



VESA Adaptive-Sync Display Certification Test Specification (Adaptive-Sync Display CTS)

Revision 1.0

29 April, 2022

vesa.org

Purpose

The purpose of this Specification is to define the tests to be used for certifying displays for the VESA CERTIFIED AdaptiveSync or MediaSync Display logo program.

Summary

This Specification defines a set of test criteria, testing methodology, and performance mandates for each of the newly established logo performance tiers in the VESA CERTIFIED AdaptiveSync or MediaSync Display logo program.

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Preface

Intellectual Property

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Support for this Specification

Clarifications and application notes to support this Specification may have been written. To obtain the latest Specification and any supporting documentation, contact VESA[®].

If you have a product that incorporates the Adaptive-Sync operation, ask the company that manufactured your product for assistance. If you are a manufacturer, VESA may assist you with any clarification you might need.

Submit all comments or reported errors to support@vesa.org.

Acknowledgments

This Specification would not have been possible without the efforts of the VESA Display Performance Metrics Task Group. In particular, [Table 1](#) lists the individuals and their companies that contributed significant time and knowledge to this revision of the Specification.

Table 1: Main Contributors to Adaptive-Sync Display CTS r1.0

Company	Name	Contribution
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Table 1: Main Contributors to Adaptive-Sync Display CTS r1.0 (Continued)

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Revision History

Table 2: Revision History

Date	Revision	Description
April 29, 2022	1.0	Initial release.

1 Introduction

1.1 Overview

Within the display domain, there are no publicly open standards for front-of-screen display performance with regard to Adaptive-Sync operation or Variable Refresh Rate performance characteristics. This Specification defines a set of test criteria, testing methodology, and performance mandates for each of the newly established logo performance tiers in the VESA[®] CERTIFIED AdaptiveSync and MediaSync Display logo programs.

This Specification is primarily designed for use in the PC industry, particularly for monitors and laptops. However, nothing in this Specification is intended to intentionally exclude other screen sizes or usage domains.

By establishing an industry-wide, open, public Specification for front-of-screen display performance of variable refresh rate displays with the VESA CERTIFIED AdaptiveSync and MediaSync Display logo programs, VESA hopes to help users easily identify which displays deliver higher-performance capabilities prior to purchase.

1.2 Document Organization

This Specification is organized as follows:

- [Section 1 – Introduction](#)

This section provides an overview of this Specification. This section also includes a list of acronyms and glossary of terms that are used within this Specification and references to related Specifications/Standards.

- [Section 2 – Mandate Summary](#)

This section summarizes the mandates for this Specification. Each test and certification mandate listed in this section's tables are explained in further detail in subsequent sections.

- [Section 3 – Test Environment](#)

This section provides guidance to manufacturers and professional test houses for achieving a correctly configured test environment for running the suite of AdaptiveSync and/or MediaSync Display logo certification tests.

- [Section 4 – Monitor OSD-related Mandates](#)

This section specifies the mandates that apply only to monitors and displays that have an On-screen Display (OSD) menu.

- [Section 5 – VESA AdaptiveSync or MediaSync Display Logo Certification](#)

This section specifies the VESA CERTIFIED AdaptiveSync or MediaSync Display logo mandates for any Adaptive-Sync operation-capable display device that provides an external interface that transports *DisplayPort*.

- [Section 6 – Refresh Rate and Flicker Testing](#)

This section describes the test criteria for the *DisplayID* or legacy *EDID* refresh rates that define the Adaptive-Sync operation refresh rate range.

- [Section 7 – Gray-to-Gray Testing](#)

This section describes the tests for **gray-to-gray** (G2G) in SDR mode.

- [Section 8 – Video Frame Drop Testing](#)

This section describes the test for verifying that video frames are **not** being dropped.

- [Section 9 – Video Frame Rate Jitter Testing](#)

This section describes the tests to be performed to ensure that all standard media video frame rates are supported, and that the video frame-to-frame jitter is minimized.

- [Section 10 – HDR Testing](#)

This section describes the testing that is needed in HDR mode for HDR-capable displays.

- [Appendix A – Example 8-bit SDR Gamma 2.2 Luminance Values \(Informative\)](#)

This appendix provides example 8-bit SDR Gamma 2.2 luminance values.

1.3 Document Conventions

1.3.1 Precedence

If there is a conflict between text, figures, and tables, the precedence shall be tables, figures, and then text.

1.3.2 Keywords

Table 1-1 lists keywords that differentiate between the levels of mandates and options within this Specification.

Table 1-1: Keywords

Keyword	Definition
informative	Information that discusses and clarifies mandates and features.
may	Indicates a choice that does not have an implied preference.
N/A	Indicates that a field or value is not applicable, does not have a defined value, and shall not be checked or used by the recipient.
normative	Features that are mandated by this Specification.
optional	Features that are not mandated by this Specification. However, if an optional feature is implemented, the feature shall be implemented as defined by this Specification (optional normative).
shall	Indicates a mandate. Designers shall implement all such mandates to ensure interoperability with other compliant devices.
should	Indicates flexibility of choice with a preferred alternative. Equivalent to the phrases “is recommended” and “it is recommended that.”

1.3.3 Units of Measure

Table 1-2 lists units of measure that are used throughout this Specification.

Table 1-2: Units of Measure

Symbol	Unit of Measure	Symbol	Unit of Measure
cd/m ²	candela per square meter	Hz	hertz
°C	degrees Celsius	in.	inch
dB	decibel	mm	millimeter
°F	degrees Fahrenheit	ms	millisecond
fps	frames per second	%	percent

1.3.4 Acronyms and Abbreviations

Table 1-3 lists acronyms and abbreviations that are used throughout this Specification. Capitalization is applied in the definition to indicate the letters used in acronyms and abbreviations.

Table 1-3: Acronyms and Abbreviations

Term	Definition
AC	Alternating Current
APL	Average Picture Level
CDF	Cumulative Distribution Function
CPU	Central Processing Unit
CTA™	Consumer Technology Association (formerly Consumer Electronics Association)
CTS	Certification Test Specification (this document)
	Compliance Test Specification (referenced documents)
CVT	Coordinated Video Timings (<i>CVT Standard</i>)
DC	Direct Current
DisplayID	Display IDentification (<i>DisplayID Standard</i>)
DisplayPort Alt Mode	DisplayPort Alt Mode on USB Type-C® (<i>DisplayPort Alt Mode</i>)
DP	<i>DisplayPort (DP Standard)</i>
DUT	Display Under Test
EDID	Extended Display Identification Data (legacy VESA structure, superseded by the <i>DisplayID</i> structure)
E-EDID	Enhanced Extended Display Identification Data (legacy VESA structure, superseded by the <i>DisplayID</i> structure)
eDP	embedded DisplayPort (<i>eDP Standard</i>)
EOTF	Electro-Optical Transfer Function (<i>SMPTE ST 2084</i> ; used with HDR)
FFT	Fast Fourier Transform
G2G	Gray-to-Gray
GPU	Graphics Processing Unit
HDR	High Dynamic Range
ICDM	International Committee on Display Metrology (SID)
KGL	Known Game List
L (elec)	electronics Latency
LCD	Liquid-Crystal Display
mDP	mini DisplayPort (<i>DP Standard</i>)
OLED	Organic Light-Emitting Diode
OS	Operating System
OSD	On-Screen Display
PC	Personal Computer
PQ	Perceptual Quantizer (<i>SMPTE ST 2084</i> ; used with HDR)

Table 1-3: Acronyms and Abbreviations (Continued)

Term	Definition
RB	Reduced Blanking
SDR	Standard Dynamic Range
SID	Society for Information Display
TCON	Timing CONTroller
UHD	Ultra High Definition
USB-C	<i>USB Type-C</i> (USB Implementers Forum)
VBlank	Vertical Blanking
VESA	Video Electronics Standards Association
VRR	Variable Refresh Rate
VTotal	Vertical Total

1.3.5 Glossary

Table 1-4 defines terms that are used throughout this Specification.

Table 1-4: Glossary

Terminology	Definition
AdaptiveSync	AdaptiveSync (without either hyphen or space) is a proper noun or it is used to represent the VESA CERTIFIED AdaptiveSync Logo program as VESA CERTIFIED AdaptiveSync, VESA AdaptiveSync logo performance tier, VESA AdaptiveSync, and AdaptiveSync.
Adaptive-Sync	Adaptive-Sync (with a hyphen between Adaptive and Sync) is an adjective, or it is used for explaining a function or subitem as in the Adaptive-Sync data block of the <i>DisplayID</i> , Adaptive-Sync SDP, and Adaptive-Sync operation.
average picture level APL	Mean luminance level of all pixels within a picture.
display	Full display assembly including <i>monitor</i> , and drive electronics in either a laptop (this would typically comprise components within the laptop lid), or a monitor where this would comprise the display-related components of a monitor, excluding the chassis, speakers, <i>USB</i> ports, etc.
DisplayID	Current and recommended description of Display Identification Data from VESA.
DisplayPort or DP	Connector or <i>DP</i> port presented through a connector defined in <i>DP Standard</i> .
DisplayPort Alt Mode	Alternate mode in which, when entered, a <i>USB-C</i> interface behaves in <i>DisplayPort</i> Mode (<i>DP Standard</i>), as defined by <i>DisplayPort Alt Mode Standard</i> .
EDID or E-EDID	Either the Extended Display Identification Data or Enhanced Extended Display Identification Data structure. Both of these standards apply to legacy devices. VESA superseded <i>EDID</i> and E-EDID with the <i>DisplayID</i> structure. Throughout this Specification, <i>DisplayID</i> shall be used; <i>EDID</i> or E-EDID usage may substitute for <i>DisplayID</i> usage where applicable for a legacy device.
Flicker _{MAX}	Flicker measured from the static test pattern described in Section 6.3.1. Calculated as follows: $Flicker_{Max} = 10 \times \log_{10} \left[\frac{P_f^{max} \times w(f^{max})}{P_0} \right] \quad [\text{dB}]$ <p>See Section 6.4.2 for further details.</p>
gray-to-gray duration	Time that it takes for the <i>display</i> hardware to transition from one luminance level to another in SDR mode (see Section 7).
high dynamic range HDR	Display that exceeds typical display color and luminance, and includes <i>SMPTE ST 2084</i> PQ code values that use special electro-optical transfer function (EOTF) mapping.
MaxLuminance	Generically used to mean either of the following <i>DisplayID</i> or legacy <i>EDID</i> variables: <ul style="list-style-type: none"> <i>DisplayID Standard</i> – NativeMaximumLuminance EDID r1.3 (and higher) with the ANSI/CTA-861-H block – DesiredContentMaxLuminance <p>In both cases, the value represents the maximum peak luminance that the display device may achieve with a 10% white patch at the screen's center for a period of at least 30 minutes.</p>
MediaSync	One of two <i>Adaptive-Sync</i> -related certification programs and logos defined by this Specification (see Section 2).

Table 1-4: Glossary (Continued)

Terminology	Definition
mini DisplayPort mDP	Mini connector or <i>DP</i> port presented through a connector defined in <i>DP Standard</i> .
monitor	Complete standalone desktop monitor, including the <i>display</i> plus chassis, power, and potentially <i>USB</i> hubs and/or speakers.
panel	LCD or OLED (or other) display panel, applicable to both laptop and <i>monitors</i> .
picture	Single video frame (or interlaced field) of pixels.
refresh rate	Frequency at which the <i>display</i> updates each pixel, based on the display controller's internal timing.
screen	Graphic portion of a <i>display</i> .
standard dynamic range SDR	Display that exhibits color and luminance similar to that defined by <i>ITU BT.709</i> .
vertical blanking VBlank	Total number of lines after the last line that contains pixel data intended for display until, but not including, the next line that contains pixel data of the next video frame intended for display.
vertical total VTotal	Vertical total of transmitted main video stream, measured in line count.
video frame rate	Frequency at which a Source device transmits full video frames to the <i>display</i> for rendering.

1.4 Reference Documents

Table 1-5 lists the various reference documents that are used and/or referenced by this Specification. Users of this Specification are advised to ensure that they have the latest versions/revisions of reference documents.

Table 1-5: Reference Documents

Document	Version/ Revision ^a	Publication Date	Referenced As
<i>CIE ISO 11664-5, Colorimetry – Part 5: CIE 1976 L*u*v* colour space and u', v' uniform chromaticity scale diagram</i>	2016	2016	<i>CIE 1976</i>
<i>CIE Illuminant D65</i>	1964	1964	<i>CIE D65</i>
<i>ANSI/CTA-861, A DTV Profile for Uncompressed High Speed Digital Interfaces</i> (Formerly known as <i>CEA-861 and CTA-861</i>) ^b	H	January 2021	<i>ANSI/CTA-861-H</i> <i>CTA</i>
<i>IEC 61966-2-1, Multimedia systems and equipment – Colour measurement and management – Part 2-1: Colour management – Default RGB colour space - sRGB^c</i>	1999	October 18, 1999	<i>IEC 61966-2-1</i>
<i>Information Display Measurements Standard^d</i>	Version 1.1	July 19, 2021	<i>IDMS</i>
<i>ISO 61747-30-1 Liquid crystal display devices – Part 30-1: Measuring methods for liquid crystal display modules – Transmissive type^e</i>	Ed. 1	June 2012	<i>IEC 61747-30-1</i>
<i>Recommendation ITU BT.709, Parameter values for the HDTV standards for production and international programme exchange^f</i>	Version 6	June 2015	<i>ITU BT.709</i>
<i>SMPTE ST 2084, High Dynamic Range Electro-Optical Transfer Function of Mastering Reference Displays^g</i>	2014	August 16, 2014	<i>SMPTE ST 2084</i>
<i>Universal Serial Bus 4 (USB4TM) Specification^h</i>	Version 1.0	August 29, 2019	<i>USB4</i> <i>USB</i>
<i>Universal Serial Bus Type-C Cable and Connector Specification^h</i>	Release 2.0 ^l	August 29, 2019	<i>USB-C</i> <i>USB Type-C</i>
<i>VESA Adaptive-Sync Link Layer Certification Test Specification (Adaptive-Sync Link CTS)^m</i>	Revision 1.0	December 16, 2021	<i>Adaptive-Sync</i> <i>Link CTS</i>
<i>VESA Coordinated Video Timings (CVT) Standardⁱ</i>	Version 1.2 ^j Version 2.0 ^k	February 8, 2013 September 27, 2021	<i>CVT v1.2</i> <i>CVT v2.0</i> <i>CVT Standard</i> <i>CVT</i>
<i>VESA DisplayID Standardⁱ</i>	Version 2.0 ^l Version 2.1	September 11, 2017 November 18, 2021	<i>DisplayID v2.0</i> <i>DisplayID v2.1</i> <i>DisplayID v2.x</i> <i>DisplayID Standard</i> <i>DisplayID</i>

Table 1-5: Reference Documents (Continued)

Document	Version/ Revision ^a	Publication Date	Referenced As
<i>VESA DisplayPort Alt Mode on USB Type-C Standard (DisplayPort Alt Mode)^m</i>	Version 2.0 ^l	March 12, 2020	<i>DisplayPort Alt Mode Standard</i> <i>DisplayPort Alt Mode</i>
<i>VESA DisplayPort (DP) Standard^m</i>	Version 2.0 ⁿ Version 2.1	June 26, 2019 TBD	<i>DP Standard</i> <i>DisplayPort DP</i>
<i>DisplayPort v2.0 Errata E11^m</i>	E11	October 12, 2021	<i>DisplayPort v2.0 Errata E11</i>
<i>VESA DisplayPort 2.x DisplayID EDID Link Layer Compliance Test Specification (DisplayID EDID Link CTS)ⁱ</i>	DP 2.x Revision 1.0	December 16, 2021	<i>DisplayID EDID Link CTS</i>
<i>VESA DisplayPort 1.4a Link Layer Compliance Test Specification (Link CTS)^m</i>	DP 1.4a Revision 1.0	June 12, 2019	<i>Link CTS</i>
<i>VESA DisplayPort 1.4a PHY Layer Compliance Test Specification (PHY CTS)^m</i>	DP 1.4a Revision 1.1	June 5, 2020	<i>PHY CTS</i>
<i>VESA Embedded DisplayPort (eDP) Standard^m</i>	Version 1.5 ^m	August 26, 2021	<i>eDP Standard</i> <i>eDP</i>
<i>VESA Enhanced Extended Display Identification Data (E-EDID) Standard (which defines EDID r1.4)^{i o}</i>	Release A.2	September 25, 2006	<i>E-EDID Standard</i> <i>EDID</i>
<i>VESA High-performance Monitor and Display Compliance Test Specification (DisplayHDR CTS)^m</i>	Revision 1.1	August 29, 2019	<i>DisplayHDR CTS</i> <i>DisplayHDR</i>

- a. All references include subsequently published errata, specification change notices or engineering change notices, etc.
- b. Published by the American National Standard Institute's (ANSI) Accredited Standards Developers and the Consumer Technology Association (ANSI/CTA). See [cta.tech](#).
- c. See [global.ihs.com](#).
- d. Published by the Society for Information Display's International Committee on Display Metrology (SID ICDM). See [www.sid.org/Publications/ICDM.aspx](#).
- e. Supersedes EIAJ ED-2522, which is no longer available.
- f. Published by the International Telecommunication Union (ITU). See [www.itu.int](#).
- g. Published by the Society of Motion Picture and Television Engineers (SMPTE). See [www.smpete.org/digital-library](#).
- h. Published by USB Implementers Forum, Inc. See [usb.org/developers/docs](#).
- i. See [vesa.org/vesa-standards/](#).
- j. For standard blanking and reduced blanking timing v1 (RB Timing v1), see [CVT v1.2](#).
- k. For RB Timing v2 and v3, see [CVT v2.0](#).
- l. This version of the referenced Standard is correct at the time of publication of this Specification.
- m. See [vesa.org/join-vesamemberships/member-downloads/](#).
- n. This version of the referenced Standard is correct at the time of publication of this Specification.
- o. Legacy VESA Standard, superseded by [DisplayID Standard](#).

2 Mandate Summary

2.1 Overview

This section summarizes the mandates for this Specification. Each test and certification mandate listed in this section's tables are explained in further detail in subsequent sections. This Specification defines the mandates for the VESA CERTIFIED MediaSync and AdaptiveSync Display logo programs.

The MediaSync Display logo performance tier is designed to ensure that displays meet a high level of quality optimized for media playback, suitable for media that uses any of the 10 most-common video frame rates, which range from 23.976 to 60 Hz. This logo performance tier eliminates video frame dropping, and 3:2 pull-down jitter and other sources of jitter, while meeting its mandatory flicker performance level to make the display visually flicker free.

The AdaptiveSync logo performance tier is optimized for gaming and designed for displays that have a sufficiently large variable video frame-rate range and low latency, while also supporting high-quality media playback with a similar set of benefits as the MediaSync Display logo performance tier.

2.2 Mandates that Vary by Logo Performance Tier

Table 2-1 summarizes the high-level Adaptive-Sync Display specifications that vary across the logo performance tiers.

Table 2-1: Mandates that Vary by Logo Performance Tier

Test	Logo Performance Tier	
	AdaptiveSync Display<Hz> ^a	MediaSync Display
Adaptive-Sync operation maximum refresh rate range ^b	≥ 144 Hz	≥ 60 Hz
Adaptive-Sync operation minimum refresh rate range ^b	≤ 60 Hz	≤ 48 Hz
Testing that Overdrive factory-default setting does not result in excessive Overshoot/Undershoot ^c	≤ 20% overshoot and ≤ 15% undershoot (on any of the 16 test cases)	≤ 20% overshoot and ≤ 15% undershoot (on any of the 16 test cases)
Limit in average of the 20 G2G tests from a 5 × 5 matrix with factory-default overdrive	≤ 5-ms average over the 20 tests	N/A
Flicker _{MAX} on low-variability refresh rate tests ^{d f}	-50 dB	-50 dB
Flicker _{MAX} with high-variability refresh rate tests ^e	-50 dB ^f	Test is not performed as a logo performance tier mandate
If SuccessiveFrameDurationIncreaseTolerance is present, minimum duration for variable ^f	8.5 ms	1 ms
If SuccessiveFrameDurationDecreaseTolerance is present, minimum duration for variable ^f	9.75 ms	1 ms
Video frame-to-frame jitter duration for 23.976- to 60-Hz video frame rates ^g	±0.5 ms	±0.5 ms

- a. For example, *AdaptiveSync Display144*, *AdaptiveSync Display240*.
- b. Due to *CVT v1.2 RB Timing v1*, or *CVT v2.0 RB Timing v2* or *v3*, rounding, actual legacy *EDID* values that slightly vary from the target are allowed. Also, while integer values are listed in the Adaptive-Sync operation minimum and maximum refresh rate mandates, support for 1,000 / 1,001 timing is also needed, including for 47.952 and 59.94 Hz.
- c. **G2G 5 × 5 matrix** – The 16 tests not ending in **black**.
- d. Low-variability refresh rate tests include *Video*, *Zigzag sweep*, and *Sinewave Sweep* tests.
- e. High-variability refresh rate tests typical of gaming include *SquareWave Sweep* and *Random* tests.
- f. If either **SuccessiveFrameDurationIncreaseTolerance** or **SuccessiveFrameDurationDecreaseTolerance** is present in the display's *DisplayID* block and non-zero, the Source device test variability shall be limited to this maximum rate of change for all tests that involve measuring flicker or jitter, but **not** for the *Video Frame-drop* tests.
- g. Tested only within the legacy *EDID* range.

While the MediaSync Display logo performance tier could be used for gaming, its mandatory refresh rate range of 48 to 60 Hz would provide limited gaming benefit. It is possible, however, that some MediaSync Display logo performance tier devices may support a wider range than its minimum mandates. For example, a display that supports 48 to 120 Hz would need to be branded as MediaSync Display logo performance tier, but could potentially provide good gaming performance.

2.3 Mandates for All Logo Performance Tiers

[Table 2-2](#) summarizes the Adaptive-Sync Display specifications that apply to all logo performance tiers.

Table 2-2: Mandates for All Logo Performance Tiers

Test	Mandate	Units
Video Frame Drop Tolerance between minimum and maximum refresh rates reported to the OS	<ul style="list-style-type: none"> • 0 	Dropped Video Frames
The 10 static frequency video frame rates that are to be supported within the Jitter specification limit, potentially by using display-side or GPU video frame duplication (e.g., frame-doubling, frame-tripling, etc.)	<ul style="list-style-type: none"> • 23.976 • 24 • 25 • 29.97 • 30 • 47.952 • 48 • 50 • 59.94 • 60 	Hz, Locked Video Frame Rates

2.3.1 Additional Flexibility for eDP Connected Displays

For integrated panels in laptops and AIO PCs that use an *eDP* connection, the configuration of frame rates between the GPU and integrated display panel provides several options beyond the traditional *DisplayID* or legacy *EDID* configuration block that must be exposed in a regular external display. For this reason, flexibility is provided to the OEM/ODM/GPU vendor/panel vendor in achieving the necessary jitter-free playback behavior, without constraint as to how the *DisplayID* or legacy *EDID* is configured. As an example, for a MediaSync VESA-certified laptop, Table 2-1 lists the need to achieve 48 to 60 Hz, and footnote b of the table indicates that this also requires support for fractional frame rates, most notably 47.952 Hz for Hollywood content being displayed at 2× the native Hollywood content rate of 23.976 Hz. The available options include, but are not limited to, the following:

- Use of *DisplayID v2.x* where the spec states that 48 to 60 Hz should be treated as meaning support includes 47.952 Hz
- Use of EDID r1.4, with the range stated as 48 to 60 Hz, and a GPU driver that enables the 1,000/1,001 fractional rate of 47.952 Hz in this configuration
- When using EDID r1.4, with a GPU driver that will **not** allow fractional rates below the *EDID* minimum, a range of 47 to 60 Hz could be used to ensure range support for this content type
- If the maximum rate is capable of running sufficiently higher than 60 Hz (e.g., 96 Hz), the 23.976 Hz Hollywood rate could be tripled to 71.928 Hz, and native content at 47.952 Hz could be doubled again to 95.904 Hz
- Use of other mechanisms, such as BIOS settings, INF, or other configuration settings that allow for the GPU to achieve playback that results in a pure-integer multiple of all 10 static video frame rates in a jitter-free manner, are acceptable

Solutions that result in 3:2 pull down, frame dropping, or other such jitter-causing artifacts of any of the 10 static frequency test frame rates are **not** permitted.

For devices with integrated panels applying for the VESA CERTIFIED AdaptiveSync Display Logo Program, because the required range is 60 to 144 Hz, there is always a sufficiently wide frequency range to simply multiply by higher-integer values and fit within the required range; thus, even 59.94-Hz content could be doubled and run at 119.88 Hz.

When testing an *eDP* display device that uses different integer multiples, for the same content, based on other variables such as power source, these devices should be tested for flicker and jitter in the configuration that achieves the lowest-integer multiple of the frame rate. For example, a laptop that multiplies the Hollywood rate to 3× when connected to AC power but runs the Hollywood rate at 2× when on battery, –or– when the battery capacity drops below a certain threshold, should be tested at the lower multiple because this is the rate at which the greatest level of flicker is likely to be apparent.

2.4 VESA CERTIFIED Compliance Program

A display that passes all the compliance tests listed in [Table 2-1](#) and [Table 2-2](#) is qualified technically as a candidate for the VESA CERTIFIED AdaptiveSync logo or MediaSync logo, which is subject to licensing requirements per applicable VESA compliance policies. Subject to the applicable policies, the logo shown in [Figure 2-1](#) may apply with an appropriate AdaptiveSync logo performance tier designator that indicates the maximum video frame rate that is achievable when using the Adaptive-Sync operation at the display's factory default resolution, such as AdaptiveSync Display144 or Display240. For the MediaSync Display logo, there is no performance tier; therefore, the logo remains unchanged from that which is shown in [Figure 2-2](#).



Figure 2-1: VESA CERTIFIED AdaptiveSync Logo and Indicated Logo Performance Tier Designator



Figure 2-2: VESA CERTIFIED MediaSync Logo

3 Test Environment

3.1 Overview

Typically, users will not have the test hardware that is needed to run the suite of AdaptiveSync and/or MediaSync Display logo certification tests. Therefore, this section focuses on providing guidance to manufacturers and professional test houses for achieving a correctly configured test environment.

3.2 Ambient Temperature

The expectation of a user-facing logo program is that at-home users should expect to achieve results similar to those quoted by the Specification in normal usage environments. However, this Specification recognizes that temperature has a significant impact on display behavior. In particular warmer temperatures will typically result in faster G2G times, and higher overshoot and undershoot results. Therefore, it is necessary to define a fairly tight range of ambient room temperature for the certification process. Testing should be performed at a room temperature between 22.5° and 24.5° C (72.5° to 76° F).

3.3 Measurement Instrument and Sensor Usage

Most test hardware will be tripod-mounted, and either flush to the screen (thereby providing a baffle that prevents light leakage), –or– a darkened room set up for noncontact testing (thereby preventing ambient light that would affect the test results). See [IDMS, Section 15.1.5](#), for tips for eliminating stray light.

Except where noted, the sensor shall be placed at the screen’s center for all tests.

When placing the sensor flush to the screen, take care to ensure that the panel is **not** being deformed because deformation impacts test performance.

3.4 System Warm-up Time

The required sequence of warm-up phases and tests is defined in [Section 5.3](#).

3.4.1 Default Display Warm-up

The display under test (DUT) should be provided a 1-hour warm-up period. The display's screen saver should be disabled so that the display is active for 1 hour prior to testing. To ensure testing consistency, the display should be warmed up using a **gray** screen (code value 127). The VESA AdaptiveSync Test Tool provides a **gray** warm-up screen (by pressing the **w** key (lowercase w)), which also provides a 1-hour timer. The screen luminance should be adjusted such that **gray** code value 127 achieves 40 cd/m² in advance of the warm up. VESA AdaptiveSync Test Tool, Test Sequence #2 with the 60-Hz setting should be used for this adjustment.

For laptops, the device should be AC-powered during the warm-up period and subsequent testing procedure. The laptop should be open approximately 90° –or– with the screen at a normal usage angle, and no external display or additional devices should be attached to the laptop.

3.4.2 Secondary High-luminance Display Warm-up Phase for HDR-1000+ Displays

This secondary phase warm up is required for displays that have a *DisplayID* or legacy *EDID* MaxLuminance of 1,000 cd/m² or higher. This warm-up phase does **not** replace the default display warm up defined in [Section 3.4.1](#), but rather is used in the later stages of testing, in addition to the default display warm up defined in [Section 3.4.1](#).

This secondary phase warm up requires that the display be warmed up for at least 20 minutes, with a full-screen **white** (code value 255) adjusted by way of the OSD or OS brightness settings to achieve a luminance level of 185 cd/m² (a range of 175 to 195 cd/m² is acceptable). Within the test tool, the **W** key (uppercase W) will launch the brighter version of the warmup, using code value 255.

3.5 Measurement Instrument Specifications

Several types of measurement instruments are needed to perform the suite of AdaptiveSync or MediaSync Display logo certification tests. This includes:

- Luminance meter, to confirm that the display is adjusted to 40 cd/m².
- JEITA flicker meter, to measure flicker and calculate the JEITA-level flicker in the flicker tests. The test tool must be able to measure in steps of 0.5 Hz (or smaller), and must provide the data for the range 3 to 65 Hz.
- High-bandwidth luminance probe for measuring G2G, overshoot, and undershoot transition times and signal. The probe must have a bandwidth greater than 20 kHz.
- One of the following G2G calculation devices:
 - Oscilloscope with the ability to average multiple G2G transition samples and to calculate the rise time, fall time, overshoot, and undershoot, –or–
 - High-speed USB DAQ that can record sample voltages from the sensor probe at a rate of at least 10 kHz, with a minimum 16-bit resolution, and analogue voltage input selection that aligns to the typical 0 to 2-V output from the sensor probe being used, and analysis software to calculate the G2G, overshoot, and undershoot.
- Photographic camera capable of a manual mode in which the test user can set the shutter speed (1 second), aperture (typically F5.6), and ISO settings (100 to 1,600).

Table 3-1 lists some of the recommended hardware used in development of these tests that meet all the specifications indicated above.

Table 3-1: Measurement Instruments Needed for Performing AdaptiveSync or MediaSync Display Logo Certification Tests with Sample List of Products Known to Meet Testing Specifications

Measurement Instrument Type	Product	Description
G2G Latency Measurement probes, typically connected either to an oscilloscope –or– USB DAQ	iBoson GRT-100	Photosensor amplifier
	ThorLabs PDA36A2 ^a	Photosensor amplifier
Measurement probe capable of measuring flicker up to the DUT’s maximum video frame rate	Klein K10-A	Luminance and flicker probe
	Klein K-80	Luminance and flicker probe
	Konica Minolta™ CA-310	Luminance and flicker probe with the CA-P32/35 or CA-PS32/35 probe
	Konica Minolta CA-410	Luminance and flicker family of probes
USB DAQ	MCC DAQ USB-1608FS-Plus	16-bit, 100-kHz, input-voltage adjustable USB DAQ

a. Use requires a 50-dB gain setting.

3.6 System Configuration

Displays that use the VESA CERTIFIED AdaptiveSync or MediaSync Display logo are expected to ship in a factory-default mode that supports the Adaptive-Sync operation. Thus, all displays should be tested in the factory shipping state, or default factory mode configuration. This includes On-Screen Display (OSD) menu settings for a monitor.

3.7 Software for Semi-automated Testing

Beta versions of the VESA AdaptiveSync Test Tool are available from multiple GPU vendors. Each GPU vendor's hardware requires a different version of the test tool; thus, it is important to combine the correct set of GPU hardware, GPU driver, and test tools.

The test tool requires that the **Microsoft Visual C++** Redistributables be pre-installed. These Redistributables may already have been installed on the test tool by other software; however, test tools with few other applications installed may display an error message indicating that a **.dll** file is missing when **Visual C++** is run. Should this occur, install **vc_redist.x64.exe** from the following location:

support.microsoft.com/en-us/help/2977003/the-latest-supported-visual-c-downloads

Alternatively, the following installer link may be used to download **vc_redist.x64.exe**:

aka.ms/vs/16/release/vc_redist.x64.exe

When using **Microsoft Windows 11, version 21H2** (or later) as the test signal source, a **Known Game List (KGL)** determines which applications are enabled for variable refresh rate (VRR) by the OS. Applications that are **not** in the **KGL** list might not receive VRR support from the OS and therefore fail to demonstrate Adaptive-Sync operation capability. Should that be the case, the OS will run at a static, locked, maximum refresh rate without exhibiting the Adaptive-Sync operation. The VESA **AdaptiveSyncCertificationTests.exe** test application was added to **KGL** v2013.

To verify that the current **KGL** version loaded is at least v2013, perform the following steps:

- 1 From within **Windows**, open the **Microsoft Xbox Game Bar** application. One or more **Microsoft Xbox Game Bar** windows and/or toolbars open, depending on the user's **Microsoft Windows** setup (see [Figure 3-1](#)).
- 2 Click the **Settings** (gear) icon (highlighted **1** in [Figure 3-1](#)) to open the **Settings** dialog box.

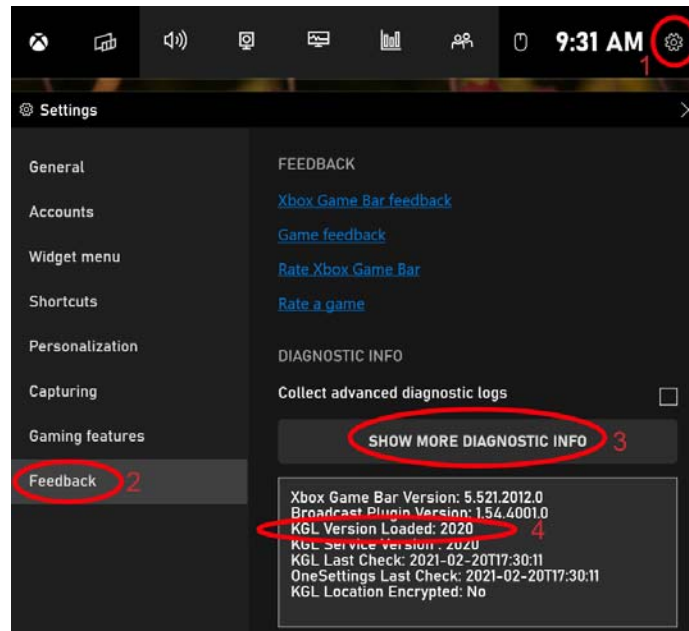


Figure 3-1: Microsoft Xbox Game Bar Application, Opened to Settings Options

- 3 Click **Feedback** (see highlighted 2 in Figure 3-1) to display the **FEEDBACK** options (see also Figure 3-1).

Note: *If the **Microsoft Xbox Game Bar** application looks completely different than Figure 3-1 (i.e., does **not** include all the **Settings FEEDBACK** options, and resembles the default **Microsoft Xbox Game Bar** application in Figure 3-2), the test user may first need to download the latest version of **Microsoft Xbox Game Bar**. Please note, however, that even with a fresh install of the latest Windows 11 21H2 OS, the original installation of the OS presents a simplified version of **Microsoft Xbox Game Bar**, and the full version needs to first be downloaded from the **Microsoft Store** before these features are exposed.*

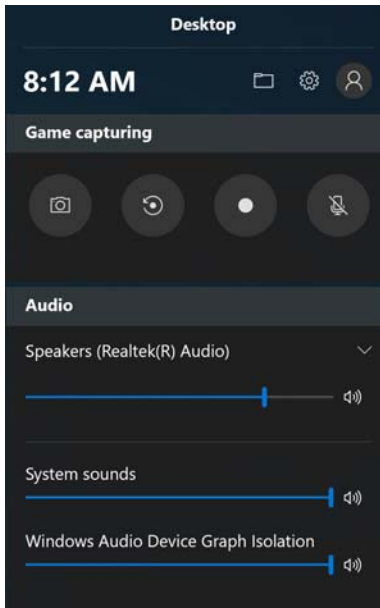


Figure 3-2: Default Microsoft Xbox Game Bar Application

- 4 Click **SHOW MORE DIAGNOSTIC INFO** (highlighted 3 in Figure 3-1) to display the diagnostic information.
- 5 Verify that **KGL Version Loaded** (highlighted 4 in Figure 3-1) indicates 2013 or later.

Note: *By default, the **KGL** automatically downloads when the **Windows** system is connected to the Internet unless the test user has indicated otherwise. The version downloaded will be indicated as the **KGL Service Version**. This will then later self-install; however, even if the download occurs quite quickly, it can take up to 24 hours between downloading the service version, and actually installing this new version. Only after a downloaded **KGL** is listed in **KGL Version Loaded** that it has actually been installed and is ready for testing.*

After confirming that the test system has **KGL v2013** (or later) loaded, perform the following steps to enable **Variable refresh rate** in the OS graphics settings:

- 1 Enable *the Adaptive-Sync operation* or *VRR* within the system's GPU vendor's configuration pages.
- 2 Open the system's Display Settings, using either of the following methods:
 - Select **Start > Settings > System > Display**
 - Right-click the desktop, and then click **Display settings**
- 3 Scroll to the bottom of the page, and then click **Graphics settings** to open the **Graphics settings** dialog box.

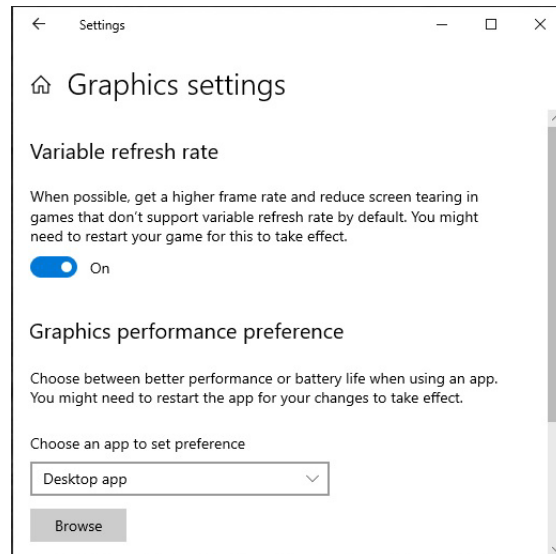


Figure 3-3: Graphics settings Dialog Box with Variable refresh rate Turned On

- 4 Turn on **Variable refresh rate**.
- 5 Click **x** to close the **Graphics settings** dialog box (upper right).
- 6 Close and restart any running application(s) that needed VRR to be enabled.

When using **Microsoft Windows** as a Source device OS for the VESA AdaptiveSync Test Tool, it is essential to ensure that pop-up windows and/or other image layers do **not** appear on top of the test tool display. [Section 3.7.1](#) explains how to avoid these during testing.

3.7.1 Avoiding Pop-up Windows/Image Layers during Testing

When using **Microsoft Windows** as a Source device OS for the VESA AdaptiveSync Test Tool, it is essential to ensure that pop-up windows and/or other image layers do **not** appear on top of the test tool display. This includes watermarks, such as **Activate Windows**, **Test Mode**, **Preview Build Version**, or other notifications, etc., that may appear on unactivated, or preview test build Windows installs. The appearance of watermarks or other notification pop-up windows might limit the ability of the OS to deliver the Adaptive-Sync operation capability; therefore, it is essential that watermarks and/or pop-up windows do **not** appear during testing.

Figures 3-4 and 3-5 represent the same hardware, software, and test scenario – VESA AdaptiveSync Test Tool, Test Sequence #3.25Hz. The only difference is that the **Activate Windows** watermark appears in the scenario shown in Figure 3-4, which disrupts the system’s ability to correctly use the Adaptive-Sync operation, hence the occurrence of jitter in this scenario.

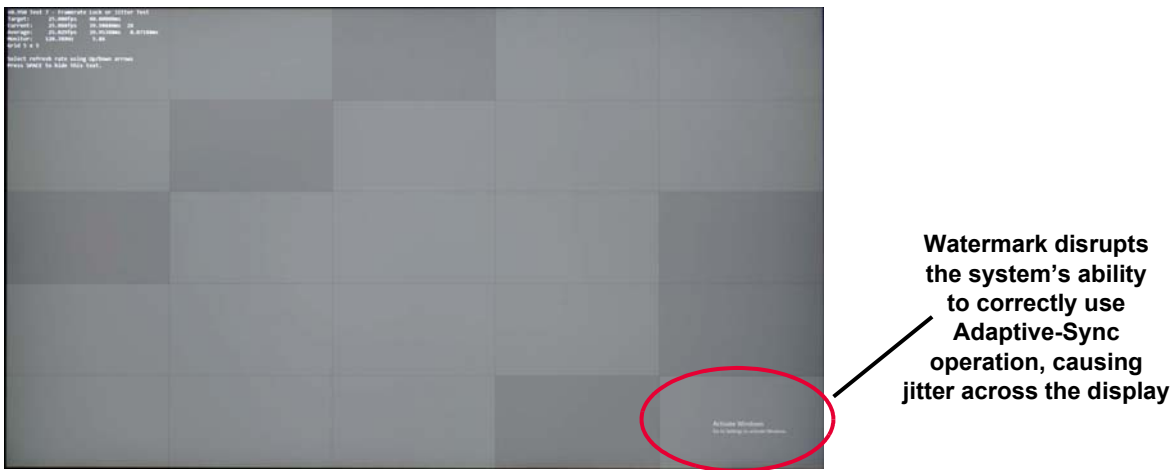


Figure 3-4: Adaptive-Sync Operation Failure, with Jitter Due to Pop-up Window/Watermark



Figure 3-5: Adaptive-Sync Operation, Working Correctly

3.8 Graphics Hardware for Semi-automated Testing

This section provides the requirements for the VESA Qualified Reference Sources that are necessary for executing the Adaptive-Sync operation tests identified within this Specification on monitors and other discrete displays. For integrated display devices, such as laptop PCs, the integrated GPU will be used as the source, and needs to be able to execute the tests as described. Hardware-based test source equipment that meets these requirements can be used, –or–, if using the Windows software tool mentioned in [Section 3.7](#), the GPU must be able to:

- 1 Deliver static video frame rates at 23.976, 24, 25, 29.97, 30, 47.952, 48, 50, 59.94, and 60 Hz without frame-doubling while using the Adaptive-Sync operation for each of the rates “within” the *EDID* range, which includes the 1,000/1,001 video frame rates (e.g., 23.976, 29.97, 47.952, and 59.94 Hz) that are fractionally below the specified *EDID* minimum. For video frame rates that are below the *EDID* minimum, even after taking into account this accommodation for the rates that are fractionally below the *EDID* minimum, the video frame rates should be multiplied by the smallest integer to achieve a rate that is then “within” the *EDID* range, again taking into account those rates that are just below the *EDID* minimum by the 1,000/1,001 fractional rate multiplier. For example, the GPU needs to be able to execute the 59.94-Hz test, without frame-doubling on a display whose *EDID* minimum is 60 Hz. Likewise, as a second example, the standard Hollywood rate of 23.976 Hz should only be frame-doubled, not frame-tripled, on a display whose minimum video frame rate is 48 Hz.
- 2 For the SineWave Sweep test and Zigzag Sweep test, which range from the *EDID* minimum to maximum, the GPU and source must **not** frame-double any of the video frames, and the video frame rate range used by these tests is within the range specified by the *EDID*.
- 3 For the highly variable tests (e.g., the SquareWave Sweep and Random tests) in which the display does **not** use *DisplayID v2.x* to place any constraints on the rate of change, the GPU must deliver a pure square-wave signal without any ramp up or ramp down, thus rendering an even number of frames for a period as close to 250 ms as possible with an even number of frames each at the minimum and maximum rate generated by the test tool, without any frame-doubling.
- 4 Displays that use *DisplayID v2.x* that have also implemented *SuccessiveFrameDurationIncreaseTolerance* or *SuccessiveFrameDurationDecreaseTolerance* values that conform to the requirements in [Table 2-1](#) must be tested in a manner that accommodates these constraints on the rate of change in test frequency in both the SquareWave Sweep and Random tests. Either a GPU that applies the *DisplayID v2.x* constraints to the signal can be used, –or– the constraints can be manually configured in the VESA AdaptiveSync Test Tool itself using simple keyboard entry to adjust the **m_SuccessiveFrameDurationIncreaseTolerance** and/or **m_SuccessiveFrameDurationDecreaseTolerance** values, respectively in the setup of the Variable Rate tests of the VESA AdaptiveSync Test Tool.
- 5 The source system must also support the display bandwidth and pixel clock that are needed to drive the display at its maximum resolution and video frame rate, using the appropriate display interfaces, display link speeds, and compression modes (e.g., VESA DSC) as required by the display to achieve its maximum resolution and video frame rate.

It should be noted that the VESA AdaptiveSync Test Tool requirements are actually atypical compared to normal usage in which GPUs, often by policy, choose to **not** drive displays at their minimum refresh rate to optimize for display performance. There are thus a limited set of GPU/driver/configuration options that can be used to correctly execute the VESA AdaptiveSync Test Tool. On request, the VESA Compliance Manager (moderator@vesa.org) will provide documentation that details the approved set of source test configurations that can be used as source systems for compliant test execution of the VESA AdaptiveSync or MediaSync Display Logo certification program. The list of suitable source configurations varies, depending on the display resolution, video frame rate, and interfaces that are used when testing, and will be updated to reflect capability updates on an ongoing basis.

3.9 Recommendation for Testing Displays that Use Panel Self Refresh or Panel Replay

When either of the following functions are enabled, the test submitter should disable the function prior to testing:

- Panel Self Refresh (PSR; see *eDP Standard*)
- Panel Replay (PR; see *DP Standard* and/or *eDP Standard*)

If changing the function from the product's default condition, the test submitter is responsible for supplying directions to enable or disable the function in the submitted test report.

3.10 Laptop Testing Configuration

When testing laptops, the laptop should be AC-powered (i.e., not running on battery power). The laptop should be open approximately 90° –or– with the screen at normal usage for both the warm-up period and testing. No additional devices or secondary external displays should be attached to the laptop while testing. For laptops with multiple built-in screens, the screens should be active or disabled based on what would be considered normal usage. For example, a second screen that is typically enabled on the keyboard deck should be enabled if that is considered normal use; however, a screen on the back that typically illuminates only when the laptop is closed should be normally configured and thus potentially disabled (i.e., turned OFF) during testing with the main screen open.

3.11 Validation of Adaptive-Sync Operation

This section provides a quick basic validation that the Adaptive-Sync operation is correctly configured and that the test environment is working correctly. Two methods are provided, either of which may be used to achieve confirmation that the Adaptive-Sync operation is working correctly.

3.11.1 Waveform Analysis

Using the VESA AdaptiveSync Test Tool, Test Sequence #3.SineWave or #3.SquareWave, will vary the refresh rate on the display from minimum to maximum and then back to minimum in a repeating pattern. Using a tool such as the Konica Minolta CA-S40's WaveForm Analysis page with a Konica Minolta CA-410 family probe will show the display's waveform and enable the test user to determine whether the display is working correctly when using the Adaptive-Sync operation, as follows:

- If the display is working correctly, the waveform will change over time
- If the display is **not** working correctly, the wave duration will remain static

To confirm whether the Adaptive-Sync operation is working correctly, the test user must only observe that the wave duration (frequency) is changing as would be expected by the SineWave Sweep or SquareWave Sweep test.

Figure 3-6 shows the display's measurement results when the Adaptive-Sync operation is **not** working correctly. The variance in wave height may be ignored because this is merely a measurement. With signal noise, the important observation is that the time from wave to wave appears static, indicating that the video frame rate is **not** variable, and thus the Adaptive-Sync operation is **not** working correctly. Conversely, Figure 3-7 shows the output of the SquareWave Sweep test working correctly, and wave-to-wave duration changes. In the example provided in Figure 3-7, with square-wave test pattern changes from 7 long waves, then to 10 fast waves, and then to 8 or more long waves. In actuality, the square-wave test pattern creates 250 ms of long waves and then 250 ms of short waves in a repeating pattern; the Figure 3-7 screenshot shows a subset of the repeating test results.

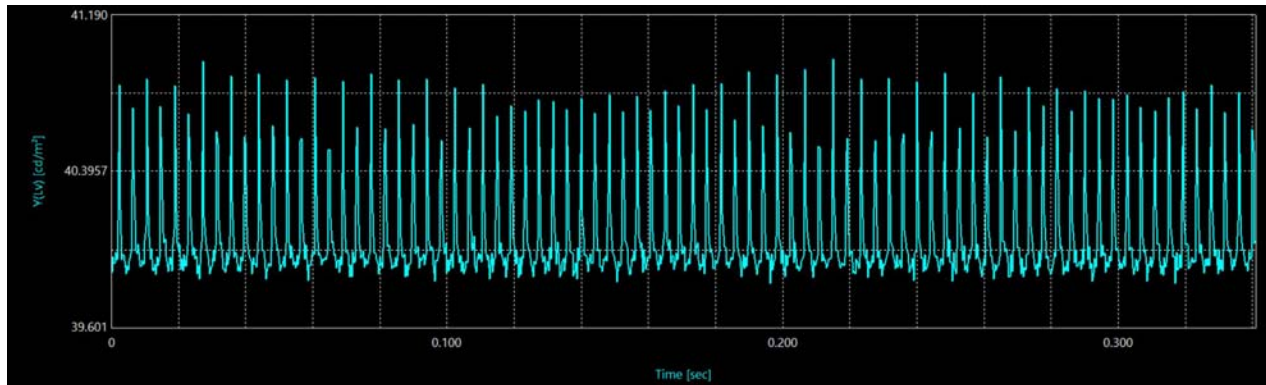


Figure 3-6: Example Failure Condition – Wave-to-wave Timing Is Static, Adaptive-Sync Operation Is Not Working Correctly (Informative)

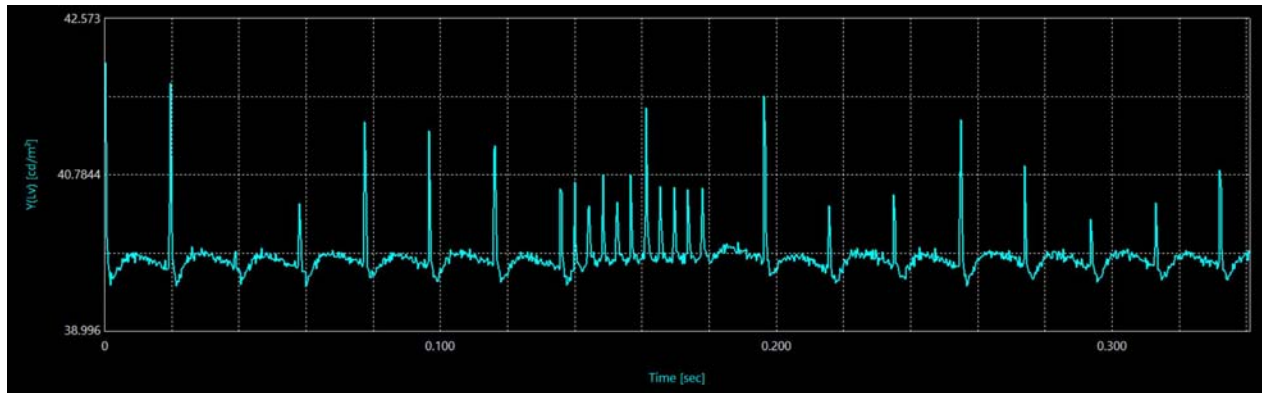


Figure 3-7: Example SquareWave Sweep Test Waveform (Informative)

3.11.2 Photographic Jitter Analysis

For cases in which the display's waveform is either overly noisy or perfectly smooth, such that a waveform is not reliably visible, the photographic jitter test can be used instead. Using the VESA AdaptiveSync Test Tool, Test Sequences #7.24Hz and #7.25Hz, should demonstrate perfectly flat images if the video frame rate is being adjusted to an integer multiple of the test frequency. However, if the display is **not** working correctly when using the Adaptive-Sync operation but is instead running at a maximum refresh rate, there is no refresh rate less than 600 Hz that is an integer multiple of both 24 and 25 Hz. Thus, any display with a maximum refresh rate other than 600 Hz will show jitter on at least one of these tests if the Adaptive-Sync operation is **not** working correctly.

Figures 3-8 and 3-10 show 24 Hz and 25 Hz, respectively with the Adaptive-Sync operation working correctly and thus rendering a perfectly flat **gray** image. Figure 3-9 with the Adaptive-Sync operation is **not** working correctly looks okay because 24 Hz is a perfect fraction of the DUT's maximum video frame rate, 240 Hz. Figure 3-9, however, shows the 25-Hz test with lots of jitter, which occurs because 25 Hz is **not** a perfect fraction of 240 Hz, and thus demonstrates jitter. By testing both 24 and 25 Hz, if the Adaptive-Sync operation is **not** working correctly, the display will show jitter on one (or both) tests which are **not** perfect fractions of the maximum video frame rate.



Figure 3-8: Example 24-Hz Test Results with Adaptive-Sync Operation Enabled (Informative)



Figure 3-9: Example 24-Hz Test Results with Adaptive-Sync Operation Disabled (Informative)



Figure 3-10: Example 25-Hz Test Results with Adaptive-Sync Operation Enabled (Informative)

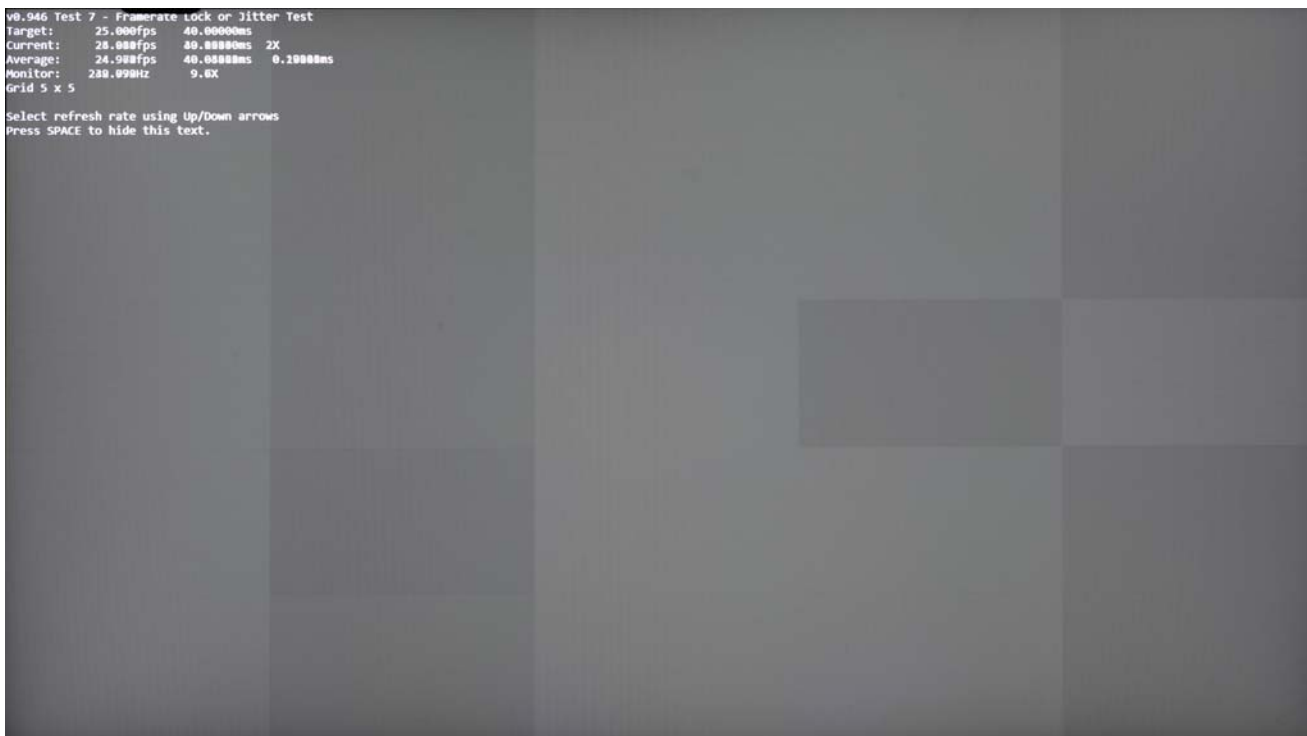


Figure 3-11: Example 25-Hz Test Results with Jitter and Adaptive-Sync Operation Disabled (Informative)

4 Monitor OSD-related Mandates

4.1 Overview

This section specifies the mandates that apply only to monitors and displays that have an On-screen Display (OSD) menu. OSDs typically do **not** exist on laptops; therefore, laptops and displays that do not have an OSD are exempt from the monitor OSD mandates.

4.2 OSD-related Mandates for Reporting Adaptive-Sync Display-compliant Modes

The tests performed in this Specification shall use the factory-default settings for all OSD menu settings. This will cause the OS to default to the “panel native” resolution listed by the display’s factory-default settings, and thus all testing shall be performed at these factory-default/native-resolution settings.

In most cases, it is expected that an Adaptive-Sync operation-capable monitor will support the Adaptive-Sync operation in all OSD modes. However, if this is **not** the case and the monitor has some OSD modes that do **not** support the Adaptive-Sync operation, the monitor’s OSD shall indicate which of its modes support –or– do **not** support the Adaptive-Sync operation to ensure that this usage capability is clear to the test user during the monitor setup process. Typically, indication is **optional** if all OSD modes (including when only one OSD mode exists) support the Adaptive-Sync operation.

If an OSD is required to indicate support or lack of support for the Adaptive-Sync operation in a particular OSD mode, there are various ways of meeting this requirement. Either the full VESA CERTIFIED AdaptiveSync or MediaSync Display logo may be used, –or– text or symbols that indicate the functionality may be used in the OSD display. The only option **not** allowed is partial use of the VESA CERTIFIED AdaptiveSync or MediaSync Display logo. An additional **option** is to display the current OSD mode’s capabilities in the OSD menu’s “information” page, where it is already common to display the Input Port, Resolution, Refresh Rate, Mode Name, Color Depth, Color Format, Signal Range, and EOTF tracking information, and thus may be easy to include indicators for whether *DisplayHDR* and/or the Adaptive-Sync operation are supported in the current OSD mode.

5 VESA AdaptiveSync or MediaSync Display Logo Certification

5.1 Overview

This section specifies the VESA CERTIFIED AdaptiveSync or MediaSync Display logo mandates for any Adaptive-Sync operation-capable display device that provides an external interface that transports *DisplayPort*. This would include *DisplayPort*, mini *DisplayPort* (mDP), *DisplayPort Alt Mode*, and *USB4™*. Internal interfaces such as eDP are exempt from these mandates.

5.2 Logo Certification

All standard input connectors that meet the criteria listed below shall first be VESA DisplayPort-certified, per the appropriate VESA licensing policy, to qualify for AdaptiveSync and/or MediaSync Display logo certification:

- Full-size *DisplayPort* (DP) inputs
- Mini *DisplayPort* (mDP) inputs
- DisplayPort Alt Mode on USB Type-C® (*DisplayPort Alt Mode*) inputs

See the appropriate VESA licensing documents to determine the compliance rules and relevant, active Specifications/Standards that guide VESA *DisplayPort* certification (see [Table 1-5](#)).

To guarantee that users experience the appropriate level of visual quality and latency performance:

- Source devices shall use the *DisplayID*- or legacy *EDID*-reported capability and appropriately signal the correct Adaptive-Sync mode to ensure that budgeted parameters such as latency and flicker may be realized with any AdaptiveSync or MediaSync Display logo-certified Source and Sink device
- Sink devices (displays) shall ensure correct capability reporting with appropriate Adaptive-Sync mode support, and latency and visual quality tradeoffs

Figure 5-1 shows the complete set of VESA CERTIFIED AdaptiveSync and MediaSync Display logo program compliance test specifications (CTSs) for both Sink and Source devices.

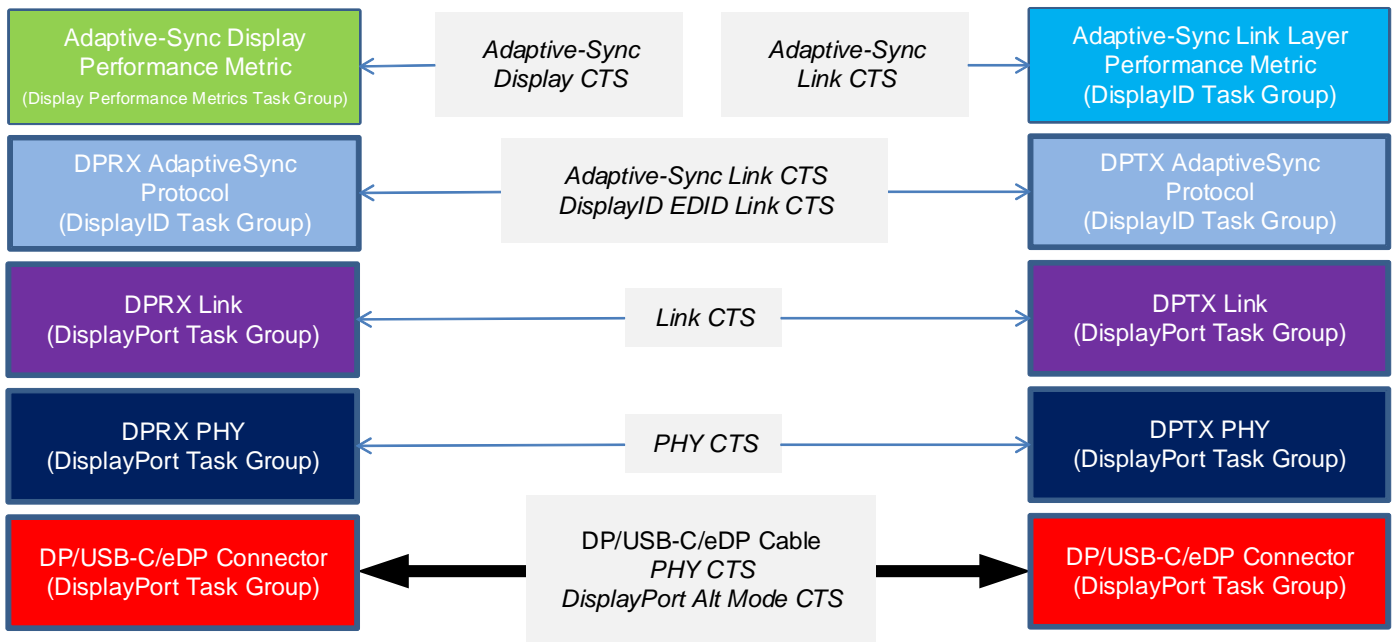


Figure 5-1: VESA CERTIFIED AdaptiveSync and MediaSync Display Logo Program CTSs

To achieve AdaptiveSync and/or MediaSync Display logo certification, Source and Sink devices shall pass all relevant compliance tests listed in Table 5-1, as follows:

- **Source devices** – Testing shall ensure that the devices meet Source rendering and video frame outputting performance mandates
- **Sink devices** – Testing shall ensure that the devices meet Sink rendering and displaying performance mandates

Table 5-1: Testing Needed to Achieve AdaptiveSync and/or MediaSync Display Logo Certification

VESA Specification	Tests within Section
<i>Adaptive-Sync Display CTS</i> (this document)	<ul style="list-style-type: none"> • All defined tests
<i>DisplayID EDID Link CTS</i>	<ul style="list-style-type: none"> • Source devices – Section 4, Source Device Compliance Tests • Sink devices (displays) – For displays that optionally use <i>DisplayID Standard</i>: Section 5, Sink Device Compliance Tests
<i>Link CTS</i>	<ul style="list-style-type: none"> • Source devices – Section 4, Source Device Tests • Sink devices (displays) – Section 5, Sink Device Tests
<i>PHY CTS</i>	<ul style="list-style-type: none"> • Source devices – Section 3, DP Source Device Compliance Tests • Sink devices (displays) – Section 4, Sink Device Compliance Tests

5.3 Required Testing Sequence and Modification for HDR-1000+ Displays

For a display that does **not** report a MaxLuminance of at least 1,000 cd/m² in its *DisplayID* or legacy *EDID* data block, the required sequence of testing is as follows:

- 1 Warm-up phase (see [Section 3.4.1](#)).
- 2 Static Flicker tests (see [Section 6](#)).
- 3 Variable Flicker tests (see [Section 6](#)).
- 4 G2G test, using the patterns defined in [Table 7-1](#) (see [Section 7](#)).
- 5 Drop frame tests (see [Section 8](#)).
- 6 Jitter tests (see [Section 9](#)).
- 7 And if the display supports HDR, then also the HDR tests in [Section 10](#).

For a display that reports a MaxLuminance of 1,000 cd/m² or higher in its *DisplayID* or legacy *EDID* data block, the required sequence of testing is as follows:

- 1 Warm-up phase (see [Section 3.4.1](#)).
- 2 Static Flicker tests (see [Section 6](#)).
- 3 Variable Flicker tests (see [Section 6](#)).
- 4 Drop Frame tests (see [Section 8](#)).
- 5 Jitter tests (see [Section 9](#)).
- 6 High-luminance warm-up phase (see [Section 3.4.2](#)).
- 7 High-luminance G2G Test, using the patterns defined in [Table 7-2](#) (see [Section 7](#)).
- 8 And if the display supports HDR, then also the HDR tests in [Section 10](#).

6 Refresh Rate and Flicker Testing

6.1 Overview

This section describes the test criteria for the *DisplayID* or legacy *EDID* refresh rates that define the Adaptive-Sync operation refresh rate range.

6.2 DisplayID or Legacy EDID Data-related Mandates

The Adaptive-Sync operation Vertical Blank (VBlank) range from maximum-to-minimum VBlank period shall be specified, which correlates to the display's supported minimum-to-maximum refresh rates. All tests within this Specification use these refresh rates as defined in the *DisplayID* or legacy *EDID* block, which are reported to applications by way of the GPU drivers and OS.

All standard input connectors that meet the criteria listed below shall be VESA DisplayPort-certified, per the appropriate VESA licensing policy, to qualify for AdaptiveSync or MediaSync Display logo certification:

- Claim support for the tests within this Specification, and
- Are either *DisplayPort* –or– DisplayPort Alt Mode on USB Type-C (*DisplayPort Alt Mode*) inputs

Standard input connectors that may be subject to the above VESA *DisplayPort* certification are:

- *DisplayPort Alt Mode* inputs
- Standard *DisplayPort* inputs
- Mini *DisplayPort* (mDP) inputs

See the appropriate VESA licensing documents to determine the compliance rules and relevant, in-force Standards and/or Specifications that guide VESA *DisplayPort* certification.

Additional mandates specifically for Adaptive-Sync operation compliance testing are included in the following compliance test specifications:

- *Adaptive-Sync Link CTS*
- *DisplayID EDID Link CTS*

6.3 Flicker Testing at Multiple Refresh Rates

Testing for flicker is performed at various refresh rates. Some tests use static refresh rates within the Adaptive-Sync operation range of the *DisplayID* or legacy *EDID*, while others use varying refresh rates.

The minimum and maximum refresh rates used for flicker testing are based on the minimum and maximum refresh rates provided by the display's *DisplayID* or legacy *EDID*.

6.3.1 Test Pattern

The test pattern used for determining the flicker level is a static, full-screen test pattern that remains unchanged during the test sequence. The test image is defined as an SDR-based image that uses an 8-bit Gamma 2.2 code value equal to 127 (i.e., 127, 127, 127). This yields a **gray** full-screen image of approximately 40 cd/m² in SDR mode when the maximum luminance is set to approximately 200 cd/m².

To achieve an output of approximately 40 cd/m², the manual brightness controls shall be used to adjust the test image's actual output brightness, as follows (variance from 40 cd/m² by ±5% (i.e., from 38 to 42 cd/m²) is acceptable):

- **Devices that have an integrated panel** – The OS's brightness adjustment slider should be used to make this adjustment
- **Devices that have an OSD and manual brightness controls** – The OSD and manual controls should be used to adjust the test patch to as close to 40 cd/m² as the available adjustments allow

For displays that are unable to adjust the flicker test luminance test patch to 40 cd/m² ±5%, results from the closest-achievable luminance, both above 40 cd/m² and below 40 cd/m², should be provided to the VESA Compliance Manager for review and consideration.

6.3.2 Flicker with Static Refresh Rates

Testing at static refresh rates shall be performed at the following frequencies:

- Logo performance tier's defined minimum *DisplayID* or legacy *EDID* Adaptive-Sync operation range (see [Table 2-1](#))
- 23.976 Hz
- 24 Hz
- 25 Hz
- 29.97 Hz
- 30 Hz
- 47.952 Hz
- 48 Hz
- 50 Hz
- 59.94 Hz
- 60 Hz

When the test frequency is lower than the *DisplayID* or legacy *EDID*-supported Adaptive-Sync operation frequencies, the VESA AdaptiveSync Test Tool shall use an integer multiplier to double or triple the video frame rate such that the video frame rate is as low as possible but also within the Adaptive-Sync operation range. For example, when testing typical Hollywood movie content with a video frame rate of 23.976 Hz, if a panel's *DisplayID* or legacy *EDID* offers a frequency of 23.976 Hz or lower, the native refresh rate will be tested. However, most panels provide a minimum refresh rate of 47.952 Hz, in which case the Hollywood movie frequency testing would be frame-doubled in the GPU and then transmitted to the display at 47.952 Hz. For cases in which the display's minimum refresh rate is 59.94 Hz, test content at 23.976 Hz would be frame-multiplied to 71.928 Hz, such that it fits within the display's Adaptive-Sync operation range.

6.3.3 Flicker with Dynamically Variable Refresh Rates

Variable Refresh Rate tests are performed to test for flicker while the refresh rate is dynamically changing. There are four kinds of tests for this scenario:

- Zigzag sweep from minimum-to-maximum refresh rate, and then back to the minimum refresh rate in a continuous sweep
- Abrupt switch from the minimum-to-maximum refresh rate, and then back to the minimum refresh rate in a continuous "square-wave" pattern
- True sine-wave sweep from minimum-to-maximum refresh rate
- Random video frame rate test between the minimum and maximum refresh rates

Although similar, the Zigzag Sweep test differs from the SineWave Sweep test, as follows:

- **Zigzag Sweep test** – When plotting the test’s frequency on the Y-axis and time on the Z-axis, the zigzag changes 1 Hz/video frame.
- **SineWave Sweep test** – Sine wave changes the frequency to follow the typical sine-wave curve. Near the minimum and maximum frequencies, the frequency only slightly adjusts from video frame-to-frame (significantly less than a 1-Hz difference). At the midpoint between the minimum and maximum frequencies, the change of video frame rate/video frame is larger.

6.3.3.1 Zigzag Sweep

In the Zigzag Sweep test, one video frame is displayed at each integer video frame rate from the minimum-to-maximum refresh rate, then for one video frame for each integer video frame rate from maximum-to-minimum refresh rate, and then the pattern repeats.

Even for the most extensive frequency ranges (i.e., 20 to 200 Hz, and 40 to 400 Hz), this will yield a cycle that travels from the minimum-to-maximum refresh rate, and then back to the minimum refresh rate in less than 5 seconds, and therefore may be easily measured.

For example, if a panel’s *DisplayID* or legacy *EDID* claims support for 24 to 144 Hz, a video signal should be transmitted that runs the gamut from 24 to 144 Hz. The testing process would be as follows:

- 1 Transmit a video signal that refreshes at 24 Hz for one video frame, then 25 Hz for one video frame, etc., one video frame per integer increase all the way up to 144 Hz.
- 2 Transmit a video signal that refreshes at 143 Hz for one video frame, then 142 Hz for one video frame, etc., one video frame per integer decrease all the way down to 24 Hz, which displays for one video frame as the start of the pattern’s second loop.

6.3.3.2 SquareWave Sweep

In the SquareWave Sweep test, an even number of frames for a duration as close to 250 ms as possible is displayed at the maximum refresh rate, and then a different but also even number of frames for a duration as close to 250 ms as possible is displayed at the minimum refresh rate, and then repeated.

For example, a display with a range of 48 to 144 Hz would emit 12 frames at 48 Hz, and then 36 frames at 144 Hz. A display with rates that are **not** divisible by 8 would need to be rounded to the closest even multiples; thus, a display with a range of 60 to 165 Hz would need to be displayed for either 14 or 16 frames at 60 Hz, because the number of frames must be an even number (i.e., 15 is not an even number, and therefore could not be used), and then 42 is the closest even integer when targeting 250 ms for frames at 165 Hz.

6.3.3.3 SineWave Sweep

In the SineWave Sweep test, a sine-wave function is applied to a continuously changing frequency that ranges from minimum to maximum and then back to minimum.

6.3.3.4 Random Video Frame Rate

In the Random Video Frame Rate test, a random function is used to determine video frame-to-frame timing that maintains a video frame rate between the *DisplayID* or legacy *EDID* minimum and maximum video frame rates.

6.4 Flicker Measurement

Using flicker measurement instruments that are capable of rapidly sampling the screen to determine the luminance level at high frequency, the amplitude modulation of the screen’s luminance level shall be measured as a fluctuation through each video frame that is displayed with a static video signal.

Flicker sampling should be performed at 0.5-Hz (or smaller) intervals for the range of 3 to 65 Hz. In many common flicker sampling tools, this results in a 2-second measurement procedure, such as that indicated in Figure 6-1. This procedure should be repeated 10 times, as quickly as possible (i.e., with 0-second interval between measurements), with an average of the 10 results used as the final result of each test.

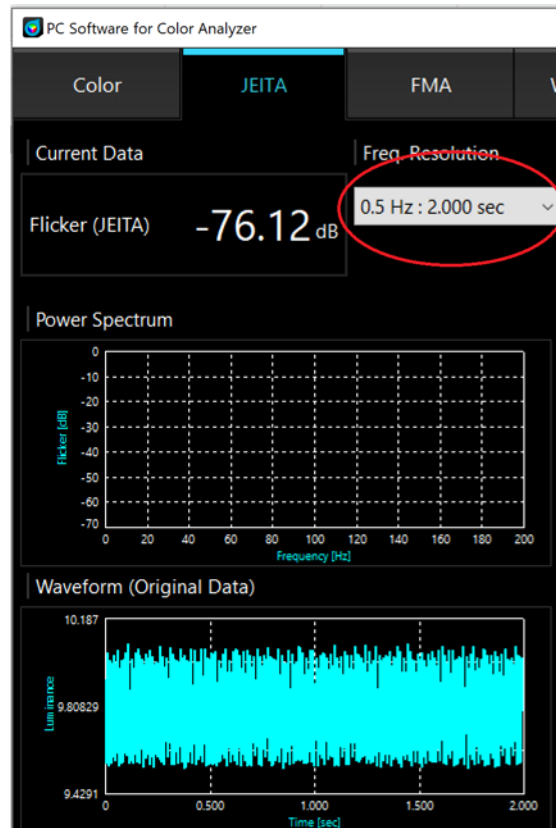


Figure 6-1: Example JEITA Flicker Sampling at 0.5-Hz Interval Setting^a (Informative)

^a Image used with permission from Konica Minolta.

6.4.1 Measurement Location(s)

For each flicker test, the sensor should be placed at the screen's center. Any flicker tests that emit flicker greater than -60 dB at the screen's center shall also be tested with the sensor moved to four additional locations by placing the sensor probe halfway between the screen's center and each corner. For any flicker test in which five sensor locations are used, all locations shall meet the flicker mandates listed in [Table 2-1](#).

6.4.2 Flicker Calculation

The flicker measured from the static test pattern described in [Section 6.3.1](#) is calculated as follows:^a

$$Flicker_{Max} = 10 \times \log_{10} \left[\frac{P_f^{max} \times w(f^{max})}{P_0} \right] \quad [\text{dB}]$$

where:

- P_f^{max} = Spectrum component with the highest power value
- P_0 = Power at 0 Hz
- $w(f)$ = Weighting factor that discounts flicker for less human-vision sensitivity above 20 Hz (see [IEC 61747-30-1](#); e.g., $w(0 \text{ Hz}) = 1.0$ at 0 Hz)^b
- for the range (f) between 3 to 65 Hz

-
- a. The $Flicker_{Max}$ equation reflects the flicker measurement definition in [IEC 61747-30-1](#) and separates the FFT component from the weighting factor for clarity. [IEC 61747-30-1](#) includes $w(f)$ within the power factor, P_f . Further note that this equation differs from the VESA and ICDM equation ([IDMS](#), page 266) by **not** including a factor of 2 that leads to a 3-dB lower resultant flicker value.
- b. Modern flicker luminance measuring devices automatically include the weighting factor in their measurement reading.

7 Gray-to-Gray Testing

7.1 Overview

This section describes the tests for **gray-to-gray** (G2G) in SDR mode. The G2G duration is the time it takes for the display hardware to transition from one luminance level to another. G2G applies equally to color as it does **black** and **white**. However, to simplify testing, tests are typically limited to only **black** to **white** and several **gray** tones between these extremes without testing color.

VESA's objective in developing a G2G 5×5 average measurement is to create a well-defined set of performance measurement methods with a static set of test patches, and a clear way of reporting the results such that everyone using this Specification would be reporting results that are easily compared without concern for whether two brands of device had used the same methodology.

IDMS defines an industry-standard G2G response methodology for SDR screen testing. In addition to leveraging the *IDMS* G2G response methodology for SDR, this Specification defines a specific matrix to use for G2G testing.

Overdrive (see [Table 2-1](#)) is sometimes used to accelerate G2G transitions, but at a cost of introducing visual artifacts. To prevent excessive overdrive use, overshoot and undershoot are measured on G2G transitions that do **not** end in **black**.

Tests are performed using the factory-default settings with regard to the overdrive settings. The only deviation from the factory default is that the luminance must be adjusted to achieve approximately 40 cd/m^2 (a range of 38 to 42 cd/m^2 is allowed) when displaying a **Gray 127** test screen. In this scenario, the factory-default settings are validated to ensure that the settings do **not** apply amounts of overdrive that result in excessive overshoot and undershoot.

7.2 Test Patterns

G2G testing shall be performed only in SDR mode; thus, the OS shall need to be configured to run the tests in SDR mode.

[Appendix A](#) includes the calculation method that is used to convert SDR code values to luminance levels for a specific luminance level, including examples with an approximately 185 cd/m² maximum.

The test, for displays that do **not** have a MaxLuminance of at least 1,000 cd/m², uses a square patch that covers 10% of the total screen area, at the screen's center. The remaining 90% of the test image is a static-**gray** level. [Table 7-1](#) defines the five test images for each SDR mode test. For displays that have a *DisplayID* or legacy *EDID* MaxLuminance of 1,000 cd/m² or higher, [Table 7-2](#) defines the test pattern.

**Table 7-1: SDR G2G Test Levels – 8-bit Gamma 2.2 Code Values,
Displays with MaxLuminance < 1,000 cd/m²**

5 × 5 Matrix Test Patch Values	SDR 10% Test Patch	SDR 90% Gray Surround
Test 1 (Black)	0	127
Test 2 (Dark Gray)	63	127
Test 3 (Mid Gray)	127	127
Test 4 (Light Gray)	191	127
Test 5 (White)	255	127

**Table 7-2: SDR High-Luminance G2G Test Levels – 8-bit Gamma 2.2 Code Values,
Displays with MaxLuminance ≥ 1,000 cd/m²**

5 × 5 Matrix Test Patch Values	SDR 10% Test Patch	SDR 90% White Surround
Test 1 (Black)	0	255
Test 2 (Dark Gray)	63	255
Test 3 (Mid Gray)	127	255
Test 4 (Light Gray)	191	255
Test 5 (White)	255	255

7.3 Testing Frequency

While testing G2G latency, the fastest display-supported refresh rate, as indicated in the Adaptive-Sync operation range of the *DisplayID* or legacy *EDID*, shall be used.

7.4 G2G Measurement Methodology

A G2G 5×5 matrix is used for this test, which means there are 20 test cases. For each test case, the time is measured for how long it takes for each of the five initial starting luminance levels to transition to the other four luminance levels. The time measured for each test is the duration from when the transition is 10 to 90% complete. Within the G2G 5×5 matrix, there are five “tests” that involve no transition (i.e., where the starting and final luminance levels are the same); these tests are ignored because they yield results of 0.

The VESA G2G average is thus the average of the 20 G2G timing results from each 10 to 90% transition.

7.5 Overshoot Measurement Methodology

Sixteen of the 20 G2G tests conclude in a final transition to a gray level of 25, 50, 75, or 100% (8-bit Gamma 2.2 code value equivalent levels). Overshoot or undershoot that occurs on these 16 transitions is measured. If overdrive is being applied, up to 10 of the transitions may overshoot, and up to 6 of the transitions may undershoot. All 16 transitions are measured and the maximum overshoot and maximum undershoot of the set of 16 samples is reported.

Figure 7-1 illustrates an example of overdrive being used while transitioning from a dark gray level (Level A) to a light gray level (Level B). The yellow boxes for Levels A, B, B, B, A, A represent one video frame with a dark gray video signal, three video frames with a light gray video signal, and then two video frames with a dark gray video signal. Note that the dark and light are not black and white, but gray tones. The red line indicates the display's actual luminance, with the display overshooting the target of Level B and going brighter. Additional luminance beyond the target (Level B in this case) is indicated as "overshoot." Three video frames later the source input transitions to Level A, at which point the luminance level temporarily drops (i.e., undershoots) to a level that is darker than the actual target, Level A. Over a period of approximately one video frame, the luminance level stabilizes at the correct level, Level A. Figure 7-2 lists the calculations used for determining overshoot and undershoot.

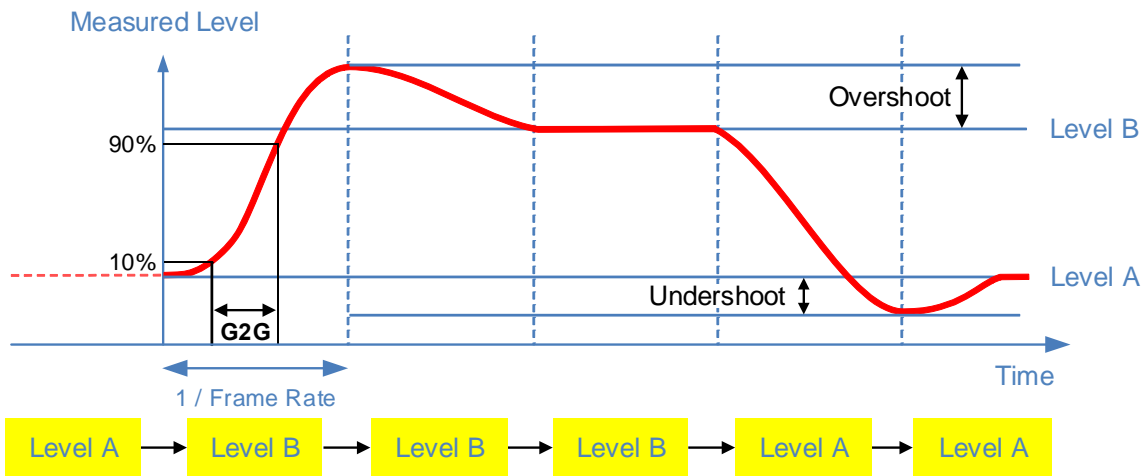


Figure 7-1: Overshoot and Undershoot Luminance Levels Due to Application of Overdrive

$$level_{90\%} = level_B - 0.1 \times (level_B - level_A)$$

$$level_{10\%} = level_A + 0.1 \times (level_B - level_A)$$

$$G2G_{rise} = time(level_{90\%}) - time(level_{10\%})$$

$$G2G_{fall} = time(level_{10\%}) - time(level_{90\%})$$

$$overshoot = \left(\frac{level_{max} - level_B}{level_B - level_A} \right) \times 100\%$$

$$undershoot = \left(\frac{level_A - level_{min}}{level_B - level_A} \right) \times 100\%$$

Figure 7-2: G2G Overshoot and Undershoot Calculations

7.5.1 Test Configuration

This section describes the system configurations that are needed for the following tests:

- [Factory Overshoot/Undershoot Compliance Test](#)
- [Average G2G Test](#)

7.5.1.1 Factory Overshoot/Undershoot Compliance Test

In this test, the display's factory-default Overdrive setting is tested to verify that the setting does **not** result in an overshoot or undershoot that exceeds the specification for the logo performance tier being tested (see [Table 2-1](#)).

This test verifies that none of the 16 test scenarios from the G2G 5×5 matrix that do not conclude in **black** exhibit more than the maximum overshoot or undershoot limit specified in [Table 2-1](#) for the factory-default Overdrive setting.

7.5.1.2 Average G2G Test

In this test, the display device remains configured with the factory-default Overdrive setting. The 10 to 90% transition times for the 20 scenarios are then tested, and the results of the 20 tests are averaged. This average shall be less than or equal to the limit specified in [Table 2-1](#) for the average G2G times for the relevant logo performance tier being tested.

Testing can be performed in at least two different ways, such as by:

- Using the fully automated loop, an option inside the G2G test suite, which executes each of the 20 G2G transitions twice over a 10-second testing period. This loop should be repeated at least 10 times so that each of the 20 G2G transitions are executed 20 times each. By using a sufficiently fast probe and sufficiently fast data recorder, this data can be analyzed for G2G, overshoot, and undershoot, but needs sophisticated analysis tools.
- Testing each pair of G2G transitions (10 pairs for coverage of all 20 G2G transitions), and using a sufficiently fast probe with an oscilloscope, with the oscilloscope gain sufficiently high to maximize use of the oscilloscope's display range, without clipping. Use the oscilloscope to average the repeating G2G pair over at least 20 transitions to report on the rise time, fall time, overshoot, and undershoot for the pair of G2G levels. This needs to be executed for each of the 10 G2G pairs to cover all 20 transitions, after which the G2G average should be calculated, and the maximum overshoot and maximum undershoot identified.

Critical mandates of the testing for G2G, overshoot, and undershoot are as follows:

- Mandatory delay of at least 250 ms is needed between G2G transitions is required. Although the automated tool implements this, the G2G pairs need to be adjusted such that the number of video frames is at least 1/4 of the maximum video frame rate (e.g., when testing the G2G pairs, use 60 video frames on a 240-Hz monitor).
- For cases in which the maximum video frame rate is **not** a multiple of four (e.g., a 165-Hz monitor), the number of video frames for each G2G transition should be at least 1/4 of the maximum video frame rate, rounded up to the next even number (e.g., 42 frames for a 165-Hz monitor).
- To successfully average the test results, testing must record at least 20 transitions for each G2G transition.
- G2G calculation is thus the average of 400 results (i.e., 20 G2G transitions, each with at least 20 measurements).
- Overshoot and undershoot should be calculated using at least 20 measurement samples of the same G2G transition. The greatest of the 10 overshoot averages is used as the Maximum Overshoot value. Likewise, the greatest of the 6 undershoot tests (i.e., those that decline in luminance, but do **not** end in **black**) is used as the Maximum Undershoot value.

8 Video Frame Drop Testing

8.1 Overview

This section describes the test for verifying that video frames are **not** being dropped. Video frames are **not** expected to drop from a video sequence when the video frame rate remains within the range specified by the *DisplayID* or legacy *EDID* minimum and maximum Adaptive-Sync operation video frame rates.

Video frame drop testing uses a simple **white** box that moves on each video frame. A camera is used to record a long 1-second exposure to capture the output video frames, and from the captured images it is easy to determine whether any video frames are dropped.

8.2 Camera-related Mandates

A tripod-mounted camera that is capable of adjusting shutter speed, aperture, and ISO speed is needed to enable a suitable 1-second exposure. The recommended camera settings are as follows:

- **Exposure** – 1 second
- **Aperture** – F5.6
- **ISO** – Approximately 4× the display’s maximum video frame rate (e.g., ISO 1000 for a 240-Hz display)

Assuming the display’s luminance was correctly configured to achieve approximately 40 cd/m², as per [Section 6.3.1](#), the screen’s luminance varies in the Static Maximum and Random Refresh Rate Video Frame Drop tests proportionally with the display’s maximum video frame rate. While the moving **white** box is the same luminance irrespective of video frame rate, each pixel on the screen is **white** for only 1/MaxFrameRate of one second. Thus, adjusting the ISO speed to be 4× the display video frame rate achieves a similar suitable **mid-gray** exposure for any display video frame rate.

8.3 Video Frame Rates Tested

Two frequency tests shall be used for testing video frame dropping:

- Static maximum refresh rate, using the highest refresh rate defined in the Adaptive-Sync operation range
- Random refresh rate (ranging from minimum to maximum, with unlimited speed of video frame rate change)

8.4 Test Pattern

The VESA AdaptiveSync Test Tool emits test images with a **white** box that moves in a sequential pattern. The test tool is able to adjust each video frame's VBlank period to vary the test sequence's video frame rate. In both tests, the **white** box fills the screen over a 1-second period, as follows:

- **Static maximum refresh rate** – Uses a consistent luminance box size that is $1 / \text{Maximum Refresh Rate}$ of the screen in size, thus filling the screen within 1 second
- **Random refresh rate** – Uses variable size and luminance boxes that are inversely correlated in size and luminance to the refresh rate to approximately fill the screen within 1 second, with an expectation of the resulting exposure to be close to a consistent **gray**, except for cases in which video frames have been dropped

For each test case, there are thin **black** horizontal lines between each row that illustrate the baseline for **black**. With LCDs, there is a certain amount of light leakage. This, combined with potential reflection on the screen, can make it difficult to distinguish between a dark video frame and a completely missing **black** video frame. The **black** horizontal lines provide an easy-to-compare level for **black**, thus making it easy to determine whether a video frame is truly missing. In other words, if the video frame matches the **black** lines in luminance, the test has failed; however, if the video frame is a little bit brighter than the **black** lines, it is just a dark video frame and thus considered a “pass” with regard to this test.

8.5 Results Analysis Methodology

Video frames, such as those in [Figure 8-1](#), show a **white** box that moves in an adjacent but non-overlapping manner, thus enabling a long exposure for capturing a sequence of video frames to show whether any video frames are dropped.



Figure 8-1: Example First Three Video Frames of the Video Frame-drop Sequence (Informative)

[Figure 8-2](#) illustrates a 1-second camera capture of the screen for the Maximum Video Frame Rate test. In this particular image, **black** horizontal lines are visible between each row. Reflections on the screen caused by ambient light, also visible, clearly show the **black** level being quite different across the screen due to reflection, thus making it easy to determine whether any of the video frames are missing. [Figure 8-2](#) shows an absolutely perfect capture in which the timing of the camera and the test for 1-second is absolutely identical; it is impossible to identify the start and end of the video frame. This is an atypically good image showing – no dropped video frames, perfect timing, and zero jitter.

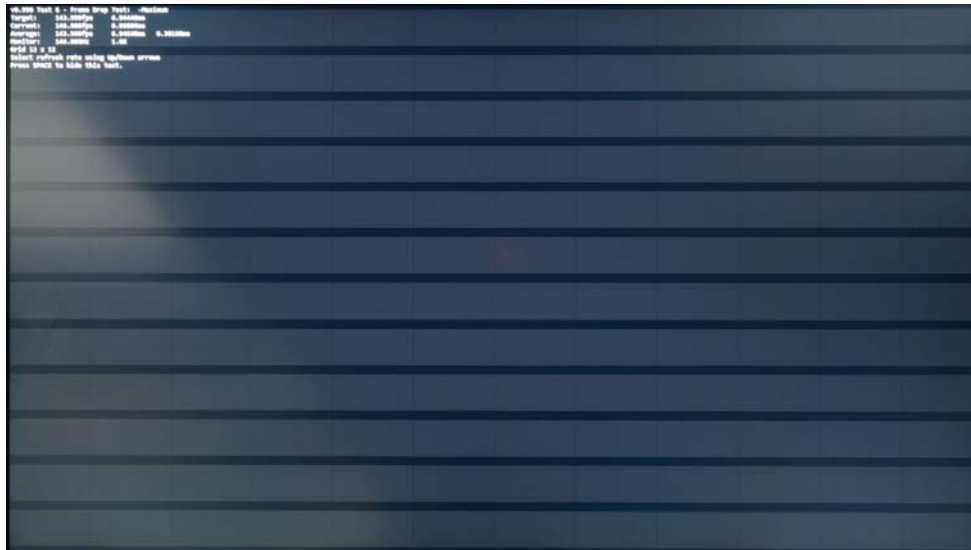


Figure 8-2: Maximum Video Frame Rate Test at 144 Hz

Figure 8-3 illustrates a 1-second camera capture of the screen for the Random Video Frame Rate test. With the single “near **black**” video frame in the top row, it is clear that the camera started capturing the 1-second exposure just to the right of this **black** video frame. The camera then captured the remainder of the video frame, looped around to the top and captured the remainder of the top row, and then captured the test’s timing. The camera was slightly different in its yielding of this single video frame gap in which the video frame is nearly **black**. This is a great demonstration of a passing condition for the Random Video Frame Rate test in which the test duration and the 1-second camera capture is slightly different, such that there is a single dark area. A single dark area like this is allowed because it is merely a difference in camera capture time vs. the test. Looking closely at the image, it is possible to see that the video frame is not quite as **black** as the **black** lines, and is actually dark **gray**, not **black**, which indicates that the video frame was captured for a short period of time. In this particular case, had the image shown multiple random dark, but not **black**, video frames scattered across the images, this too would have also been considered a test pass. Only if there are multiple video frames that are perfectly **black**, matching the horizontal line, would this be considered a test failure. Depending on the DUT’s G2G response time, the difference between the lighter and darker patches may be far greater than shown in this captured image.



Figure 8-3: Random Video Frame Rate Test Showing Start/End Overlap

Figure 8-4 also illustrates a 1-second camera capture of the screen for the Random Video Frame Rate test. Unlike Figure 8-3, this capture shows the scenario in which the test looped the screen slightly faster than the camera's 1-second exposure. In the bottom row, it is possible to see that the camera captured a few video frames twice, which are twice as bright as the other video frames. This is also considered a test pass because the video frames are obviously **not** missing, which is the only result that triggers a test failure.

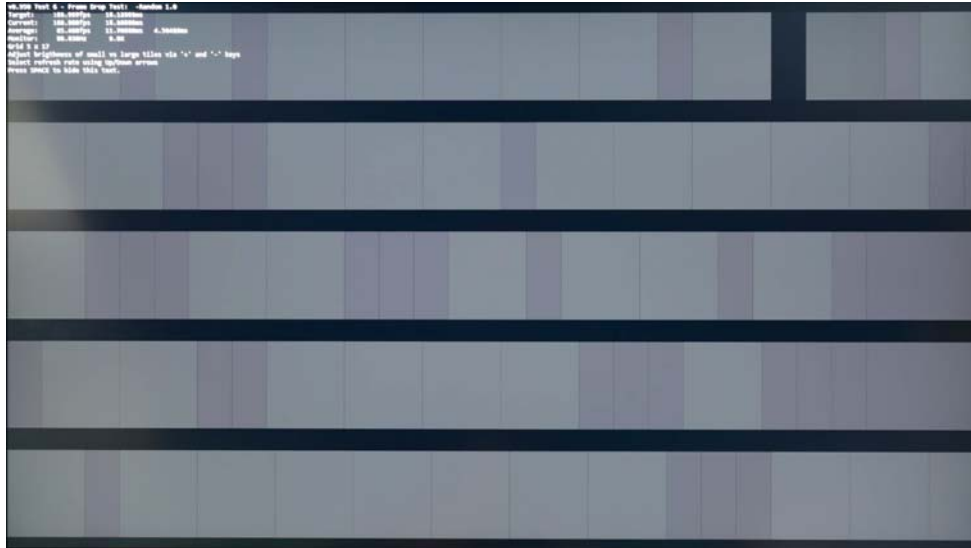


Figure 8-4: Random Video Frame Rate Test Showing Start/End Gap

9 Video Frame Rate Jitter Testing

9.1 Overview

Beyond benefiting gaming by way of Adaptive-Sync's native ability to reduce latency and reduce or eliminate tearing, there are also significant benefits to movie/video playback, and video content creation by locking the display video frame rate to an integer multiple of the content's video frame rate.

This section describes the tests to be performed to ensure that all standard media video frame rates are supported, and that the video frame-to-frame jitter is minimized.

9.2 Camera-related Mandates

A tripod-mounted camera that is capable of adjusting shutter speed, aperture, and ISO speed is needed to enable a suitable 1-second exposure. First, ensure that the instructions defined in [Section 6.3.1](#) for adjusting the display luminance to 40 cd/m^2 ($\pm 2 \text{ cd/m}^2$) for **Mid Gray** (code value 127) have been executed. Darken the test area as much as possible to reduce reflection on the screen. Position the camera to be able to capture the entire screen and as little extra background as possible within the camera's field of view.

The exposures captured by the camera are trying to achieve a **mid-gray** flat image in the 1-second exposure. By targeting **mid-gray**, the camera should have plenty of dynamic range to show segments of the image that are either lighter or darker than the other zones.

A recommended exposure on the camera is to use an F5.6 aperture, 1-second exposure duration, with the ISO sensitivity speed set to 100. This will yield **mid-gray** exposures for the image that will be suitable for inspection. If the camera settings need additional optimization (which needs additional user effort during testing), the above exposure settings of F5.6 and 1 second should be used, and the ISO sensitivity speed should be adjusted with respect to the test's video frame rate. The tests in this section range from 23.976 to 60 Hz. Thus, by setting the ISO to approximately $4\times$ the video frame rate (i.e., ISO 100 for the 23.976-Hz test, and ISO 250 for the 60-Hz test) will yield a more-similar **gray** level in each image. However, this ISO adjustment is typically **not** needed.

9.3 Video Frame Rates Tested

Each of the following video frame rates shall be supported, either at their native rates, –or– at an integer multiple of these rates, video frame multiplied by the GPU to increase the video frame rate to at least the *DisplayID* or legacy *EDID* minimum refresh rate.

- 23.976 Hz
- 24 Hz
- 25 Hz
- 29.97 Hz
- 30 Hz
- 47.952 Hz
- 48 Hz
- 50 Hz
- 59.94 Hz
- 60 Hz

9.4 Test Pattern

This test uses the same test pattern as the static maximum refresh rate Video Frame Drop Testing defined in [Section 8](#). The two primary differences from the [Section 8](#) testing are the test frequencies, and that when supported by both the GPU and display, the more-accurate Static-average VTotal timing shall be used to display the test sequence frequency.

9.5 Results Analysis Methodology

Photographs of the screen, using a 1-second exposure, are collected for each test frequency listed in [Section 9.3](#). Each photograph is first desaturated to remove the color channels to reduce the photograph to **grayscale**, and then the photograph brightness is adjusted so that the average brightness becomes 8-bit code value 187 (representing 50% luminance in 8-bit Gamma 2.2 code values). Any moiré created during the image-capture process may be removed with a Gaussian blur.

Typically, it is easy to visually distinguish which photographs exhibit a perfectly flat **gray** output (ignoring the starting and ending squares, which may slightly vary) versus video frames that exhibit jitter by way of obvious variance in luminance from square to square. The description that follows provides a fairly complex method that mathematically proves the pass or fail condition; however, these steps are usually unnecessary because the visual observation of the photographs can quickly distinguish between images that are flat versus “checker boarded.”

Identify the brightest and darkest test boxes within the photograph, excluding any test boxes that may be touching the image’s edges because these are likely to be dimmer due to LCD light falloff at the edges, and measure each test box only at the center of each test. The following should be ignored:

- Test boxes that are clearly **black** because the shutter duration was shorter than a full-screen refresh (see [Figure 9-1](#))
- Squares that appears at both the start and end of the image capture, thus doubling the image brightness (see [Figure 9-2](#))

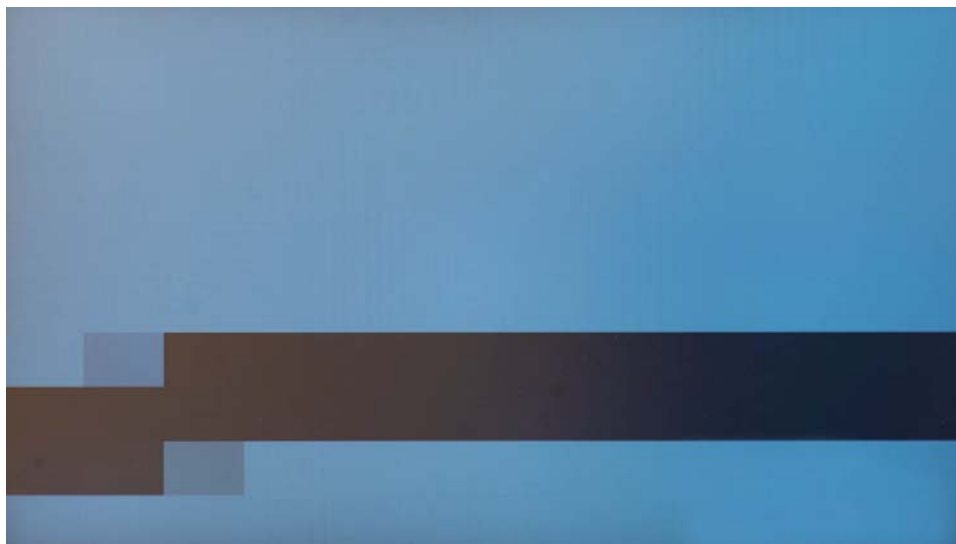


Figure 9-1: Example of Photograph Capture of Slightly Shorter than 1 Second (Informative)

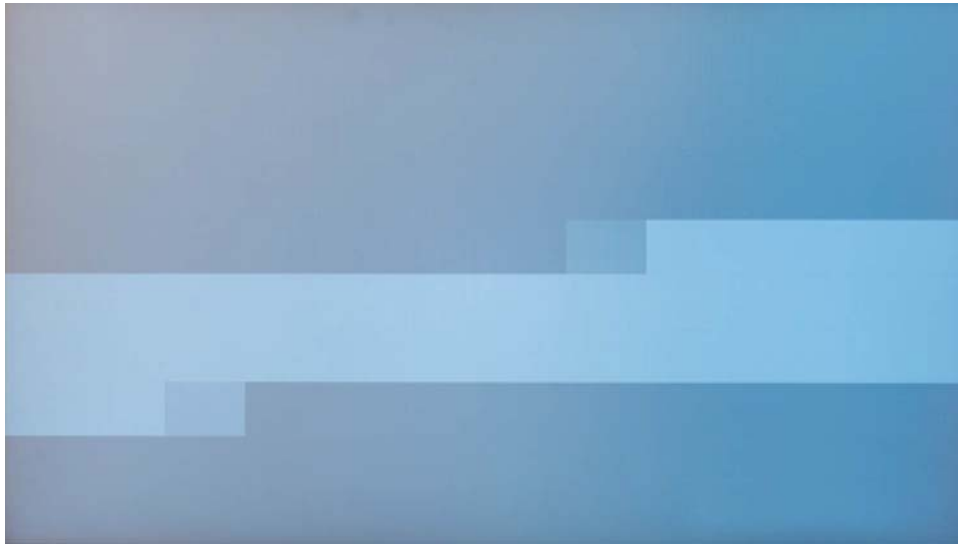


Figure 9-2: Example of Photograph Capture of Slightly Longer than 1 Second (Informative)

For example, when testing at 48 Hz, there would be 48 test boxes on the screen, 24 of which would touch at least one edge of the screen and thus should be ignored. Perhaps zero, one, or two test boxes may potentially be completely **black** or 2× as bright as other test patches, indicating an inconsistency in the camera’s 1-second timing and the test application, such that the camera captures slightly less than a complete screen cycle, –or– slightly more than a complete test cycle, thus capturing one or two test boxes being illuminated twice. This leaves approximately 22 test boxes to compare. Inspect the center of each test box to identify the 8-bit Gamma 2.2 code values of the darkest test box and brightest test box.

With an allowable jitter of ±0.5 ms (see [Table 2-1](#)), the expected video frame duration at 48 Hz is 20.8 ms. A 1-ms total variance between the longest and shortest video frames would allow a 4.8% variance. Converting this 4.8% luminance into Gamma 2.2 code values and multiplying this by the video frame average of code value 187 yields the following range:

$$\text{Allowed Minimum-to-Maximum 8-bit Gamma 2.2 Code Value Range} = 187 \times (1.048^{(1/2.2)} - 1) = 4.03$$

Because code values are integers, the value is rounded up to identify the range of code value variance. A variance of 5 or more would thus indicate jitter of more than ±0.5 ms.

[Table 9-1](#) identifies the limit of passing minimum-to-maximum code value ranges. Ranges that are larger than those indicated in [Table 9-1](#) indicate an out-of-range jitter condition and thus are considered test failures.

Table 9-1: Passing Minimum-to-maximum Code Value Range Limits

Test Frequencies (Hz)		Minimum-to-Maximum 8-bit Gamma 2.2 Code Value Range Limit
Minimum	Maximum	
23.976	25	2
29.97	30	3
47.952	50	4
59.94	60	5

As an example of one particular tool commonly used for photograph editing, **Adobe® Photoshop®** may be used to perform the following:

- 1 Ensure that text display in the VESA AdaptiveSync Test Tool is turned OFF.
- 2 Take a 1-second photograph.
- 3 Open the photograph in **Adobe Photoshop** (see [Figure 9-3](#)).

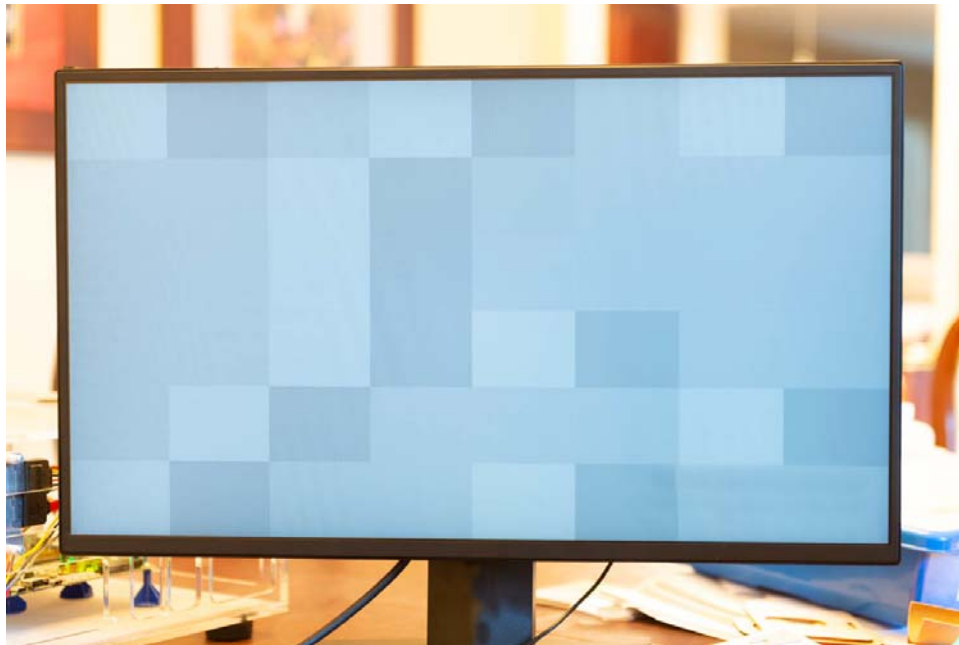


Figure 9-3: Original 1-second Photograph, Including Background

- Crop the photograph to contain only the panel, not the display bezel or any background. Any test boxes along the edges should be removed as well. A tight cropping that loses some of the screen-photograph edge is fine (see [Figure 9-4](#)).

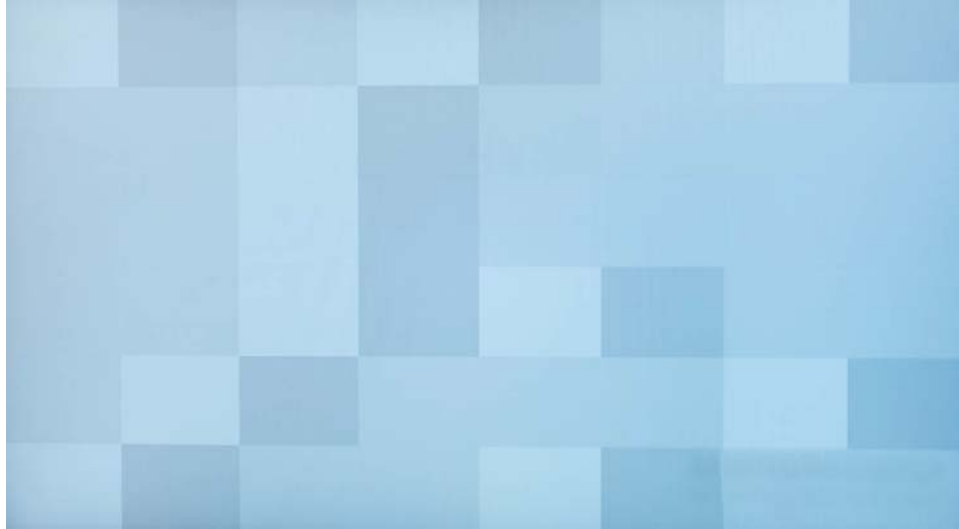


Figure 9-4: 1-second Photograph, Cropped to Contain Only the Panel

- Remove the color: **Image > Adjustments > Hue/Saturation > Saturation = -100** (see [Figure 9-5](#)).

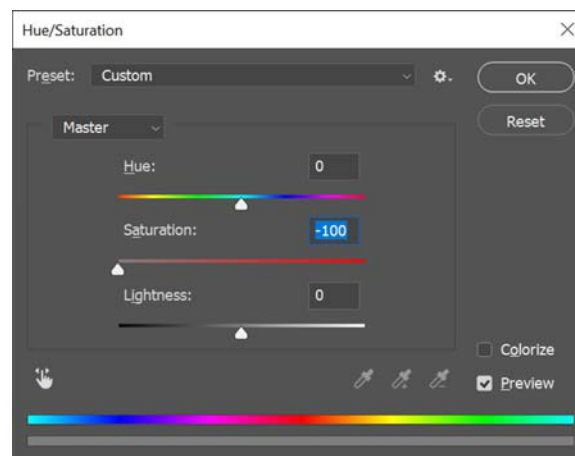


Figure 9-5: Adobe Photoshop Effect – Adjust the Saturation to -100 to Reduce the Saturation to the Minimum Level at which to Achieve Grayscale

- Blur to remove moiré: **Filter > Blur > Gaussian Blur > Radius = 10** (see [Figure 9-6](#) and [Figure 9-7](#)).

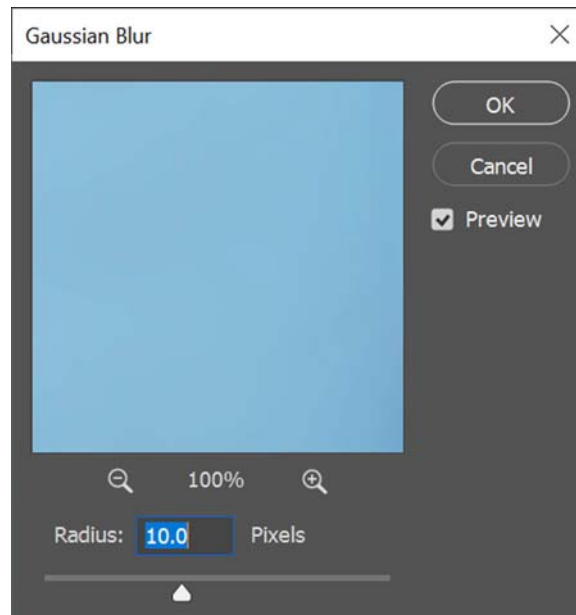


Figure 9-6: Adobe Photoshop Effect – Use the Gaussian Blur Filter to Reduce Moiré



Figure 9-7: Photograph Now Cropped, Desaturated, and with Gaussian Blur

- 7 The following steps temporarily blur the entire photograph to an average so that the correct brightness adjustment may be determined.
 - a **Filter > Blur > Average.** The photograph loses all detail and changes to a single flat gray tone (see [Figure 9-8](#)).

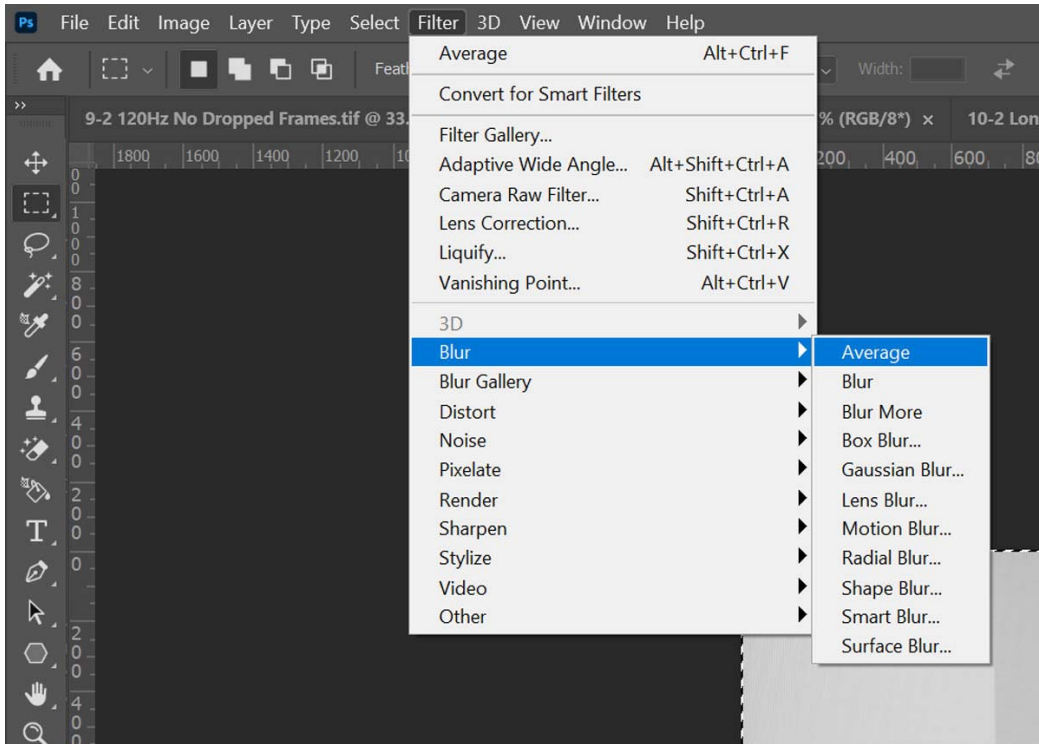


Figure 9-8: Adobe Photoshop Effect – Use Blur Average Filter to Flatten the Photograph to the Average Luminance

- b **Window > Info.** The **Info** window opens. Hover over the photograph to display the photograph's average **gray** level in the **Info** window (see [Figure 9-9](#)).

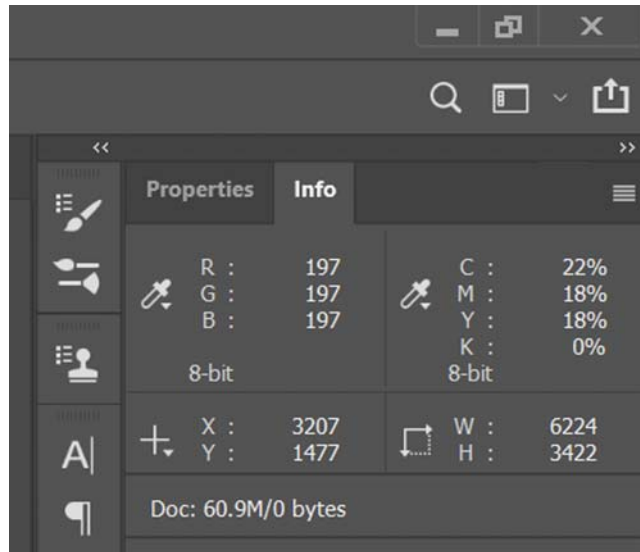


Figure 9-9: Adobe Photoshop – Use the Info Window to Show the Photograph's RGB 8-bit SDR Levels

- c **Image > Adjustments > Brightness/Contrast > Brightness** – Adjust the *Brightness* value up –or– down to achieve an average that indicates 187 in the **Info** window (see [Figure 9-10](#)).

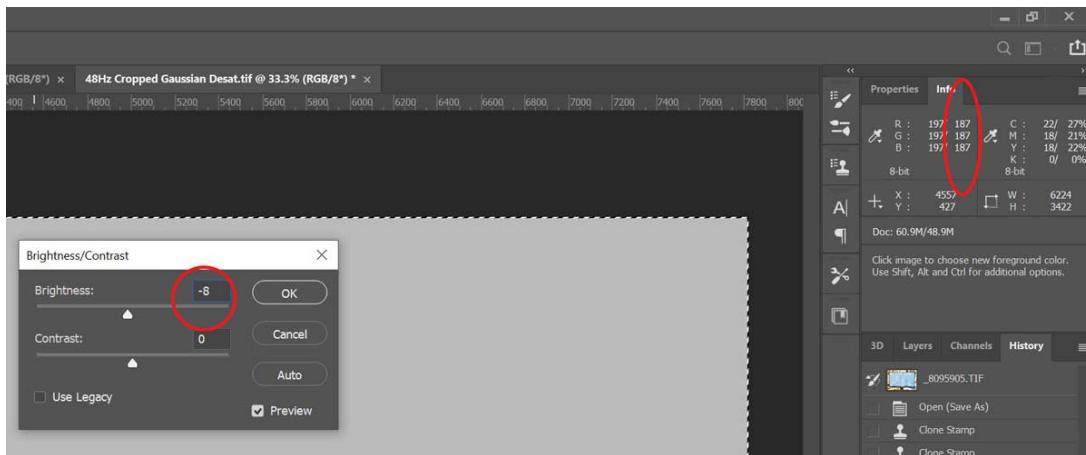


Figure 9-10: Adobe Photoshop – Brightness Adjustment Tool

- d Record the *brightness adjustment* value determined in step 7c.

- e **Window > History.** The **History** window opens. Select the *history step* that occurred prior to the *Average* function applied in step 7a (see Figure 9-11).

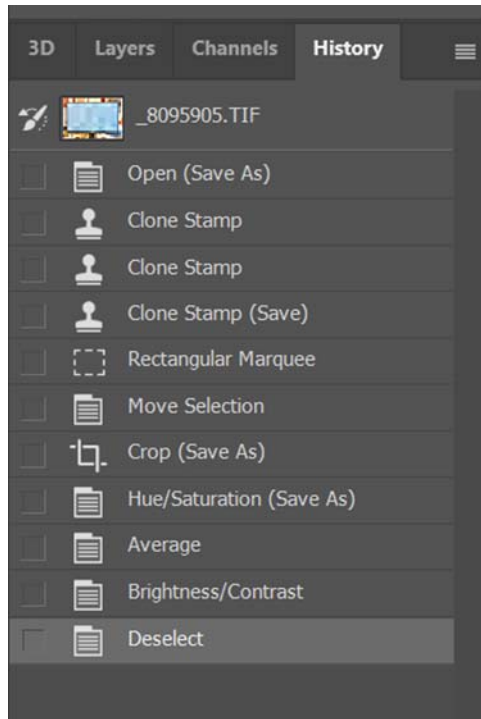


Figure 9-11: Adobe Photoshop – History List

- f **Image > Adjustments > Brightness/Contrast > Brightness** – Adjust the *Brightness value* by the value determined in step 7c (see Figure 9-12).



Figure 9-12: Photograph, Cropped, Desaturated, Blurred, and Adjusted with an Average of 187

- 8 Hover the mouse over the middle of each test patch to record the brightest and darkest patches that do not include the previously noted excluded boxes (start/end and edges) to see the range that may be computed to calculate the jitter variance (see [Figure 9-13](#)). With a minimum-to-maximum range of 175 to 202, with the difference of 27 that far exceeds the permitted limit of 4 as specified in [Table 9-1](#) for a 48-Hz test, this image would result in a test failure due to excessive jitter.

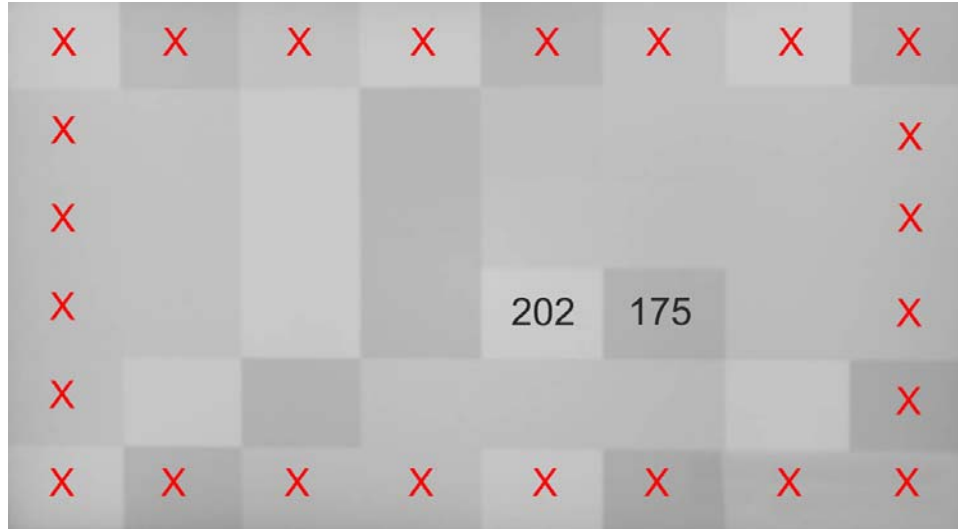


Figure 9-13: Red Xs Show Edge Zones to Be Excluded, and 8-bit SDR Code Values for Brightest and Darkest Patches

10 HDR Testing

10.1 Overview

This section describes the testing that is needed in HDR mode for HDR-capable displays.

For displays that support HDR, the VESA certification further ensures that the Adaptive-Sync operation works correctly in SDR and HDR modes. Due to signal bandwidth processing, it is possible that the display may place additional constraints on the supported range of frequencies. For example, an AdaptiveSync Display144 display may operate at 144 Hz in SDR mode, but in HDR mode the display may be limited, such as due to using 10-bit signaling to a lower frequency.

10.2 HDR Mode Performance Tests

To confirm that the Adaptive-Sync operation works correctly in HDR mode, change the OS mode to HDR, and then run the tests provided in [Section 3.11](#).

A Example 8-bit SDR Gamma 2.2 Luminance Values (Informative)

SDR Gamma 2.2 code values reference the following luminance:

$$Luminance = MaxLuminance \times \left(\frac{8\text{-bit Code Value}}{255} \right)^{2.2}$$

This luminance is relative to the SDR display's MaxLuminance setting, which can be set as follows:

- Within the operating system
- Within the OSD menu
- Within the operating system and within the OSD menu

[Table A-1](#) lists example 8-bit SDR Gamma 2.2 luminance values when **gray** level 127 is set to 40 cd/m².

Table A-1: Example 8-bit SDR Gamma 2.2 Luminance Values when Gray Level 127 Is Set to 40 cd/m² (Informative)

8-bit SDR Gamma 2.2 Code Value	Luminance (cd/m ²)
0	0
63	8.6
127	40
191	98
255	185