High Resolution Gray Scale Medical Displays - Technical Developments and Actual Products

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Abstract

The trend in improvements to the brightness and contrast of LCD panels is accelerating the shift in medical displays from CRT to LCD panels. In the field of medical displays a precise relative image evaluation between multiple displays is an essential function. However, the alignment of the white points across multiple LCD panels and the deviation of white points caused by deterioration with age are tend to result in a significant increase in the costs and service expenses. The newly developed displays introduced below employ a "new backlight system (called X-Light®)" with a white point adjustment capability that enables long hours of use with stable white points and brightness. Other features that allow the new displays to support accurate medical image diagnoses include the SA-SFT LCD panel that features high brightness and contrast, 11.5-bit gamma circuitry and an integral calibration system.

Keywords

medical radiogram LCD, CCFL, color calibration, acceptance test, uniformity test

1. Introduction

The medical displays for use in the reading and referencing of images are usually used in pairs in order to compare previous and current images. What is important in this application is that the brightness and white points of the two displays are identical and that their brightness and white points do not vary as time passes. We have developed new gray scale displays that incorporate an innovative backlight system that features a white point color adjustment capability and an internal sensor for use in maintaining the luminance and chromaticity constant.

This paper introduces these new displays by focusing on the technology adopted for the new backlight system (X-Light®) as well as on the service life simulation for accurately identifying the period for which the luminance and chromaticity can be constantly maintained. It also considers the structure for obtaining the backlight and the GammaCompMD, which is a tool for managing the display quality. In addition, it introduces the copy function that enables the new backlight system to fully manifest its effects.

2. Product Lineup

The new MD21GS series of displays include a total of four models, which are composed of the 3M models with QXGA-equivalent resolution and 2M models with UXGA-equivalent resolution. Both model types are available in the blue base specification with high color temperature and in the clear base specification with a low color temperature. **Photo** shows external views of two 3M clear base model units.

3. A New CCFL Backlight System (X-Light®) with a 3-Color Independent Brightness Adjustment[1]

The backlight of an LCD display is usually provided by cold cathode fluorescent tubes (CCFLs). The CCFLs generate visi-

Photo External view (With the optional MD-D2M5B on top of each product).

ble light when UV-rays produced by the collision of electrons with mercury collide with fluorescent substances, as in a fluorescent lamp. The visible light is composed of three wavelengths corresponding to RGB, and the human eye senses it as white light because of the mixture of the wavelengths. The light produced by a fluorescent lamp becomes yellowish as time passes and this is because the blue fluorescent substance degrades faster than the other colors. With the LCD panel backlight, too, the quality of the light generated by the blue fluorescent substance deteriorates over time, causing the white point to deviate toward the yellow. The "new backlight system (X-Light®)" is capable of correcting this deviation of the white point. Its whiteness is produced by the color mixing of the 3-color CCFLs installed on both sides of the LCD panel, and the white point can be varied by adjusting the brightness of the two CCFLs independently. Considering the rapid degradation of the blue fluorescent substance, the adjustment for the blue CCFL is
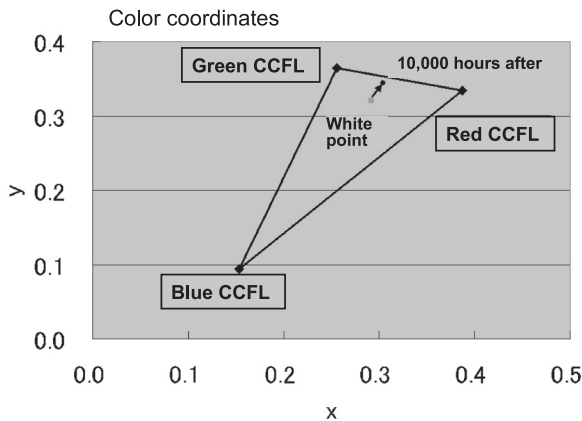
set as a greater amount than for the other CCFLs **(Fig. 1)**.

Fig. 2 shows a block diagram of the new backlight system.

The LCD panel employs the edge light method, and the light leaking from the side of the light guide plate is read using the color sensor. This design ensures that the sensor is exposed to high-luminance light so that a stable adjustment is possible. The signal read by the sensor is digitized by a 13-bit ADC and used for the independent adjustment of the CCFLs of different colors by means of PWM (Pulse Width Modulation) with 9-bit resolution. The minimum adjustment of the white point is 0.5cd/m^2 for luminance and xy color coordinates of 0.0005, which are the values capable of satisfying the gray scale display function (GSDF)[1] that indicates the minimum brightness difference distinguishable by the human eye. The desired brightness set using the external sensor and the color sensor value representing the white point are stored in the EEPROM, and a feedback loop is used to maintain the color sensor value permanently at the set value.

The LCD panel, which is located on the outside of the color sensor and feedback loop has a temperature dependency. Temperature compensation is therefore applied by installing temperature sensors in the proximity of the sensor and the panel.

Fig. 1 Three-color fluorescent tubes (Clear base model).

4. Copy Calibration

Medical displays are mostly used in pairs so that the doctor can watch changes in a disease by comparing a previous image on one of the displays and the current image on the other. What is important in this observation method is that the brightness and white points of the two displays are as near to identical as possible. The new backlight and calibration systems make this possible by copying the luminance and chromaticity of a display from one to the other.

Fig. 3 shows the principles of copy calibration. When the

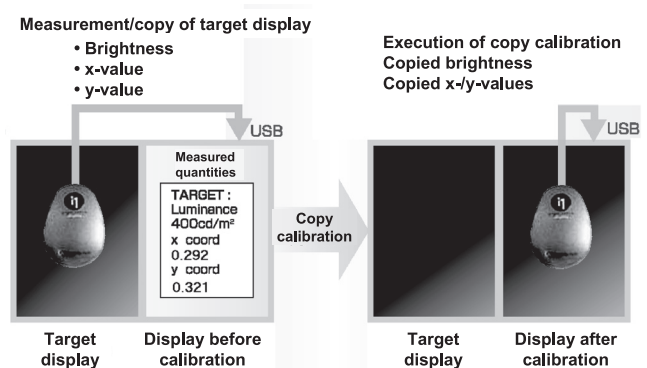Fig. 2 New CCFL back light system with 3-color independent brightness adjustment.

Fig. 3 Copy calibration.

user selects the copy function using the OSM (On-Screen Manager) of the copy source unit and performs a series of operations as instructed on the screen, the optional external sensor (EYE-ONE Display mfd. by GretagMacbeth) measures the luminance and chromaticity of the copy target display. When the user then attaches the external sensor to the copy target display and executes the copy operation, the internal calibration functions and rewrites its settings to the target values. This makes it possible to align the brightness and white points of the two units more accurately.

5. Construction of the Light Amount Pickup Using an Internal Sensor[2]

The backlight brightness has previously been measured by detecting the light leaked through the reflective sheet on the backside, but its brightness was at a low level because it was transmitted light. However, since a higher level of brightness is required for the 3-tone light that is highly accurate, we invented a method of detecting light from the side of the light guide plate. The structure of this optical pickup is shown in **Fig. 4**.

Part of the side of the light guide plate is exposed and a reflective surface is provided on the outside to extract light from the rear side. Installing the optical sensor in this position makes it possible to detect the back light brightness with little loss for use in highly accurate control procedures.

To reduce the irregularities on the display surface near to the light sensor, the size of this section is minimized and part of the reflected light is returned to the light guide plate by setting the angle of the reflective surface greater than 45 degrees (this development was achieved with the cooperation of NEC LCD Technologies, Ltd.).
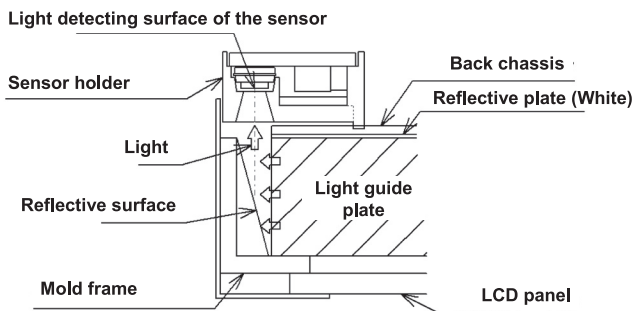
6. GammaCompMD

Since the display characteristics of a medical display directly affect the accuracy of a diagnosis, it is required to apply continual quality management of the displays used in medical fields. Therefore, we have developed the GammaComMD and GammaCompMD Server as suitable tools for maintaining the quality of the medical displays in order to save the large amount of labor that would normally be required for their management.

(1) Features of GammaCompMD
· DICOM compliance tested
· Acceptance and consistency tested according to various standards:
AAPM TG-18: American Association of Physicists in Medicine[2]
DIN V 6868-57: German Institute for Standardization[3]
JESRA X-0093-2005: Japan Industries Association of radiological Systems standard
· brightness, chromaticity and gamma calibrated
· Test and calibration history data managed and saved
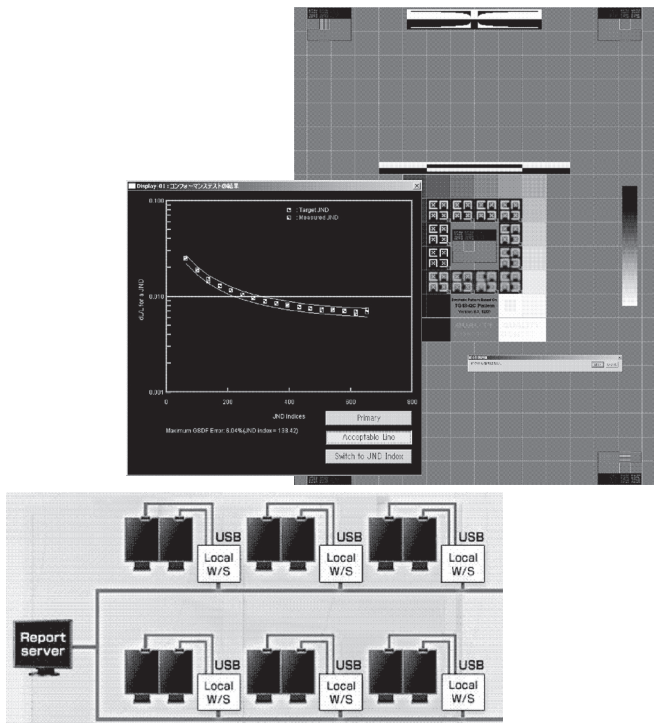· Color sensors and brightness sensors of various makes sup-

Fig. 5 Examples of display image and connection of GammaCompMD.

Fig. 4 Structure of optical pickup.

ported

(2) Features of GammaCompMD Server

· Surveillance via a network of display units installed in various locations in a hospital

· Remote execution of DICOM compliance testing and calibration (when the MD-N2M5B Retractable Sensor is used)

· Test reporting according to various standards

· Automatic mail notification of the manager in case of an alarm, including failure or a deterioration in display quality

Fig. 5 shows examples of display images and connection arrangement of the Gamma Comp MD.

7. CCFL Life Simulation

We introduced the CCFL life simulation system in order to determine the optimum service lives of CCFLs so as to set the three optimum kinds of CCFL emitted chromaticity (R, G, B,) which maintain the target chromaticity and luminance of the new CCFL backlight system.

CCFL life simulation estimates the life (degradation) of each CCFL by using the four factors determining its service life (degradation characteristic of the fluorescence substance in CCFL, target chromaticity and luminance of the monitor, the fluorescent substance composition ratio and lamp light emission intensity of the CCFL, and the transmittance of the LCD panel) as the input parameters.

For each of the three kinds of CCFLs (R, G, B), a simulation curve is drawn by setting as the vertical axis, the ratio between the luminance after a certain period has elapsed and the luminance at 100% lighting and the elapsed time period as the horizontal axis. This process identifies the expiration of the
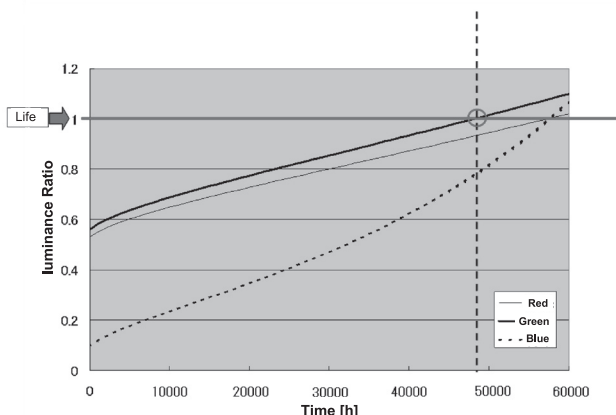

Fig. 6 Simulation results (Example with the MD21GS2MP-CB).

service life when the value of the vertical axis reaches 100%.

Fig. 6 shows an example of simulation.

In the example shown, the green CCFL reaches the end of its life first, becoming incapable of maintaining the target chromaticity and brightness. We determined the optimum CCFL chromaticity values by adjusting the fluorescent substance composition ratios of the CCFLs so that their service lives expire (i.e. their brightness ratios becomes equal to 1) after an identical time period has elapsed.

8. Options

The following options are available for the display models introduced in this paper.

· Video boards (2M/3M gray scale 10-bit compatible)

Vrengine/SMD2 mfd. by RealVision

MED 2mp mfd. by Matrox

· External sensor

EYE-ONE Display mfd. by GretagMacbeth

· Retractable sensor

MD-N2M5B (see Photo)

Remote measurement/adjustment of display luminance and chromaticity.

· Protection filter

MD21PS-BK

Light transmittance of 98.5% or more (500 to 600nm)

9. Conclusion

As medical display systems shift from CRT to LCD displays, the display manufacturers are trying various measures to improve the accuracy and service life related to brightness. However, with regard to the white point, although they have been concerned about the initial performance of displays, they have not been too concerned about display deterioration due to age. As the guidelines for color deviation in multi-display systems have also been recently established in Japan, it is expected that the technology that supports these display products will continue to attract attention in the future.

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References

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●The details about this paper can be seen at the following.
Related URL: http://www.nec-display.com/ products/model/md21gs-3mp_2mp/index.html