White Paper:

Requirements for Medical Display

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Requirements for Medical Display

INTRODUCTION

Medical imaging involves the use of technologies such as x-ray, ultrasound, magnetic resonance imaging (MRI), and computed tomography (CT) to visualize patients' physical and functional attributes for diagnostic and treatment purposes. Because clear and consistent images are crucial to making accurate diagnoses and identifying the best options for treatment, image quality must be strictly controlled. Previously, with the use of hard-copy film, the quality of medical images was controlled during image exposure and development. However, with the recent switch to digital imaging systems, image quality is largely dependent on the characteristics of the electronic displays. Although commercial off-the-shelf displays offer some of the capabilities of medical-grade systems, and often cost less, medical displays are purpose-built solutions that provide enhancements in viewing angle, longevity, luminance, and noise reduction to ensure substantially superior accuracy and effectiveness.

PRACTICAL REQUIREMENTS FOR MEDICAL IMAGING APPLICATIONS

Requirement 1: Sufficient Luminance

The majority of displays used for medical imaging are liquid crystal displays (LCDs) backlit with either cold-cathode fluorescent lamps (CCFLs) or light-emitting diodes (LEDs). The maximum luminance capacity of an LCD is determined by the backlight system. Luminance is an important consideration because of its negative impact on diagnostic accuracy. If a display is too dim, the difference between shades of gray may be lost. Because radiology images contain up to 256 shades of gray that must be distinguishable to the human eye, displays used for medical imaging applications must offer sufficient luminance to create 256 visually perceptible shades of gray.

In addition to high luminance, medical displays must be capable of achieving the correct brightness output immediately and maintaining desirable luminance over time. Luminance stabilization typically relies on sensors that monitor backlight output and a feedback circuit that modulates the backlight voltage. Without this capability, displays can require up to 15 minutes run time from power activation to warm up to acceptable levels for general use and up to 30 minutes run time for reliable image viewing and interpretation.

Requirement 2: Gamma Correction

Gamma is a parameter that describes the nonlinear relationship between the numerical value of a pixel and the luminance output of a display. The purpose of gamma correction is to bridge the difference between linear representations of light intensities and the nonlinear response of the human eye, which is more sensitive to variations in low light than to equal variations in bright light. Because every display device has inherent tone-reproduction characteristics, gamma correction is necessary to compensate for the display's gamma response to nonlinear image encoding. A gamma value of 2.2 provides the closest representation of human light perception, and is the target value specified in the sRGB color space standard.

Although most modern displays, both commercial and medical, have a native gamma approximate to 2.2, to ensure high-quality imaging for accurate diagnosis, medical displays must support gamma correction. Gamma correction is accomplished by forcing the luminance output to obey the gamma relationship and requires a functional transformation performed with a look-up table (LUT). This can be conducted by the graphics hardware or using specific software.

Requirement 3: DICOM Grayscale Compliance

The Digital Imaging and Communications in Medicine (DICOM) 3.14 grayscale standard display function (GSDF) provides a quantitative mechanism for mapping digital image values into a given range of luminance values and is the standard for displaying grayscale medical images. Developed to ensure high fidelity image presentation regardless of imaging modality or display device, the DICOM GSDF curve is also based on how the human visual system perceives luminance and changes in contrast.

For medical imaging, displays must be equipped with luminance stabilization and calibration technology in order to maintain grayscale characteristics that continually conform to DICOM GSDF specifications.

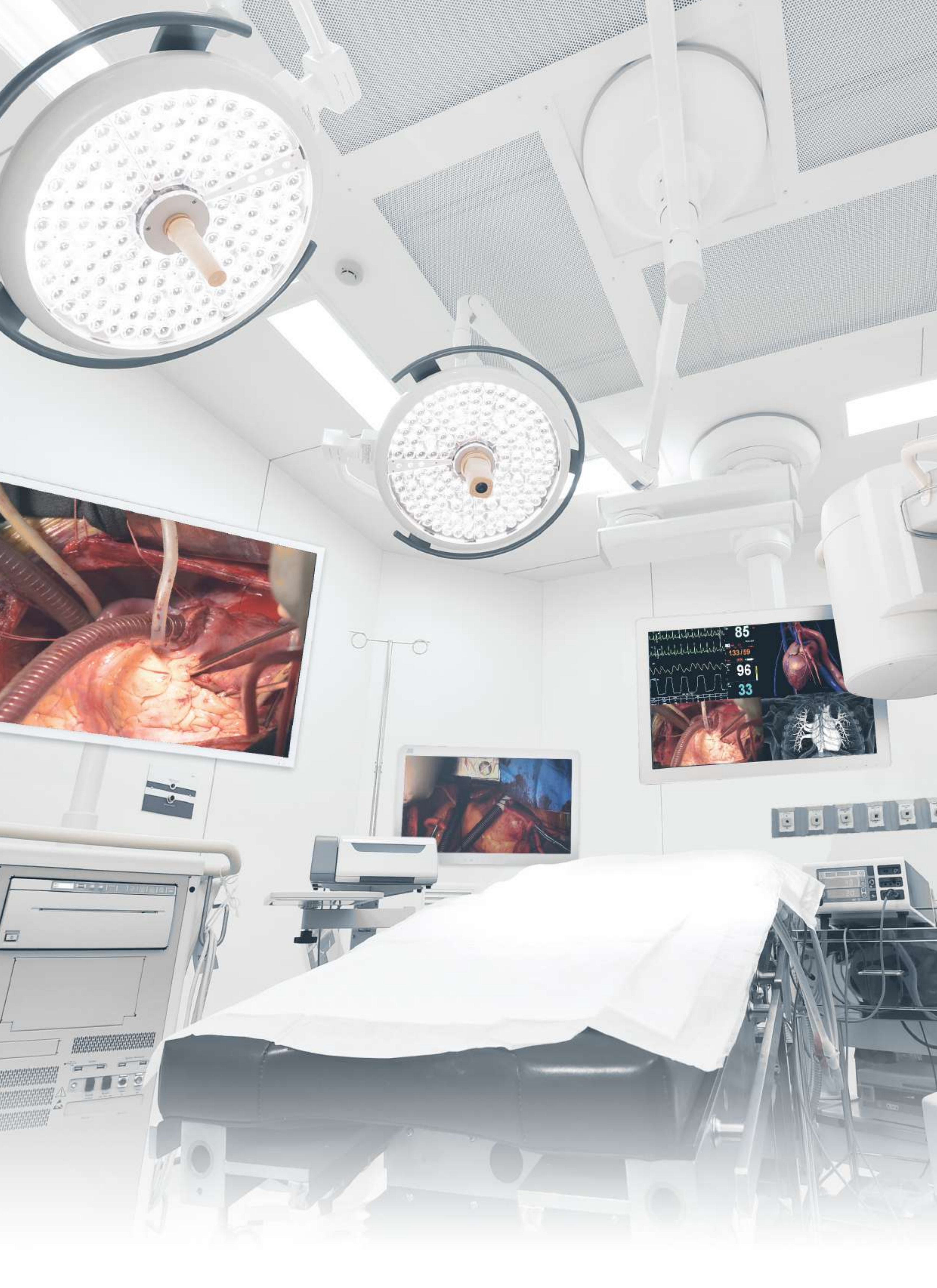
Requirement 4: Compatibility with Legacy Equipment

In today's healthcare facilities, medical devices are no longer operated in isolation. Instead, all medical equipment must be integrated and interconnected to achieve optimal efficiencies. Healthcare providers seek to invest in innovative, cost-effective technology with a long lifecycle that can be integrated with existing networks and devices to not only reduce costs, but also enable rapid deployment with minimal workflow disruption.

Therefore, displays selected for medical use must support legacy interfaces such as VGA and S-Video, as well as modern interfaces such as HDM and DisplayPort to allow input from the widest range of analog and digital equipment. Additionally, medical displays must feature high-capacity ports to facilitate high-capacity data transmissions with minimal latency. This capacity is crucial for presenting 4K resolution images and videos.

Requirement 5: Support for Color and Monochrome Displays

Although medical imaging is still primarily monochrome, color monitors are increasingly employed in diagnostic imaging for the purposes of economy. However, the use of color displays for grayscale imaging applications necessitates testing for consistent and accurate presentation to guarantee the diagnostic value of the displayed grayscale and color images. When color and monochrome images are displayed simultaneously on conventional monitors, both images are presented using the same luminance level and grayscale tones. Monochrome calibration is much simpler to achieve than color calibration. Color displays have a tendency towards color drift, which must be corrected with color calibration. However, most display systems do not have the ability to make fine color adjustments. Additionally, no widely accepted color calibration method or standard currently exists for medical imaging applications.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ADVANTAGES OF MEDICAL DISPLAYS

The operational capabilities of a display can affect the image display quality and thus influence diagnostic imaging. Despite the widespread availability of high-end commercial platforms equipped with premium color monitors, medical display systems feature advanced technologies that offer significant advantages for diagnostic imaging.

Luminance and Contrast

Medical displays offer a maximum luminance of more than 1000 cd/m^2 (similar to that of conventional film) and a contrast ratio of more than 1000:1, which is drastically superior to the 250 ~ 300 cd/m^2 luminance and 300:1 contrast ratio offered by commercial displays. Because ambient light reflected in a monitor screen can compress or “wash out” the darker parts of an image and reduce contrast, making it difficult to distinguish between image levels, a higher luminance range and contrast ratio is necessary to enable a broader spectrum of grayscales that are easily discernable by the human eye. This allows medical professionals to more easily detect subtle lesions and recessed anatomy, thereby accelerating diagnosis.

Another key difference between medical and commercial displays is that medical displays feature a closed-loop control circuit to maintain stable peak luminance from a cold start to thermal stability when fully warmed up.

DICOM and Gamma 2.2

For medical imaging applications, images must be presented with the correct number of gray levels and contrast to facilitate accurate interpretation and diagnosis. The primary effect of gamma on image quality concerns shadow detail and depth. If the gamma is too low, the image will show high shadow detail but the black levels will be noticeably elevated and the image will appear flat and washed out (contrast will be reduced). If gamma is too high, the image will show deep, dark blacks but shadow detail will be compromised. A gamma value of 2.2 provides the optimum color curve to produce true colors without washout or excessive shadow. To effectively conform to relevant industry requirements, medical displays are calibrated to the DICOM 3.14 standard and utilize gamma correction based on a 14-bit LUT to achieve a display gamma of 2.2.

By mapping displays according to the contrast sensitivity of the human eye, gamma correction and DICOM calibration ensure accurate and uniform grayscale and color image rendering across diverse display platforms throughout a hospital network.

Image Consistency

Because medical images are often viewed by multiple medical professionals at different locations on displays with varying configuration, image reproduction must be visually consistent to eliminate interpretation difficulty and ensure diagnostic accuracy. Cross-platform consistency is essential for accurate and reliable clinical perception. Additionally, because display brightness can degrade over time, display calibration tools are necessary for ensuring optimum image quality and compliance with relevant standards.

Medical-grade displays are equipped with several technologies aimed at image accuracy, including uniformity correction and backlight brightness stabilization, to ensure consistent brightness and color across the entire display. For monitoring and adjusting display brightness and backlight levels over time, medical displays are also equipped with sophisticated backlight sensor technology that enables remote quality control checks and calibration. For most commercial displays, the lack of image quality and uniformity control capabilities means luminance can vary by more than 20% within the first several hours after startup and frequent calibration checks are required to maintain DICOM-compliant luminance.

Grayscale Range

The number of available shades of gray on most commercial displays is limited to 256 (8 bit). Medical displays feature a much wider grayscale range (12 ~ 16 bits, 4,096 ~ 65,536 shades of gray) to enable image rendering according to the DICOM GSDF standard. The result is clearer differentiation of visual detail for easier identification of important features, whatever the particular medical application.

Viewing Angle

Liquid crystal display (LCD) panels typically have a limited viewing angle, with perceived luminance, color, and contrast changing significantly when viewed off-axis. For medical imaging applications, because more than one person may view a display simultaneously, a wide viewing angle is necessary for comfortable use and optimum image interpretation performance. Unlike commercial displays that use the less-expensive vertical alignment (VA) liquid crystal technology, medical displays are equipped with in-plane switching (IPS) technology that maintains high contrast over a much larger angle, allowing the screen to be viewed from the side with minimal color shift and curve distortion.

Resolution and Application Correlation

High-density, high-resolution images are imperative for reliable imaging analysis and diagnostic accuracy. The required resolution is at least 2560×2048 (5.24 megapixels) for mammography imaging, 2048×1536 (3 megapixels) for chest radiography (X-ray) images, and 1600×1200 (2 megapixels) for general computed radiography (CR), digital radiography (DR), magnetic resonance imaging (MRI), and computed tomography (CT) images. Unlike commercial displays that offer limited resolution and a form-fit screen orientation, medical displays support resolutions of up to 2560×2048 in both portrait and landscape orientation to better correspond with medical image formats. Additionally, with the number of display pixels sufficient for the image pixels, medical displays eliminate the need to zoom and pan to view all the image information.

Multimodality Support

With the rapid evolution of medical imaging technology, hospitals are now handling a greater volume and wider range of image data. Accordingly, medical facilities are faced with adopting a variety of display systems for image interpretation. Multimodality imaging allows multiple images of diverse medical modality (both color and grayscale) to be displayed on a single screen, enabling side-by-side comparisons and image fusions. To improve diagnostic convenience and streamline system infrastructure, most medical displays are designed to support multimodality imaging.

OTHER CONSIDERATIONS FOR MEDICAL USE

Large Display for Optimal Visibility

Because medical display systems must be capable of presenting multiple images simultaneously, hospitals require displays with larger screen sizes. Monitors with a 16:9 widescreen display provide significantly more horizontal space compared to conventional monitors featuring the standard 4:3 aspect ratio. Large-size displays offer greater image clarity and reduce on-screen window/image overlap, optimizing visibility and productivity.

Display Interfaces

To facilitate integration with existing hospital technologies, such as electronic medical records (EMRs) and picture archiving and communication systems (PACS), and to support configurable data visualization for on-site and virtual collaborations between medical professionals, medical displays must be equipped with a wide range of video, communication, and data acquisition interfaces. Moreover, the provision of additional support for 3D-SDI, fiber optic extenders, video routing systems, and signal converters will ensure that medical display systems not only satisfy the requirements of various critical healthcare applications, but also feature future-proof connectivity.

Regulatory Compliance

Medical displays must comply with relevant industry regulations regarding usage environment, patient proximity, and electrical performance, including those specified in the ACR-AAPM-SIIM Technical Standard for Electronic Practice of Medical Imaging, IEC 60601-1 Medical Electrical Equipment, and ISO 13485 Quality Management System for Medical Devices standards.

System Stability

To protect against power losses and operational interruptions, medical displays must be equipped with an alternative power supply or failsafe solution.

Usability Gloved Operation

Because medical staff wear gloves in operating rooms, support for gloved operation and a well-spaced device layout is essential for convenient operation.

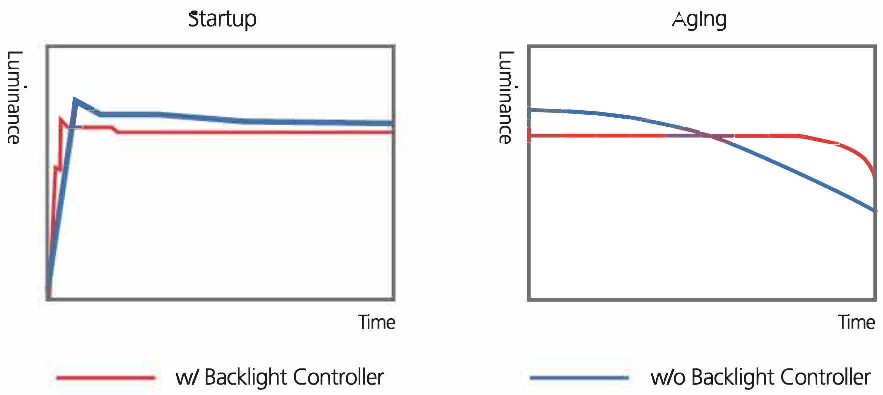
INNOVATIVE SOLUTIONS FOR MEDICAL IMAGING

Advantech Kostec has developed a wide range of 19" SXGA to 84" ultra-high definition display solutions featuring innovative technologies that enable high-performance, premium-quality imaging for diverse medical applications.

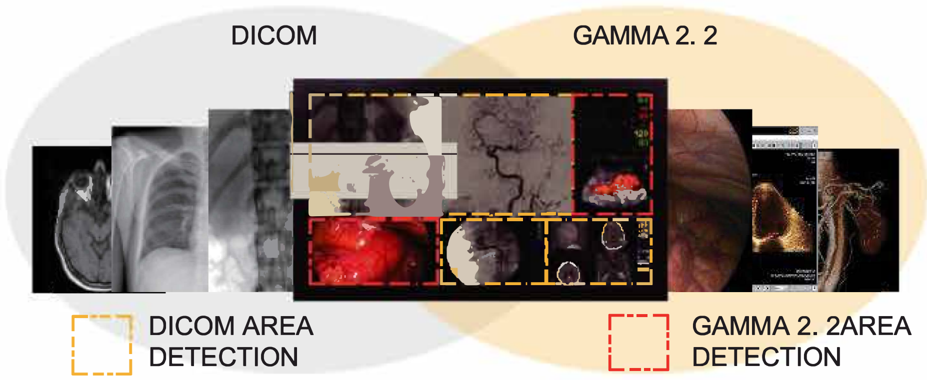
Key Features

Display Uniformity

- Brightness leveling technology (BLT) is an auto-sensing luminance technology installed at the rear of the LCD panel. This technology maintains screen brightness at the pre-calibrated maximum luminance level (L'max) by consistently matching the just noticeable difference (JND) level for image quality. This reduces the backlight warm-up time and extends the overall product lifecycle.



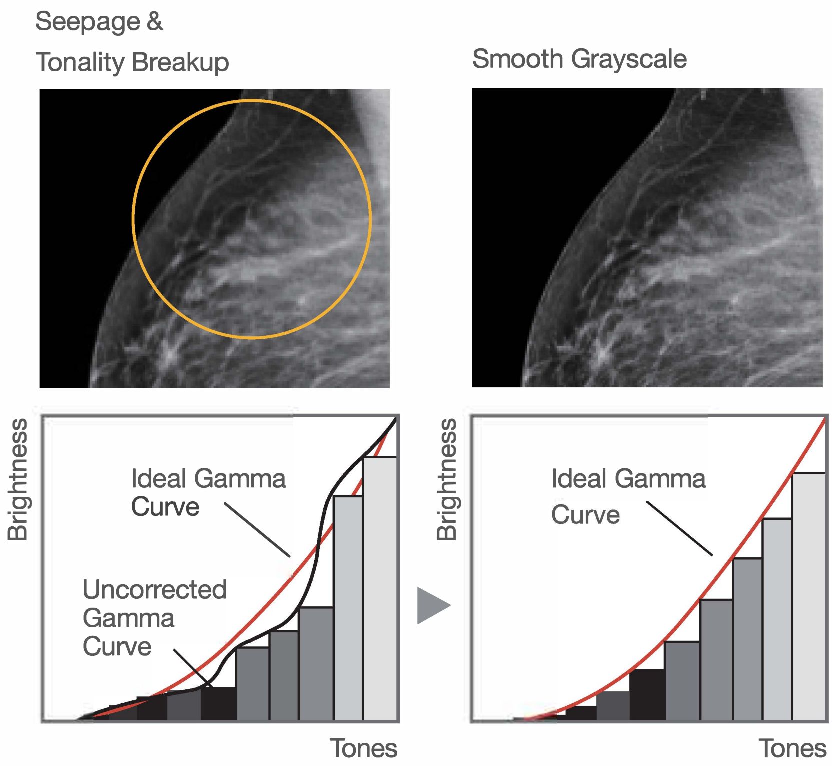
- Advantech Kostec's medical displays are equipped with hybrid gamma functionality that enables the simultaneous display of monochrome and color images with varying gamma curves on a single screen. This hybrid gamma technology automatically identifies whether the images are monochrome or color and displays monochrome images in DICOM Part 14-adjusted mode and color images in gamma 2.2-adjusted mode for optimal luminance and high fidelity.



DICOM-Compliant Grayscale

- Advantech Kostec's medical displays are pre-calibrated to the DICOM 3.14 standard for consistent and precise representation of grayscale images. Moreover, to effectively conform to the DICOM GSDF curve, the displays are equipped with gamma correction capabilities based on a 14-bit LUT that supports 16,384 shades of gray.

- A micro sensor is embedded in the front bezel and integrated with QA's PerfectLum software for quality assurance monitoring, including acceptance testing, constancy testing, and white level and uniformity verification, to enable automated self-calibration and ensure compliance with DICOM 3.14, AAPM TG18, DIN6868-157, JESRA X-0093, and IEC 62563-1 regulations.



High Connectivity

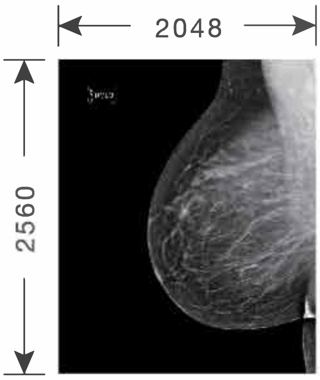
- Equipped with a full range of analog and digital video interfaces, including DP 1.2, 3G/4G SDI, S-Video, HDMI 2.0, and dual-link DVI-D, Advantech Kostec's medical displays offer high connectivity for displaying images from various sources.
- The provision of advanced I/O and video display technology, as well as support for 4K Ultra HD resolution ensures long-term product functionality and future connectivity.

Large Format Display

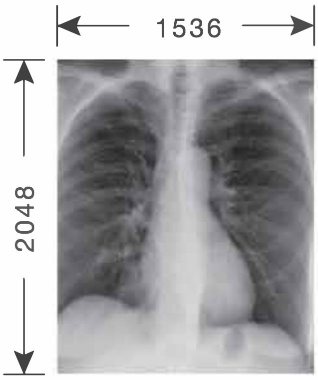
- Advantech Kostec's medical displays are available in a range of sizes with Full HD and 4K Ultra HD resolutions that support a 16:9 widescreen format to provide substantial onscreen space.
- The provision of IPS technology maintains high contrast over a wide viewing angle, resulting in no noticeable color shift when viewing the screen from oblique angles.
- With a maximum brightness of 1,000 cd/m² and contrast ratio of 1100:1, these medical monitors are suitable for displaying 3-D rendered and fusion color images as well as monochrome CT and MRI images.

Multimodality

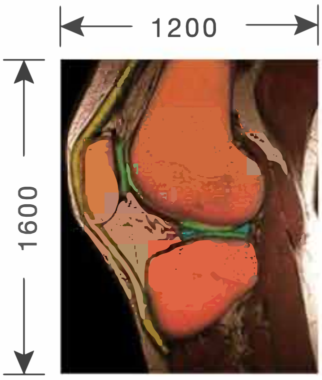
- PiP/PbP functionality allows users to display two images of differing modality from different sources, which is particularly useful for complex medical applications, such as ultrasound imaging during endoscopic procedures.



Breast Imaging

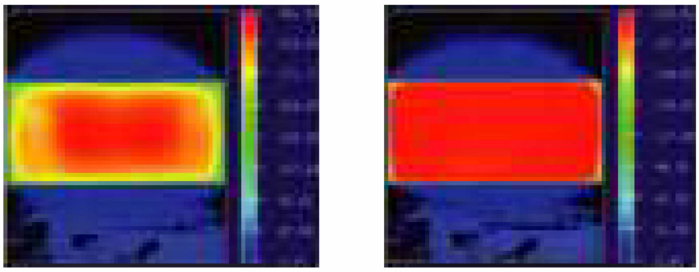


Chest Imaging



General Imaging

- Subdivision uniformity control (SUC) technology with quad Full HD resolution allows users to subdivide the screen into multiple grayscale areas for high-definition multimodality imaging without sacrificing luminance and chromatic uniformity or visual accuracy.



BEFORE/AFTER UNIFORMITY CORRECTION

CONCLUSION

Effective High-Resolution Imaging Improves Healthcare Outcomes

High-resolution imaging and detection technologies enable more precise timely diagnoses, reduce invasive and unnecessary procedures, and support preventive care. Medical displays feature essential medical imaging technologies that ensure effective performance according to the DICOM 3.14 GSDF standard for enhanced image interpretation and diagnostic accuracy. Because image consistency is crucial to medical applications, every effort should be made to optimize displays for specific modalities to improve the rendering of monochrome and color images. The required calibration precision is dependent on several considerations (modality, anatomy being imaged, diagnostic or clinical use, etc.). In many cases, the difference in luminance between an area of interest and the surrounding area is barely perceptible to the human eye. Thus, without proper attention to display calibration, the display devices themselves can adversely affect image interpretation and diagnosis. However, with the advanced calibration tools currently available for medical displays, regular checks can be conducted to ensure all devices within a hospital network are compliant with international DICOM standards for medical imaging.

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