Flanders Scientific Inc.

XMP550 Professional QD-OLED Display

Technical Overview v2

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The XMP550 is a 55” UHD resolution QD-OLED monitor designed for professional HDR and SDR mastering environments. To create something of this size that meets the requirements for HDR program mastering is a unique challenge that has been met with 3 specific design elements:

- The QD-OLED panel itself
- The professional I/O interface
- A Color Management System equipped with Direct Connect Volumetric AutoCal

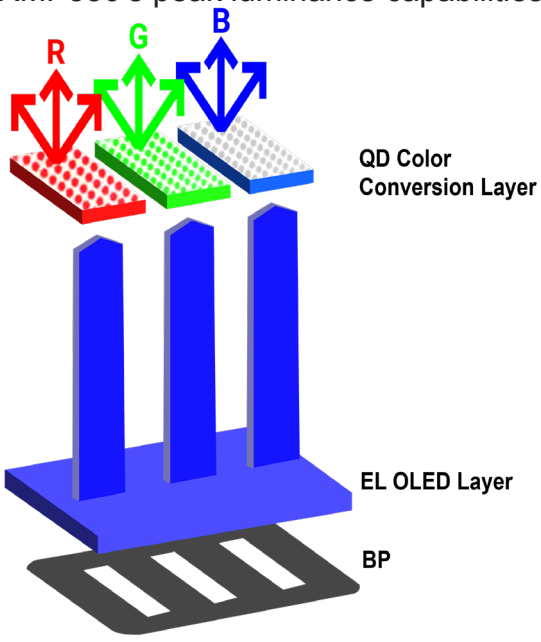
This document provides a technical overview of these three design elements.

QD-OLED Panel

The QD-OLED panel used in the XMP550 has been designed to meet 6 critical benchmarks for the professional large format HDR monitoring viewing environment:

- First, it gets bright enough with a peak luminance around 2000nits. This provides ample headroom for creating 1000nit HDR masters, even as the panel ages over years of use.
- Second, it has a very wide color gamut allowing for full P3 coverage and over 90% coverage of Rec2020.
- Third, it exhibits off-axis viewing characteristics that allow clients sitting off-axis of the display to reliably see the same image as the colorist.
- Fourth, it is truly RGB additive for White ensuring consistent color reproduction through the entire target display volume.
- Fifth, it has exceptional lowlight response providing accurate and smooth progression from black to lowlight levels just above black.
- Sixth, it offers per-pixel light output control for high contrast, artifact free HDR image production.

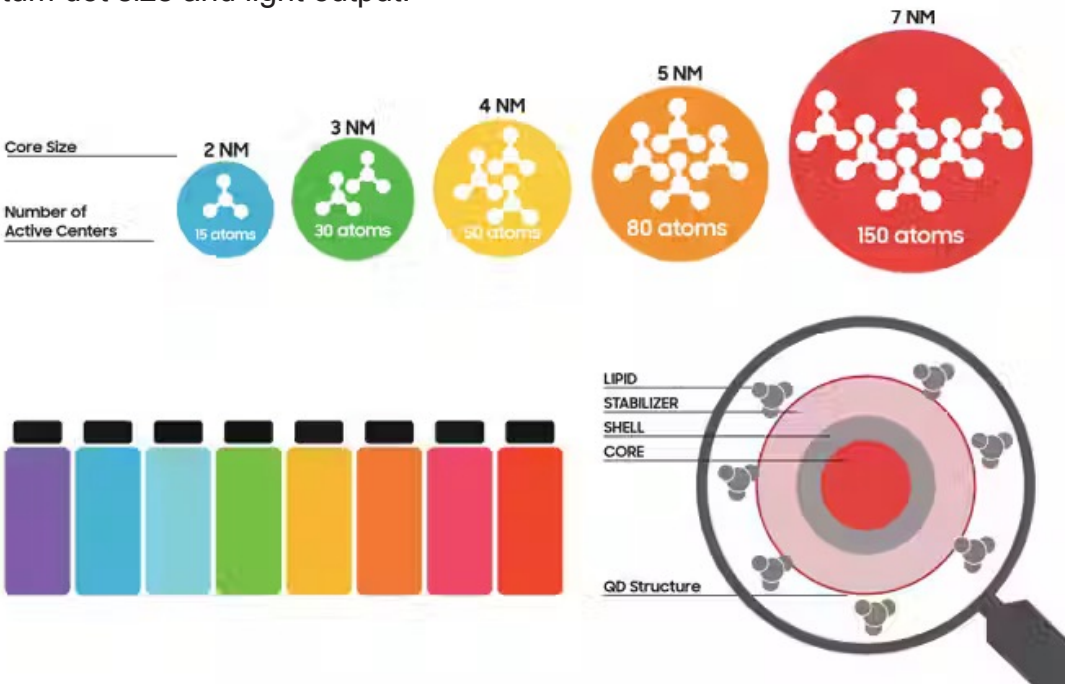
The principle of operation behind the QD-OLED panel and the major contributing factor to the XMP550’s peak luminance capabilities is the combination of a hyper efficient electroluminescent OLED layer with a quantum dot color conversion layer.

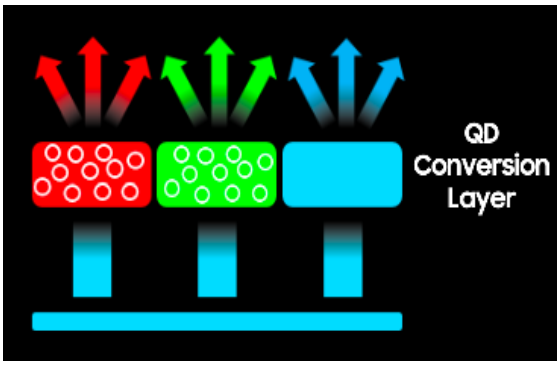


Each subpixel of the QD-OLED panel starts with an electroluminescent (EL) OLED material producing blue light. This blue light then interacts with a quantum dot color conversion layer that absorbs the blue light and then emits red and green light for red and green subpixels respectively. Blue itself is a pass through at this layer with no color conversion required. The blue EL material is made with a heavy hydrogen isotope, deuterium, that provides for extended lifespan and greater light output than alternative OLED materials.

The quantum dot layer is comprised of inorganic nanocrystals providing for stable and consistent light output. The principle and namesake of quantum dot operation is that the size of these nanocrystals determines the discrete, or quantized, wavelengths of light they can absorb and re-emit.

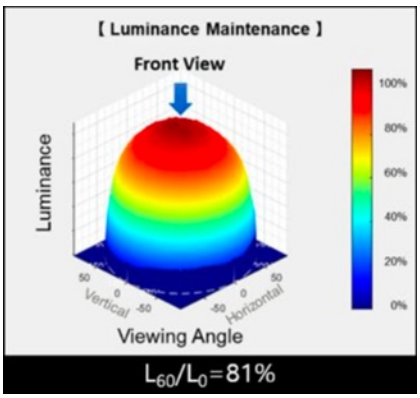
The size of the quantum dots is what determines their specific peak wavelength outputs allowing for the desired primaries of the QD-OLED panel to be finely tuned. As a result the XMP550 not only has a high peak luminance capability, it also has the widest color gamut in FSI's current product portfolio with over 90% coverage of Rec2020 gamut. The illustration below helps to explain the relationship between quantum dot size and light output.





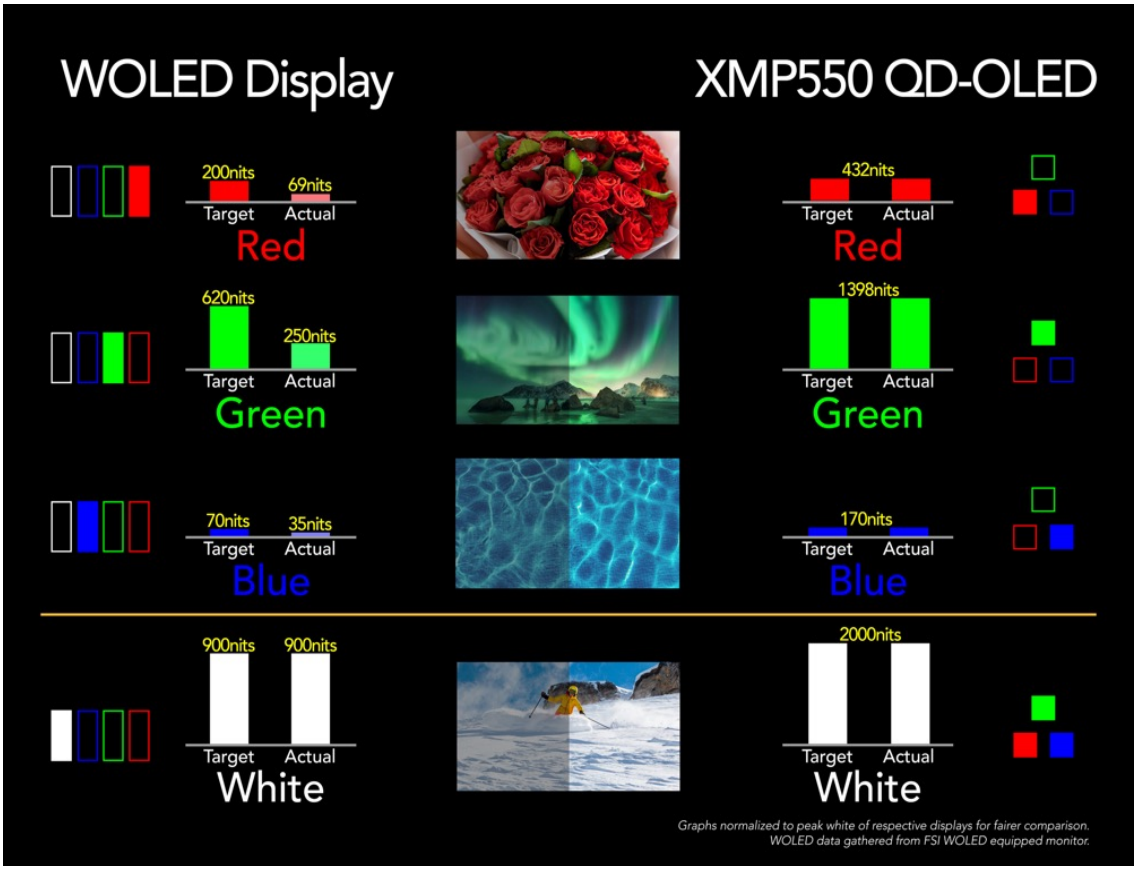
An important consideration for large format reference displays is the degree to which clients sitting off-axis of the display are seeing the same image that a colorist sitting on-axis to the display sees. The QD-OLED panel in the XMP550 is a top emission technology. The Oxide Backplane that drives the EL OLED material sits underneath the EL Layer and the emissive QD layer is one of the final layers in the panel stack. The QD-OLED light energy emitted by the panel is also dome shaped or lambertian in nature. This ensures very wide viewing angles with minimal color deviation or luminance loss off-axis.

At 60 degrees off-axis the XMP550 retains over 80% of the luminance found on-axis of the display. To put this in proper context this compares to about 55% luminance retention at 60 degrees off-axis found on previous FSI large format OLEDs, which themselves already outperformed LCD based solutions in terms of off-axis luminance retention. Additionally, the XMP550 exhibits less than 0.006 delta u', v' color shift at 60 degrees off-axis compared to previous generations of large format OLEDs with approximately double the amount of color shift at closer to 0.012 delta u', v' at 60 degrees off-axis.



images on this page courtesy of SDC

The XMP550 is truly RGB additive for white allowing it to produce color accurately even in HDR use cases. This is an important distinction from previous generations of large format OLEDs from FSI that were suggested only for SDR, not HDR, mastering as they utilized WOLED panels that were non-additive for white leading to volumetric collapse in HDR. WOLEDs could attain relatively high luminance peak white, but any non-white bright color output targets were either produced too dimly or were necessarily desaturated when attempting to reproduce HDR display volumes on screen. The XMP550's QD-OLED panel eliminates this limitation by being truly RGB additive for white. A comparison of the previous generation's WOLED equipped models with this generation of QD-OLED equipped display is shown below.



While almost all OLED technologies do feature a very dark black level a common challenge with some OLED technology is progressing smoothly and accurately out of black. Many OLEDs exhibit a black crush and/or black jump behavior that causes poor shadow detail reproduction. This typically manifests as a large number of low-range code values being measurably clipped and then suddenly seeing a large luminance jump at some arbitrary number of code values well over black. By contrast the XMP550 comes out of black very subtly and accurately for excellent lowlight reproduction.

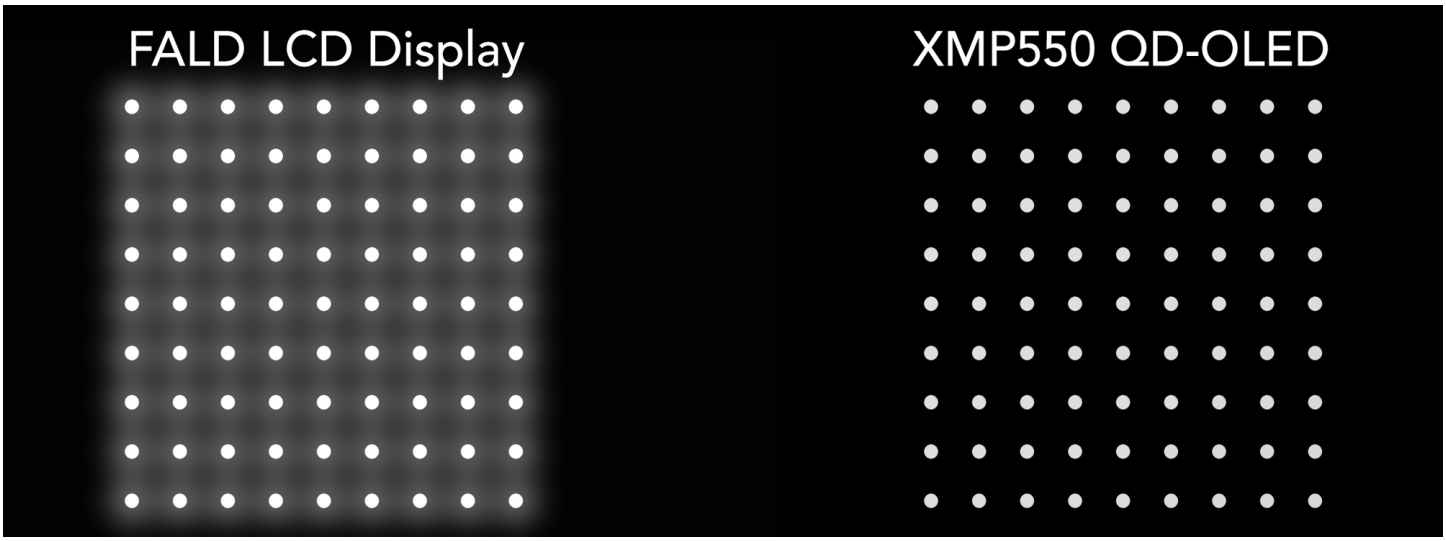
XMP550 **OLED with Black Clipping Issue**

The XMP550's QD-OLED panel is an emissive technology with accurate per-pixel luminance control, giving it a significant performance advantage over both full array local dimming (FALD) and global dimming LCD based solutions.

FALD LCDs typically have to contend with at least 4 core issues caused by their zoned and modulated backlight design:

- Highlight detail that is obscured due to backlight zone flaring.
- Shadow detail and black levels compromised due to halation.
- Color shift or flicker with fast moving bright objects.
- Scene cut anomalies that can result from differential rise/fall times of LED backlight phosphors.

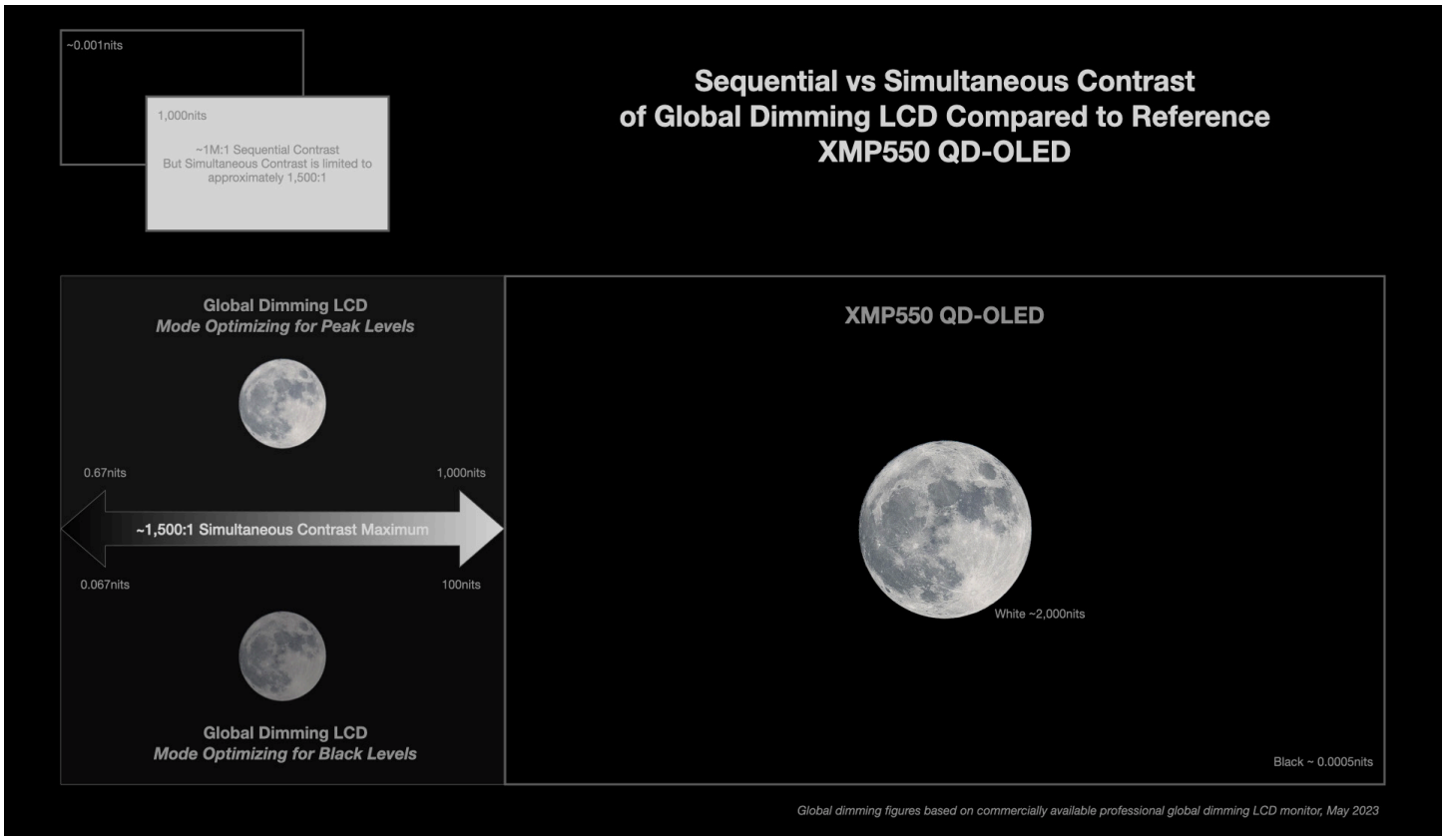
While the amount of halation can vary greatly between FALD LCDs, all FALD systems will show at least some degree of raised black levels and haloing when rendering a high contrast image like the example below of a white circles on a black background graphic. The XMP550's QD-OLED panel on the other hand can render these types of very bright highlights while maintaining the intended deep black background.



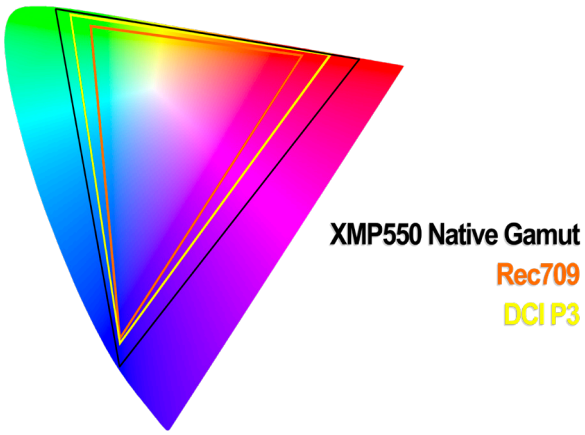
FALD LCD were a necessary compromise for some time as they were one of the few methods of creating 1000nit+ HDR displays, but contending with these artifacts always proved challenging for operators as it took a lot of experience to know what was native to the image vs. simply a display artifact. The XMP550's QD-OLED panel resolves this compromise and provides true black levels at all times with none of the small bright objection or motion artifact limitations found on FALD LCDs.

Reference grade HDR displays should be able to produce high simultaneous contrast, not just a bright image. Global dimming LCDs can either produce a bright image or a dark image, but cannot produce images that simultaneously have bright highlights and dark lowlights. Global dimming LCD specifications often quote high sequential contrast ratio figures, where a display's peak luminance and black level are measured at different times, but this can be quite misleading as simultaneous contrast is problematically low on these devices for any HDR content mastering use-cases. The XMP550

features class leading simultaneous contrast rendering both bright highlights and dark lowlights with incredible clarity and accuracy at the same time.



XMP550 panel specifications:
Resolution: 3840x2160
Peak luminance: ~2000nits @L20, ~1300nits @L32
Black level: ~0.0005nits
Contrast Ratio: ~4,000,000:1
Bit Depth: 10bit (1.073Billion Colors)
Reflectance: 1.1% SCI (specular component included)



Professional Connectivity

To facilitate high quality connectivity in the professional grading suite the XMP550 is equipped with 4 multi-rate 12Gbps SDI inputs that each support single link 12Gbps SDI, 6Gbps SDI, 3Gbps SDI, and 1.5Gbps SDI signals. Additionally, these inputs can be combined for support of Dual-Link 6Gbps SDI, Dual-Link 3Gbps SDI, or Dual-Link 1.5Gbps SDI. Quad-Link 3Gbps SDI and Quad Link 1.5Gbps SDI are also supported.

Each of these SDI inputs also has a dedicated matching reclocked multi-rate SDI output allowing for clean loop through of any input signal.

In addition to the 4 clean loop outputs the XMP550 is also equipped with 4 processed multi-rate SDI monitor outputs. These processed outputs can be configured in a number of useful ways to accomplish a variety of unique tasks. One such capability is providing a downscaled 1/4 resolution output of a 4K or UHD input to 2K or HD output. This allows an operator to send 4K or UHD to the XMP550 and then receive 2K or HD out of the device that can then be sent downstream to equipment such as HD monitors or scopes that may not natively support 4K or UHD. The processed monitor output can also be used to mirror some on-screen capabilities such as look LUTs so that a look LUT could be applied on the XMP550 and then mirrored to connected downstream devices.

The XMP550 supports 12, 10, and 8bit signals at 4K, UHD, 2K, and HD resolutions. 4:2:0, 4:2:2, and 4:4:4 YCbCr in addition to 4:4:4 RGB and XYZ signals are all supported to provide robust signal handling for just about all professional SDI signal formats.

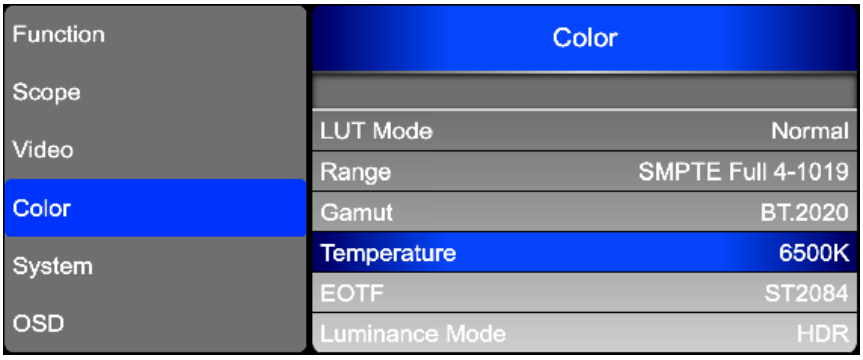
XMP550 Signal Support

SMPTE-274M	1080i (60/59.94/50) 1080p (30/29.97/25/24/24PsF/23.98/23.98PsF)
SMPTE-296M	720p (60/59.94/50/30/29/25/24/23.98)
2K	2048x1080 (30p/30PsF/29.97p/29.97PsF/25p/25PsF/24p/24PsF/23.98p/23.98PsF)
SMPTE-372M	1080p (60/59.94/50) 4:2:2 YCbCr, RGB 1080i (29.97/25/24/23.98) 4:4:4 YCbCr, RGB 1080p (30/29.97/25/24/23.98) 4:4:4 YCbCr, RGB 720p (60/59.94/50) 4:4:4 YCbCr, RGB
SMPTE-425M-AB	12 & 10bit 4:2:2 1920x1080p (60/59.94/50) 4:4:4 1280x720p (60/59.94/50/30/29.97/25/24/23.98) 12 & 10bit 4:4:4 1920x1080i (60/59.94/50) 12 & 10bit 4:4:4 1920x1080p (30/29.97/25/24/23.98 + PsF variations) 12 & 10bit 2k (2048x1080)p (30/29.97/25/24/23.98 + PsF variations) 12 & 10bit 2K (2048x1080)p (60/59.94/50/48/47.95) *XYZ mapped to Selected Color Gamut on Color Management Menu
ST2081 & ST2082 4K & UHD Single-Link 12G Single-Link 6G Dual-Link 6G Dual-Link 3G Square Division Quad-Link 3G Level A Square Division Quad-Link 3G Level B Square Division Quad-Link 1.5G Square Division	10 & 8bit 4:2:2 4096x2160p (60/59.94/50/48/47.95/30/29.97/25/24/23.98) 10 & 8bit 4:2:2 3840x2160p (60/59.94/50/48/47.95/30/29.97/25/24/23.98) 12 & 10bit 4:4:4 4096x2160p (30/29.97/25/23/23.98) YCbCr & RGB 12 & 10bit 4:4:4 3840x2160p (30/29.97/25/23/23.98) YCbCr & RGB

Color Management & GaiaColor™ Direct Connect Volumetric AutoCal

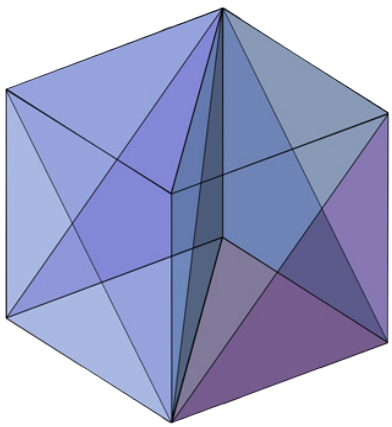
The core of the XMP550's color management system is the proprietary Direct Connect Volumetric AutoCal, which allows operators to simply plug a compatible probe directly into the XMP550 to perform calibration. Just a probe and the monitor are needed, no standalone computer is necessary.

AutoCal works by measuring the native uncalibrated state of the panel and saving this data to the XMP550's non-volatile memory. This is a volumetric capture of the display's native state, not just a simple white balance capture or adjustment. After profiling is complete a user can select any combined settings of Gamut, EOTF, and white point and 3D and 1D LUTs will then be generated on the fly by the display using the saved native profile data. These calibration LUTs are then automatically saved to the display for instant future recall. Calibration LUTs for any selection need only be generated by the display the first time a particular selection is made. AutoCal operates this way as there are thousands of potential settings combinations and it would be inefficient to calculate and store LUTs for combinations the operator may never use. However, if any new unique combination of color management settings is desired the display does not have be re-profiled. The new calibration state is simply calculated from the last saved native profile data, on demand, whenever needed.



AutoCal supports a wide variety of colorimeters and spectroradiometers. When using a colorimeter AutoCal will select and use the matrix stored on the probe's flash memory that matches the monitor name. This allows the correct display specific matrix to be stored on the colorimeter and for the XMP550 to use this correct matrix so that the calibration uses highly accurate measurement data. This is a fundamental part of the AutoCal system that ensures that when colorimeters are used they still provide measurement data that would match what a more light source agnostic spectroradiometer would measure.

AutoCal has been designed to address the otherwise complex task of display calibration by making it a process that has fewer points of potential failure and requires far less expertise than traditional calibration approaches. A user will simply plug in a probe, position it at the center of the screen, and then from the Color Management Menu on the monitor instruct the display to start the AutoCal process. However, in addition to the AutoCal capability the XMP550 does maintain a very open calibration architecture that also supports highly customized expert calibration. Any end user or 3rd party program that generates 1D and 3D LUTs in an FSI compatible calibration LUT format can save these LUTs to dedicated 3rd party memory slots. This facilitates highly customized calibration where any custom white point, EOTF, or gamut can be loaded to the display by an end user. All LUTs are also processed using tetrahedral LUT interpolation to ensure smooth grey



scale axis reproduction and high overall color accuracy.

In addition to this 3rd party LUT upload support the XMP550 is also equipped with very familiar manual adjustments including gain, bias, luminance, brightness, and contrast toggles allowing for very fast manual tweaks to display setup.

Further Technical Inquiries

We hope this overview has provided some technical background on how the combination of high performance QD-OLED panel, professional I/O interface, and highly accurate and flexible Color Management system allow the XMP550 to meet the requirements of a primary reference display in HDR program mastering environments, but we also welcome any additional questions or feedback you may have about this display. Please send any inquiries to XMP550@FlandersScientific.com.