

A New Approach for Efficient Evaluation of Switchable Privacy Displays

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Switchable privacy is a hot topic for smartphones (data privacy in public e.g. Samsung S26 Ultra) and for codriver displays (CDD) in cars. Our focus is on the latter, where driver distraction by a CDD is not permitted. An important task for industrialization is standardization. We propose an easy-to-measure method that uses viewing angle areas and thresholds based on our measurements and evaluations.

1 Introduction

Switchable privacy displays (SPD) are used for data security in public spaces (e.g. Samsung S26 Ultra) and for CDDs in cars ([1], Fig. 1). Common definitions of SPDs are (Fig. 2 top left):

- Public mode: The display content is visible to “everyone” with high image quality.
- Private mode: Only observers with an on-axis orientation to the display can read the content, which is blocked at oblique angles.

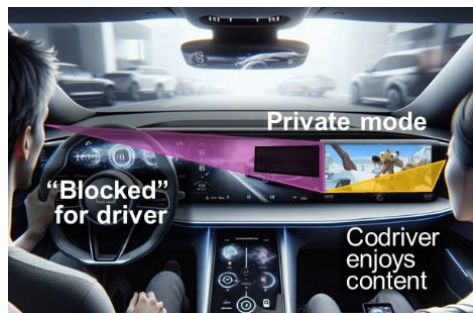


Fig. 1 Visualization of a codriver display in private mode blocking the content for the driver and enabling viewing for codriver. Image generated by Microsoft's Copilot using the prompts “modern car interior with driver and codriver”, “codriver display” including some fine tuning by KB.

This paper presents a possible way to specify the optical performance of SPDs in cars efficiently. Details on SPDs regarding applications, techniques, optical measurements and evaluations can be found in [2] and [3] for example.

2 Codriver Displays: Typical Geometry in Cars and Conoscopic Measurements

Fig. 2 shows a typical geometry of a car with a left-hand steering wheel and a 10.5" CDD. The CDD is usually positioned 60 cm from the codriver, providing a field of view (FoV) of 24° for a width of 25 cm. The driver's viewing distance is usually around 100 cm, resulting in a FoV of approximately 11° at an oblique horizontal angle of between -40° and -50° for a driver for the center of the display. These figures depend heavily on vehicle parameters, the size

and position of the CDD, and the heights and seat adjustments of the driver and codriver.

The angular characteristics of the white luminance for an SPD in public (driver) and private (codriver) modes, are the fundamental measurements. Viewing angle characteristics are typically visualized as polar plots and are measured most efficiently by using an imaging light measuring device (ILMD) with a conoscopic lens, see Fig. 3 for reference.

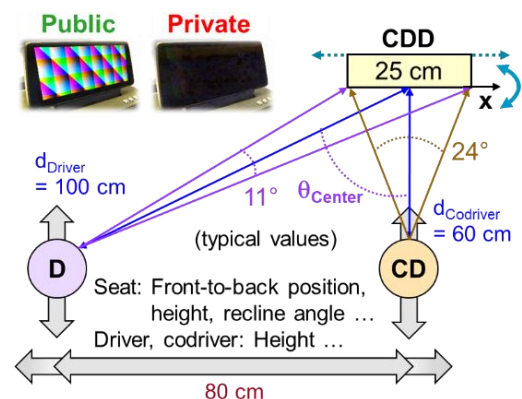


Fig. 2 Visualization of the typical horizontal geometry and its variations for the driver (D) and codriver (CD) in relation to the codriver display (CDD). Inset: SPD modes.

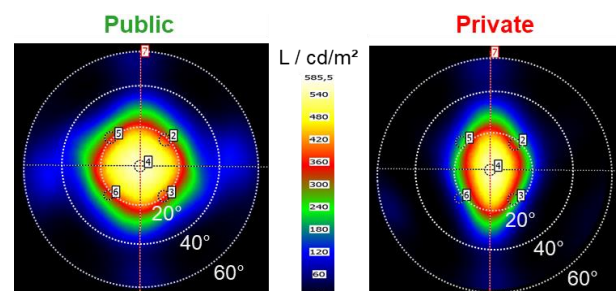


Fig. 3 Measurement example as viewing angle polar plots (left: public, right: private mode) for a switchable privacy display acquired by our TechnoTeam LMK 6-30 Color ILMD with a conoscopic lens ($\pm 60^\circ$) mounted.

3 Efficient Specification for SPDs

Specifying the optical performance of automotive displays is usually very complex. As a consequence, German original equipment manufacturers

(OEMs) and the Displayforum (DFF, www.displayforum.org) established a specification [4], which significantly reduces measurement and reporting. One fundamental concept is to define viewing angle areas (Tab. 1, Fig. 4) rather than using polar plots as in Fig. 3 or charts with e.g. luminance over horizontal viewing angle (see e.g. [3]). Values for an area can easily be extracted from viewing angle measurements, as shown in Fig. 3, and only a check, if the luminance threshold in area A+ is exceeded across the entire area, is needed. Therefore, only an area "D" in Tab. 1 for the driver in private mode had to be added for SPDs. A+ refers to the codriver watching a CDD (in both public and private modes), while 'A' and 'B' refer to the driver in public mode.

Topic	Viewing Angle Definitions
Public mode for driver and codriver	A+ / A / B areas (see [4])
Private mode for codriver	A+ area (see [4])
Private mode for driver; definition of area "D"	H-35° / V+20° H-35° / V-10° H-60° / V+20° H-60° / V-10°
Nominal view angle on close edge of CDD	H-45° / V0°

Tab. 1 Definitions of viewing angles and area "D".

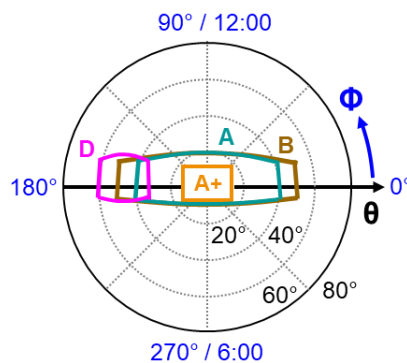


Fig. 4 Definitions of viewing angle areas acc. Tab. 1.

The final step is then to define the threshold values for these areas. This is listed in Tab. 2 based on the standard display requirements ([4] and [5]). The normalized luminance values are derived from our evaluations [3], OEM experience and other sources.

4 Summary

Our measurements and evaluations result in an efficient specification for switchable privacy displays. A standard on SPD will be issued by the DFF [6].

5 Acknowledgements

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Schaffer, Sven Beyer, Otto Bader, Tae-Yong Park and Ingo Rotscholl, for their valuable contributions to the SPD standard [6].

Topic	Values
Maximum luminance for white for A+	> 800 cd/m ²
Normalized luminance L_N , m = private or public	$L_N(\alpha, m) = L(\alpha, m) / L(H0^\circ / V0^\circ, m)$
Normalized white luminance over A viewing angle for public mode	>56%
Normalized white luminance over B viewing angle for public mode	>37.5%
Normalized white luminance over A+ viewing angle for private mode	>50%
Normalized white luminance within "D" (driver) viewing angle for private mode	<1%
Normalized luminance at nominal position for driver in private mode; H-45° / V0°	<0.5%
Normalized horizontal luminance ratio for driver of far to close edge	>50%
Black mura [5] uniformity luminance in public mode (H0° / V0°) for codriver	>75%
Black mura uniformity [5] white luminance in private mode (H0° / V0°) for codriver	>75%

Tab. 2 Threshold values of the DFF proposal [6].

References

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- [4] DFF standard "Display Specification for Automotive Application V5.1 (OEM Specification)" available on demand via www.displayforum.org
- [5] DFF standard "Uniformity Measurement Standard for Displays V 1.3 (Black Mura)" available on demand via www.displayforum.org
- [6] DFF draft (as of July 2026) standard "Switchable Privacy Mode" available on demand via www.displayforum.org