



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

Revision 1.1

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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 r1.1

Company	Name	Contribution
Advanced Micro Devices, Inc.	Chas Boyd	Test Tool Developer, Technical Content
	Syed A. Hussain	Technical and Editorial Content
Allion Labs, Inc.	Lexus Lee	Technical and Editorial Content
Apple, Inc.	Alan Kobayashi	Technical and Editorial Content
Avatar Tech Pubs	Trish McDermott	Technical Writer
Dell, Inc.	Stefan Peana	Technical and Editorial Content
	Venson Tseng	Technical and Editorial Content
HP, Inc.	Greg Staten	Technical and Editorial Content
	Alexander Williams	Technical and Editorial Content
Intel Corp.	Sagar Karalatti	Test Tool Developer, Technical Contribution
	Roland Wooster	Chair, Primary CTS Author
LG Display Co., Ltd.	Jongho Jeong	Technical and Editorial Content
	Jang Jin Yoo	Technical and Editorial Content
LG Electronics, Inc.	Won-Jong Choi	Technical and Editorial Content
	DK (Do-Kyun) Kim	Technical and Editorial Content
	Yoon-Jong Lee	Technical and Editorial Content
	Seung-Hyun Yoo	Technical and Editorial Content
MediaTek, Inc.	Tung-Sheng Lin	Technical and Editorial Content
NVIDIA Corp.	Jean-Marc Guiraudet	Technical and Editorial Content
Open Sky Communications	David Moreno	Marketing / Communications / Logo Development
Polytechnic Marketing	Joel Boardman	Marketing / Communications / Logo Development
Realtek Semiconductor Corp.	Jay Lin	Technical and Editorial Content
Samsung Electronics Co., Ltd.	Frank Seto	Technical and Editorial Content
	Dale Stoltzka	Technical and Editorial Content
VESA Compliance Program Manager	Jim Choate	Technical and Editorial Content

Revision History

Table 2: Revision History

Date	Revision	Description
May 19, 2023	1.1	<ul style="list-style-type: none"> Corrected typographical error of the sum of the total number of G2G tests from 63 to 64
May 16, 2023	1.1	<ul style="list-style-type: none"> Added changes made to r1.0 of this Specification through ratification of the following SCRs: <ul style="list-style-type: none"> <i>AdaptiveSync Display – Jitter Methodology Replacement</i> (lightly edited) <i>AdaptiveSync Display – Factory Default Mode</i> (lightly edited) Added updates applied by the following SCR: <ul style="list-style-type: none"> <i>AdaptiveSync Display – CTS 1.0 to 1.1 Spec Update, v4</i> (lightly edited, and also included its Comment 5114 and 5116 updates) Applied changes requested in Comments 5118 and 5119 Trademarks – Updated VESA trademarks Table 1-5 – Updated to list current release dates of referenced documents Appendix C – New, added contributor history
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.
- [Appendix B – Pseudo Code for Calculating the Combined Observed Gamma of a Display and Measurement System \(Informative\)](#)
This appendix provides an informative example of how to calculate the combined Observed Gamma of a display and measurement system.
- [Appendix C – Main Contributor History \(Previous Revisions\)](#)
This appendix lists the contributors to past releases of this Specification.

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 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-R 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>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</i> <i>CTA</i>
Barten, P. G. J., <i>Contrast Sensitivity of the Human Eye and its Effects on Image Quality</i> , SPIE PRESS		1999	<i>Barten</i>
Pytlarz, J. and R. Atkins, <i>Perceptual Color Volume, “Measuring the Distinguishable Colors of HDR and WCG Displays,”</i> Dolby Laboratories ^c	v7.2	2023	<i>Pytlarz and Atkins</i>
<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>IEC 61966-2-1, Multimedia systems and equipment – Colour measurement and management – Part 2-1: Colour management – Default RGB colour space - sRGB</i> ^d	1999	October 18, 1999	<i>IEC 61966-2-1</i>
<i>Information Display Measurements Standard</i> ^e	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</i> ^{d f}	Ed. 1	June 2012	<i>IEC 61747-30-1</i>
<i>ITU-R Recommendation BT.709, Parameter values for the HDTV standards for production and international programme exchange</i> ^g	Version 6	June 2015	<i>ITU-R BT.709</i>
<i>ITU-R Recommendation BT.2246-5, The present state of ultra-high definition television</i> ^g		July 2015	<i>ITU-R BT.2246-5</i>
<i>SMPTE ST 2084, High Dynamic Range Electro-Optical Transfer Function of Mastering Reference Displays</i> ^h	2014	August 16, 2014	<i>SMPTE ST 2084</i>
<i>Universal Serial Bus 4 (USB4™) Specification</i> ⁱ	Version 2.0 ^m	October 28, 2022	<i>USB4</i> <i>USB</i>
<i>Universal Serial Bus Type-C Cable and Connector Specification</i> ⁱ	Release 2.2 ^m	October 28, 2022	<i>USB-C</i> <i>USB Type-C</i>
<i>VESA Adaptive-Sync Link Layer Certification Test Specification (Adaptive-Sync Link CTS)</i> ⁿ	Revision 1.0	December 16, 2021	<i>Adaptive-Sync</i> <i>Link CTS</i>

Table 1-5: Reference Documents (Continued)

Document	Version/ Revision ^a	Publication Date	Referenced As
VESA Coordinated Video Timings (CVT) Standard ^d	Version 1.2 ^k Version 2.0 ^l	February 8, 2013 September 27, 2021	CVT v1.2 CVT v2.0 CVT Standard CVT
VESA DisplayID Standard ^d	Version 2.0 Version 2.1 ^m	September 11, 2017 November 18, 2021	DisplayID v2.0 DisplayID v2.1 DisplayID v2.x DisplayID Standard DisplayID
VESA DisplayPort Alt Mode on USB Type-C Standard (DisplayPort Alt Mode) ⁿ	Version 2.0 ^m	March 12, 2020	DisplayPort Alt Mode Standard DisplayPort Alt Mode
VESA DisplayPort (DP) Standard ⁿ	Version 2.1 ^m	October 10, 2022	DP Standard DisplayPort DP
VESA DisplayPort 2.x DisplayID EDID Link Layer Compliance Test Specification (DisplayID EDID Link CTS) ^j	DP 2.x r1.4	December 16, 2021	DisplayID EDID Link CTS
VESA DisplayPort 1.4a Link Layer Compliance Test Specification (Link CTS) ⁿ	DP 1.4a Revision 1.0	December 31, 2020	Link CTS
VESA DisplayPort 1.4a PHY Layer Compliance Test Specification (PHY CTS) ⁿ	DP 1.4a Revision 1.1	December 31, 2020	PHY CTS
VESA Embedded DisplayPort (eDP) Standard ⁿ	Version 1.5a ⁿ	February 27, 2023	eDP Standard eDP
VESA Enhanced Extended Display Identification Data (E-EDID) Standard (which defines EDID r1.4) ^j ^o	Release A.2	September 25, 2006	E-EDID Standard EDID
VESA High-performance Monitor and Display Compliance Test Specification (DisplayHDR CTS) ⁿ	Revision 1.1	August 29, 2019	DisplayHDR CTS DisplayHDR

- 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 professional.dolby.com/siteassets/pdfs/measuringperceptualcolorvolume_v07.253.pdf.
- d. See global.ihs.com.
- e. Published by the Society for Information Display's International Committee on Display Metrology (SID ICDM). See sid.org/Publications/ICDM.aspx.
- f. Supersedes EIAJ ED-2522, which is no longer available.
- g. Published by the International Telecommunication Union (ITU). See itu.int.
- h. Published by the Society of Motion Picture and Television Engineers (SMPTE). See smpte.org/digital-library.

- i. Published by USB Implementers Forum, Inc. See usb.org/developers/docs.*
- j. See vesa.org/vesa-standards/.*
- k. For standard blanking and reduced blanking timing v1 (RB Timing v1), see [CVT v1.2](#).*
- l. For RB Timing v2 and v3, see [CVT v2.0](#).*
- m. This version of the referenced Standard is correct at the time of publication of this Specification.*
- n. See vesa.org/join-vesamemberships/member-downloads/.*
- 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	≤ Delta-PQ Tolerance of each section (see Table 2-2)	≤ Delta-PQ Tolerance of each section (see Table 2-2)
Limit in average of the 64 G2G tests from a 9 × 9 matrix with factory-default overdrive	≤ 5-ms average over the 64 tests	N/A
Flicker _{MAX} on low-variability refresh rate tests ^{c e}	-50 dB	-50 dB
Flicker _{MAX} with high-variability refresh rate tests ^d	-50 dB ^e	Test is not performed as a logo performance tier mandate
If SuccessiveFrameDuration IncreaseTolerance is present, minimum duration for variable ^e	8.5 ms	1 ms
If SuccessiveFrameDuration DecreaseTolerance is present, minimum duration for variable ^e	9.75 ms	1 ms
Video frame-to-frame jitter duration for 23.976- to 60-Hz video frame rates ^f	±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. Low-variability refresh rate tests include Video, Zigzag sweep, and Sinewave Sweep tests.
- d. High-variability refresh rate tests typical of gaming include SquareWave Sweep and Random tests.
- e. 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.
- f. Tested only within the legacy EDID range.

Table 2-2 illustrates the maximum 10-bit Delta-PQ overshoot and undershoot values that are permitted for the VESA CERTIFIED AdaptiveSync and MediaSync Display logo programs. The axes of the table with the **From** and **To** values are the starting and ending test pattern **gray** levels, respectively. Delta-PQ tolerance values are **not** provided for tests that start and end with the same code value, and for tests that finish in either code value 0 or 31.

Table 2-2: Delta-PQ Tolerance Table

To/End	0	31	63	95	127	159	191	223	255
From/Start	0		18	18	18	18	18	18	15
	31		15	15	18	18	18	18	10
	63			13	15	15	15	18	10
	95			20		10	15	15	10
	127			20	20		10	10	10
	159			20	20	15		8	10
	191			30	20	20	13		8
	223			30	20	20	20	12	
	255			30	30	20	20	10	10

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 2-3 summarizes the Adaptive-Sync Display specifications that apply to all logo performance tiers.

Table 2-3: Mandates for All Logo Performance Tiers

Test	Mandate	Units
Video Frame Drop Tolerance between minimum and maximum refresh rates reported to the OS	• 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.)	• 23.976 • 24 • 25 • 29.97 • 30	• 47.952 • 48 • 50 • 59.94 • 60

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 2-3](#) 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), ISO settings (100 to 1,600) in 1/3 EV steps, control the **White Balance**, and a lens that enables manual focusing. Additionally a tripod, or rigid camera mounting capability will be required, a remote or timed trigger capability (e.g., self-timer) to prevent camera shake when firing the shutter. It is further advised that using a camera with an electronic shutter, rather than mechanical shutter, will prevent camera shake when the shutter opens.

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.
Luminance, G2G, and Flicker Probe	Admesy Asteria	High speed luminance probe.
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.
Photographic Camera	Nikon Z6, Z7, Z9 cameras	The Nikon Z9 has a fully electronic shutter that eliminates any potential for camera shake caused by the camera. The Nikon Z6 and Z7 have an “EFCS” mode option that enables an electronic shutter option. Other camera brands also offer these features.

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.

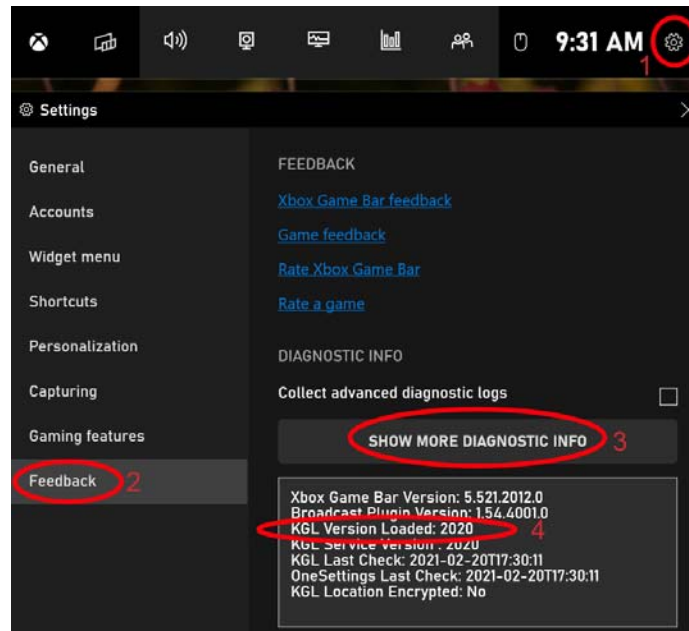


Figure 3-1: Microsoft Xbox Game Bar Application, Opened to Settings Options

- 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.*

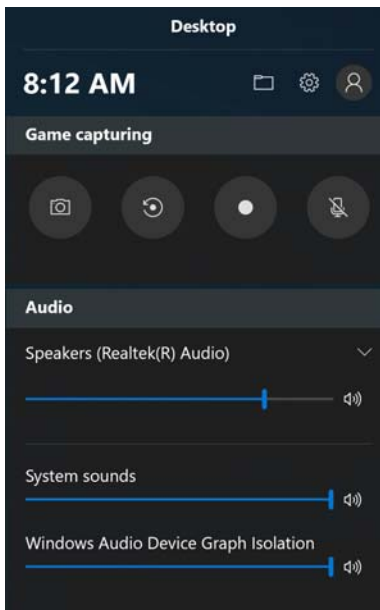


Figure 3-2: Default Microsoft Xbox Game Bar Application

- 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.

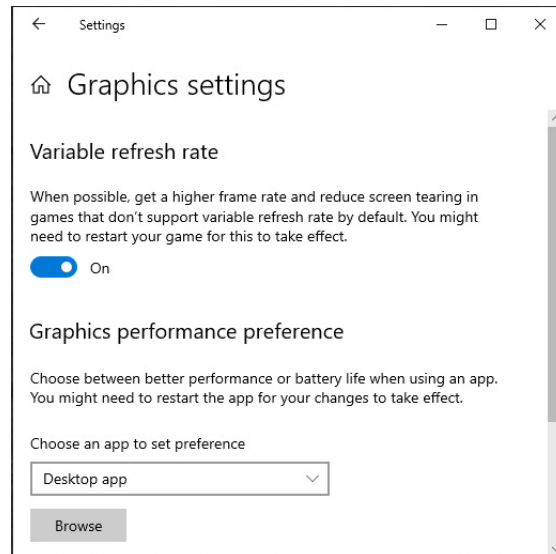


Figure 3-3: Graphics settings Dialog Box with Variable refresh rate Turned On

- 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.

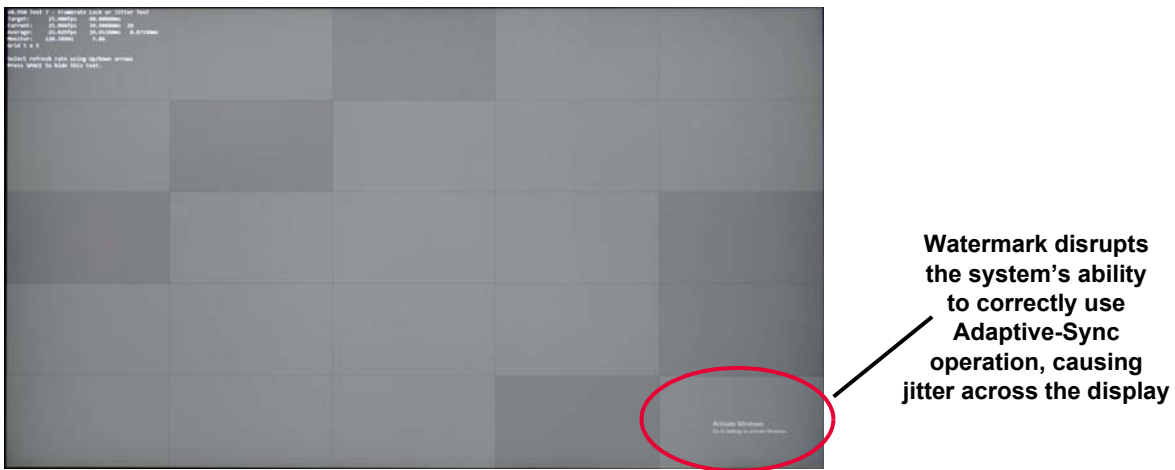


Figure 3-4: Adaptive-Sync Operation Failure, with Jitter Due to Pop-up Window/Watermark



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.

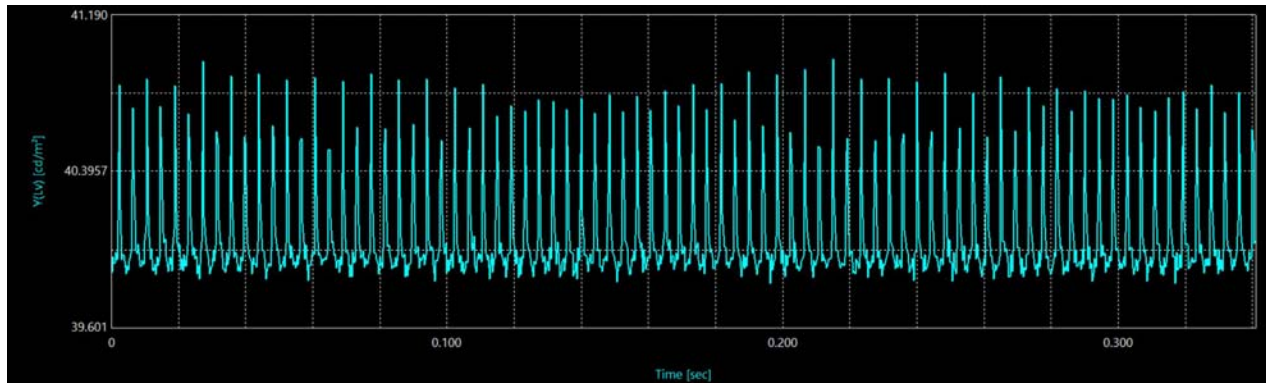


Figure 3-6: Example Failure Condition – Wave-to-wave Timing Is Static, Adaptive-Sync Operation Is Not Working Correctly (Informative)

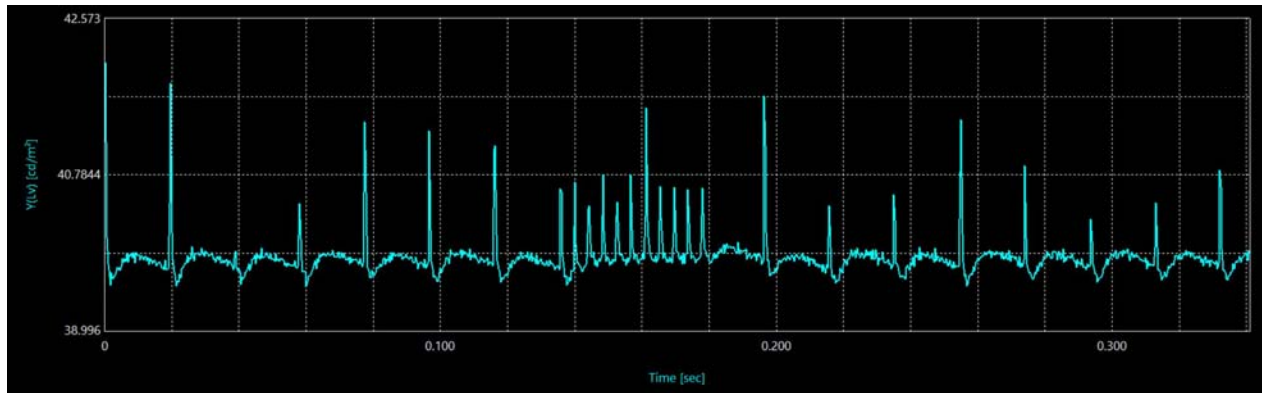


Figure 3-7: Example SquareWave Sweep Test Waveform (Informative)

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.

```
v0.946 Test 7 - Framerate Lock or Jitter Test
Target:    24.000fps    41.66667ms
Current:   24.000fps    41.00000ms  2X
Average:   24.000fps    40.00000ms  0.00000ms
Monitor:   48.000Hz    2.0X
Grid 4 x 6

Select refresh rate using Up/Down arrows
Press SPACE to hide this text.
```

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

```
v0.946 Test 7 - Framerate Lock or Jitter Test
Target:    24.000fps    41.66667ms
Current:   20.000fps    41.00000ms  2X
Average:   23.988fps    41.60000ms  0.13000ms
Monitor:   240.000Hz    10.0X
Grid 4 x 6

Select refresh rate using Up/Down arrows
Press SPACE to hide this text.
```

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)

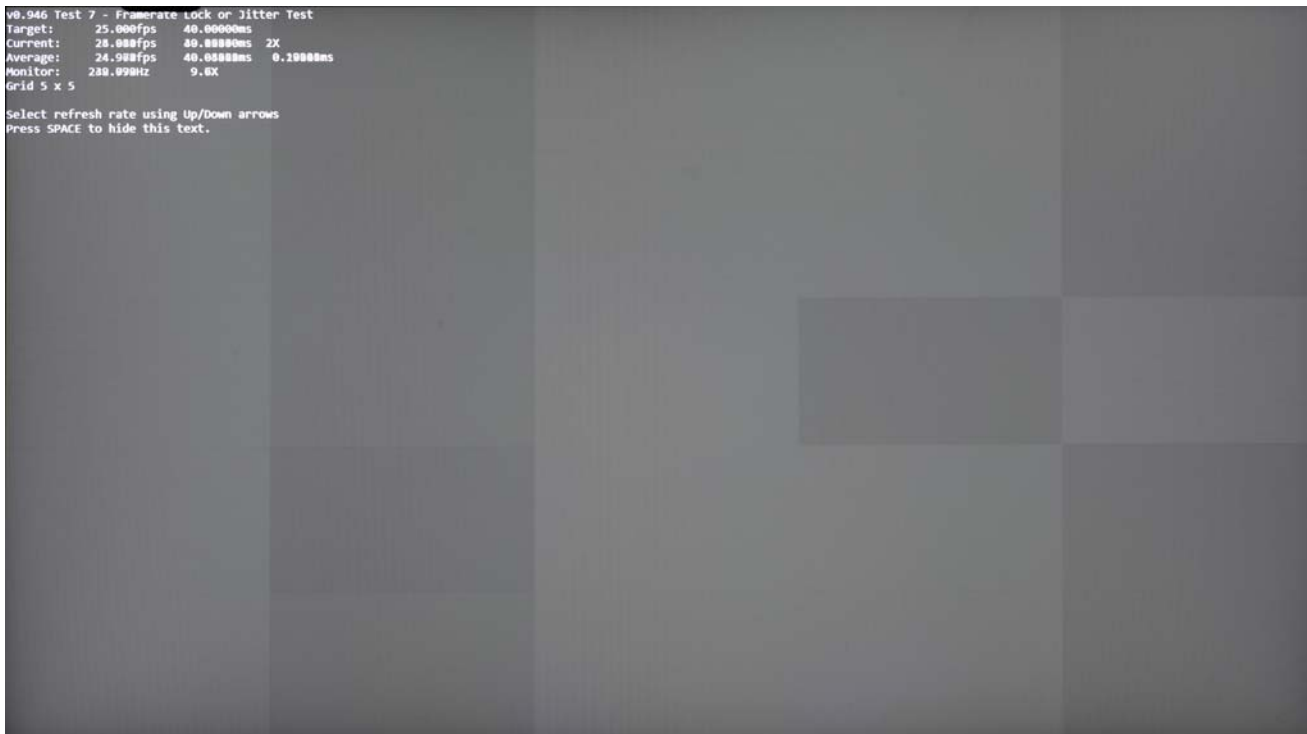


Figure 3-11: Example 25-Hz Test Results with Jitter and Adaptive-Sync Operation Disabled (Informative)

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, except where the regional power restriction noted in [Section 4.2.1](#) applies. 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 the display’s native resolution with factory-default settings.

4.2.1 Exception for Regional Power Restriction

In the case that regional power efficiency requirements necessitate the OEM to configure the factory default to a lower-than-maximum resolution, or lower-than-maximum refresh rate, or with Adaptive-Sync turned OFF, the OEM can instruct the test house to which display mode the display should be changed for testing of AdaptiveSync Display compliance and certification. This OEM recommended mode would then be used rather than the factory-default mode. It should be noted that this mode must enable testing of the display at maximum native resolution, and all requirements listed in [Section 4.2.2](#) remain in place.

4.2.2 OSD Labeling Requirements

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, the following requirements apply:

- Monitor’s OSD shall indicate which of its modes support Adaptive-Sync operation, –or–
- Monitor’s OSD shall indicate which modes are **not** Adaptive-Sync-capable

Typically, indication is **optional** if all OSD modes support Adaptive-Sync operation. For clarity, the requirement stated in the first paragraph remains in force, only the monitor’s default mode is subject to CTS verification. The only exception to this is when regional power requirements drive the need for the exception listed in [Section 4.2.1](#), in which case the Specification would be tested in only the one mode recommended by the OEM.

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.

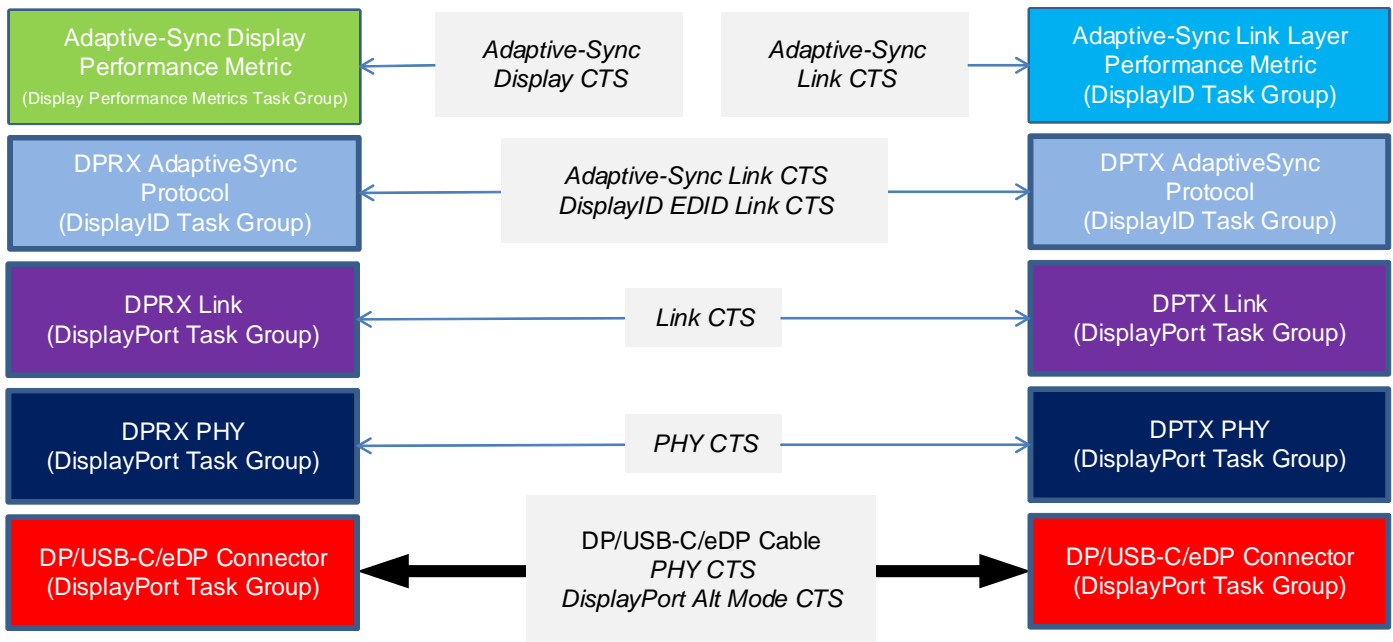


Figure 5-1: VESA CERTIFIED AdaptiveSync and MediaSync Display Logo Program CTSs

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 code value equal to 127 (i.e., 127, 127, 127). The display luminance shall be modulated to 40 cd/m^2 in SDR mode before testing either by adjusting the OSD or the Windows Display luminance.

To achieve an output of approximately 40 cd/m^2 , the manual brightness controls shall be used to adjust the test image's actual output brightness, as follows (variance from 40 cd/m^2 by $\pm 5\%$ (i.e., from 38 to 42 cd/m^2) 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/m^2 as the available adjustments allow

For displays that are unable to adjust the flicker test luminance test patch to $40 \text{ cd/m}^2 \pm 5\%$, results from the closest-achievable luminance, both above 40 cd/m^2 and below 40 cd/m^2 , 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.

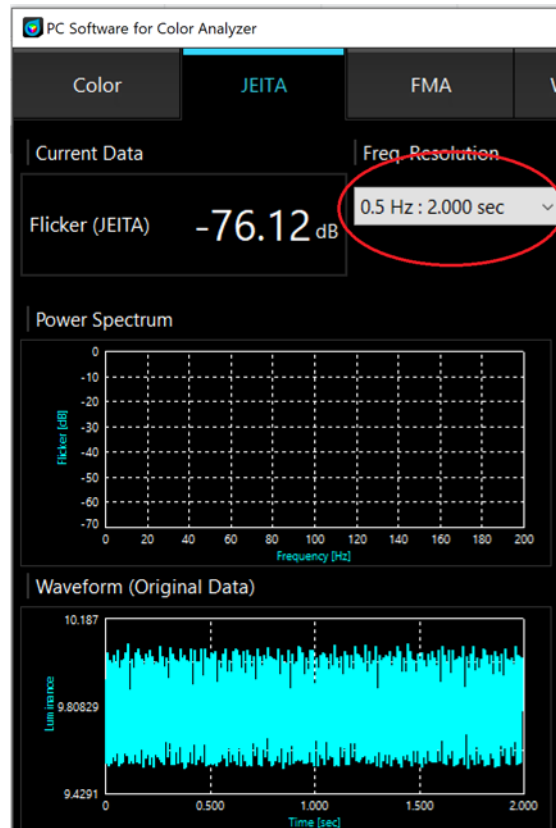


Figure 6-1: Example JEITA Flicker Sampling at 0.5-Hz Interval Setting^a (Informative)

^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 9×9 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. The 9×9 test matrix spaces code values at approximately $1/8^{\text{th}}$ steps, from 0 to 255 (See Table 7-1 and Table 7-2). Testing values ending in 0 and 31^{a} are excluded.

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.

a. Tests that end at code value 31 are excluded because at the 1.79 cd/m^2 luminance level, testing tools are typically **not** both sufficiently fast and sufficiently accurate to obtain reliable results.

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**

9 × 9 Matrix Test Patch Values	SDR 10% Test Patch	SDR 90% Gray Surround
Test 1 (Black)	0	127
Test 2 (Very Dark Gray)	31	127
Test 3 (Dark Gray)	63	127
Test 4 (Dark-Mid Gray)	91	127
Test 5 (Mid Gray)	127	127
Test 6 (Light Mid Gray)	159	127
Test 7 (Light Gray)	191	127
Test 8 (Bright Gray)	223	127
Test 9 (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**

9 × 9 Matrix Test Patch Values	SDR 10% Test Patch	SDR 90% White Surround
Test 1 (Black)	0	255
Test 2 (Very Dark Gray)	31	255
Test 3 (Dark Gray)	63	255
Test 4 (Dark-Mid Gray)	91	255
Test 5 (Mid Gray)	127	255
Test 6 (Light Mid Gray)	159	255
Test 7 (Light Gray)	191	255
Test 8 (Bright Gray)	223	255
Test 9 (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 9×9 matrix is used for this test. For each test case, the time is measured for how long it takes for each of the initial starting luminance levels to transition to the other seven luminance levels. The time measured for each test is the duration from when the transition is 10 to 90% complete.

The VESA G2G average is thus the average of the 64 G2G timing results from each 10 to 90% transition.

7.5 Overshoot Measurement Methodology

Fifty-six of the 64 G2G tests conclude in a final transition to a **gray** level other than black or code value 31. Overshoot or undershoot that occurs on these 56 transitions is measured. If overdrive is being applied, up to 35 of the transitions may overshoot, and up to 21 of the transitions may undershoot. In each of the 56 transitions, the overshoot and undershoot limits are compared to a mandate defined in 10-bit PQ values, in which the change of the measured overdrive compared to the target level is called the Delta-PQ (see Table 2-2). The PQ representation is suggested in *ITU-R BT.2246-5* to best represent the *Barten* model, which is a good representation of human vision sensitivity as compared to other contemporary methods such as a gamma-based value or linear percentage value of overdrive. Although *ITU-R BT.2246-5* uses static viewing conditions for bit-depth analysis, VESA extends the concept for overdrive modeling.

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 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.

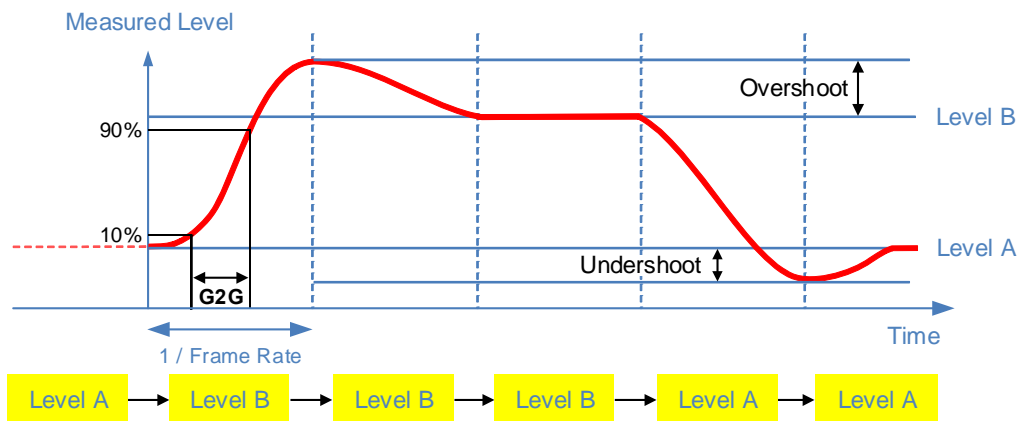


Figure 7-1: Overshoot and Undershoot Luminance Levels Due to Application of Overdrive

$$\begin{aligned}
 level_{90\%} &= level_B - 0.1 \times (level_B - level_A) \\
 level_{10\%} &= level_A + 0.1 \times (level_B - level_A) \\
 G2G_{rise} &= time(level_{90\%}) - time(level_{10\%}) \\
 G2G_{fall} &= time(level_{10\%}) - time(level_{90\%})
 \end{aligned}$$

Figure 7-2: G2G Overshoot and Undershoot Calculations

L_O is the maximum overshoot luminance.

L_B is the luminance of Level B shown in [Figure 7-1](#).

L_A is the luminance of Level A shown in [Figure 7-1](#).

L_U is the minimum undershoot luminance.

PQ is calculated using a formula that uses a one-line **Matlab** function, as shown in the following pseudo code (see [Pytlarz and Atkins](#)):

```

1  % Code where Lin is the luminance value of the levels shown above in cd/m2 and
2  % invEOTF is the inverse electro-optical transfer function resulting in a
3  % decimal between 0 and 1. The invEOTF is multiplied by the full number of
4  % coding bits, this CTS uses 10-bit encoding, therefore, the maximum number of
5  % bits is 1023. Evaluate PQ at relevant levels without rounding, carry decimal
6  % fractions to the same precision as the luminance value, usually three to
7  % four significant bits.
8
9  invEOTF = @(Lin) (((3424/4096)+(2413/128)*(max(0,Lin)/10000).
    ^((2610/16384)) / (1+(2392/128)*(max(0,Lin)/10000).^(2610/16384))).^(2523/32);
10
11 PQ = 1023 * invEOTF(Lin);

```

Figure 7-3: PQ Calculation Method for Calibrated Probes

Calculating the overshoot and undershoot is simple if the probe being using for measuring the overshoot and undershoot is a calibrated light measurement device that reports luminance. The logic in [Figure 7-3](#) can be used. Do **not** round, or truncate, the stable plateau's PQ value and overshoot or undershoot's PQ value before subtracting one from the other.

If, however, the probe being using for overshoot and undershoot measurement is **not** a calibrated luminance probe, or is **not** linear, or reports anything other than luminance (e.g., voltage), the gamma behavior of the combined system, including both the display and probe combined, must be calculated. The most-accurate method to achieve this is to identify the nine stable voltage levels of the test patterns, using these values, remove the voltage level of the 0 value from them all, and then use an R^2 calculation to determine the best-fit power function. This defines the display and probe system gamma. Next, using this calculated system gamma, and the requirement that code value 127 was calibrated to 40 cd/m^2 , the PQ values of the stable G2G levels and the PQ values of the overshoot and undershoot peaks and troughs of each G2G transition can be calculated and the difference is thus the Delta-PQ value with which to compare the requirements listed in [Table 2-2](#).

The Delta-PQ value for a particular overshoot can be calculated using the following steps documented in [Figure 7-4](#).

- 1 *Gamma “G” = Best-fit power function of the 9 voltages measured for the stable G2G levels, adjusted for the zero-level offset. An example is provided in [Appendix B](#).*
- 2 *Knowing CodeValue 127 was adjusted to 40 cd/m2 we can calculate MaxWhite.*
 - a *MaxWhite (i.e., CodeValue 255) = 40 * (255/127)^G*
- 3 *Also, each G2G level’s luminance can be calculated using their code value and MaxWhite*
 - a *For example the luminance of CodeValue 95 = MaxWhite * (95/255)^G.*
 - b *All the G2G levels can be calculated in this manner.*
- 4 *Multiplying the Overshoot or Undershoot calculated as a percentage by the luminance difference of the G2G’s To and From levels gives us the luminance over or undershoot from the target To Gray level.*
- 5 *Comparing the PQ values via a calculation, for the Target To Gray level luminance calculated in step 3 and the overshoot luminance value calculated in step 4 will render the Delta-PQ value.*

Figure 7-4: Delta-PQ Calculation Method for Voltage Probes

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 any overshoot or undershoot that exceeds the specification for the logo performance tier being tested (see [Table 2-2](#)).

This test verifies that none of the 56 test scenarios from the G2G 9×9 matrix that do not conclude in **black**, or code value 31, exhibit more than the maximum overshoot or undershoot limit specified in [Table 2-2](#) 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 64 scenarios are then tested, and the results of the 64 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 64 G2G transitions twice over a 36-second testing period. This loop should be repeated at least 10 times so that each of the 64 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 64 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.
- To successfully average the test results, testing must record at least 20 transitions for each G2G transition.
- G2G calculation is thus the average of 1,280 results (i.e., 64 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. Each averaged set of at least 20 samples of each G2G transition, calculated in Delta-PQ values, should be compared with [Table 2-2](#).

7.6 Display Spike-Noise Suppression

Some displays inherently exhibit brief fluctuations in luminance that are so brief as to not be human visible, and thus do **not** register within the JEITA calculations of flicker. Examples included the OLED frame synchronous reset that briefly occurs once per frame, and PWM backlight display switching in local dimming of LCDs, normally at a frequency of 1 kHz or higher. This behavior should be excluded from the calculations of undershoot or overshoot, which when sampling at 10 kHz or higher makes these spikes visible to the test tools, but not to users, and thus the analysis needs to exclude this as noise and not include this as part of the overshoot or undershoot calculation.

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.

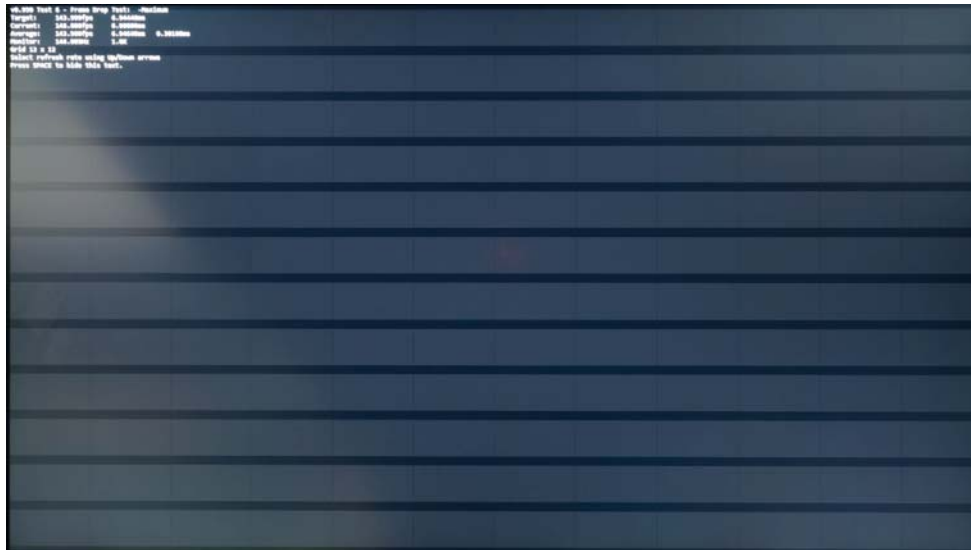


Figure 8-2: Maximum Video Frame Rate Test at 144 Hz

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.

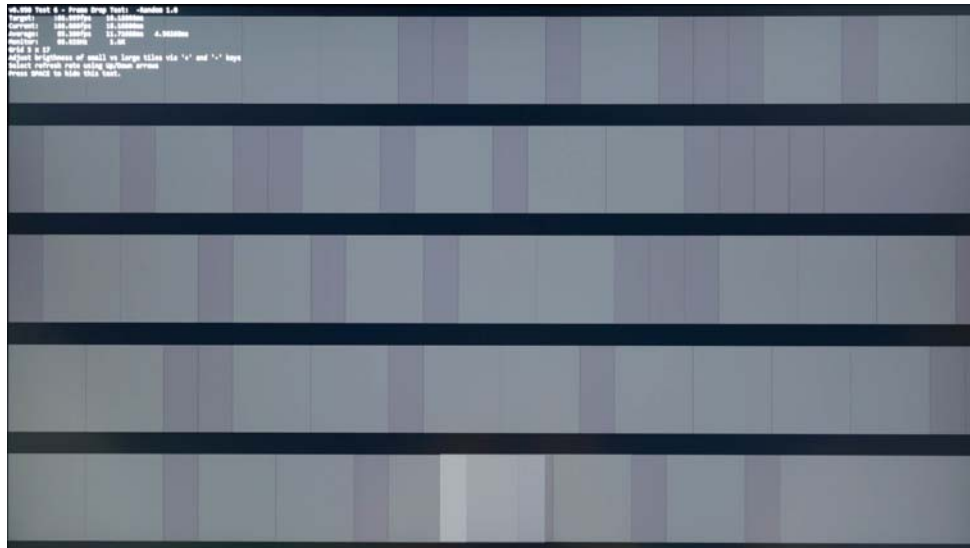


Figure 8-3: Random Video Frame Rate Test Showing Start/End Overlap

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.

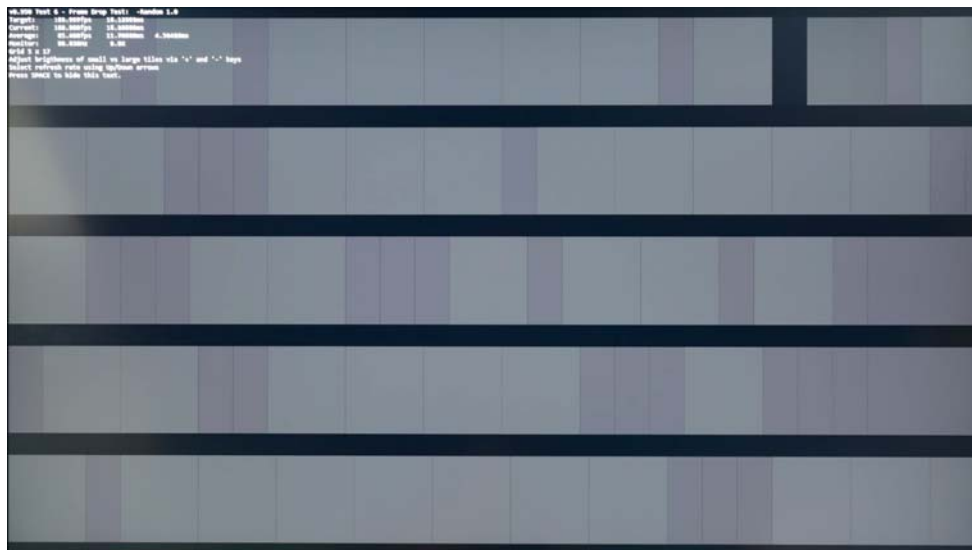


Figure 8-4: Random Video Frame Rate Test Showing Start/End Gap

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 some extra background within the camera's field of view. Most camera lenses exhibit some level of vignette (darkening of the corners). Changing of the camera's position, changing the focal length of the lens, and/or zooming of the lens enables the camera to capture a border of approximately 2 to 4 inches around the screen and avoid the majority of the corner darkening caused by lens vignette effects. Further, if using a zoom lens, it is recommended to use the mid to tele end of the zoom range.

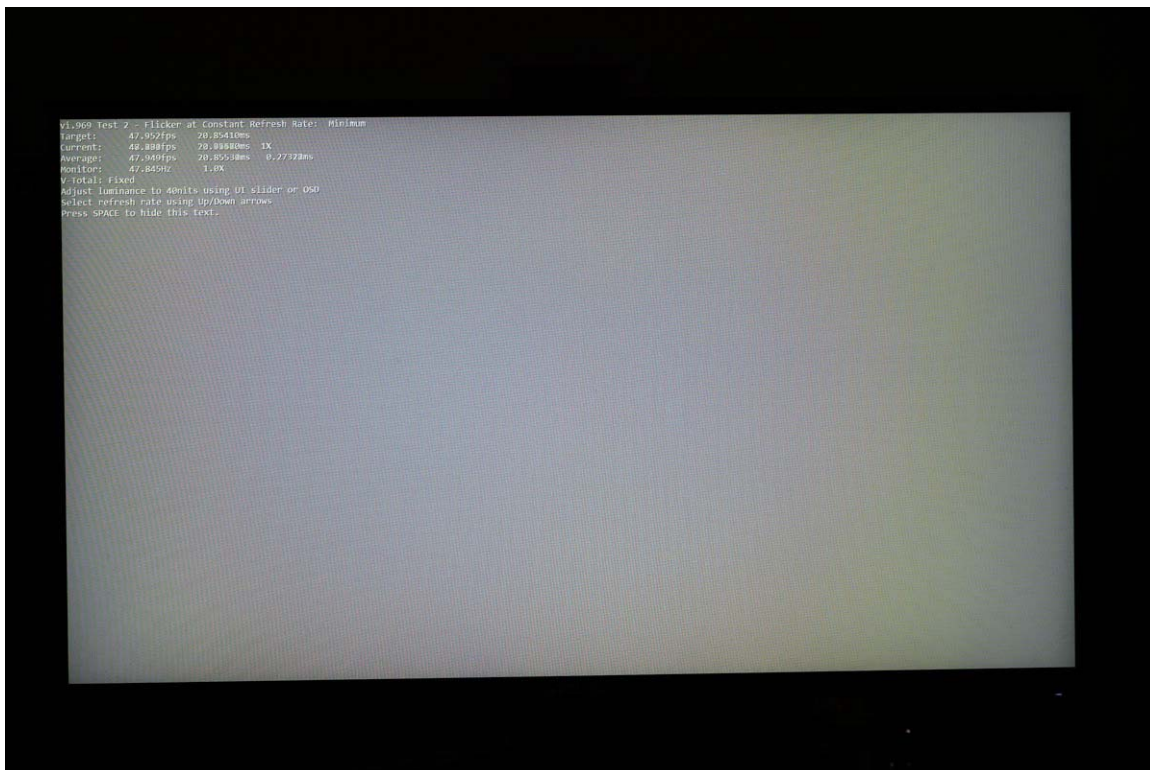


Figure 9-1: Image Showing Sufficient Background around the Screen to Avoid Lens Vignette Effects

The exposure timings on the camera are aiming to achieve a **middle gray** flat image with the 1-second exposure. By targeting **middle 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. **Middle gray** in this context is defined as achieving an output within the range of code values 100 to 210 (8 bit), in the captured photographic image. These values represent the Gamma 2.2 luminance code values of the photograph, not the test image on the DUT.

It is required that the 1-second photographed images of the jitter test sequences yield a **gray** level code value, in the photographs, of between code value 100 and 210 (8 bit). To achieve this, the following recommended set of camera exposures are provided:

It is mandatory to use a 1-second exposure for each of the jitter test image captures. It is also recommended to use F5.6 aperture, and an ISO speed that is 4x faster than the frame rate under test. With a camera capable of setting the ISO speed in 1/3 EV stops, the following recommendation is made:

Table 9-1: ISO Recommendations for Jitter Test Frequencies to Achieve Middle-Gray Photographs

Jitter Test Frequencies (Hz)	ISO Speed
23.976, 24, 25	100
29.97, 30	125
47.952, 48, 50	200
59.94, 60	250

By adjusting the ISO, each of the images of the different frequency tests should achieve similar **gray-level** results.

It is important to manually set the **White Balance** of the camera before capturing the images. On Nikon cameras, the “Cloudy” setting matches D65 white, alternatively manually setting 6,500 Kelvin white point can be used.

Elimination of Moiré patterns is extremely important. This can best be achieved by ensuring that the camera is centered to the middle of the screen, and perpendicular to the screen, which is itself perpendicular, and then by manually defocusing the lens.

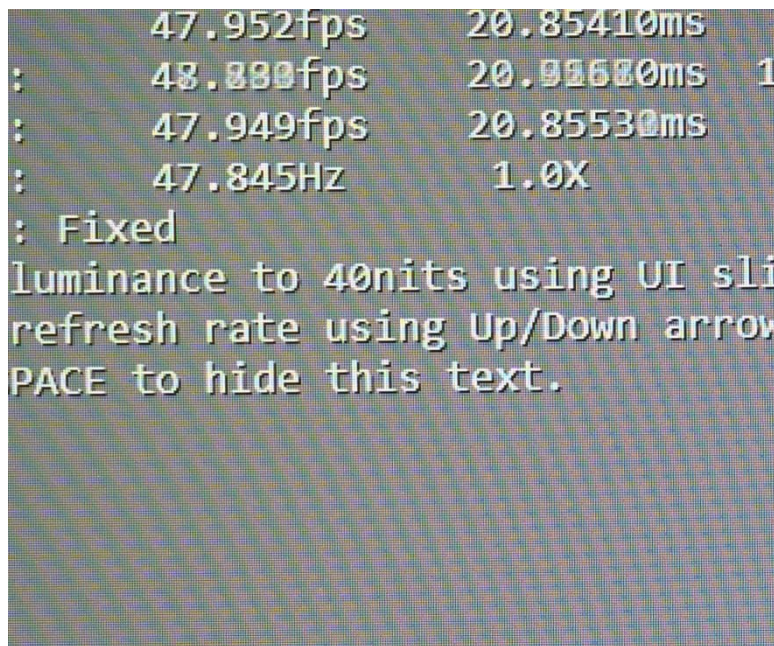


Figure 9-2: Zoomed Segment of Figure 9-1 Illustrating the Moiré Patterns Visible in the Image

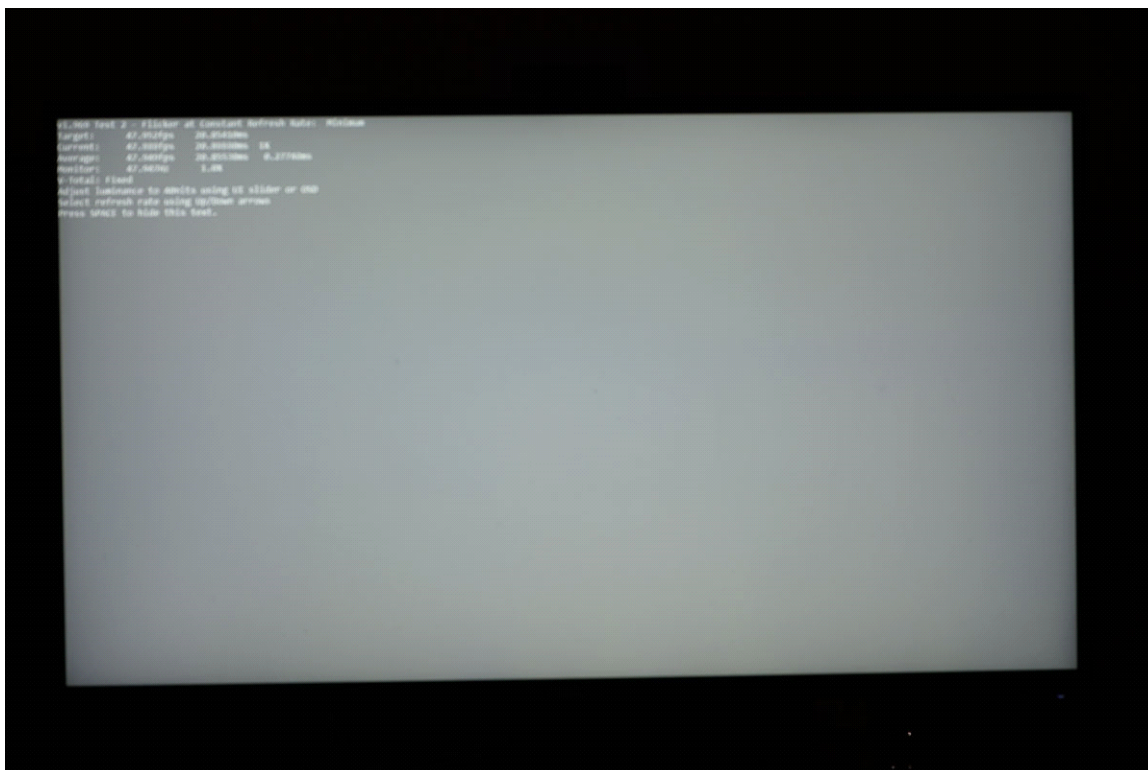


Figure 9-3: Manually Defocusing the Lens to the Point that the Text Is Almost Unreadable Eliminates the Moiré Patterns

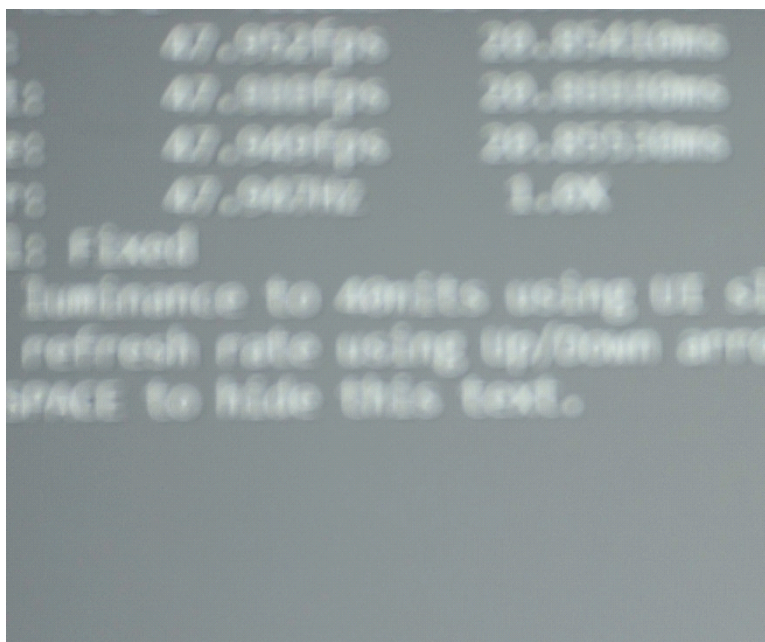


Figure 9-4: Zoomed Segment of Figure 9-2 Illustrating that the Moiré Patterns Are No Longer Visible

Achieving a shutter duration of exactly 1 second is important. If the camera's interpretation of 1-second does **not** match the DUT, images such as the following two will occur. In [Figure 9-5](#), the camera' does **not** record sufficiently long to capture the full screen being painted by the jitter test. In [Figure 9-6](#), the jitter test wraps around and double paints some segments. The examples presented in [Figures 9-5](#) and [9-6](#) are exaggerated because they are 0.8- and 1.3-second exposures. Normal timing errors will exhibit far-smaller dark or light areas, typically just one zone.

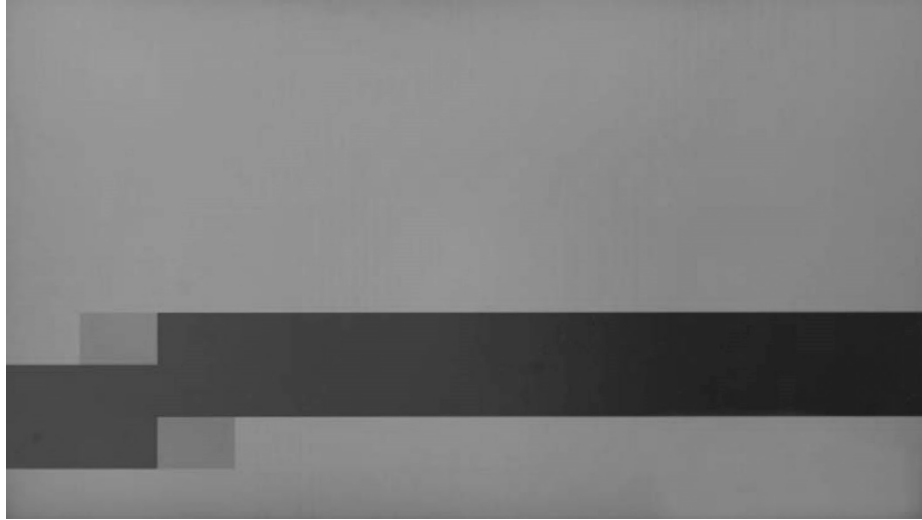


Figure 9-5: Example of 0.8-second Photograph Capture (Informative)



Figure 9-6: Example of 1.3-second Photograph Capture (Informative)

Slight differences in timing are likely unavoidable. These slight timing differences will render only one jitter box that is slightly brighter or darker, which is fine and will be suitably handled later in this methodology. [Figure 9-7](#) shows a slight difference in luminance in one box, near the center of the screen toward the upper right corner from center that is slightly darker.



Figure 9-7: Slight Timing Differences Resulting in One Box of a Different Luminance

Use of a Tripod to avoid camera shake is important. The best option is to use a camera that has a fully electronic shutter. Many cameras, even some of those with mechanical shutters, provide a mode for an electronic shutter option. Nikon Z6 and Z7 cameras call this mode EFCS (Electronic First Curtain Shutter), which can prevent camera shake due to the mechanical shutter.



**Figure 9-8: Example Image Capture with Camera Shake
(Intentional Physical Shaking of the Camera)**



Figure 9-9: Electronic Shutter, with No Camera Shake (Same Display as Figure 9-8)

When using cameras that have image stabilization either in the camera body (IBIS) or lens-based stabilization, image stabilization should be disabled because the moving **white** box of the jitter test may fool the stabilization into following the jitter box, and may artificially create unintentional camera shake.

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, with the 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

This Specification permits only a ± 0.5 -ms jitter for each box being painted to the screen in the jitter test, this is thus a 1-ms range from min to max. In the most difficult test, at 23.976 fps, where the expected frame duration is 41.67 ms, a 1-ms delta is only a 2.4% difference. The 60 fps test is relatively speaking much easier where a 1-ms delta allows for a 6% difference. However, the testing methodology needs to accommodate several challenges:

- Camera-based capture can easily suffer 50% luminance vignette in the corners due to the lens optics.
- LCD displays are sometimes as much as 25% darker in the corners than the center.
- Moiré patterns can easily create a significant luminance difference with repeated patterns across the screen.
- Mura on the display panel can easily be far larger than these permitted ranges.
- Finally, even our test image, which comprises of a box moving across the screen, does not actually paint every pixel on the screen, because the box size is calculated by dividing the width of the screen by 5, 6, or 10, and obviously almost no screen resolution will be perfectly divisible by all of these combinations. When we do not have a perfect division, the image will yield a single pixel that is black between the placement of one jitter box and the adjacent one creating a 100% luminance difference at the pixel level.

Furthermore, the permitted 2.4% delta or even the 6% delta is represented by a small difference in the Gamma 2.2 code value for **mid-gray** code values. [Table 9-2](#) illustrates the code value delta that is beyond our limits, and thus [Table 9-2](#) indicates the failure condition.

Table 9-2: Failure Condition Code Value Deltas for Average Gray Level Starting Level

Gray Level	Frames Per Second Jitter Testing					
	24	25	30	48	50	60
100	2	2	2	3	3	3
105	2	2	2	3	3	3
110	2	2	2	3	3	3
115	2	2	2	3	3	4
120	2	2	2	3	3	4
125	2	2	2	3	3	4
130	2	2	2	3	3	4
135	2	2	2	3	4	4
140	2	2	2	4	4	4
145	2	2	2	4	4	4
150	2	2	3	4	4	5
155	2	2	3	4	4	5
160	2	2	3	4	4	5
165	2	2	3	4	4	5
170	2	2	3	4	4	5
175	2	2	3	4	4	5
180	2	3	3	4	5	5
185	3	3	3	4	5	5
190	3	3	3	5	5	6
195	3	3	3	5	5	6
200	3	3	3	5	5	6
205	3	3	3	5	5	6
210	3	3	3	5	5	6

Using [Table 9-2](#), we can see that for a photograph whose **average-gray** level in the center of the screen is 150, would imply that a code value of 2 away from the average of 150, e.g. 148 or lower, and 152 or higher would be a failure condition when testing at 24 fps. When testing at 60 fps, a code value of 5 or more different from the average would indicate failure. This level of accuracy would be impossible to measure without eliminating all the optical issues listed above.

The following methodology attempts to eliminate all of the false negatives, and enables processing the image data in a way that exhibits only the genuine jitter, which can then easily be analyzed.

- 1 For each of the 10 jitter tests, take two pictures of each test, we will then identify the difference between the two images and this will reveal the jitter, as any other optical effect will be present in both images and thus not cause any difference between the images. Capture the two images, and then load them into a photo editing tool. The screen shots use **Adobe® Photoshop®** as an example.
- 2 After opening an images in **Photoshop**, configure the size of the **Eyedropper** tool (shortcut key **I**) by adjusting the tool sampling already, from the **Sample Size** drop-down list, change this to “11 by 11 Average”.

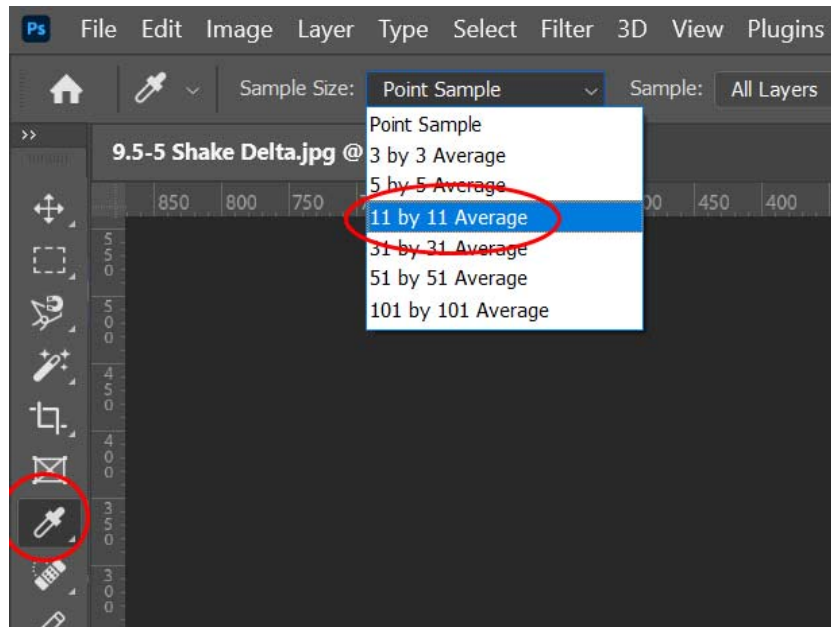


Figure 9-10: Selecting the Eyedropper Tool Selection Size to 11 × 11 Average

- 3 Desaturate both photographs (**CTRL-U**, and reduce Saturation to 0).

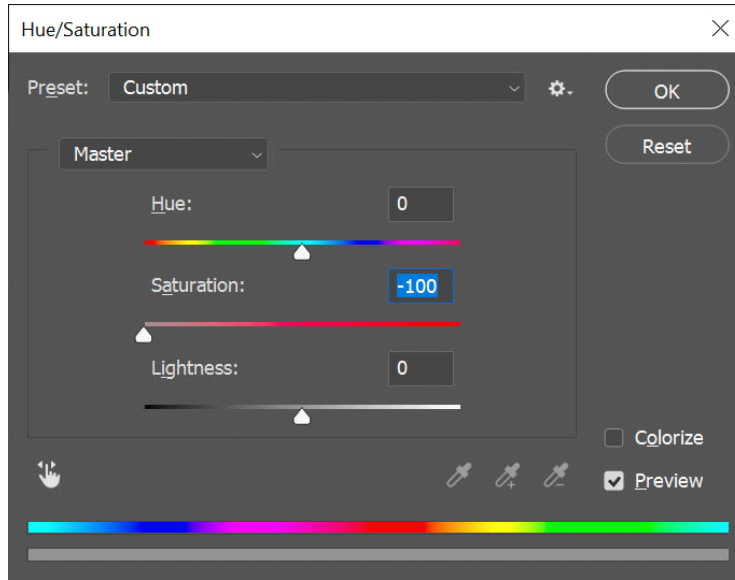


Figure 9-11: Desaturation Tool in Photoshop

- 4 Use the **Info Tool (F8)** to check the R, G, B values for the center of the image of the screen, you will need this number to look up the failure conditions for this particular test in [Table 9-2](#).

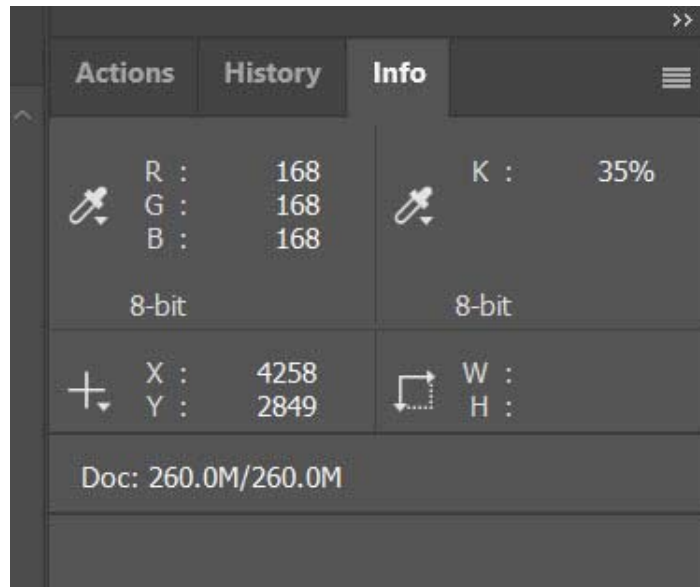


Figure 9-12: Info Tool Window Showing R, G, B Code Value of 168

- 5 Select either image from the pair, and then duplicate that image as a layer into the other image. First select one of the images, and then **Layer > Duplicate Layer**, and then add it into the other image by selecting the **Destination Document** as the other image.

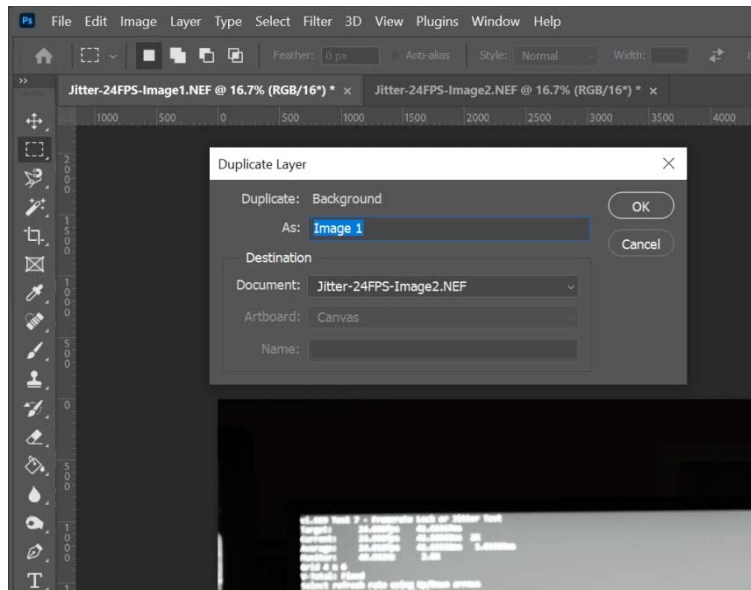


Figure 9-13: Duplicate Layer

- 6 Select the second image file (the one with both images as layers), view the layers panel (**F7**) and right-click the top layer (which was labeled Image 1 in the previous step). Choose Blending Options from the popup menu. Now choose “**Difference**” in the **Blend Mode**.

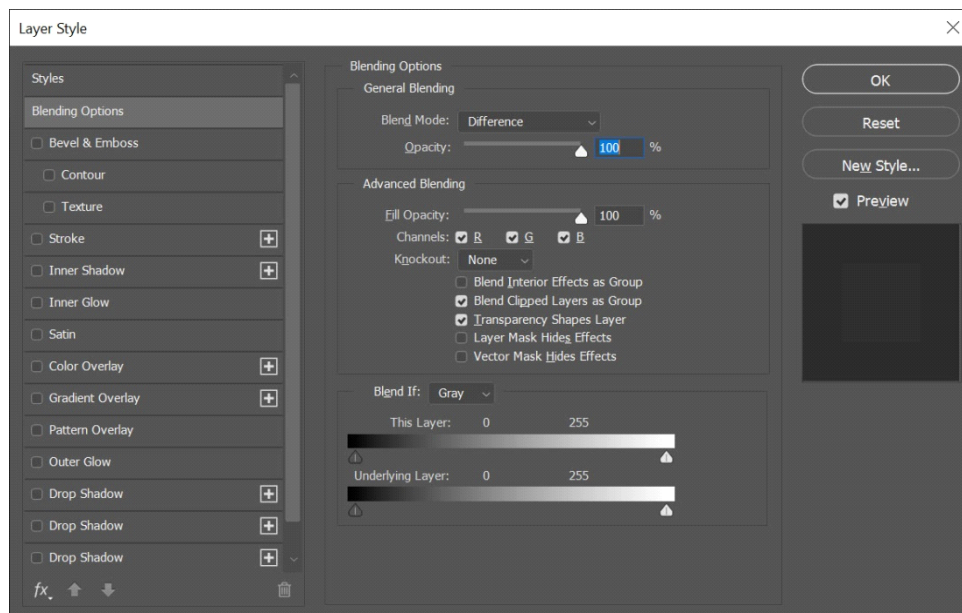


Figure 9-14: Blend Mode – Difference

- 7 If the images are perfectly identical, the result will be a totally **black** image because it shows only the difference between the two images. Using the **Info Window (F8)**, you can move the pointer throughout the image and should see that the difference is at-most the same code value for all pixels. If you see any form of image, this would be because of jitter differences between the first and second image.
- 8 As a test example, taking two images suffering from camera shake, as shown in [Figure 9-8](#) and its similar pair, and finding the difference between these two images renders a difference illustrated in [Figure 9-15](#). Delta images that exhibit this type of vertical or horizontal edge boundaries, caused by vibration in the photographic result due to either the display or camera shaking, should be ignored.



Figure 9-15: Camera Shake Delta

- 9 Taking the example image from [Figure 9-7](#) and its pair image, the delta shows a difference of three code values, which for a **center-gray** level of 167 would have even been a pass for tests at 47.952 Hz and higher, but as this test was done at 24 fps this level of error be defined as a failure if it were caused by jitter. However, as previously mentioned, if the delta is just one box that is brighter or darker that is likely due to the camera and DUT not measuring the 1-second interval exactly the same. Given that we are checking the delta between one frame and another, it is quite likely that the single brighter or darker zone on each image will be in a different location, so while checking the difference test, we need to allow up to two zones having deltas that are larger than what is permitted in [Table 9-2](#).
- 10 Thus, if three or more zones illustrate a code value matching, or higher than, the values in [Table 9-2](#), for the particular frame rate, and **average-gray** level, this is a jitter failure condition.

9.6 Visual Examples (Informative)

In many cases, it is clear that either a significant checkerboard pattern is present, demonstrating a failure condition, or that the screen is a perfect flat **gray** indicating jitter-free success. This section illustrates a set of simulated test images. For simplicity of illustration, all the diagrams use a 24-zone diagram, as would exist in the 24 fps test; however, the luminance levels apply to all the tests in the same way.

When testing several monitors, with the recommended exposure of 1 second, F5.6 aperture, and ISO set for each test as defined in [Table 9-1](#), using a Nikon Z camera, the average **gray**-level luminance achieved was approximately code value 160 in the photograph itself. Thus, these example images are simulated using a flat **gray** of code value 160. Using [Table 9-2](#), we can see that with an average **gray** level of 160, the failure levels of deviation are as listed in [Table 9-3](#).

Table 9-3: Subset of Table 9-2 for Code Value 160

Gray Level	Frames Per Second Jitter Testing					
	24	25	30	48	50	60
160	2	2	3	4	4	5

Thus, for the 23.976 and 24, 25 Hz tests, only a variance of 1 code value is permitted after executing the difference calculation explained in [Section 9.5](#). As soon as the variance is as much as 2 code values, this becomes a failure condition. For the higher-frequency tests, such as 60 Hz, code value variances of up to 4 are permitted, and a difference of 5 would become a failure.

The following simulated images show examples of an average 160 **gray** level, with a code value variance of 1, 2, 3, 4, and 5. In all cases, if there is one zone that is either brighter or darker, this should be ignored because this is due to the timing difference of 1 second as computed by the GPU versus the camera.

In the example shown in [Figure 9-16](#), there are 4 zones of code value 161. This level of 1 code value variance would be permitted for all frequency jitter tests.



Figure 9-16: Example 1 – Average Code Value 160, Ignore the One Bright (or Dark) Zone Caused by Timing Differences

In the example shown in [Figure 9-17](#), there are 3 zones of code value 162, this level 2 code values of variance would be a failure in the tests from 23.976 to 25 Hz, but permitted as a pass the 29.97 Hz and faster tests.

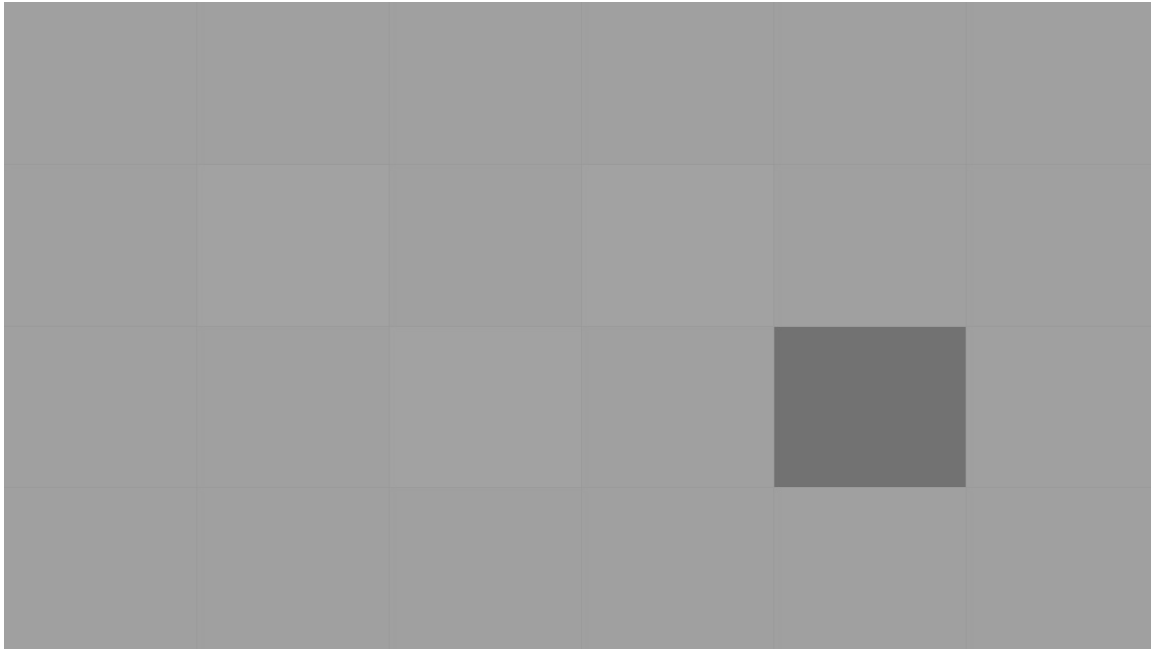


Figure 9-17: Example 2 – Average Code Value 160, Ignore the One (Bright or) Dark Zone Caused by Timing Differences

In the example shown in [Figure 9-18](#), there are 4 zones of code value 163, this level of variance would be a failure in the tests from 23.976 to 30 Hz, but permitted as a pass the 47.952 Hz and faster tests.

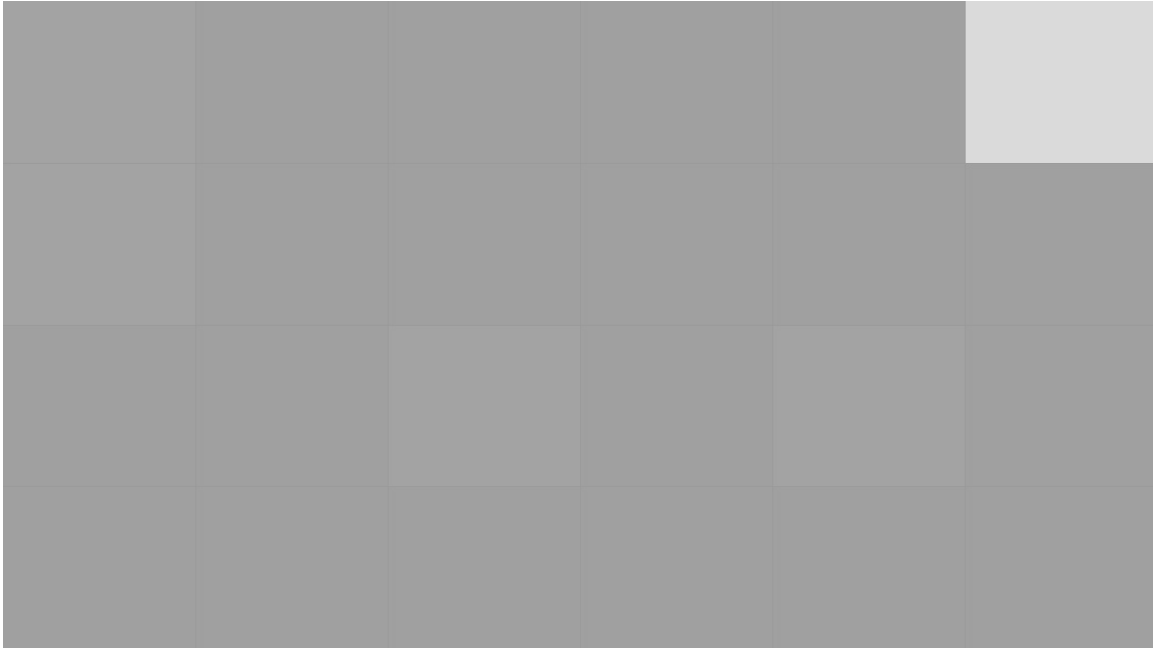


Figure 9-18: Example 3 – Average Code Value 160, Ignore the One Bright (or Dark) Zone Caused by Timing Differences

In the example shown in [Figure 9-19](#), there are 6 zones of code value 164, this level of variance would be a failure in the tests from 23.976 to 50 Hz, but permitted as a pass only in the 59.94 and 60 Hz tests.

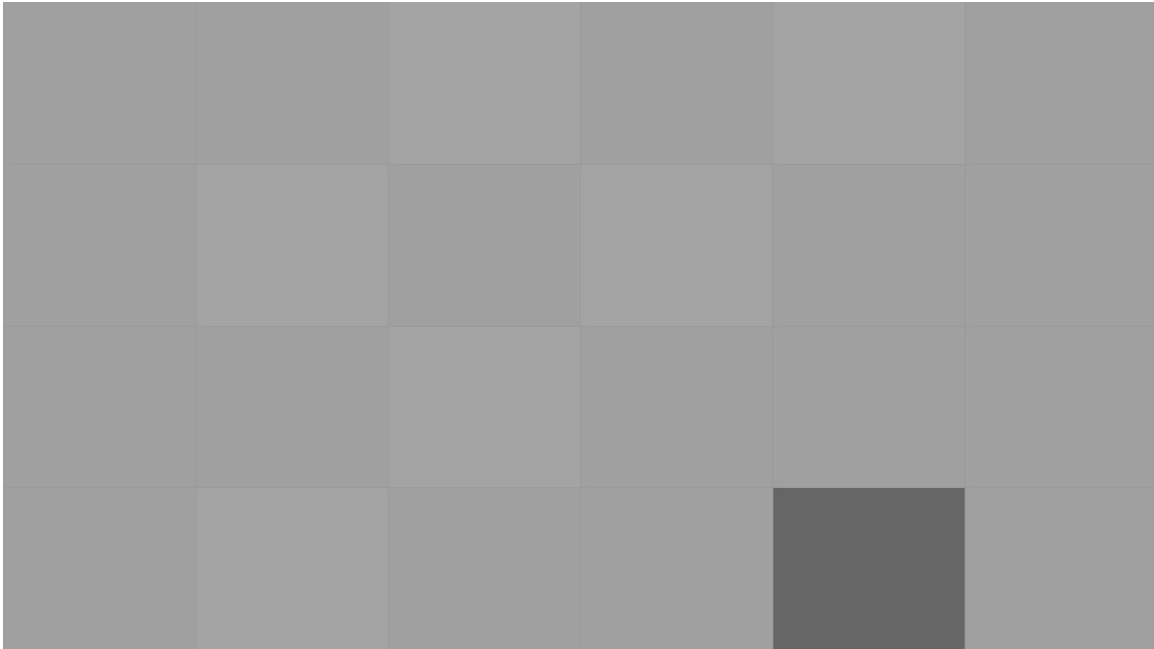


Figure 9-19: Example 4 – Average Code Value 160, Ignore the One (Bright or) Dark Zone Caused by Timing Differences

In the example shown in [Figure 9-20](#), there are 6 zones of code value 165, this level of variance, 5 code values, would be a failure at all frequencies.

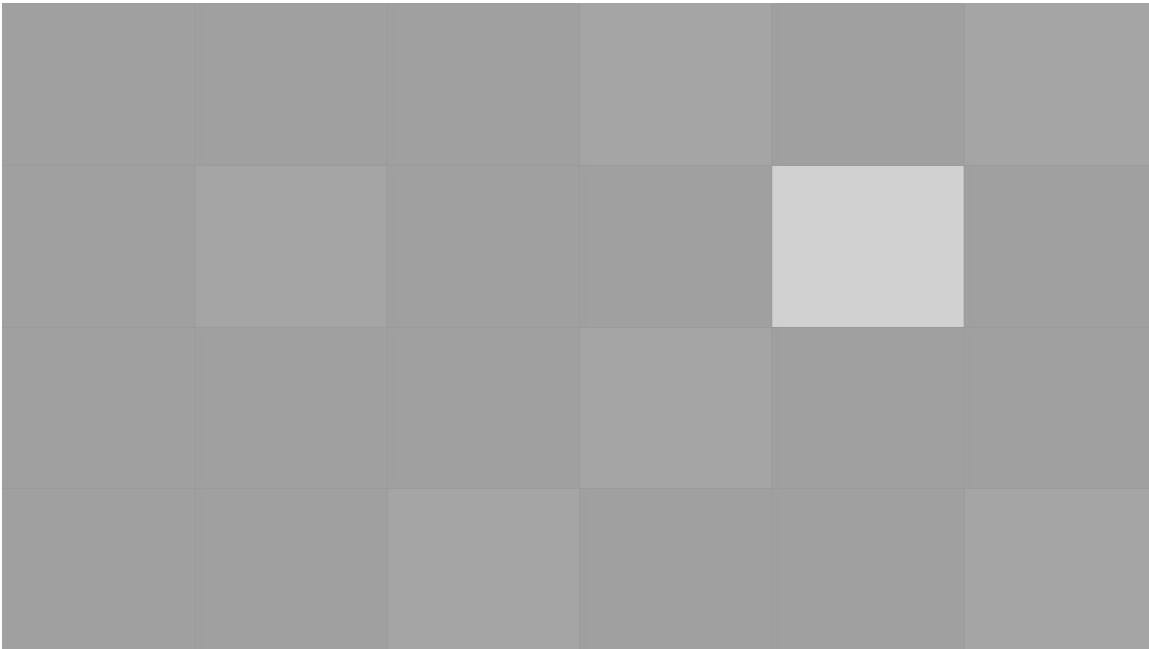


Figure 9-20: Example 3 – Average Code Value 160, Ignore the One Bright (or Dark) Zone Caused by Timing Differences

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](#). With some PWM based HDR displays, the variance in brightness due to the PWM is larger than the variance in luminance due to frame-rate changes, which makes identifying the Square Wave test signal impossible. To assist with resolving this, when executing the Adaptive-Sync test of this section in HDR mode, a **White** version of the Square Wave tool, code value 255 can be used instead of a **gray** patch to increase the HDR duty cycle to make the waveform signal easier to read. The automated test tool uses the **K** key to switch between a test patch with code value 127 and code value 255.

Additionally, during the HDR test any OS or OSD brightness sliders can be increased to max to further increase the brightness and thus increase the PWM-based backlight duty cycle. This includes the standard **Brightness** slider, typically used for integrated laptop panels in HDR mode, and the **SDR Content Brightness** slider, typically used for monitors in HDR mode or any other brightness control to increase the duty cycle of the backlight.

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)	10-bit PQ Value
0	0	0
31	1.80	186
63	8.56	294
95	21.1	370
127	40.0	429
159	65.6	477
191	98.2	518
223	138	553
255	185	584

B Pseudo Code for Calculating the Combined Observed Gamma of a Display and Measurement System (Informative)

The following pseudo code provides an informative example of how to calculate the combined Observed Gamma of a display and measurement system, using a loop to determine the minimum R^2 error for a sequence of Gamma values.

Start with an array of the 9 voltages for the 9 observed Gray Levels from 0d to 255d, and then subtract the black level offset, simply by subtracting the voltage for 0d from all 9 voltage levels.

```
1  for (test Gamma values 1.3 to 3.3 in 0.001 steps) // Gamma assumed to be within this range
2  {
3    for each of the six voltages represented by code values 63 through 223
4    // ignore code values 0, 31, 255 as the R2 value for 0 and 255
    // will always be zero, and 31 is too noisy
5    {
6      Calculate  $R^2$  as the squared difference between the measured voltage,
7      and the calculated voltage using the gamma for this iteration of the loop
8      for each of the 6 code values from 63d to 223d.
9
10     Sum these 6  $R^2$  values
11   }
12   Find the Gamma value when the sum of the six  $R^2$  values is smallest
13 }
```

C Main Contributor History (Previous Revisions)

Table C-1: Main Contributor History (Previous Revisions)

Company	Name	Contribution	Revision
Advanced Micro Devices, Inc.	Chas Boyd	Test Tool Developer, Technical Content	1.0
	Syed A. Hussain	Technical and Editorial Content	1.0
	Shaylesh Mehta	Technical and Editorial Content	1.0
Allion Labs, Inc.	Lexus Lee	Technical and Editorial Content	1.0
Apple, Inc.	Alan Kobayashi	Technical and Editorial Content	1.0
	Kevin Sliech	Technical and Editorial Content	1.0
ASUSTeK Computer Inc.	Nicky Lin	Technical and Editorial Content	1.0
Avatar Tech Pubs	Trish McDermott	Technical Writer	1.0
Dell, Inc.	Stefan Peana	Technical and Editorial Content	1.0
	Venson Tseng	Technical and Editorial Content	1.0
HP, Inc.	Greg Staten	Technical and Editorial Content	1.0
	Alexander Williams	Technical and Editorial Content	1.0
Intel Corp.	Rekha Bangalore	Technical and Editorial Content	1.0
	Murali Iyengar	Technical and Editorial Content	1.0
	Jackson Tsai	Technical and Editorial Content	1.0
	Roland Wooster	Chair, Primary CTS Author	1.0
LG Display Co., Ltd.	Noah Choi	Technical and Editorial Content	1.0
	Wayne Jung	Technical and Editorial Content	1.0

Table C-1: Main Contributor History (Previous Revisions) (Continued)

Company	Name	Contribution	Revision
LG Electronics, Inc.	DK (Do-Kyun) Kim	Technical and Editorial Content	1.0
	Yoon-Jong Lee	Technical and Editorial Content	1.0
	Seung-Hyun Yoo	Technical and Editorial Content	1.0
Microsoft Corp.	Steve Dudgeon	Technical and Editorial Content	1.0
NVIDIA Corp.	Jean-Marc Guiraudet	Technical and Editorial Content	1.0
	Adrian Muntianu	Technical and Editorial Content	1.0
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Parade Technologies, Ltd.	Craig Wiley	Marketing / Communications / Logo Development	1.0
Polytechnic Marketing	Joel Boardman	Marketing / Communications / Logo Development	1.0
Realtek Semiconductor Corp.	Jay Lin	Technical and Editorial Content	1.0
Samsung Electronics Co., Ltd.	Dale Stolzka	Technical and Editorial Content	1.0
Teledyne LeCroy	Alok Soni	Technical and Editorial Content	1.0
	Mikhail Voldman	Technical and Editorial Content	1.0
VESA Compliance Program Manager	Jim Choate	Technical and Editorial Content	1.0
Xrite, Inc.	Tom Schuneman	Technical and Editorial Content	1.0