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TECHNICAL REPORT

colour inside

3D display devices – Part 51-1: Generic introduction of aerial display

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FOREWORD

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IEC TR 62629-51-1, which is a Technical Report, has been prepared by IEC technical committee 110: Electronic displays.

The text of this Technical Report is based on the following documents:

Draft TR	Report on voting
110/1178/DTR	110/1190/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62629 series, published under the general title *3D display devices*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

This document intends to gather technical information on aerial displays, and to clarify the relationship to normative aspects of the standardization in this technology area.

3D DISPLAY DEVICES –

Part 51-1: Generic introduction of aerial display

1 Scope

This part of IEC 62629, which is a Technical Report, provides general information for the standardization of aerial displays. This document includes an overview of the technology, critical performance characteristics, issues of optical measurements, and other information.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
aerial display
display that forms a real image in mid-air by use of an incoherent light-source display and a passive optical component to converge diverging light from the light-source display

Note 1 to entry: See 4.1 and 4.2.

3.2 Abbreviated terms

AIRR	aerial imaging by retro-reflection
BS	beam splitter
CMA	crossed-mirror array
CTF	contrast transfer function
DCRA	dihedral-corner-reflector array
DFD	depth-fused 3D
FPD	flat-panel display
FPGA	field programmable gate array
GPU	graphics processing unit
HMD	head-mounted display
HOE	holographic optical element
HUD	head-up display
LCD	liquid-crystal display
LED	light-emitting diode

LMD light measuring device
MLA micro-lens array
MTF modulation transfer function
NA numerical aperture
OLED organic light-emitting diode
PD photo detector
PL polarizer
PSF point-spread function
QWR quarter-wave retarder
RR retro-reflector
SMA slit-mirror array

4 Aerial display technologies

4.1 General

In a general sense, an aerial display refers to a display that shows information in mid-air, where there is no hardware. Thus, a display carried by a drone or a balloon is not an aerial display. There are a variety of display techniques that show information in mid-air. Perception of a floating image can be evoked by use of conventional 3D display techniques, such as stereoscopic displays, holographic displays, and light-field displays. In a stereoscopic display, the perceived 3D position depends on the viewer's eye positions. However, the real image of a light-source display is perceived at the same 3D position for everyone.

Classification of 3D display techniques is shown in Table 1. 3D display techniques are classified as real-image formation and virtual-image formation with or without hardware on the image. Aerial displays in the general sense are indicated in the upper left side in Figure 1.

Table 1 – Classification of displays that show an image in mid-air

	No hardware on or in front of the image	Hardware on or in front of the image
Real image	Holographic display Light-field display Information screen that is formed by use of a passive optical component, such as lens, MLA, DCRA, SMA, RR, and HOE	Transparent display Light-field display Semi-transparent screen, such as nano-diamond screen, fog, mist with a projector Rapid motion of a display hardware Laser-induced plasma
Virtual image	None	Pepper's ghost HUD HMD

The essentials of an aerial display in a strict sense are shown in Figure 1. An aerial display in the strict sense forms a real image in mid-air by use of an incoherent light-source display and a passive optical component to converge diverging light from the light-source display.

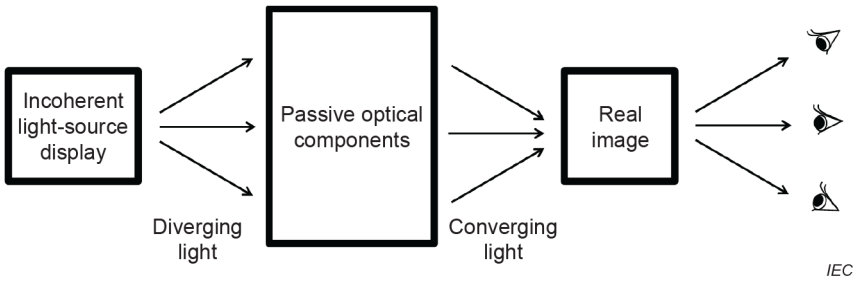

Figure 1 – Essentials of aerial display in the strict sense

As shown in Table 1, a holographic display can form a real image in mid-air. However, a holographic display is not an aerial display in the strict sense because the electric holographic display uses a coherent light source and an active optical component for image formation.

A light-field display can be composed of an incoherent source display and a passive optical component, such as an MLA on an FPD. Furthermore, some light-field displays can converge light rays and form an information screen in mid-air. As illustrated in Figure 1, the optical component in the aerial display converges the diverging light rays from the light-source display, while a light-field display controls the direction of the semi-paralleled lights from the MLA. The aerial display does not reproduce the light field.

Real-image formation makes possible aerial applications. Aerial displays for interaction and public signage require the following features:

a) the image can be handled directly with a naked hand;

b) the image position is the same for everyone;

c) the image is visible to the naked eyes without eyewear;

d) the image is altered within a sufficiently short latency.

The features a) and b) are maintained by forming a real image in mid-air without hardware on the screen. Because feature c) depends on the applications of the aerial display, the requirements and performance factors will be discussed based on the interaction, including human factor, in the future. Note that a passive optical component does not increase latency.

Use of an incoherent light source is free from laser safety issues. For use by the general public, a limited group of aerial display techniques is suitable with regard to eye safety, cost, mass production, and 3D position. Use of mass-produced passive optical elements reduces their production cost and driving circuit. The real image in mid-air is perceived at the same position by multiple viewers. Thus, the aerial display maintains the requirements mentioned above.

The depth perception of the aerial image is given with physiological depth cues. Thus, the aerial display is a kind of 3D display, which is defined as a display device giving depth perception with physiological depth cues.

4.2 Principle

An aerial display can be realized by use of a light-source display and some imaging optics, [1] to [10][1]. The following methods use a passive optical component. The role of the passive optical component in the aerial display in the strict sense is to converge diverging light rays from the light-source display to the aerial real image. The incoherent light-source display emits diverging light rays. The diverging light impinges on the passive optical component, which changes the direction of each light ray so that light converges to the image position in mid-air. Thus, the real image of the light source is formed because diverging plural rays emitted from a source position converge to the single position. The formed real image is visible over a wide range of angles

[1] Numbers in square brackets refer to the Bibliography.