Dell UltraSharp Monitors Competitive Analysis For IPS Black

HOT TECH

VISION
AND
ANALYSIS

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Deeper Blacks

IPS Black monitors have deeper black levels (<.1 Nits) and higher contrast ratios (2000:1) than standard IPS monitors.

Color Accuracy

The Dell U3223QE, U3223QZ, and U2723QE offer excellent color accuracy. The monitors exhibited among the best maximum Delta E (ΔE <1) values in their respective categories.

Off-Axis Superiority

IPS Black monitors offer superior 45° (horizontal) and 30° (vertical) off-axis contrast and color shift characteristics versus standard IPS and VA monitors.

Gamut Coverage

The Dell U3223QE, U3223QZ, and U2723QE offered the best sRGB Gamut Coverage of the group, with excellent DCI P3 Gamut Coverage.

Grey Level Accuracy

Deeper blacks, superior contrast ratios and class-leading color Gamut Volume result in excellent grey level accuracy, with low maximum Delta E values (ΔE <.8) for the darkest grays.

Mixed Environments

Dell monitors with IPS Black and the Dell Display Manager utility are ideally suited for mixed OS environments, where multiple color profiles and Windows and Macintosh systems are used.

IPS Black: A More Refined Evolution Of In Plane Switching Technology

There are a wide array of display panel technologies in-market currently, including IPS, VA, TN, and OLED, among others, and each technology has its strengths and weaknesses. **The panel technology leveraged in a monitor will have a significant impact on its visual fidelity and overall performance**, so choosing the correct type for a particular use case is paramount.

In current mainstream market segments, IPS (In-Plane Switching) and VA (Vertical Alignment) panel technologies are the most common. TN (Twisted Nematic) technology is often used in the low-cost, entry-level segment. And OLED (Organic Light Emitting Diode) technology, while increasing in prevalence, remains a premium, niche solution that's relegated to a more limited array of panel sizes. IPS panels generally offer better viewing angles and color accuracy than VA panels, while VA panels may have faster response times and better on-axis contrast ratios.

To build upon the benefits of IPS technology, Dell has introduced a family of new monitors featuring an updated evolution and refinement to IPS, dubbed IPS Black, with improved performance in a number of key metrics. IPS Black-enabled monitors offer deeper black levels, without hindering white level output, color accuracy or viewing angles. As such, higher contrast ratios are possible, without sacrificing any of the inherent benefits of standard IPS displays. Dell's new UltraSharp monitors with IPS Black technology are targeted at similar audiences to standard IPS, including product designers, visual artists, architects, technology enthusiasts, and discerning business and home users that want high visual fidelity.

Evaluating Monitors And Their Impact On Workflows And User Experiences

To assess how an array of modern LCD monitors compared in multiple areas, Dell commissioned HTVA to conduct independent testing and benchmarking of ten 4K resolution monitors of various sizes, ranging from 27" to 32". The testing was done independently in HTVA's facilities, using our own tools and equipment. Our goals in this research effort were to determine which monitors offered the best performance in a variety of key categories, and which had the most extensive feature sets and useful real-world functionality.

The particular monitors used in this paper include the Dell U3223QE, U3223QZ and U2723QE and seven competitive models; four 32" and three 27"/28". The Dell monitors feature IPS Black panel technology, while six of the competitive models featured standard IPS (In Plane Switching) panels and one featured a VA (Vertical Alignment) panel. All of the monitors had native resolutions of 3840x2160, with DisplayPort and HDMI inputs, and most had built-in USB hubs, with both USB-C and USB-A connectivity.

We directly compared all of the panels to evaluate their luminance, contrast ratios, color shift, color accuracy and viewing angles. We also evaluated any available display management utilities to assess overall functionality and determine whether they were available and function properly in mixed compute environments, which require support for both Windows PCs and Macintosh systems.
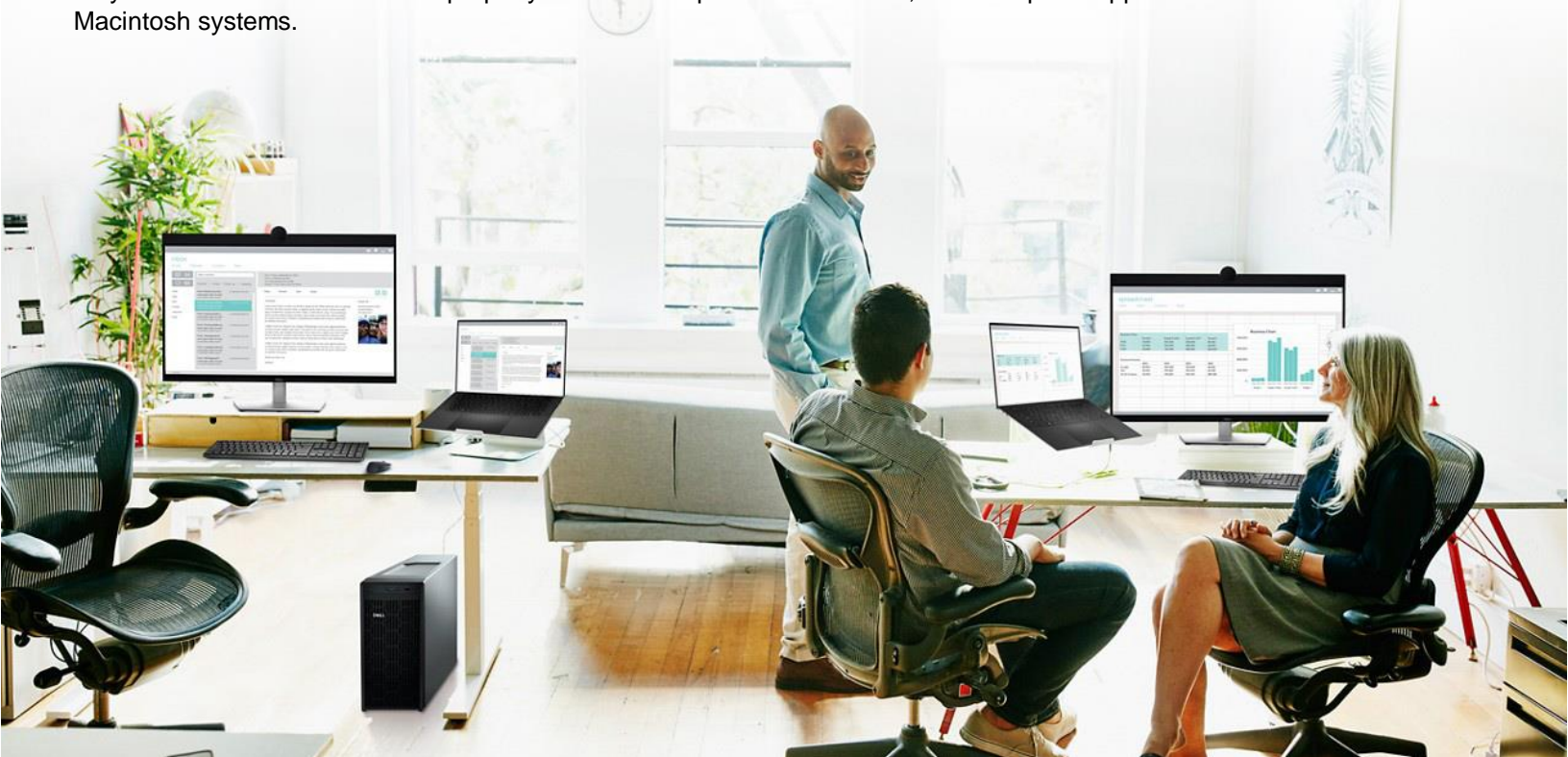
Straight-On (0°) And Off-Axis (45° Vertical) Viewing Comparisons

Though we will be providing data to quantify the perceived visual differences when viewing a monitor off-axis shortly, a picture is worth 1,000 words. These real-world images show a Dell UltraSharp monitor with IPS Black (model U3223QE) being compared to competitive standard IPS and VA-based monitors. The images are a composite of straight-on (0°) and 45° off-axis viewing. (Note the seam down the center of each image where the straight-on image [left] meets the 45° off-axis [right])
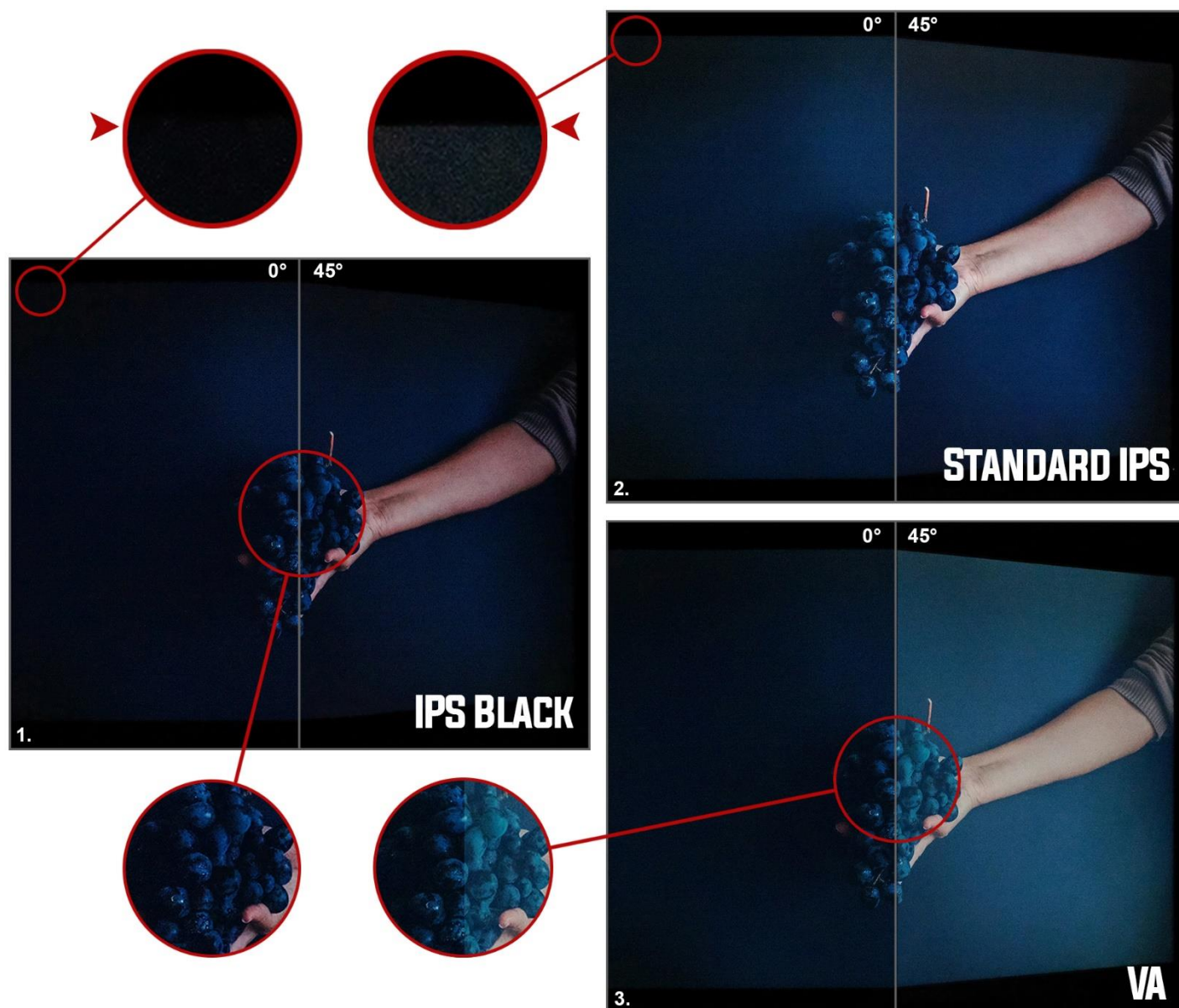
1. IPS Black vs. 2. Standard IPS vs. 3. VA: 0° and 45° Off-Axis Black Levels and Color Shift

All of these images were captured with the monitors calibrated and set to similar brightness levels (as close to 200 cd/m2 as possible), with the camera's exposure locked. Complete reference images, from multiple angles (0°, 45° vertical, 30° horizontal), for all of the monitors we tested are available in Appendixes D, E, and F at the end of this document.

Straight-on, the images show the Dell monitor with IPS Black exhibiting the deepest blacks – most visible in the darkest corners of the reference image. When viewed off-axis from a wide 45° angle, the Dell monitor with IPS black also maintains more consistent contrast and black levels, and color shift is less prevalent. This is especially noticeable in comparison to the VA-based monitor, which exhibits drastic color shift when viewed off-axis that strays significantly from the straight-on image.

For color-sensitive work or content consumption, the Dell monitors with IPS Black offer a superior viewing experience with better contrast and more accurate colors, both straight-on and from wide viewing angles. This is an important consideration for multi-monitor configurations or in collaborative environments, for example in financial institutions or the visual arts, where it may not be possible for users to always be positioned directly in the center of a display.

We used an array of tools to evaluate and benchmark the monitors featured in this report. To asses initial straight-on performance and calibrate the displays, we used a SpyderX Elite colorimeter and for our off-axis tests we used a Konica Minolta CS-2000 precision spectroradiometer. All tests were conducted in a climate-controlled, low-light environment with the displays warmed-up and pre-conditioned prior to taking any measurements.

We are presenting actual, measured contrast ratios here, while measuring display performance straight-on (0°), off-axis by 45° and 80° horizontally, and 30° vertically.

Off-Axis Horizontal Contrast Ratios
(32" Monitors)
Higher Scores = Better Performance
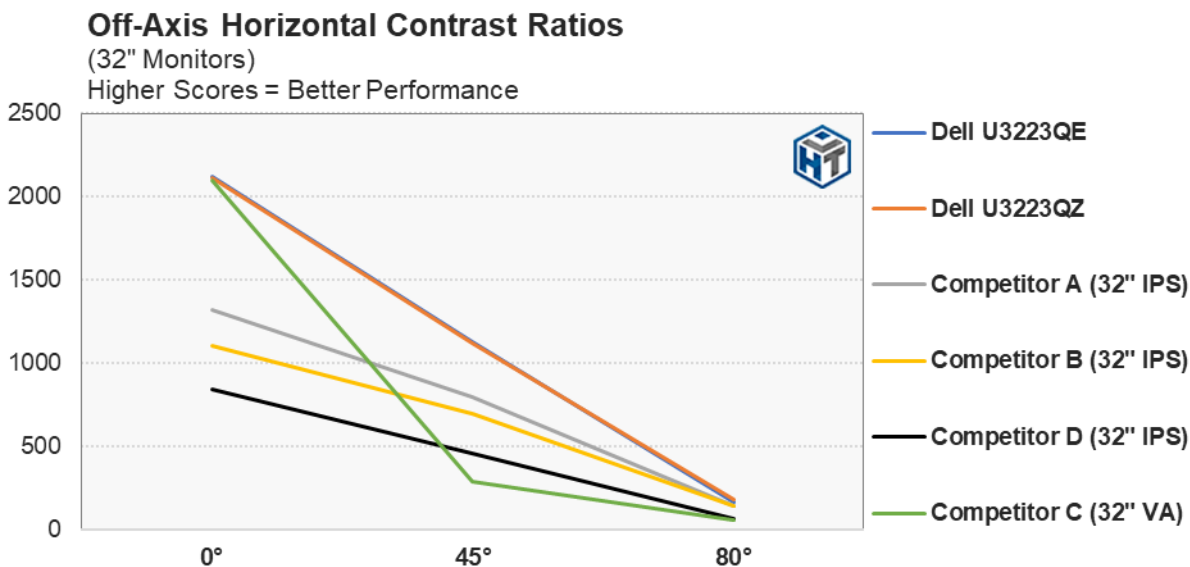
Note as you view this chart, that the Dell 32-inch monitors performed identically, and their lines overlap. As you can see, the 32" Dell monitors with IPS Black offered class-leading contrast ratios striaght on, clearly outperforming the competing IPS monitors we tested. The VA-based monitor offered competitve contrast performance straight on, but sharply fell when measured off-axis.

These results illustrate a key weakness of VA monitors for any work that requires precise color accuracy, or for high-fidelity media consumption. When not viewed straight-on, VA monitors are simply too inaccurate, in our opinion.

Off-Axis 30° Vertical Contrast Ratios
(32" Monitors)
Higher Scores = Better Performance
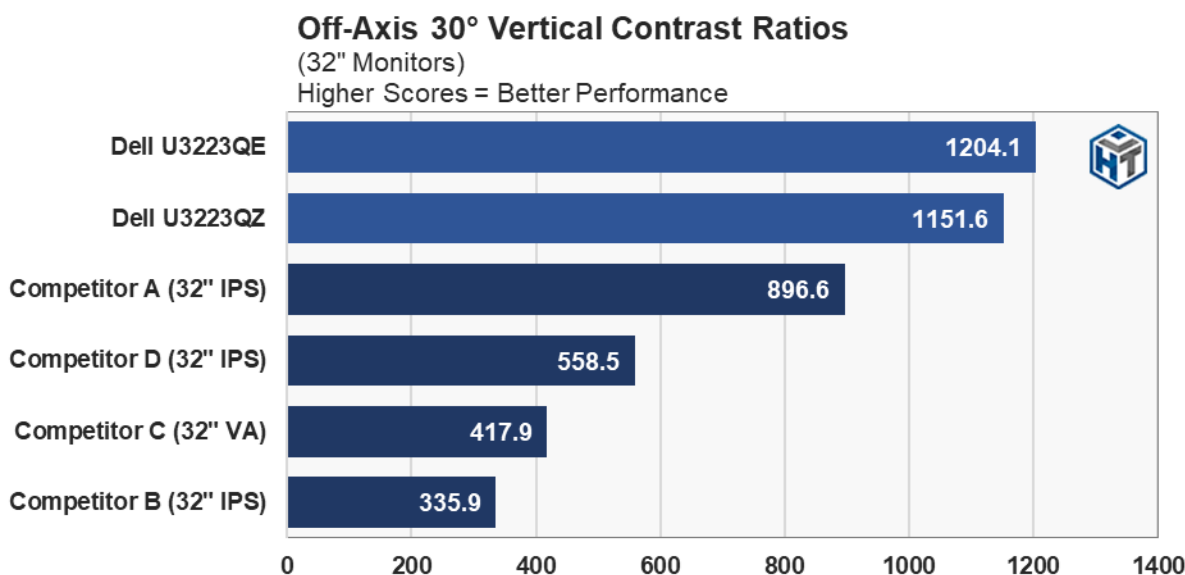
There is a similar performance disparity when viewing the monitors tilted vertically by 30°. The 32" Dell monitors with IPS Black offered significantly better contrast ratios in this scenario as well.

An identical array of tests were performed on the 27" and 28" monitors, in the same environment, using the same equipment.

Once again, the results presented here are actual, measured contrast ratios, while viewing the displays straight-on (0°), and off-axis by 45° and 80° horizontally, and 30° vertically.

Off-Axis Horizontal Contrast Ratios
(27 / 28" Monitors)
Higher Scores = Better Performance
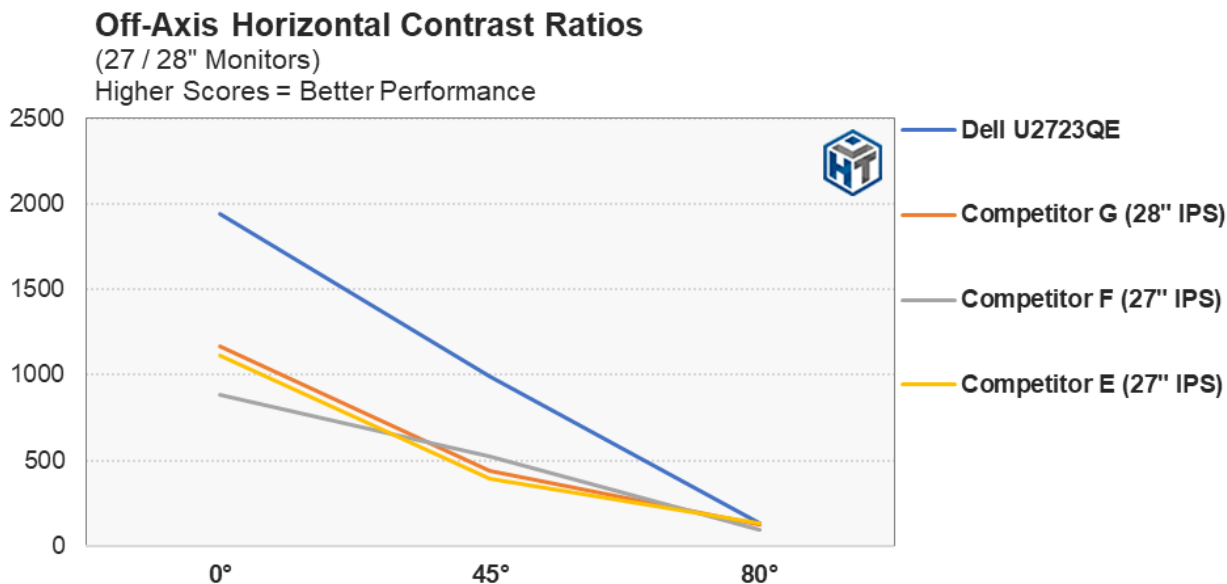
Like its larger 32" counterparts, the 27" Dell monitor with IPS Black clearly outperformed its competitors across the board, in both the straight-on and off-axis tests.

Off-Axis 30° Vertical Contrast Ratios
(27" / 28" Monitors)
Higher Scores = Better Performance
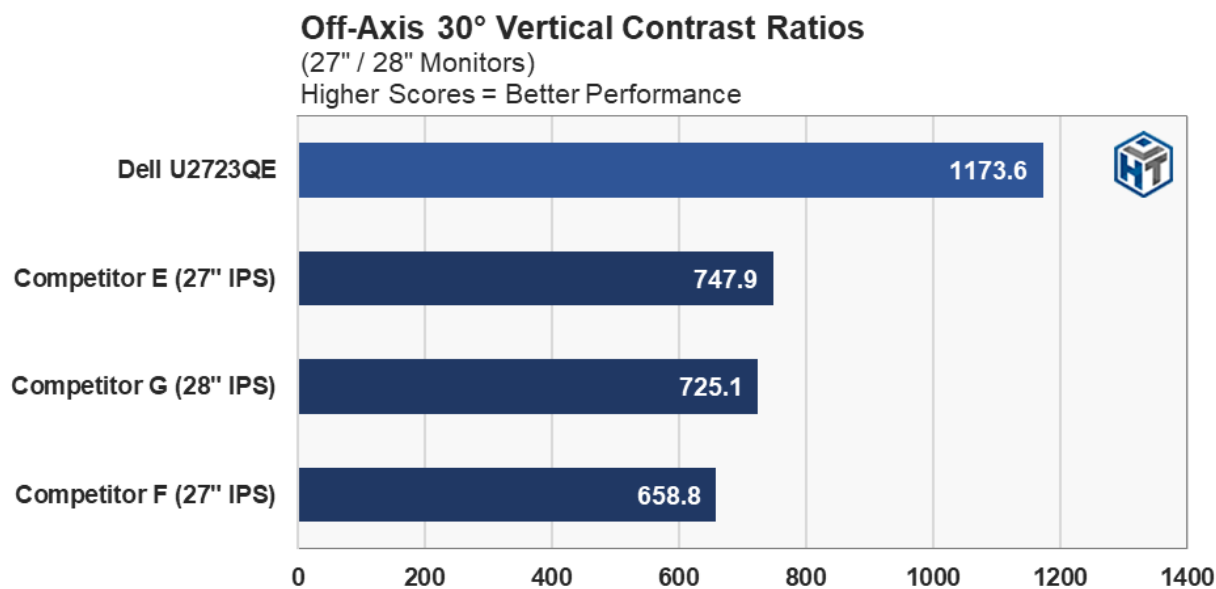
These vertical off-axis tests produced similar results. The Dell U2723QE offered the best off-axis contrast ratio in its category as well.

Dell monitors with IPS Black are able to achieve **better overall contrast than standard IPS monitors by producing darker, deeper black levels**. The difference in luminance between pure black and pure white on a monitor, determines that monitor's contrast ratio. Here, Dell's U3223QE, U3223QZ and U2723QE monitors are the only IPS monitors capable of achieving <.1 nits, which is significantly darker than standard IPS.

Black Levels (0°)
Values In cd/m^2
Lower Scores = Better Performance

Monitor	Value
Dell U2723QE	0.0944
Dell U3223QZ	0.0944
Dell U3223QE	0.0947
Competitor C (32" VA)	0.0947
Competitor A (32" IPS)	0.1617
Competitor E (27" IPS)	0.1751
Competitor G (28" IPS)	0.1757
Competitor B (32" IPS)	0.1891
Competitor D (32" IPS)	0.2427
Competitor F (27" IPS)	0.2962

With all of the monitors calibrated to similar brightness levels, our data shows the Dell monitors with IPS Black offering significantly better black levels than any of the competitive standard IPS monitors. The VA-based monitor offered similar black levels straight-on, but as the earlier off-axis data shows, contrast degrades significantly when viewing a VA-based monitor at wide angles. As such, the Dell monitors with IPS Black are more suitable for dual or multi-monitor setups like those in finance and trading environments, where users will benefit from the deeper blacks, better contrast and wide viewing angles when inspecting charts and other related content.

Maximum Delta E (ΔE*76)
Lower Scores = Better Performance

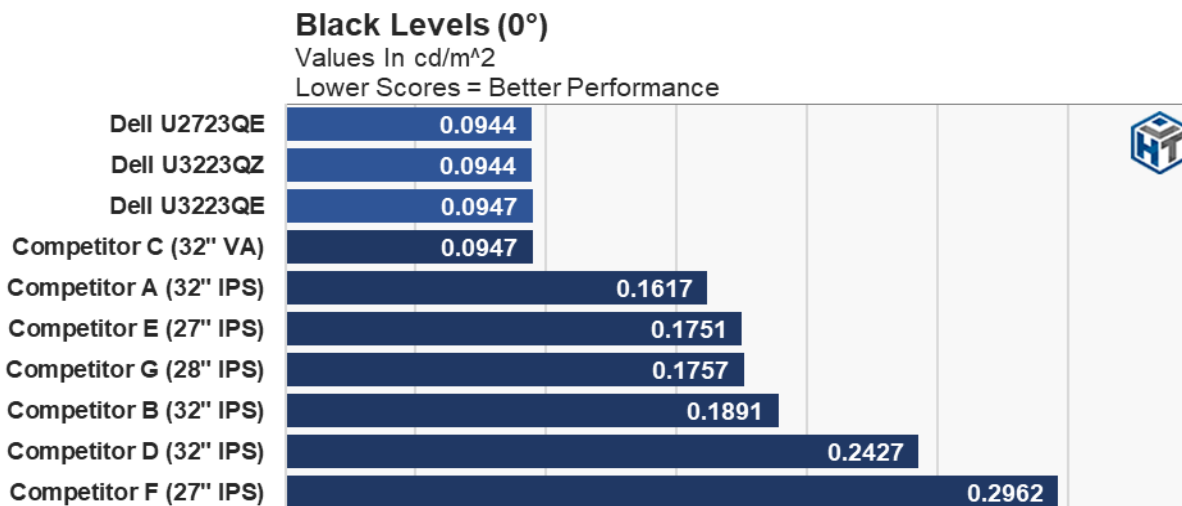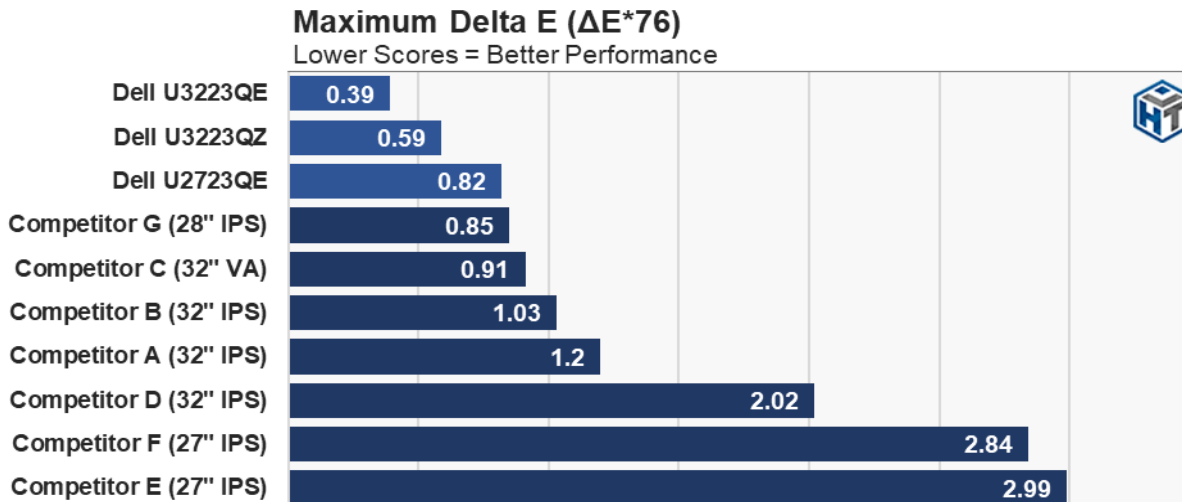| Monitor	Value
Dell U3223QE	0.39
Dell U3223QZ	0.59
Dell U2723QE	0.82
Competitor G (28" IPS)	0.85
Competitor C (32" VA)	0.91
Competitor B (32" IPS)	1.03
Competitor A (32" IPS)	1.2
Competitor D (32" IPS)	2.02
Competitor F (27" IPS)	2.84
Competitor E (27" IPS)	2.99

In addition to offering superior contrast and off-axis viewing characteristics, Dell monitors with IPS Black provided some of the best sRGB and DCI P3 Gamut Coverage of the group, with the highest Gamut Volume for the sRGB and DCI P3 color spaces (Appendix B).

Over and above their excellent gamut coverage and volume, however, Dell monitors with IPS Black also offered superior color accuracy in our tests. The Dell U3223QE, U3223QZ, and U2723QE exhibited the lowest max Delta E (ΔE) of the group. Delta E measures the difference between a color input versus the color standard. Values below 1 are considered very good and represent color differences that are normally imperceptible to users. Values between 1 – 2 may show small differences to a trained eye, while values above 2 are typically obvious to even an untrained eye.

The Dell monitors with IPS Black's superior color accuracy and deeper black levels translate to excellent grey level performance as well (Appendix B). For users that require color and grey level accuracy, like content creators, media professionals or digital visual artists producing high-contrast content, Dell monitors with IPS Black are an ideal solution. Dell monitors with IPS Black display deeper blacks and truer dark greys than standard IPS.

Proprietary display management utilities, which give users the ability to control many monitor features and manage application window layouts, are available for all of the monitors tested in this paper.

Among this group of utilities, Dell Display Manager (DDM) offered the most preset options for screen layouts, for both portrait and landscape display configurations, with a diverse set of controls to maximize productivity. In many professional environments, it is preferable to launch commonly used applications in pre-determined screen layouts -- DDM offers the most versatile array of options in this regard. DDM is also easily accessible from the system tray, where brightness, contrast, and window layout configuration tools (among others) are immediately available.

There are also multiple DisplayPort, HDMI, and USB ports on most of the monitors we tested, which make it possible to connect more than one system to each monitor; for example, a desktop and a laptop. As such, it is possible to switch between multiple systems on the fly. The Dell monitors, however, are the only

Dell Display Manager offered the most preset grid options (38) and features, gives users easy access to advanced KNM functionality, and it is available for both Microsoft Windows and Apple macOS platforms.

models in the group with user-friendly KVM (Keyboard Video Mouse) and multi-client functionality built-in. One of the competitive monitors also had integrated KVM functionality, but its configuration and user interface was more difficult to use and cumbersome then Dell's.

Because most of these monitors feature switchable inputs and USB upstream port options, it is technically possible to manually switch between multiple systems connected to a single display, but this is not true KVM functionality and the user experience is poor. The new Dell monitors with IPS Black offer easy to use KVM functionality, enabled by multiple USB upstream connections, flexible input configurations, and innovative software, offering a better, more versatile experience than the other

monitors for multi-client use cases. These Dell monitors also feature integrated wizards in their On-Screen Displays (OSD) that walk users through the setup process, step-by-step. KVM functionality is also available via DDM through the KVM Wizard feature for ease of setup and use.

These features are important for professionals and power users that may want to quickly switch between systems to perform different tasks. Common uses cases for these features include switching between personal and

professional devices, or digital artists and content creators switching between high-powered systems designed for complex rendering and more mainstream systems for daily computing tasks.

Dell's user-friendly monitor OSD and Dell Display Manager's expansive feature set, which is available for both Windows and macOS*, represent the most comprehensive monitor configuration and control tools suite in this group. (*Refer to http://Dell.com/DDM for details on monitor and OS support.)
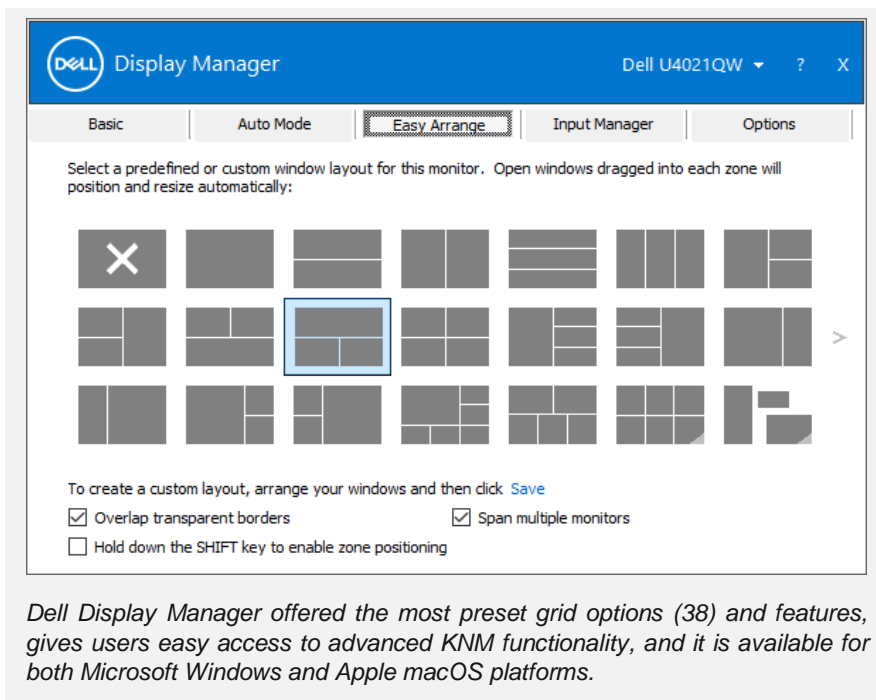
Assessing Usability And Adaptability In A Mixed OS Environment

It is increasingly more common for both home and professional office work environments to feature a mix of Microsoft Windows and Apple Macintosh systems. As an added benefit for those users in mixed-environments, Dell Display Manager is available for both Windows and macOS, and the macOS version is virtually indistinguishable from the Windows version. Of the competitive monitors we tested, display management utilities for only two models were available for macOS, but their functionality differed greatly from the Windows versions and was more limited.

In addition to Dell's hardware and software being suitable for mixed OS environments, some of the features of the new Dell UltraSharp monitor with IPS Black further enhance flexibility and the user experience. For example, these Dell monitors offer up to 90 Watts of USB-C power delivery through their integrated ports, so the latest MacBooks, or virtually any USB-C enabled Windows laptop PC, can be connected to the monitor and charged simultaneously using only a single cable.

This flexibility in mixed OS environments is especially important for monitors employed in Hoteling / Hot-Desking hybrid work setups, where each station should ideally be universally compatible with various client systems.

Over and above their superior visual fidelity and performance, all of these advanced features and software support culminate in some key usability wins for the Dell monitors with IPS Black, including:

- Extensive display management utilities support for Windows and Mac Systems

- Easy to use KVM functionality

- USB-C support with up to 90W charging

- Most customizable display configurations
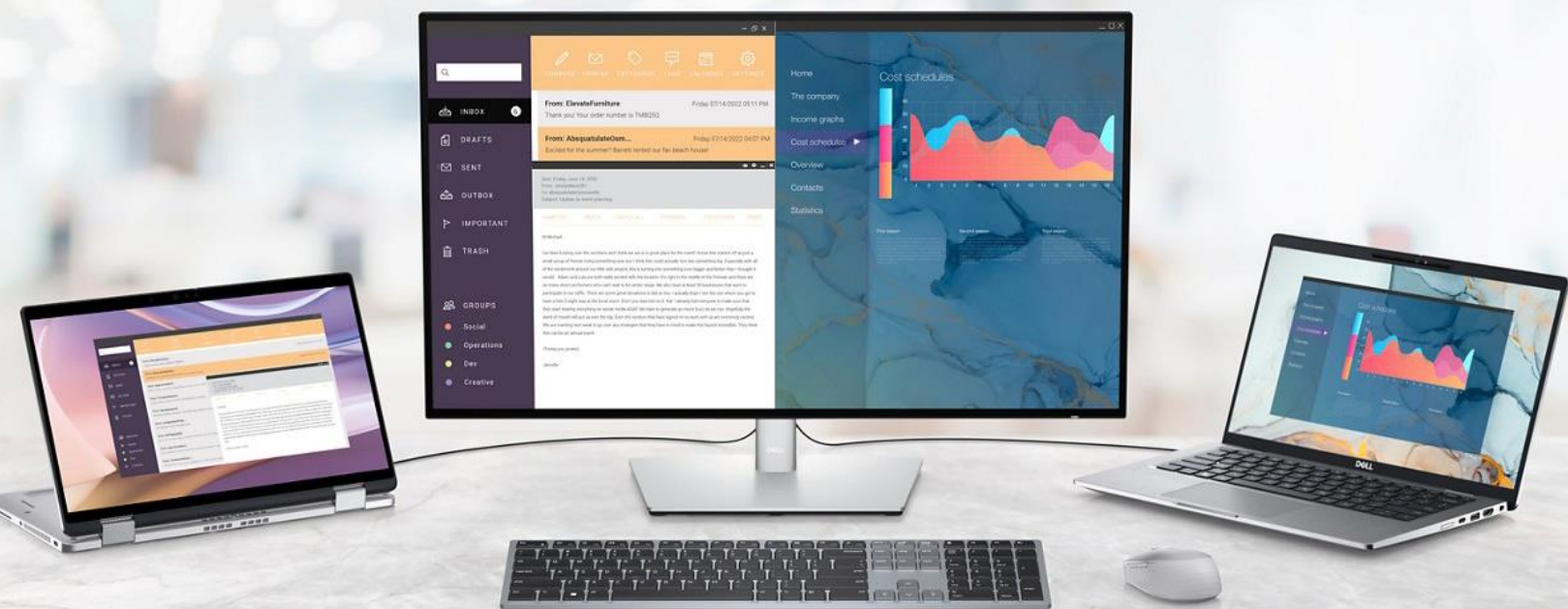
Dell And IPS Black: Superior Monitors For Better User Experiences

Throughout all of our testing, Dell U3223QZ, U3223QE and U2723QE monitors consistently offered the best, or among the best, performance in virtually every category we tested.

The promised claims of IPS Black displays are deeper blacks, with superior contrast to standard IPS panels, without sacrificing color accuracy or viewing angles. That is exactly what our testing showed. Whether viewed straight-on or off-axis, Dell's U3223QE, U3223QZ, and U2723QE monitors with IPS Black offered some of the best performance versus their respective competitors. The VA-based monitor specifically showed drastic color shift when viewed off-axis, which makes them poorly suited for any color-critical use cases. Black levels, contrast ratios, color accuracy, gamut volume and gamut coverage are all excellent with these new Dell monitors with IPS Black.

Deeper Blacks

Off-Axis Superiority

Color Accuracy

Gamut Coverage

Mixed Environments

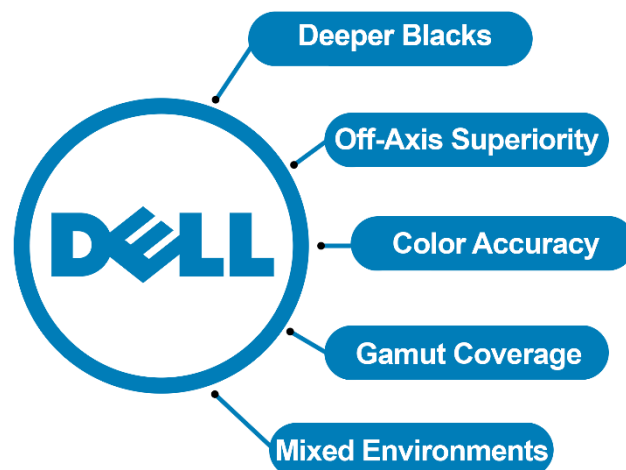Their strong performance make Dell UltraSharp monitors ideally suited for an array of applications and use cases. Their superior accuracy in 45° (horizontal) and 30° (vertical) off-axis viewing makes these Dell monitors an excellent choice for multi-monitor configurations, which are common in financial institutions, or with creators and creative professionals. Content creators in particular should look to Dell's offerings with IPS Black. With their class-leading off-axis performance and color accuracy, **Dell UltraSharp monitors with IPS Black are simply a better choice than standard IPS, and they are clearly superior to VA panels**, which perform poorly in off-axis viewing.

Excellent performance isn't the only benefit offered by these Dell monitors, however. In addition to offering high-quality, fully adjustable stands and a flexible array of ports and I/O connectivity, Dell Display Manager also makes them an ideal solution for mixed environments with both Microsoft Windows and Apple Mac systems. Dell Display Manager offers the most extensive array of preset application window configurations, and a multitude of toggles and features to configure the monitors exactly to a user's particular needs. Dell's built-in KVM functionality with easy-to-use on-screen setup wizard also makes it simple for users of all skill levels to connect and configure their monitors to multiple systems. In addition, the up to 90 Watt-enabled USB-C port on these Dell monitors are powerful enough to charge high-performance notebooks like the Dell XPS 13 or a MacBook Pro, while the machines are actually being used and under load.

In terms of their performance, functionality, and user experience, the Dell U3223QZ, U3223QE and U2723QE monitors are clear leaders in their respective categories, and represent excellent options for a wide array of users, from discerning enthusiasts and productivity-focused task workers, to creative professionals that rely on critical accuracy for their work.

More information regarding the many features and benefits of Dell's UltraSharp monitors is available here.

All of the monitors featured in this paper were tested in their default, out-of-box configurations, with only brightness and color settings altered via their respective OSD utilities where applicable. No physical modifications were made to any of the monitors and identical cables, systems, and test equipment were used throughout our testing and analysis. The monitors featured in this paper include:

	Dell U3223QE	Dell U3223QZ	Competitor A (32" IPS)
Size (in inches)	31.5"	31.5"	31.5"
Size (in cm)	80.01 cm	80.01 cm	80.01 cm
Aspect Ratio	16:9	16:9	16:9
Resolution	3840 x 2160	3840 x 2160	3840 x 2160
Viewing Angle (Horizontal/Vertical)	178°/178°	178°/178°	178°/178°
Panel Technology	In Plane Switching (IPS Black)	In Plane Switching (IPS Black)	In Plane Switching (IPS)
Brightness (typical)/(peak)	400 cd/m² (Typical)	400 cd/m² (Typical)	400 cd/m² (Typical)
Color Space	98% DCI-P3, 100% sRGB, 100% Rec.709	98% DCI-P3, 100% sRGB, 100% Rec.709	98% DCI-P3, 99% sRGB
Color Depth	1.07 Billion	1.07 Billion	1.07 Billion
Pixel Per Inch	140	140	140
Panel-bits	10Bits (8Bits + FRC)	10Bits (8Bits + FRC)	10Bits (8Bits + FRC)
Contrast Ratio	2000:1 (Typical)	2000:1 (Typical)	1000:1 (Typical)
Panel Response Time	8ms (Normal), 5ms (Fast) (GTG)	8ms (Normal), 5ms (Fast) (GTG)	4ms (GTG)
Variable Sync	No	No	No
Refresh Rate	60Hz	60Hz	60Hz
Bezel	Infinity Edge Bezel	3-sided Ultrathin Bezel	3-sided Narrow Bezel
Curved/Flat	Flat	Flat	Flat
HDR	DisplayHDR 400	DisplayHDR 400	DisplayHDR 400
Panel Backlight Technology	LED	LED	LED
Low Blue Light (Software / Hardware)	Yes, Hardware Low Blue Light	Yes, Hardware Low Blue Light	Yes, Hardware Low Blue Light
Flicker Free	Yes	Yes	Yes
Energy Star	Yes, ES 8.0	Yes, ES 8.0	No
USB Hub	5 x USB 3.2 Gen2 Downstream (10Gbps, BC 1.2 charging)	5 x USB 3.2 Gen2 Downstream (10Gbps, 1 x BC 1.2 charging)	3 x USB Downstream (5Gbps)
VGA	No	No	No
DisplayPort	DP 1.4 (DSC)	DP 1.4 (DSC)	1 x DP 1.4
DisplayPort Out	DP out (DSC)	DP out (DSC)	No
HDMI	1 x HDMI 2.0	1 x HDMI 2.0	1 x HDMI 2.0
USB-C	1 x USB-C 3.2 Upstream (DSC, DP 1.4 Alt Mode, PD 90W, 2/4 lane switch), 1 x USB-C 3.2 Upstream (Data only), 1 x USB-C 3.2 Downstream (PD 15W)	1 x USB-C 3.2 Upstream (DSC, DP 1.4 Alt Mode, PD 90W, 2/4 lane switch), 1 x USB-C 3.2 Upstream (Data only), 1 x USB-C 3.2 Downstream (PD 15W)	1 x USB-C Upstream (PD 65W)
RJ45 Port	1 x RJ45 (Up to 1 Gbps, PXE Boot, MAC Address Pass-Through, Wake-on-LAN)	1 x RJ45 (Up to 1 Gbps, PXE Boot, MAC Address Pass-Through, Wake-on-LAN)	No
Thunderbolt	No	No	No
DVI-D	No	No	No
mini DisplayPort	No	No	No
Audio Line-In	No	No	No
Audio Line-Out /Headphone	1 x 3.5 mm Audio Out	1 x 3.5 mm Audio Out	1 x 3.5 mm Audio Out
Height Adjustability	Yes, 150mm	Yes, 150mm	Yes, 150mm
Pivot and Swivel	Yes/Yes. Pivot : 30° clockwise & 30° counter-clockwise, Swivel : 60° left & 60° right	No/Yes. Pivot : No, Swivel : 60° left & 60° right	Yes/Yes. Pivot : 90° clockwise & 90° counter-clockwise, Swivel : 35° left & 35° right
Tilt	Yes, 5°/21°	Yes, -5°/21°	Yes, -5°/23°
Power consumption	29.4W (Typical), 220W (Max)	30W (Typical), 240W (Max)	45W (Typical), 155W (Max)
Internal/External PSU	Internal	Internal	External
Soundbar option	Dell Slim Soundbar - SB521A	No	No
Internal Speaker	No	2 x 14W (Front-Firing)	No
KVM	Yes, (Auto KVM)	Yes, (Auto KVM)	No
In-Built Microphone	No	Yes (Dual Array Microphone) (Grade A)	No
In-Built Camera	No	Yes, 4K Camera + IR (Automatic Safe Shutter, Windows Hello, Auto Framing & Focus, Express Sign-in 1.0)	No
Colorimeter Supported	No	No	No
Productivity Software	Dell Display Manager (Windows OS), Dell Display and Peripheral Manager (MacOS)	Dell Display Manager (Windows OS), Dell Display and Peripheral Manager (MacOS)	Yes (Windows)
Inbox cables/accessories	1 x DP, 1 x USB-A to C, 1 x USB-C	1 x DP, 1 x USB-A to B, 1 x USB-C	1 x DP, 1 x HDMI, 1 x USB-C, 1 x External Power Adapter
PiP/PbP	Yes/Yes	Yes/Yes	No
Daisy Chain availability	Yes (Supports daisy-chaining two 4K monitors with Display Stream Compression, DSC)	Yes (Supports daisy-chaining two 4K monitors with Display Stream Compression, DSC)	No

	Competitor B (32" IPS)	Competitor C (32" VA)	Competitor D (32" IPS)
Size (in inches)	31.5"	31.5"	31.5"
Size (in cm)	80.01 cm	80.01 cm	80.01 cm
Aspect Ratio	16:9	16:9	16:9
Resolution	3840 x 2160	3840 x 2160	3840 x 2160
Viewing Angle (Horizontal/Vertical)	178°/178°	178°/178°	178°/178°
Panel Technology	In Plane Switching (IPS)	Vertical Alignment (VA)	In Plane Switching (IPS)
Brightness (typical)/(peak)	300 cd/m² (Typical)	250 cd/m² (Typical)	250 cd/m² (Typical)
Color Space	98.2% DCI-P3, 99.5% AdobeRGB, 100% sRGB, 100% BT. 709, 79.3% BT. 2020	91.6% DCI-P3, 99.9% sRGB, 85% AdobeRGB, 87.2% CIE 1976	95% DCI-P3, 100% sRGB, 100% Rec. 709
Color Depth	1.07 Billion	1.07 Billion	1.07 Billion
Pixel Per Inch	138	138	140
Panel-bits	10Bits (8Bits + FRC)	Not Available	10Bits (8Bits + FRC)
Contrast Ratio	1000:1 (Typical), 3M:1 (Dynamic)	2500:1 (Typical), 1M:1 (Dynamic)	1000:1 (Typical), 20M:1 (Dynamic)
Panel Response Time	6ms (Normal), 4ms (Fast) (GTG)	8ms (GTG)	5ms (GTG)
Variable Sync	No	No	No
Refresh Rate	60Hz	60Hz	60Hz
Bezel	3-sided Narrow Bezel	3-sided Narrow Bezel	4-sided Narrow Bezel
Curved/Flat	Flat	Flat	Flat
HDR	No	HDR 10	HDR 10
Panel Backlight Technology	WLED	Not Available	LED
Low Blue Light (Software / Hardware)	Yes, Software Low Blue Light	Yes, Software Low Blue Light	Yes, Software Low Blue Light
Flicker Free	No	Yes	Yes
Energy Star	No	No	No
USB Hub	4 x USB 3.0 Downstream (1xBC 1.2 charging), 2 x USB 3.0 Upstream	2 x USB 3.0	3 x USB 3.1 Gen2 Downstream (5Gbps), 1 x USB 3.1 Gen2 Upstream
VGA	No	No	No
DisplayPort	1 x DP 1.2	1 x DP 1.2	1 x DP 1.4
DisplayPort Out	No	No	No
HDMI	2 x HDMI 2.0	1 x HDMI 2.0	2 x HDMI 2.0
USB-C	No	No	1 x USB-C Downstream
RJ45 Port	No	1 x RJ45 (Up to 1 Gbps)	No
Thunderbolt	1 x Thunderbolt™ 3.0 Upstream (PD 45W), 1 x Thunderbolt™ 3.0 Downstream	1 x Thunderbolt™ 3.0 Upstream (PD 90W), 1 x Thunderbolt™ 3.0 Downstream (PD 15W)	1 x Thunderbolt™ 3.0 (DP 1.4 Alt Mode, PD 85W), 1 x Thunderbolt™ 3.0 (DP 1.4 Alt Mode, PD 15W)
DVI-D	No	No	No
mini DisplayPort	No	No	No
Audio Line-In	No	No	No
Audio Line-Out /Headphone	1 x 3.5 mm Audio Out	1 x 3.5 mm Audio Out	1 x 3.5 mm Audio Out
Height Adjustability	Yes, 110mm	Yes, 135mm	Yes, 150mm
Pivot and Swivel	Yes/Yes. Pivot : 90° clockwise & 90° counter-clockwise, Swivel : 45° left & 45° right	Yes/Yes. Pivot : 90° clockwise & 90° counter-clockwise, Swivel : 45° left & 45° right	Yes/Yes. Pivot : 90° clockwise & 90° counter-clockwise, Swivel : 30° left & 30° right
Tilt	Yes, -5°/22°	Yes, -7°/13°	Yes, -5°/20°
Power consumption	57W (Typical)	54W (Typical)	220W (Typical)
Internal/External PSU	Not Available	Internal	Internal
Soundbar option	No	No	No
Internal Speaker	No	No	2 x 2W
KVM	Yes	No	Yes
In-Built Microphone	No	No	No
In-Built Camera	No	No	No
Colorimeter Supported	No	No	No
Productivity Software	Yes (Windows)	Yes (Windows)	Yes (Windows, MacOS)
Inbox cables/accessories	1 x DP (1.8m), 1 x HDMI (1.8m), 1 x USB 3.0 1 x Thunderbolt 3 (2m)	1 x HDMI, 1 x Thunderbolt 3	1 x HDMI 2.0, 1 x mDP to DP, 1 x USB 3.0, 1 x Thunderbolt 3
PiP/PbP	Yes/Yes	Yes/Yes	Yes/Yes
Daisy Chain availability	Yes	Yes	Yes

	Dell U2723QE	Competitor E (27" IPS)	Competitor F (27" IPS)	Competitor G (28" IPS)
Size (in inches)	27"	27"	27"	28"
Size (in cm)	68.50 cm	68.58 cm	68.58 cm	71.12 cm
Aspect Ratio	16:9	16:9	16:9	16:9
Internal Lookup Table (LUT)	No	No	No	No
Resolution	3840 x 2160	3840 x 2160	3840 x 2160	3840 x 2160
Viewing Angle (Horizontal/Vertical)	178°/178°	178° / 178°	178° / 178°	178° / 178°
Panel Technology	In Plane Switching (IPS)	In Plane Switching (IPS)	In Plane Switching (IPS)	In Plane Switching (IPS)
Brightness (typical)/(peak)	400 cd/m² (Typical)	400 cd/m² (Typical)	250 cd/m² (Typical)	300 cd/m² (Typical)
Color Space	98% DCI-P3, 100% sRGB, 100% Rec.709	95% DCI-P3	95% DCI-P3, 100% sRGB, 100% Rec.709	90 DCI-P3, 100% sRGB,
Color Depth	1.07 Billion	1.07 Billion	1.07 Billion	1.07 Billion
Pixel Per Inch	163	163	163	157
Panel-bits	10Bits (8Bits + FRC)	10Bits (8Bits + FRC)	10Bits (8Bits + FRC)	10Bits (8Bits + FRC)
Contrast Ratio	2000:1 (Typical)	1200:1	1200:1	1000:1 (Typical), 3M:1 (Dynamic)
Panel Response Time	8ms (Normal), 5ms (Fast) (GTG)	5ms (Fast) (GTG)	5ms (Fast) (GTG)	6ms (Normal), 4ms (Fast)
Variable Sync	No	Yes, AMD FreeSync	No	No
Refresh Rate	60Hz	60Hz	60Hz	60Hz
Bezel	Infinity Edge Bezel	3-sided Narrow Bezel	4-sided Narrow Bezel	3-sided Narrow Bezel
Curved/Flat	Flat	Flat	Flat	Flat
HDR	DisplayHDR 400	DisplayHDR 400	DisplayHDR 400	DisplayHDR 400
Panel Backlight Technology	LED	LED	LED	WLED
Low Blue Light (Software /	Yes, Hardware Low Blue Light	Yes, Software Low Blue Light	Yes, Software Low Blue Light	Yes, Software Low Blue Light
Flicker Free	Yes	Yes	Yes	No
Energy Star	Yes, ES 8.0	No	No	Yes, ES 8.0
USB Hub	5 x USB 3.2 Gen2 Downstream (10Gbps, 1xBC 1.2 charging)	2 x USB 3.0 Downstream (5Gbps)	1 x USB 3.1 Gen1 Upstream (USB-B), 2 x USB 3.1 Gen1 Downstream (5Gbps)	No
VGA	No	No	No	No
DisplayPort	DP 1.4 (DSC)	1 x DP 1.4	1 x DP 1.4	1 x DP 1.2
DisplayPort Out	DP out (DSC)	No	No	No
HDMI	1 x HDMI 2.0	2 x HDMI 2.0	2 x HDMI 2.0	1 x HDMI 2.0
USB-C	1 x USB-C 3.2 Upstream (DSC, DP 1.4 Alt Mode, PD 90W, 2/4 lane switch), 1 x USB-C 3.2 Upstream (Data only), 1 x USB-C 3.2 Downstream (PD 15W)	1 x USB-C 3.2 Upstream (DP 1.4 Alt Mode, PD 96W)	-	-
RJ45 Port	1 x RJ45 (Up to 1 Gbps, PXE Boot, MAC Address Pass-Through, Wake-on-LAN)	No	No	No
Thunderbolt	No	No	1 x Thunderbolt™ 3.0 Upstream (PD 65W) , 1 x Thunderbolt™ 3.0 Downstream (PD 15W)	No
DVI-D	No	No	No	No
mini DisplayPort	No	No	No	No
Audio Line-In	No	No	No	No
Audio Line-Out /Headphone	1 x 3.5 mm Audio Out	1 x 3.5 mm Audio Out	1 x 3.5 mm Audio Out	1 x 3.5 mm Audio Out
Height Adjustability	Yes, 150mm	Yes, 110mm	Yes, 150mm	No
Pivot and Swivel	Yes/Yes. Pivot : 90° clockwise & 90° counter-clockwise, Swivel : 60° left & 60° right	Yes/No. Pivot : 90° clockwise & 90° counter-clockwise, Swivel : No	Yes/Yes. Pivot : 90° clockwise & 90° counter-clockwise, Swivel : 30° left & 30° right	No
Tilt	Yes, 5°/21°	Yes, -5°/20°	Yes, -5°/20°	Yes, -5°/22°
Power consumption	26W (Typical), 220W (Max)	44W (Typical), 185W (Max)	44W (Typical), 185W (Max)	31W (Typical), 48W (Max)
Internal/External PSU	Internal	External	Internal	Internal
Internal Speaker	No	2 x 2.5W	2 x 2.5W	No
KVM	Yes, (Auto KVM)	Yes	Yes	Yes
In-Built Microphone	No	No	No	No
In-Built Camera	No	No	No	No
Colorimeter Supported	No	No	No	No
Productivity Software	Dell Display Manager (Windows OS), Dell Display Peripheral Manager (MacOS)	Yes (Windows)	Yes (Windows, MacOS)	Yes (Windows)
Inbox cables/accessories	1 x DP, 1 x USB 3.2 Gen2 A to C, 1 x USB-C	1 x HDMI, 1 x DP, 1 x USB-C	1 x HDMI 2.0, 1 x mDP to DP, 1 x Thunderbolt 3, 1 x USB 3.0	1 x DP (1.8m) (US & Canada), 1 x HDMI
PiP/PbP	Yes/Yes	No/Yes	Yes/Yes	No/No
Daisy Chain availability	Yes (Supports daisy-chaining two 4K monitors with Display Stream Compression, DSC)	No	Yes	No

Appendix B: Actual Measured Luminosity, Color and Contrast Data

	Gamut Coverage (%)		Gamut Volume (%)		DE*76			Contrast	Values In cd/m^2		
	sRGB	DCI P3	sRGB	DCI P3	Avg.	Max	RMS	Ratio	Black Level	50% Level	White Level
Dell U3223QE	100	97.6	152	107.7	.05	.39	.1	1920:1	.0947	39.57	181.78
Dell U3223QZ	100	95.9	150.2	106.4	.06	.59	.12	2048:1	.0944	41.88	193.36
Competitor A (32" IPS)	99.9	97.3	145.2	102.8	0.06	1.2	0.19	1232:1	.1617	43.76	199.15
Competitor B (32" IPS)	99.6	86.2	148.7	105.3	0.17	1.03	.32	1054:1	.1891	43.37	199.37
Competitor C (32" VA)	99.9	90.1	130.9	92.7	.08	.91	.18	2041:1	.0947	43.68	193.3
Competitor D (32" IPS)	99.5	96.1	140.5	99.5	.06	2.02	0.24	757:1	.2427	40.73	183.63

	Gamut Coverage (%)		Gamut Volume (%)		DE*76			Contrast	Values In cd/m^2		
	sRGB	DCI P3	sRGB	DCI P3	Avg.	Max	RMS	Ratio	Black Level	50% Level	White Level
Dell U2723QE	100	97.2	149.6	106	.14	.82	.26	2047:1	.0944	42.17	193.21
Competitor E (27" IPS)	99.9	95.7	149.4	105.8	.1	2.99	.33	1078:1	.1751	41.71	188.73
Competitor F (27" IPS)	98.9	87.2	126.8	89.8	.08	2.84	.33	654:1	.2962	42.87	193.84
Competitor G (28" IPS)	96.6	81.7	120.7	85.5	.16	.85	.29	1100:1	.1757	42.16	193.27

* Best Results Highlighted GREEN

Black Levels

32" Panels	0°			45°			80°			30° (v)		
	Lv cd/m^2	x	y	Lv	x	y	Lv	x	y	Lv	x	y
Dell U3223QE	.08990	.2725	.2820	.1179	.3073	.3112	.08361	.3358	.3301	.1132	.2911	.3011
Dell U3223QZ	.09140	.2638	.2786	.1263	.2915	.3022	.08625	.3265	.3257	.1095	.2832	.2978
Competitor A (32" IPS)	.1518	.2559	.2537	.1912	.2682	.2668	.07103	.2837	.2869	.1460	.2688	.2635
Competitor B (32" IPS)	.1836	.2663	.2952	.2004	.2811	.3040	.09850	.2773	.3127	.3409	.3413	.3440
Competitor C (32" VA)	.09543	.2987	.2737	.3013	.2953	.2854	.1449	.3095	.3018	.2776	.3196	.3057
Competitor D (32" IPS)	.2190	.2579	.2566	.2931	.2667	.2699	.1234	.2814	.2865	.2247	.2704	.2679

White Levels

	0°			45°			80°			30° (v)		
	Lv cd/m^2	x	y	Lv	x	y	Lv	x	y	Lv	x	y
Dell U3223QE	190.3	.3190	.3309	132.4	.3198	.3322	13.32	.3106	.3255	136.3	.3252	.3365
Dell U3223QZ	193	.3186	.3289	140.9	.3179	.3280	15.03	.3072	.3212	126.1	.3249	.3337
Competitor A (32" IPS)	200.6	.3147	.3303	151.4	.3216	.3371	10.08	.3179	.3368	130.9	.3150	.3282
Competitor B (32" IPS)	202.4	.3151	.3302	139.3	.3172	.3379	13.48	.3177	.3490	114.5	.3207	.3342
Competitor C (32" VA)	200	.3173	.3312	86.59	.3300	.3476	8.246	.3278	.3823	116	.3248	.3369
Competitor D (32" IPS)	184.8	.374	.3308	134.2	.3285	.3437	7.997	.3335	.3620	125.5	.3140	.3275

Black Levels

27/28" Panels	0°			45°			80°			30° (v)		
	Lv cd/m^2	x	y	Lv	x	y	Lv	x	y	Lv	x	y
Dell U2723QE	.0975	.2786	.2945	.1354	.3163	.3190	.08827	.3287	.3258	.1290	.3017	.3090
Competitor E (27" IPS)	.1713	.2592	.2526	.3317	.3382	.3281	.08748	.3010	.2783	.1690	.2578	.2482
Competitor F (27" IPS)	.2242	.2489	.2520	.2553	.2639	.2537	.09786	.2808	.2683	.2034	.2587	.2593
Competitor G (28" IPS)	.1644	.2707	.2815	.2873	.3296	.3324	.08229	.3224	.3317	.1575	.2857	.2963

White Levels

	0°			45°			80°			30° (v)		
	Lv cd/m^2	x	y	Lv	x	y	Lv	x	y	Lv	x	y
Dell U2723QE	188.9	.3200	.3309	134.6	.3216	.3308	11.78	.3120	.3215	151.4	.3220	.3308
Competitor E (27" IPS)	191	.3118	.3242	131.8	.3206	.3352	11.95	.3189	.3279	126.4	.3140	.3324
Competitor F (27" IPS)	199	.3152	.3348	133.8	.3289	.3405	9.235	.3391	.3325	134	.3103	.3269
Competitor G (28" IPS)	192.2	.3147	.3339	126.5	.3243	.3387	10.32	.3354	.3489	114.2	.3136	.3308

Off-Axis Actual Measured Contrast Ratios

	0°	45°	80°	30°(v)
Dell U3223QE	2116.8	1123.0	159.3	1204.1
Dell U3223QZ	2111.6	1115.6	174.3	1151.6
Competitor A (32" IPS)	1321.5	791.8	141.9	896.6
Competitor B (32" IPS)	1102.4	695.1	136.9	335.9
Competitor C (32" VA)	2095.8	287.4	56.9	417.9
Competitor D (32" IPS)	843.8	457.9	64.8	558.5

	0°	45°	80°	30°(v)
Dell U2723QE	1937.4	994.1	133.5	1173.6
Competitor E (27" IPS)	1115.0	397.3	136.6	747.9
Competitor F (27" IPS)	887.6	524.1	94.4	658.8
Competitor G (28" IPS)	1169.1	440.3	125.4	725.1

* All monitors warmed up and pre-conditioned for 30 minutes before testing.
** ~0 lux ambient lighting, 68°F climate controlled space.

Low Grey Delta E*00 Comparisons

R	G	B		DELL U3223QE	DELL U3223QZ	DELL U2723QE	Competitor A	Competitor B	Competitor C	Competitor D	Competitor E	Competitor F	Competitor G
0	0	0		0.44	0.5	0.48	0.97	0.96	0.37	1.47	1.18	1.79	0.68
13	13	13		0.5	0.08	0.28	0.92	0.7	0.46	0.8	0.43	0.74	0.77
26	26	26		0.29	0.34	0.14	0.51	0.44	0.4	0.21	0.68	0.21	0.6
38	38	38		0.28	0.46	0.38	0.35	0.55	0.46	0.14	0.75	0.26	0.52
51	51	51		0.15	0.24	0.78	0.18	0.57	0.35	0.18	0.26	0.28	0.53
64	64	64		0.28	0.46	0.63	0.29	0.6	0.82	0.18	0.18	0.29	0.54
			Average	0.32	0.35	0.45	0.54	0.64	0.48	0.50	0.58	0.60	0.61

IPS Black vs. Standard IPS

Black Levels		Constrast Ratios 45° (Horizontal)		Accuracy (AVG Delta E*76)	
Dell U3223QZ	Competitor A	Dell U3223QZ	Competitor A	Dell U3223QZ	Competitors A, D
0.0944	0.1617	1115.6	791.8	0.06	0.06
41.62 % Better		40.89 % Better		0.00 % Better	
1.42 X Better		1.41 X Better		1.00 X Better	

Black Levels		Constrast Ratios 45° (Horizontal)		Accuracy (AVG Delta E*76)	
Dell U3223QE	Competitor A	Dell U3223QE	Competitor A	Dell U3223QE	Competitors A, D
0.0947	0.1617	1123	791.8	0.05	0.06
41.43 % Better		41.83 % Better		16.67 % Better	
1.41 X Better		1.42 X Better		1.17 X Better	

Black Levels		Constrast Ratios 45° (Horizontal)		Accuracy (AVG Delta E*76)	
Dell U2723QE	Competitor A	Dell U2723QE	Competitor A	Dell U2723QE	Competitors A, D
0.0944	0.1617	994.1	791.8	0.14	0.06
41.62 % Better		25.55 % Better		-57.14 % Better	
1.42 X Better		1.26 X Better		-2.33 X Better	

IPS Black vs. VA

Black Levels		Constrast Ratios 45° (Horizontal)		Accuracy (AVG Delta E*76)	
Dell U3223QZ	Competitor C	Dell U3223QZ	Competitor C	Dell U3223QZ	Competitor C
0.0944	0.0947	1115.6	287.4	0.06	0.08
0.32 % Better		288.17 % Better		25.00 % Better	
1.00 X Better		3.88 X Better		1.25 X Better	

Black Levels		Constrast Ratios 45° (Horizontal)		Accuracy (AVG Delta E*76)	
Dell U3223QE	Competitor C	Dell U3223QE	Competitor C	Dell U3223QE	Competitor C
0.0947	0.0947	1123	287.4	0.05	0.08
0.00 % Better		290.74 % Better		37.50 % Better	
1.00 X Better		3.91 X Better		1.38 X Better	

Black Levels		Constrast Ratios 45° (Horizontal)		Accuracy (AVG Delta E*76)	
Dell U2723QE	Competitor C	Dell U2723QE	Competitor C	Dell U2723QE	Competitor C
0.0944	0.0947	994.1	287.4	0.14	0.08
0.32 % Better		245.89 % Better		-42.86 % Better	
1.00 X Better		3.46 X Better		-1.75 X Better	

IPS Black vs. IPS (27")

Black Levels		Constrast Ratios 45° (Horizontal)	
Dell U2723QE	Competitor E	Dell U2723QE	Competitor F
0.0944	0.1751	994.1	524.1
46.09 % Better		89.68 % Better	
1.85 X Better		1.90 X Better	

IPS Black vs. Standard IPS (45° Horizontal)

Black Levels 45° (Horizontal)	
Dell U3223QZ	Competitor A (32")
0.1263	0.1912
33.94 % Better	
1.34 X Better	

Black Levels 45° (Horizontal)	
Dell U3223QE	Competitor A (32")
0.1179	0.1912
38.34 % Better	
1.38 X Better	

Black Levels 45° (Horizontal)	
Dell U2723QE	Competitor A (32")
0.1354	0.1912
29.18 % Better	
1.29 X Better	

Black Levels 45° (Horizontal)	
Dell U2723QE	Competitor F (27")
0.1354	0.2553
46.96 % Better	
1.47 X Better	

IPS Black vs. VA (45° Horizontal)

Black Levels 45° (Horizontal)	
Dell U3223QZ	Competitor C (32" VA)
0.1263	0.3013
58.08 % Better	
1.58 X Better	

Black Levels 45° (Horizontal)	
Dell U3223QE	Competitor C (32" VA)
0.1179	0.3013
60.87 % Better	
1.61 X Better	

Black Levels 45° (Horizontal)	
Dell U2723QE	Competitor C (32" VA)
0.1354	0.3013
55.06 % Better	
1.55 X Better	

Install & Access	Monitor Configuration		Multi-tasking		Asset Manageability (ITDMs)	

Install & Access	Dell Display Manager Dell Display Peripheral Manager (macOS)	Competitor A Utility	Competitor B Utility	Competitor C Utility	Competitor E Utility	Competitor F Utility
Ease of Setup	★★★	★★★	★★★	★★★	★★★	★★★
OS Compatibility	Windows, MAC (Win 7,8,8.1,10,11)	Windows (Win 10,11)	Windows (Win 10,11)	Windows (Win 7,8,8.1,10)	Windows, MAC (Win 10,11)	Windows, MAC (Win 10,11)
Software Update	Yes	Yes	Yes	No	Yes	Yes
Supported Language	11 Languages	1 Language	33 Languages	14 Languages	22 Languages	1 Language
Hot Keys for UI	Yes	No	Yes	No	No	Yes
Set Shortcut Key	Yes	No	Yes	No	No	No

Monitor Configuration

	Dell Display Manager / DDPM (macOS)	Competitor A Utility	Competitor B Utility	Competitor C Utility	Competitor E Utility	Competitor F Utility
Brightness, Contrast, Resolution	Yes, Yes, Yes (via Windows)	Yes, Yes, Yes	Yes, Yes, Yes	No, No, No	Yes, Yes, Yes	No, Yes, Yes
Low Blue Light	Yes	Yes	Yes	No	No	Yes
Portrait Mode (Auto Rotation)	Yes	Yes (No auto rotation)	Yes (No auto rotation)	No	Yes (No auto rotation)	Yes (Auto rotation on selected models)
Application Preset	Yes	Yes	Yes	No	Yes	Yes
Auto Restore	Yes	Yes	No	No	No	No
Matrix Control (change of brightness/contrast/color preset for all connected monitors)	Yes	No	Yes	No	No	No
Color Calibration	No	Yes (Visual Based)	Yes (Visual Based)	No	No	Yes (ICCsync)
Webcam & Audio Settings Adjustment	Yes (Webcam)*	Yes	Yes	No	No	No

Multi-tasking

	Dell Display Manager / DDPM (macOS)	Competitor A Utility	Competitor B Utility	Competitor C Utility	Competitor E Utility	Competitor F Utility
Number of Screen Layouts	38	35	10	11	10	11
Number of Screen Split	Up to 48	0	0	0	Up To 8	0
Customized Partition	Yes (Up to 5)	Yes (Unlimited)	Yes	Yes	No	Yes
KVM Wizard, File Transfer	Yes, No	No, No	Yes, No	No, No	No, No (Separate SW - Dual Controller)	No, No
Picture-In-Picture & Picture-By-Picture	Yes	No	Yes	PIP only	No	Yes
Picture-By-Picture w Auto-Switch (50:50 screen split)	Yes	No	Yes	No	No	No
Multi-Monitor Control	Yes (Up to 16 monitors Span Control)	No	Yes	No	No	No

Asset Manageability

	Dell Display Manager / DDPM (macOS)	Competitor A Utility	Competitor B Utility	Competitor C Utility	Competitor E Utility	Competitor F Utility
Power Setting	Yes	Yes	Yes	No	No	No
Remote Control	Yes (Comprehensive Remote Control Functions)	No (Separate SW)	Yes	No	No	No
Asset Management	Yes (Comprehensive Asset Details)	No (Separate SW)	Yes	No	No	No
Security	No	Theft Deterrence	No	No	No	No
Support other OEM Brand Monitors	No	Yes	No	No	No	No
Update Firmware	No	No (Separate SW)	Yes	No	No	No

* For Dell Display Peripheral Manager (DDPM macOS) with Dell U3223QZ and Dell WB7022 only.

DELL U3223QE

DELL U3223QZ

COMPETITOR A (32" IPS)

COMPETITOR B (32" IPS)

COMPETITOR C (32" VA)

COMPETITOR D (32" IPS)

DELL U2723QE

COMPETITOR E (27" IPS)

COMPETITOR F (27" IPS)

COMPETITOR G (28" IPS)

DELL U3223QE

DELL U3223QZ

COMPETITOR A (32" IPS)

COMPETITOR B (32" IPS)

COMPETITOR C (32" VA)

COMPETITOR D (32" IPS)

DELL U2723QE

COMPETITOR E (27" IPS)

COMPETITOR F (27" IPS)

COMPETITOR G (28" IPS)

DELL U3223QE

DELL U3223QZ

COMPETITOR A (32" IPS)

COMPETITOR B (32" IPS)

COMPETITOR C (32" VA)

COMPETITOR D (32" IPS)

DELL U2723QE

COMPETITOR E (27" IPS)

COMPETITOR F (27" IPS)

COMPETITOR G (28" IPS)

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