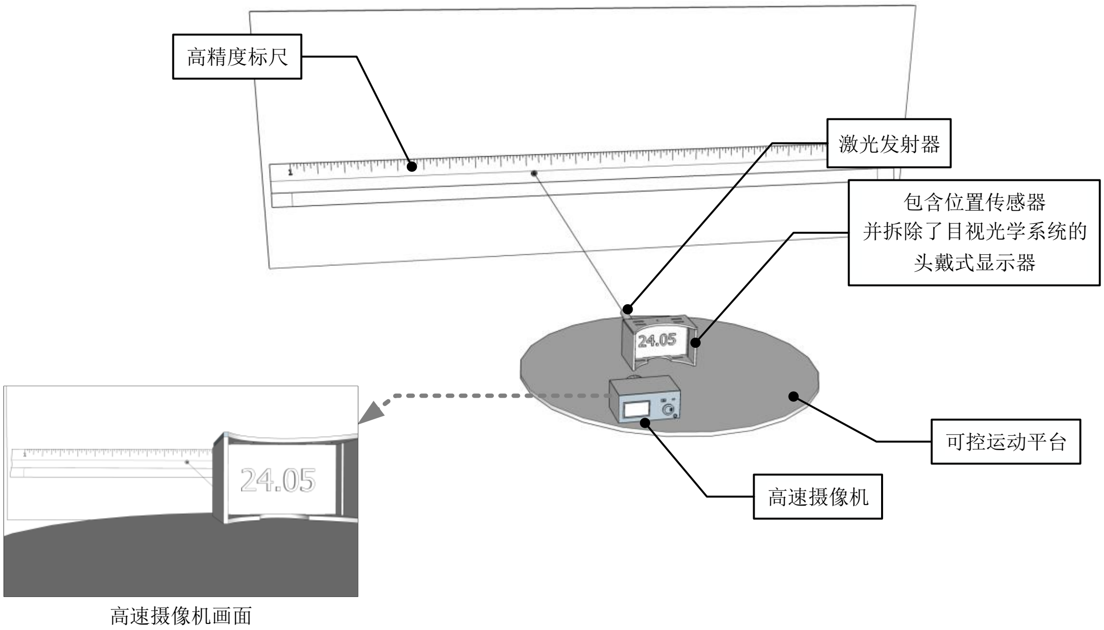
(Note: 高精度标尺: High-precision ruler; 可控运动平台: Controllable motion table: 高速摄像机：High-speed camera; 滑块: Slider; 包含位置传感器并拆除了目视光学系统的头戴显示器: HMD with a position sensor and without the visual optical system; 高速摄像机画面: Images captured by the high-speed camera)

Fig. 10 Test equipment for mobile motion-to-photo latency

10. 19. 2. 2 Test equipment for rotary motion-to-photo latency

As is shown in Fig. 11, test equipment for rotary motion-to-photo latency consists of the following parts: a high-speed camera, a controllable motion table that can rotate around a fixed spindle, a high-precision ruler, a laser-firing device, and the HMD with an angle sensor.

The high-speed camera is fixedly installed relative to the motion table. The HMD with an angle sensor is fixedly installed in the front of the high-speed camera so that the high-speed camera can clearly capture the contents on the display screen. The HMD and the laser-firing device are installed on the turntable of the controllable rotary table. The laser dots that laser-firing device fires are projected onto a vertical baffle in the front of the laser-firing device. The high- precision ruler system is also installed on the baffle. When the table rotates, the laser dots move along the high-precision ruler in a straight line and the high-speed camera can read data on the ruler based on the position of the laser dots. The HMD's computing unit implements a trial procedure. The HMD shifts the data of the position sensor so that the laser dot's corresponding ruler readings in digital forms at any time will be shown on the screen of the HMD.



(Note: 高精度标尺: High-precision ruler; 可控运动平台: Controllable motion table: 高速摄像机：High-speed camera; 滑块: Slider; 包含位置传感器并拆除了目视光学系统的头戴显示器: HMD with a position sensor and without the visual optical system; 高速摄像机画面: Images captured by the high-speed camera; 激光发射器: Laser-firing device)

Fig. 11 Test equipment for rotary motion-to-photo latency

10.19.3 Test for mobile motion-to-photo latency

Use the test equipment for mobile motion-to-photo latency to do the test. Specify a location p on the parts of the ruler within the high-speed visual camera's visual range. Record the value u_p on the screen beforehand when the slider pointer points at position p. Make the slider of the controllable motion module move at a certain speed in the test direction in a straight line. Meanwhile, the high-speed camera captures images of the slider during the whole moving process. When the slider pointer moves to location p, record the camera's frame number n_1; When the screen number reaches value u_p, record the camera's frame number n_2. Assuming that the high-speed camera's frame rate is f, the mobile motion-to-photo latency for the system is:

$$\frac{1}{f} \times (n_2 - n_1) \quad \text{(12)}$$

Where:

f: High-speed camera's frame rate;

n_2: Camera's frame number when the screen number reaches value u_p;

n_1: Camera's frame number when the slider pointer moves to location p.

10.19.4 Test for rotary motion-to-photo latency

Use the test equipment for rotary motion-to-photo latency to do the test. Specify a location p on the parts of the ruler within the high-speed visual camera's visual range. Record the value u_p on the screen beforehand when the laser dot points at position p. Make the rotary block of the controllable motion module rotate at a certain angular speed in test direction. Meanwhile, the high-speed camera captures images of laser dots during the whole moving process. When the laser dot moves to location p, record the camera's frame number n_1; When the screen number reaches value u_p, record the camera's frame number n_2. Assuming that the high-speed camera's frame rate is f, the rotary motion-to-photo latency of the system is:

$$\frac{1}{f} \times (n_2 - n_1) \qquad (13)$$

Where:

f: High-speed camera's frame rate;

n_2: Camera's frame number when the screen number reaches value u_p;

n_1: Camera's frame number when the laser dot moves to position p.

10.19.5 Notes

To test the VR system formed after the external HMD is connected to the host and the overall motion-to-photo latency of the integrated virtual reality HMD, including mobile latency and rotary latency.

During the test process, all fixed parts must be stable to avoid jitter due to moving parts. The distance between the ruler and the high-speed camera should be appropriate, never too near or too far. The high-speed camera shall clearly capture the ruler readings and the HMD's screen. The system shall be calibrated before use so that the sensor data changes and the ruler reading changes will not differ by orders of magnitude. Present the final data with the experimental environment parameters given, such as temperature, etc.

10.19.5.1 High-speed camera's acquired frame rate

The acquired frame rate of high-speed camera f_1 shall be higher than the screen refresh rate of the HMD f_2 and shall keep the time intervals between adjacent acquired frames the same. If the high-speed camera's frame rates meet the above-mentioned conditions, the minimum motion-to-photo latency to be measured is as follows:

$$t = \frac{1}{f_1}, f_1 > f_2 \qquad (14)$$

Where:

t: Minimum motion-to-photo latency;

f_1: High-speed camera's acquired frame rate f_1;

f_2: The HMD's screen refresh rate.

If time intervals between adjacent acquired frames cannot be kept the same, multiple tests can be done using a statistical method, thus minimizing the adverse impact of unstable acquired frame rates on test results. If the number of tests is k, the motion-to-photo latency can be represented as:

$$\frac{1}{k}\sum \frac{1}{f_1}(n_{k+1} - n_1), f_1 > f_2 \qquad (15)$$

Where:

k: Number of tests;

f_1: High-speed camera's acquired frame rate f_1;

f_2: The HMD's screen refresh rate.

The minimum motion-to-photo latency (statistical results) to be measured t_k is:

$$t_k = \frac{1}{kf_1}, f_1 > f_2 \quad (16)$$

Where:

t_k: Minimum latency of the statistical results;

k: Number of tests;

f_1: High-speed camera's acquired frame rate f_1;

f_2: The HMD's screen refresh rate.

10.19.5.2 Accuracy of the high-precision ruler

During mobile motion-to-photo latency test, the controllable motion table shall move at constant speed v_1; During rotary motion-to-photo latency test, the rotary speed ω of the controllable motion table shall be able to keep the rotary angular speed the same. If so, its linear speed is $v_2 = \omega \cdot r$ (r is the radius of the turntable).

10.19.5.3 During motion-to-photo latency test, the movement and rotary speed of the controllable motion table

The minimum accuracy of the high-precision ruler s shall satisfy the formula:

$$s = \frac{v_{min}}{f_1} \quad (17)$$

Where:

s: The minimum accuracy of the high-precision ruler;

v_{min}: Minimum working speed of the controllable table v_1 and the minimum rotary linear speed v_2;

f_1: High-speed camera's acquired frame rate.

10.20 Test method for opacity

10.20.1 Test equipment

Brightness meter (having a fiber optic probe).

10.20.2 Test procedure

Prepare 4 head models of different sizes and genders. Each wears an HMD with the brightness meter's probe fixed in the front of their eyes. Expose a complete set of equipment under indoor lighting and outdoor lighting, observe the brightness meter's reading and rate the opacity level based on the table below.

Table 1: Opacity grading table

Opacity grade	Excellent	Good	Poor

Brightness meter's reading	Less than 3.4×10^{-6} cd/m^2	3.4×10^{-6}～0.034 cd/m^2	More than 0.034 cd/m^2

According to the working range of the rods of a human eye divided, the opacity's function range is 3.4×10-6～0.034 cd/m^2.

10.21 Test method for heat dispersion

10.21.1 Test equipment

a) Thermostatic cabinet with humidity control;
b) Standard data acquisition device;
c) Device under test;
d) Infrared thermograph.

10.21.2 Test procedure

Place products in the thermostatic cabinet with humidity control where the temperature and humidity can be accurately controlled. Use calibrated the standard data acquisition device to collect the temperature signal. The measuring end is a calibrated T-shape thermocouple. Read the real-time converted temperature signal value with the help of the software on the standard data acquisition device. When the standard test is being conducted, the test time shall be 15 min and the maximum value in the process shall be taken. The ambient temperature shall be 25 ℃. As for test points of other products' surface temperature, an infrared thermograph shall be utilized first to obtain the highest temperature point for measurements.

10.22 Test method for tracking errors and sensitivity

10.22.1 Test equipment

Similar to the test equipment in 10.19.1.

10.22.2 Test for sensitivity and errors of the mobile tracking

HMD shows the position calculated by the tracking system by slowly moving the slider from one end of the guide track to the other end, with the high-speed camera shooting continuously during the process. Finally, using photographs, collect the variation of values shown on the display (Δp_i) and the variation of scales at which the corresponding laser dot points (Δm_i) between two adjacent frames if the display's position changes. Assuming that during the whole process, the position change N times, then:

The sensitivity of the mobile tracking is:

$$\frac{1}{N}\sum \Delta m_i \qquad (18)$$

Where:
N: Number of changes;
Δmi: Variation of scales at which the corresponding laser dot points.
The errors of the mobile tracking are:

$$\frac{1}{N}\sum |\Delta p_i - \Delta m_i| \qquad (19)$$

Where:
N: Number of changes;

Δp_i: Variation of values shown on the display;

Δm_i: Variation of scales at which the corresponding laser dot points.

Change the direction and the distance of the slide track to measure the device's sensitivity and errors in different directions and with different distances.

With this method, the tested errors also include errors due to jitter.

10. 22. 3 Test for the sensitivity of the angular tracking

HMD shows the angle calculated by the tracking system, rotating the table in one direction, with the high-speed camera shooting continuously during the process. Finally, using photographs, collect the variation of values shown on the HMD (Δp_i) and the variation of scales at which the corresponding laser dot points (Δm_i) between two adjacent frames if the HMD's position changes. Assuming that during the whole process, the position change N times, then:

Angular tracking's sensitivity is:

$$\frac{1}{N}\sum \Delta m_i \quad (20)$$

Where:

N: Number of changes;

Δm_i: Variation of scales at which the corresponding laser dot points.

The errors of angular tracking are:

$$\frac{1}{N}\sum |\Delta p_i - \Delta m_i| \quad (21)$$

Where:

N: Number of change;

Δp_i: Variation of values shown on the HMD;

Δm_i: Variation of scales at which the corresponding laser dot points.

Change the direction and distance of the turntable to measure the device's sensitivity and errors in different directions and with different distances.

With this method, the tested errors also include errors due to jitter.

10. 23 Test method for angle drift

10. 23. 1 Test equipment

HMD under test.

10. 23. 2 Test procedure

To test the average angle drift of the HMD in the horizontal direction after it horizontally stands for 30 minutes. HMDs available at present can be roughly categorized into three types: with gyroscope positioning, inside-out tracking and outside-in tracking. Different test methods are adopted for different devices.

10. 23. 2. 1 With Gyroscope Positioning

With built-in recording program, location information of the HMD can be recorded.

Place the HMD horizontally on the horizontal plane XOY (the plane can be a desk) as is shown in Fig. 12 and record the angle at this time as the initial angle. Start recording program, let it stand for 30 minutes and record drift. Horizontal drift can be calculated with initial value and final value.

(Calculation method: if the absolute value of the drift is less than 180°, take the absolute value; if the absolute value of the drift is large than 180°, subtract the absolute value from 360°.)

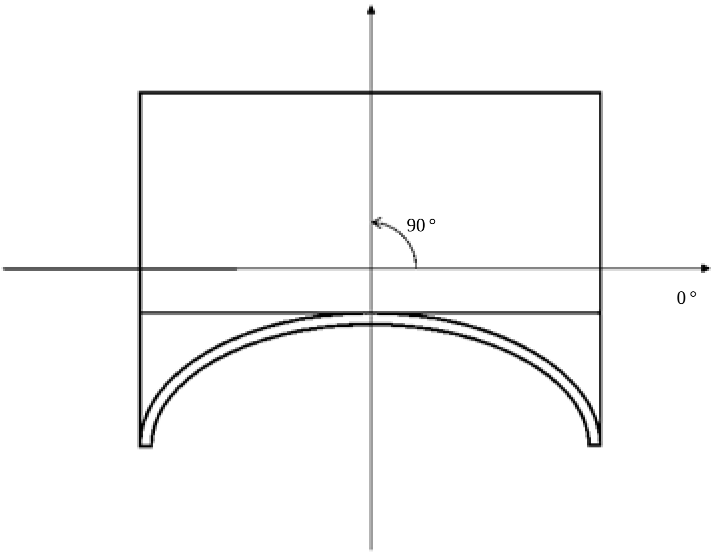


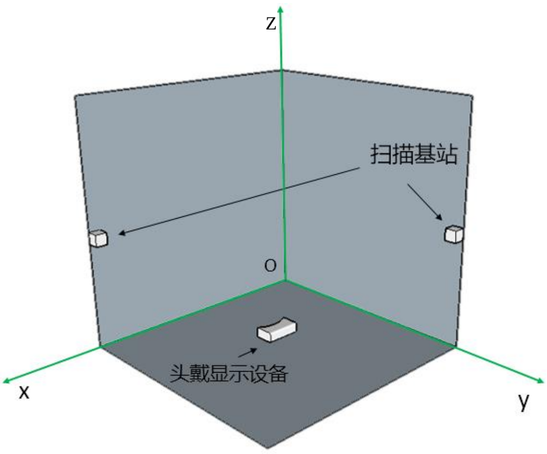
Fig. 12 Definition of Angle for HMDs (Top View)

10.23.2.2 Outside-In Tracking

Set up the scenario and connect the HMD with the host.

As is shown in Fig. 13, place the device on XOY plane, export horizontal position data of the device at this time through the host and record the data (In the figure, the location of the host is not drawn. The host can be put at any place as long as it does not influence scanning positioning of the base station.

Let the device stand for 30 minutes and capture its horizontal position data through the host again. Calculate horizontal drift with two angles according to the calculation method marked in the section "With Gyroscope Positioning".



(Note: 头戴式显示设备: HMD; 扫描基站：Scanning base station)

Fig. 13 Outside-In Tracking Test

10. 23. 2. 3 Inside-Out Tracking

Set up the scenario and connect the HMD with the host.

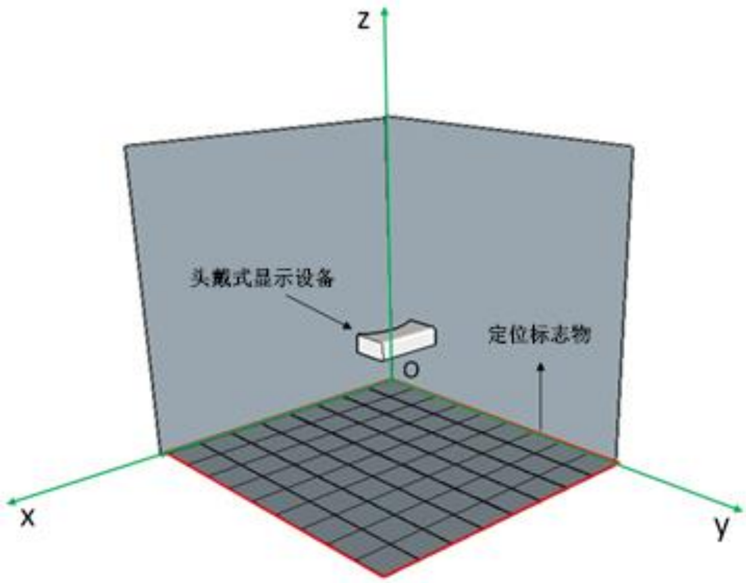
As is shown in Fig. 14, place the device in XYZ space and ensure:

a) Place the device horizontally and ensure the device is not deflected from the coordinate system;

b) Positioning marker is observable through the device and the device can be positioned by the marker (In the figure, the plan to place the marker under the device is chosen).

After the requirements above are fulfilled, export horizontal position data of the device at this time through the post and record the data (In the figure, the location of the host is not drawn. The host can be put at any place as long as it does not influence the scanning positioning of the base station.

Let the device stand for 30 minutes and capture its horizontal position data through the host again. Calculate horizontal drift with two angles according to the calculation method marked in the section "With Gyroscope Positioning".



(Note: 头戴式显示设备: HMD; 定位标志物：Positioning marker)

Fig. 14 Inside-Out Tracking Test

No matter which type of device is chosen, a corresponding test is required to repeat 3 times and average three drifts as the angle drift of the HMD.

10. 24 Test methods for sampling rates of angle and position

10. 24. 1 Test equipment

Upper Computer (Computer).

10. 24. 2 Test procedure

10. 24. 2. 1 Test Method for Angular Sampling Rate

Connect the DUT with the upper computer and run the most simple testing program for 1 minute. Given that n data are obtained within 1 minute, then the angular sampling rate is:

$$RA=n/60 \quad (22)$$

Where:

RA: Angular Sampling Rate;

N: Number of data obtained within 1 minute.

Procedural requirements: only fetch angle data and record the data.

10. 24. 2. 2 Test Method for Position Sampling Rate

Connect the DUT with the upper computer and run the most simple testing program for 1 minute. Given that n data are obtained within 1 minute, then the position sampling rate is:

$$RS=n/60 \quad (23)$$

Where:

RS: Position sampling rate;

N: Number of data obtained within 1 minute.

Procedural requirements: only fetch position data and record the data.

10. 25 **Test method for mobile tracking range**

10. 25. 1 **Test equipment**

Tape measure (precision is 1mm).

10. 25. 2 **Test procedure**

A tester wears the HMD and stands in the tracking space. The initial position is provided by the manufacturer to ensure the device is trackable at the position.

In accordance with the figure below, the tester moves in a testing direction until the tracking signal disappears. Then the tester goes back to the initial position and moves in the next testing direction until tracking boundaries of all testing directions are found.

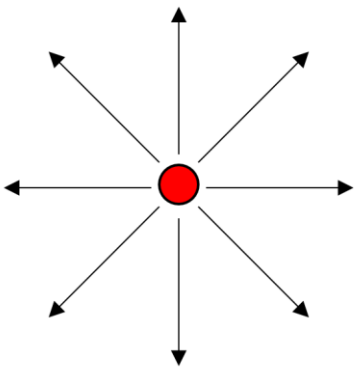


Fig. 15 The red point is the initial position of the tester and 8 arrows stand for testing directions

Based on boundary information, a rectangle is used to mark the tracking range. The area and shape of the rectangle refer to the size and the shape of the device's mobile tracking range.

10. 26 **Test method for power supply adaptability of integrated VR HMDs**

10.26.1 **Test equipment**

Device under test (DUT).

10.26.2 **Test procedure**

10.26.2.1 Test on Adaptability of Alternating Current Power Supply

Carry out tests on the DUT in combination in Table 2 and run checking program once for each combination. Samples under test shall work normally.

Table 2 Adaptability of Alternating Current Power Supply

Combination	Nominal value	
	Voltages V	Frequency Hz
1	220	50
2	198	49
3	198	51
4	242	49
5	242	51

10.26.2.2 Test on Adaptability of Direct Current Power Supply

Adjust the direct current voltage respectively in a unidirectional and bidirectional way to make its deviation nominal value ±5 % and run checking program once. The DUT shall work normally.

10.27 **Test method for battery capacity of integrated VR HMDs**

10.27.1 **Test equipment**

Battery Power Monitor.

10.27.2 **Test procedure**

Take out the batteries of the HMD to ensure no other electric elements interfere with the test. Choose proper battery power monitors and carry out charging tests on the batteries. Discharge the batteries and re-charge them. Repeat the process for three times and average the test data as the actual battery capacity.

If the batteries of the HMD are undetachable, disassemble the device and take out the batteries.

Discharging can be completed by laying the batteries back in the device and using the equipment or through circuits with the same power consumption.

10.28 **Test method for power consumption of integrated VR HMDs**

10.28.1 **Test equipment**

Battery Simulator, should be with appropriate output voltage 4V.

10.28.2 **Test procedure**

10.28.2.1 Nominal Power Consumption

Disassemble the sample DUT and remove the batteries. Charge the sample DUT and carry out sampling with the battery simulator, whose service voltage is set as 4V. After opening the DUT properly, ensure its Bluetooth function is working and is connected. Operate the game interface properly and start to record current values after the current becomes stable. Collect current values for 10 minutes and average the current values as I_{avg}.

Power consumption of the DUT while powered-off is

$$P=4V\times I_{avg} \quad (24)$$

Where:

P: Power consumption;

I_{avg}: Average current.

10.28.2.2 Stand-by power consumption

To test the nominal power consumption of integrated VR HMDs at gaming status and overall power consumption at standby status.

While the testing program is running, the DUT is required to be at normal working status, instead of specific testing mode.

No light requirements for test environment.

10.28.2.2.1 Bluetooth disconnection mode

Disassemble the sample DUT and remove the batteries. Charge the sample DUT and carry out sampling with the battery simulator, whose service voltage is set as 4V. After opening the DUT properly, ensure Bluetooth function is working and is not connected to any other devices. Do not carry out any other operations and record the current value after the current becomes stable. Collect current values for 30 minutes and average the current values as I_{avg}.

At bluetooth disconnection status, the standby power consumption of the DUT is:

$$P=4V\times I_{avg} \quad (25)$$

Where:

P: Power consumption;

I_{avg}: Average current.

10.28.2.2.2 Bluetooth connection mode

Disassemble the sample DUT and remove the batteries. Charge the sample DUT and carry out sampling with the battery simulator, whose service voltage is set as 4V. After opening the DUT properly, ensure its Bluetooth function is working and is connected. Do not carry out any other operations and record the current value after the current becomes stable. Collect current values for 3 minutes and average the current values as I_{avg}.

At bluetooth connection status, the standby power consumption of the DUT is:

$$P=4V\times I_{avg} \quad (26)$$

Where:

P: Power consumption;

I_{avg}: Average current.

10.29 **Test method for battery life of integrated VR HMDs**

10.29.1 Test equipment

Test computer.

10.29.2 Test procedure

While the testing program is running, the DUT is required to be at normal working status, instead of specific testing mode.

No light requirements for test environment.

Charge the DUT to 100% capacity.

The testing program of the DUT completes the following functions: looping certain videos; sending the unique address of test equipment to test computer at intervals of one second. Typically, the unique address is the equipment number.

The software on test computer completes following functions: recording the time from the beginning of the test to initial receipt of an equipment number; recording the latest time of receipt of equipment data; when there is more than 1 minute between a certain equipment's the latest time of data receipt and the current system time, the test of the equipment ends; when the test ends, displaying the gap between the time of receipt of the last data and the time of receipt of the first data, namely the battery life of the DUT.

10.30 Test method for adaptable MCT types of shell VR HMDs

10.30.1 Test equipment

Adapted MCT.

10.30.2 Test procedure

10.30.2.1 Test the adaptability of the adapted MCT and the HMD in hardware structure

Install the MCT under test to a specific place of HMD according to instructions, connect related interfaces and lock related fixtures.

Expected results: after installation, the adapted MCT shall be stable, insertable, and apt to lie flat, and the HMD shall be still closable.

10.30.2.2 Test the adaptability of the adapted MCT in optics

After completing the foregoing steps, run the corresponding VR application at the MCT under test, wear the HMD on the head and observe through the HMD.

Expected results: the opacity of the whole system is good and other optical parameters like eye relief, diopter difference, and brightness range meet the standard requirements. When the tester turns his head with three degrees of freedom on xyz axis, the MCT, relative to the HMD, shall not drift, swing, loosen or have other problems. The specified software of the HMD shall run to completion on the adapted MCT, the installation and launch shall not fail, and the software shall not crash at run time. Detaching the MCT from the HMD shall not be required to complete interactive operations. In optics, visible light leaks through lens, distortion, and inability to in-focus of images in both eyes shall not occur. The field of view shall fit in with the size of MCT screen and other related parameters of shell HMDs shall be fulfilled.

10.31 Test method for external sensors of shell VR HMDs

10.31.1 Test equipment

The MCT adapted with the HMD.

10.31.2 Test procedure

10.31.2.1 Test the adaptability of the adapted MCT and the HMD in hardware structure

Install the MCT to the specific place of the HMD according to the instructions, ensure proper physical connection of data transfer interfaces (such as Micro USB, Type C, Lighting interface, etc.), and ensure the MCT can be inserted properly into the HMD.

Expected results: after the adapted MCT is inserted and fixed through the HMD, the adapted MCT shall be unshakable, insertable, and apt to lie flat, and the HMD shall not be non-closable.

10.31.2.2 Test software adaptability of the adapted MCT

Run specific VR applications at the MCT under test.

Expected results: the MCT can run specific VR applications normally, recognize the insertion of HMD through software, and respond with software installation, software start-up and other operations. The installation and launch shall not fail, and the software shall not crash at run time. Detaching the MCT from the HMD shall not be required to complete interactive operations.

10.31.2.3 Test adaptability of external sensors

First test working status after inserting the adapted MCT, namely turn the HMD, and observe follow-up status of images; then test working status of external sensors based on the standards, namely test whether the system motion-to-photo latency meets the nominal value, even though a high-speed camera is used.

Expected results: insert the HMD into the MCT, wear it on the head and turn the head with three degrees of freedom on the xyz axis. Follow-up status of images are good; with a high-speed camera, it turns out that the system motion-to-photo latency meets the product's nominal value.

Appendix A
(Informative Appendix)
List of Performance Requirements

Table A. 1 List of Performance Requirements

Requirement Type	Requirement Item	Device Type		
		External	Integrated	Shell
Chinese Information Processing	Character set	The product shall use the character set specified by national standards in the following scope: a) A mapping relationship must be established between the compulsory part of GB 18030 or the corresponding part of GB 13000 and GB 18030; b) The compulsory part of GB 18030 and its optional part in Chinese, or the corresponding part of GB 13000 (must have a mapping relationship with GB 18030).	The product shall use the character set specified by national standards in the following scope: a) A mapping relationship must be established between the compulsory part of GB 18030 or the corresponding part of GB 13000 and GB 18030; b) The compulsory part of GB 18030 and its optional part in Chinese, or the corresponding part of GB 13000 (must have a mapping relationship with GB 18030).	The product shall use the character set specified by national standards in the following scope: a) The compulsory part of GB 18030, or the corresponding part of GB 13000 must have a mapping relationship with GB 18030; b) The compulsory part of GB 18030 and its optional part in Chinese, or the corresponding part of GB 13000 (must have a mapping relationship with GB 18030).
	Chinese font	a) Dot matrix font The bitmap font used by the product shall be selected from the dot matrix series regulated by GB/T 11460. No products shall use a dot matrix of less than 11×12. b) Non-bitmap font The products shall use a non-bitmap font in accordance with the following requirements:	a) Dot matrix font The bitmap font used by the product shall be selected from the dot matrix series regulated by GB/T 11460. No products shall use a dot matrix of less than 11×12. b) Non-bitmap font The products shall use a non-bitmap font in accordance with the following requirements:	a) Dot matrix font The bitmap font used by the product shall be selected from the dot matrix series regulated by GB/T 11460. No products shall use a dot matrix of less than 11×12. b) Non-bitmap font The products shall use a non-bitmap font in accordance with the following requirements:

Table A. 1 (Continued)

Requirement Type	Requirement Item	Device Type		
		External	Integrated	Shell
Chinese Information Processing	Chinese font	1) Between each formed dot matrix, the pencil shall conform to the standards, the structures shall be reasonable, and the styles shall be consistent, beautiful and practical; 2) The strokes of formed low dot matrix (24 dot matrix or below) shall be consistent with relevant low dot matrix standards; 3) Adjacent strokes shall not be connected (following strokes are not included). c) Characters in decoration explanation The decorative and instructional character pencils shall comply with the national language and characters.	1) Between each formed dot matrix, the pencil shall conform to the standards, the structures shall be reasonable, and the styles shall be consistent, beautiful and practical; 2) The strokes of formed low dot matrix (24 dot matrix or below) shall be consistent with relevant low dot matrix standards; 3) Adjacent strokes shall not be connected (following strokes are not included). c) Characters in decoration explanation The decorative and instructional character pencils shall comply with the national language and characters.	1) Between each formed dot matrix, the pencil shall conform to the standards, the structures shall be reasonable, and the styles shall be consistent, beautiful and practical; 2) The strokes of formed low dot matrix (24 dot matrix or below) shall be consistent with relevant low dot matrix standards; 3) Adjacent strokes shall not be connected (following strokes are not included). c) Characters in decoration explanation The decorative and instructional character pencils shall comply with the national language and characters.
Basic Requirements	The concentration limitation of restricted substances	When applicable, the concentration limitation of the hazardous and noxious substances shall conform to the provisions in GB/T 26572.	When applicable, the concentration limitation of the hazardous and noxious substances shall conform to the provisions in GB/T 26572.	When applicable, the concentration limitation of the hazardous and noxious substances shall conform to the provisions in GB/T 26572.
	The weight of the head mounted part	The weight shall be less than or equal to 0.8 kg and specified in the product manual.	The weight shall be less than or equal to 0.8 kg and specified in the product manual.	The weight shall be less than or equal to 0.5 kg and specified in the product manual.

Table A. 1 (Continued)

Requirement Type	Requirement Item	Device Type		
		External	Integrated	Shell
Basic Requirements	The dimensions of the head mounted part	The width shall be less than or equal to 215 mm, the thickness shall be less than or equal to 125 mm, and the height shall be less than or equal to 160 mm. The width shall be specified in the product manual.	The width shall be less than or equal to 215 mm, the thickness shall be less than or equal to 125 mm, and the height shall be less than or equal to 160 mm. The width shall be specified in the product manual.	The width shall be less than or equal to 215 mm, the thickness shall be less than or equal to 110 mm, and the height shall be less than or equal to 160 mm. The width shall be specified in the product manual.
	Types of adaptable mobile communication terminals (MCTs)	—	—	The type shall fit in with the adaptability of hardware structure and optics and shall be specified in the product manual.
Optical requirements	Field of view	First-level indicator: shall be greater than or equal to 100 °; second-level indicator: shall be greater than or equal to 80 °. The field of view shall be specified in the product manual.	First-level indicator: shall be greater than or equal to 100 °; second-level indicator: shall be greater than or equal to 80 °. The field of view shall be specified in the product manual.	First-level indicator: shall be greater than or equal to 100 °; second-level indicator: shall be greater than or equal to 80 °. The field of view shall be specified in the product manual.
	Effective pixel ratio	Shall be greater than or equal to 65%.	Shall be greater than or equal to 65%.	Shall be greater than or equal to 60%.
	The range of inter-pupillary distance	For adults, inter-pupillary distance should be between 50 mm and 75 mm. For children, inter-pupillary distance should be between 50 mm and 65 mm. Inter-pupillary distance should be adjustable. The range of inter-pupillary distance shall be specified in the product manual.	For adults, inter-pupillary distance should be between 50 mm and 75 mm. For children, inter-pupillary distance should be between 50 mm and 65 mm. Inter-pupillary distance should be adjustable. The range of inter-pupillary distance shall be specified in the product manual.	For adults, inter-pupillary distance should be between 50 mm and 75 mm. For children, inter-pupillary distance should be between 50 mm and 65 mm. Inter-pupillary distance should be adjustable. The range of inter-pupillary distance shall be specified in the product manual.
	Eye relief	Eye relief shall be greater than or equal to 10 mm.	Eye relief shall be greater than or equal to 10 mm.	Eye relief shall be greater than or equal to 10 mm.
	Exit pupil diameter	Exit pupil diameter shall be greater than or equal to 4 mm.	Exit pupil diameter shall be greater than or equal to 4 mm.	Exit pupil diameter shall be greater than or equal to 4 mm.

Table A. 1 (Continued)

Requirement Type	Requirement Item	Device Type		
		External	Integrated	Shell
Optical requirements	Distortion	After the software algorithm corrects distortion, with 30 ° half-field of view, distortion shall be less than or equal to 3%.	After the software algorithm corrects distortion, with 30 ° half-field of view, distortion shall be less than or equal to 3%.	After the software algorithm corrects distortion, with 30 ° half-field of view, distortion shall be less than or equal to 3%.
	Adjustable range of diopter	The adjustable range should be greater than or equal to 6D, and it shall be specified in the product manual.	The adjustable range should be greater than or equal to 6D, and it shall be specified in the product manual.	The adjustable range should be greater than or equal to 6D, and it shall be specified in the product manual.
	Diopter adjustment	For devices supporting diopter adjustments, it should be adjusted for both eyes simultaneously or separately for each eye. It shall be specified in the product manual.	For devices supporting diopter adjustments, it should be adjusted for both eyes simultaneously or separately for each eye. It shall be specified in the product manual.	For devices supporting diopter adjustments, it should be adjusted for both eyes simultaneously or separately for each eye. It shall be specified in the product manual.
	Chromatic aberration	With 30 °half field of view, distortion shall be less than or equal to 3%.	With 30 °half field of view, distortion shall be less than or equal to 3%.	With 30 °half field of view, distortion shall be less than or equal to 3%.
	The parallel deviation of the binocular optical axis	Horizontally, divergence angle shall be less than or equal to 1 °; horizontally, convergence angle shall be less than or equal to 0.5 °; vertically, intersection angle shall be less than or equal to 1 °.	Horizontally, divergence angle shall be less than or equal to 1 °; horizontally, convergence angle shall be less than or equal to 0.5 °; vertically, intersection angle shall be less than or equal to 1 °.	Horizontally, divergence angle shall be less than or equal to 1 °; horizontally, convergence angle shall be less than or equal to 0.5 °; vertically, intersection angle shall be less than or equal to 1 °.
Display requirements	Display resolution	First-level indicator: shall be greater than 1200 ×1080; second-level indicator: shall be higher than 960 ×1080; this shall be specified in the product manual.	First-level indicator: shall be greater than 1200 ×1080; second-level indicator: shall be higher than 960 ×1080; this shall be specified in the product manual.	—

Table A. 1 (Continued)

Requirement Type	Requirement Item	Device Type		
		External	Integrated	Shell
Display requirements	Screen refresh rate	First-level indicator: shall be greater than or equal to 90 Hz; second-level indicator: shall be greater than or equal to 60 Hz. The screen refresh rate shall be specified in the product manual.	Frequency shall be greater than or equal to 60 Hz. The screen refresh rate shall be specified in the product manual.	—
	Brightness and contract	First-level indicator: LCD contrast shall be greater than or equal to 500:1; OLED contrast shall be greater than or equal to 5000:1; second-level indicator: LCD contrast shall be greater than or equal to 300:1; OLED contrast shall be greater than or equal to 1000:1.	First-level indicator: LCD contrast shall be greater than or equal to 500:1; OLED contrast shall be greater than or equal to 5000:1; second-level indicator: LCD contrast shall be greater than or equal to 300:1; OLED contrast shall be greater than or equal to 1000:1.	—
Overall performance requirements	Virtual image distance	The distance shall be greater than or equal to 0.3 m.	The distance shall be greater than or equal to 0.3 m.	—
	Angular resolution	Both horizontal and vertical angular resolution shall be greater than or equal to 9PPD and specified in the product manual.	Both horizontal and vertical angular resolution shall be greater than or equal to 9PPD and specified in the product manual.	—
	System motion-to-photo latency	First-level indicator: should be less than or equal to 33 ms; second-level indicator: should be less than or equal to 45 ms, or as defined in product standards. The system motion-to-photo latency shall be specified in the product manual.	Latency should not be longer than 45 ms or shall be consistent with the product standards. The system motion-to-photo latency shall be specified in the product manual.	—
	Opacity	No requirements.	No requirements.	—

Table A. 1 (Continued)

Requirement Type	Requirement Item	Device Type		
		External	Integrated	Shell
Overall performance requirements	Cooling property	The highest temperature of the device surface shall be less than or equal to 55 ℃ (when the environment temperature is 25 ℃).	The highest temperature of the device surface shall be less than or equal to 55 ℃ (when the environment temperature is 25 ℃).	—
	Adaptability to power supply	—	Products with alternating current power supply shall operate normally at 220 V ±22 V and 50 Hz ±1 Hz. Products with direct current power supply shall operate normally under the condition that the nominal value of the direct current is (100 ±5)%.	—
	Battery capacity	—	First-level indicator: greater than or equal to 3500 mAh; second-level indicator: greater than or equal to 2200 mAh. The battery capacity shall be specified in the product manual.	—
	Power consumption	—	Shall be specified in the product manual.	—
	Endurance	—	First-level indicator: in movie mode, it shall be longer than 180 min; in game mode, it shall be longer than 90 min; second-level indicator: in movie mode, it shall be longer than 120 min; in game mode, it shall be longer than 60 min. The endurance shall be specified in the product manual.	—

Table A. 1 (Continued)

Requirement Type	Requirement Item	Device Type		
		External	Integrated	Shell
Tracking requirement	Tracking Mode	For the HMD that supports tracking, it shall support at least 3DOF; it is recommended for the device to support 6DOF. The tracking mode shall be specified in the product manual.	For the HMD that supports tracking, it shall support at least 3DOF; it is recommended for the device to support 6DOF. The tracking mode shall be specified in the product manual.	—
	Angle drift	At static status, drift shall be less than or equal to 18 °.	At static status, drift shall be less than or equal to 18 °.	—
	Angular sampling rate	Frequency shall be greater than or equal to 60 Hz.	Frequency shall be greater than or equal to 60 Hz.	—
	Mobile tracking range	Mobile tracking range level or detailed parameters shall be specified in the product manual.	Mobile tracking range level or detailed parameters shall be specified in the product manual.	—
	Mobile tracking errors	Error shall be less than or equal to 15 mm.	Error shall be less than or equal to 15 mm.	—
	Position sampling rate	Frequency shall be greater than or equal to 60 Hz.	Frequency shall be greater than or equal to 60 Hz.	—
	Tracking stability	First-level indicator: the angular tracking jittering range shall be less than or equal to 1 °, the position tracking jittering range shall be less than or equal to 5 mm. Second-level indicator: the angular tracking jittering range shall be less than or equal to 2 °, the position tracking jittering range shall be less than or equal to 10 mm.	First-level indicator: the angular tracking jittering range shall be less than or equal to 1 °, the position tracking jittering range shall be less than or equal to 5 mm. Second-level indicator: the angular tracking jittering range shall be less than or equal to 2 °, the position tracking jittering range shall be less than or equal to 10 mm.	—

Table A. 1 (Continued)

Requirement Type	Requirement Item	Device Type		
		External	Integrated	Shell
Tracking requirement	Tracking sensitivity	First-level indicator: the minimum angle shall be less than or equal to 1 °, and the moving distance shall be shorter than or equal to 5 mm; second-level indicator: the minimum angle shall be less than or equal to 2 °, and the moving distance shall be shorter than or equal to 10 mm. Tracking sensitivity shall be specified in the product manual.	First-level indicator: the minimum angle shall be less than or equal to 1 °, and the moving distance shall be shorter than or equal to 5 mm; second-level indicator: the minimum angle shall be less than or equal to 2 °, and the moving distance shall be shorter than or equal to 10 mm. Tracking sensitivity shall be specified in the product manual.	—
Requirements for external sensor devices	External sensors	—	—	External sensors shall fit in with adaptability and shall be specified in the product manual.