Introduction to Color Management Functions

Dec/03/2002

1. Preface

This document contains information about the Color Management functions of the MD22292 9.2 Million Pixels Color TFT LCD Monitor (hereafter called the "monitor") as well as how to use it, as a supplement to the following manuals:

- **MD22292B 9.2 Million Pixels Color TFT LCD Monitor User's Guide**
- **MD22292C 9.2 Million Pixels Color TFT LCD Monitor User's Guide**

The next section describes a conceptual overview of Color Management and Color Calibration for a computer system including the monitors. Even those who are quite familiar with these topics are strongly encouraged to read through the next section for the precise definitions of the terms as used in this document.

2. Overview of Color Management and Color Calibration

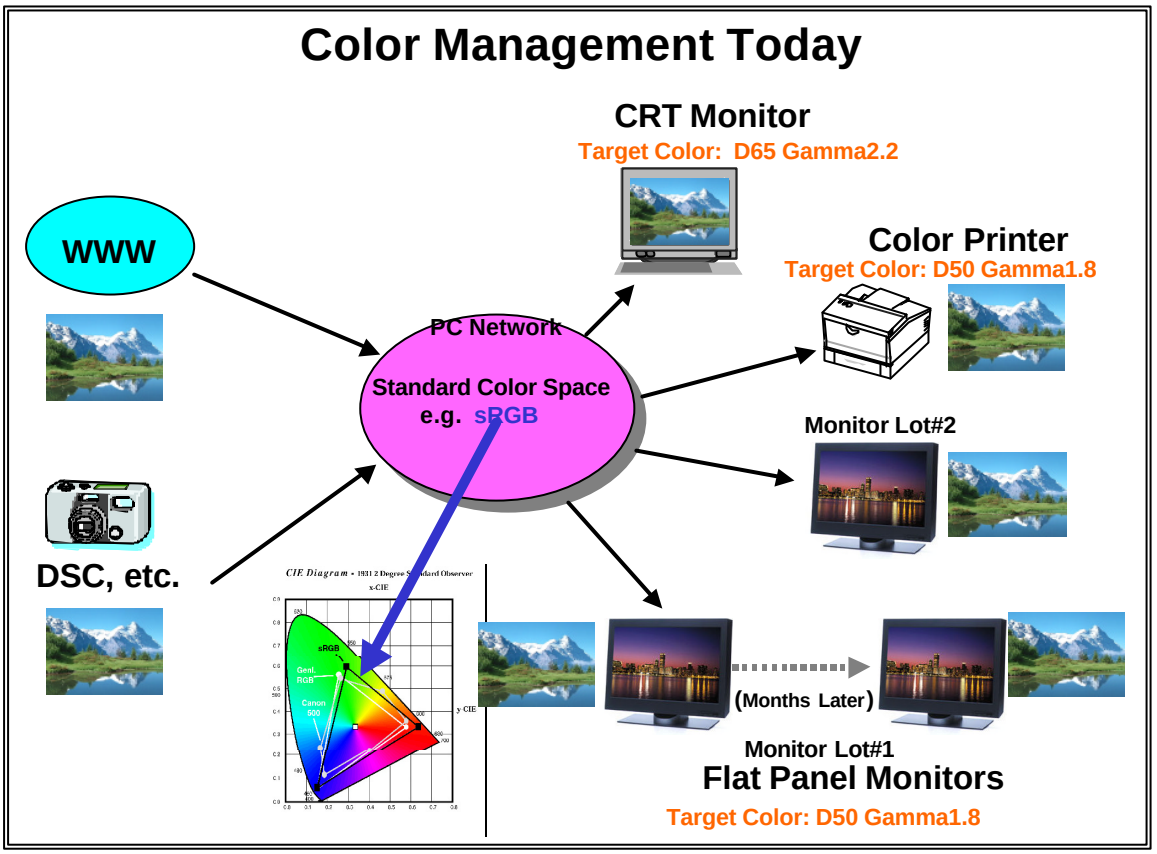
2.1. What is Color Management?

The term "**Color Management**" (Also known as "**Color Matching**") generally means to control or manage the colors to achieve exact color matching among various color input devices (e.g. digital still camera, video camera, scanner, etc.) and output devices (e.g. printing press, color printer, CRT monitor, LCD monitor, etc.), each of which usually has unique color characteristics for color sensing (for input devices) or reproduction (for output devices).

The personal computer or workstation (hereafter called the PC) to which the above color input and output devices are connected has a feature embedded in the OS (Operating Systems) to conveniently handle the color management. We refer to this as the **CMS (Color Management System)**. "**Microsoft ICM**" in the Windows OS, and "**Apple ColorSync**" in the Macintosh OS are typical CMSs.

The CMS itself does not perform the color management, but an application program called the "**Color Management Application Program**" which utilizes the CMS is required. Two of the

typical Color Management Application Programs are **Adobe PhotoShop** and **Adobe Illustrator**.



It is necessary for the CMS to correctly recognize the color characteristics of each color input or output device in order to perform accurate color management. Typical color characteristics for a monitor are the color chromaticity coordinates of the white point and each of the three primary colors, R (Red), G (Green), and B (Blue), the gamma curve characteristics of the white (achromatic color), and similar characteristics. To determine these color characteristics is called **Color Characterization**, and a set of the characteristic data stored on the PC in a form that the CMS can recognize is called a **Color Profile** (or **ICC Profile**).

In the CMS, the color data is handled based on a temporary color space called the **Working Color Space**, and a color space called **sRGB** is usually used as the working space. The sRGB is one of the typical standard color spaces. For sRGB, the color characteristics are defined as follows:

White Point …….. D65 (Color temperature is 6,500 K)
Gamma Value …….. 2.2
Color Reproduction Space (Gamut) …… narrower than that of NTSC or Adobe RGB

If a color profile for a monitor connected to a PC has been assigned, then this means that the CMS knows that the actual color characteristics for the monitor are identical to those described in the color profile.

There are two purposes for color management.

1. To make the color characteristics of the image displayed on the monitor be identical to the characteristics of the working color space defined by the CMS.

2. To make the color characteristics of the image displayed on the monitor be identical to the native (original) characteristics of the monitor without regard to the characteristics of the working color space of the CMS.

For example, if the current working color space is sRGB (D65, Gamma=2.2), and the color characteristics described in the color profile for the monitor is D50 (i.e. Color temperature is 5,000K, Gamma=1.8), then for Purpose 1 above, the CMS tries to adjust the color characteristics of the image displayed on the monitor to be identical to sRGB. It first compares the data of the characteristics in the color profile for the monitor (D50, Gamma=1.8) with the characteristics of the working color space (sRGB), performs calculations, and prepares a conversion table for the color data sent to the monitor.
For Purpose 2 in the same situation, the CMS doesn't have to do any color data conversion. The color characteristics of the image displayed on the monitor screen are just D50, Gamma=1.8, as described in the color profile for the monitor.

Users can usually select either of those two purposes using a menu in the color management application program.

2.2. Color Calibration for Monitors

The above descriptions are all based on the assumption that the actual color characteristics of the monitor are identical to the characteristics described in the color profile for the monitor. This means that if the actual color characteristics of the monitor are different from what is described in the color profile, accurate color management is no longer possible.

However, although the major color characteristics of the monitor itself are usually described in the specification document for the monitor, the characteristics values for each monitor vary within the tolerances defined in the specifications, due to lot-to-lot or individual variations. This variation in the characteristics cannot be ignored in color management. One of the practical ways to deal with such variations is to have a color characteristics adjusting or calibrating mechanism somewhere in the system consisting of the PC and the monitor. We call this calibration mechanism the **Color Calibration**.

2.3. Color Calibration Tool and Its Function

In order to carry out the color calibration for the monitor, some kind of commercially available

Color Calibration Tool (also known as **Color Management Tool**) must be installed and used. A color calibration tool in general is composed of a Color Sensor and Calibration Software.

The **Color Sensor** (Also known as a **Colorimeter**) is mounted on the surface of the screen of the monitor, and is connected to the PC via a USB interface or some other link. During calibration, it measures the chromaticity of each color test pattern that is displayed on the screen in sequence, and sends the data to the PC.

The **Calibration Software** is installed on the PC. It first asks the user to assign the target color characteristics (i.e. What kind of color characteristics the user wants to calibrate the monitor with), then it begins to display color test patterns in sequence. Finally it performs calculations based on the chromaticity data sent from the Color Sensor, and creates a **Color Conversion Table** (also known as a **Color Look-Up Table**, or a **Gamma Correction Table**, or by other names) which indicates how the color data should be converted before it is displayed on the monitor in order to have the proper target color characteristics.

One of the typical commercially available Color Calibration Tools is the **GretagMacbeth i1 (Eye-One)** series.

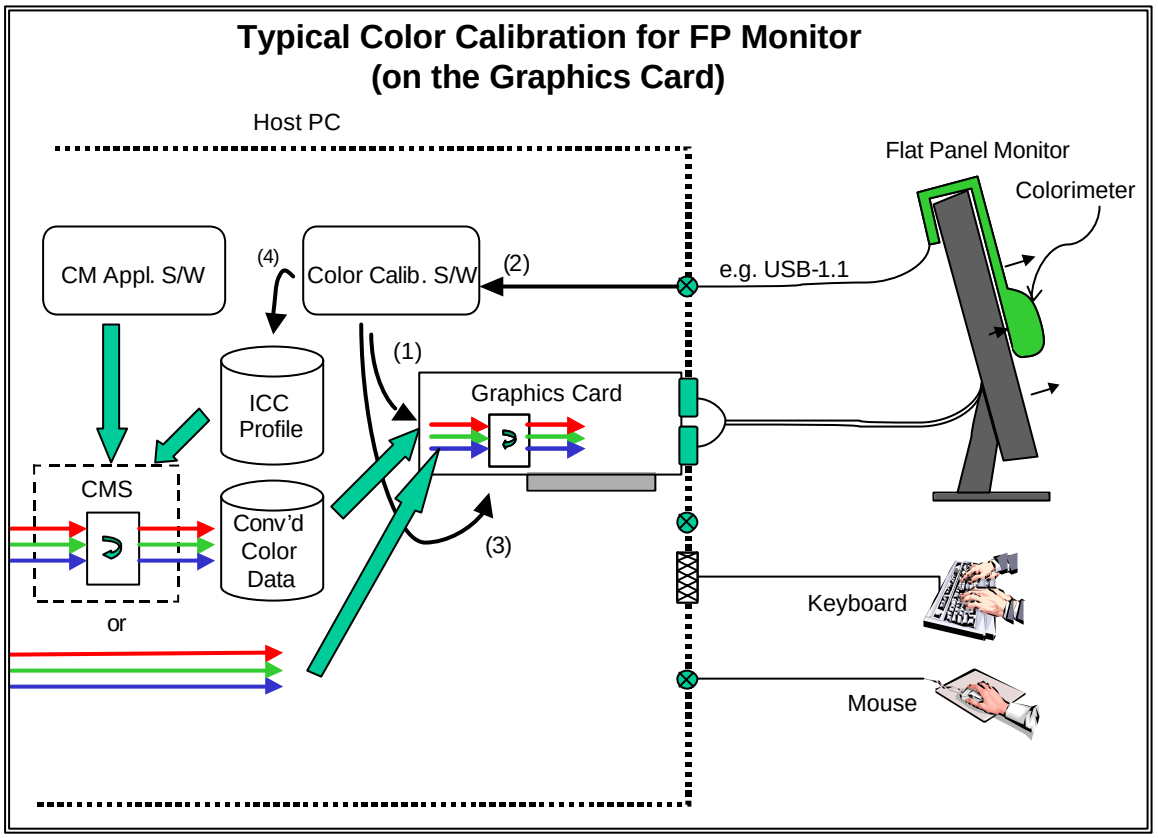
(1) Color Calibration using the Graphics Card

In general, the Color Calibration Tool loads the data of the Color Conversion Table that was created in advance (as described above) into a **Color Conversion Mechanism** (also known as a **Color Adjustment Mechanism**, **Gamma Correction Mechanism**, or by other names) of the graphics card. The loading of the Color Conversion Table is done according to an OS-based standard API (Application Protocol Interface). If both the Color Calibration Tool and the graphics card comply with this API, the load will be successful. Otherwise color calibration is not possible.

The Color Conversion Table loaded into the Color Conversion Mechanism of the graphics card converts each pixel of color data that passes through the card, so that color images with the target color characteristics will be displayed on the monitor screen as expected. This is what we call the **Color Calibration using the graphics card**.

The other important role of the Color Calibration Tool is to register with the CMS a Color Profile for the monitor that is created by consolidating the profile of the target color characteristics that was assigned by the user, and the Color Conversion Table that was created by the Calibration Software. Based on this registration, the CMS knows that the color characteristics of the currently attached monitor are identical to the target characteristics assigned by the user.

The Color Calibration using the graphics card is effective when the monitor does not have a built-in Color Conversion Mechanism, or when the monitor has such a mechanism but it is not controllable from the PC.



(2) Color Calibration using the Monitor's Built-in Color Conversion Mechanism

Some of the inconvenient features of the calibration described in this Section 2.3 Part (1) are as follows:

1. The content of each Color Conversion Table sent to each graphics card differs slightly due to the individual differences in the color characteristics of the attached monitors. Therefore each time a user replaces a monitor with a new one, the Color Calibration must be performed again in order to create a new Color Conversion Table reflecting the color characteristics of the new monitor.

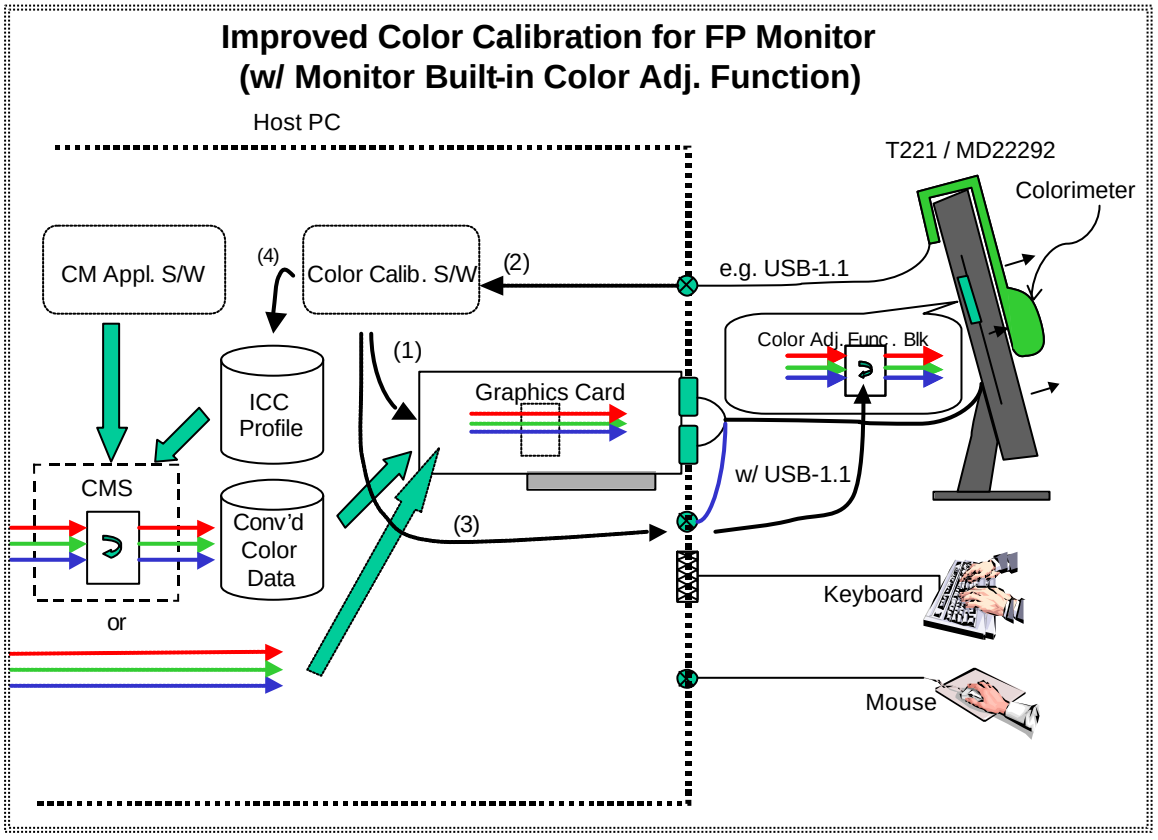
2. For the color conversions of almost all graphics cards, the number of bits assigned to the color data after the color conversion is same as before the conversion. That is, if 8 bits are used to express the color of each pixel in R (Red), G (Green), and B (Blue), the same number of bits are used both before and after the color conversion. However, the number of gray scale levels for the reproducible colors after the conversion is in general reduced from the original number of gray scale levels (i.e. 256 gray scale levels for 8-bit color) when the color conversion is done between color data with the same number of bits. We call this phenomenon **Gray Scale Degeneracy**. One of the major side effects of Gray Scale Degeneracy after color conversion is that when displaying a gradation pattern (a

monotonously changing pattern going from the darkest to the brightest saturations for the same color tone such as R, G, B, or White (Gray)), some **tone bands** will appear due to the combination of relatively steep and gentle tone gradations.

The method to solve the inconvenience of Part 1 is for the monitor to have a built-in Color Conversion Mechanism, and the Color Conversion Table created by the Color Calibration Tool can be loaded into the monitor and used for the color conversion. In addition, the data of the Color Conversion Table needs to be retained even through power cycling (by saving it in a non-volatile memory), so that it can be reused later without reloading it from the PC.

The method to solve the inconvenience of Part 2 is for the monitor's built-in Color Conversion Mechanism to comply with a bit-extension type of Color Conversion Table (e.g. 8-bit input color data is converted to 10-bit output color data).

We call the color calibration having both features of the above methods, the **Color Calibration using a Monitor Built-in Color Conversion Mechanism**.



In addition to the Color Conversion Mechanism in the monitor, we need a utility program to handle the loading of the Color Conversion Table created by the Color Calibration Tool, from the PC to the monitor. We call this program the **Color Management Utility**.

3. Color Management Utility Installation and Usage Guide

3.1. Required Firmware Version

Using the Color Calibration using the Monitor Built-in Color Conversion Mechanism described in above Section 2.3. Part (2), applies to the monitor with firmware at the following levels:

- DDC CPU	Version 3.1 or higher
- OSD CPU	Version 5.0 or higher (Version 4.9 or higher, in case of Machintosh Version)
- USB CPU	Version 4.0 or higher
- FPGA Logic	Version 35 or higher (Version 34 or higher, in case of Machintosh Version)

When any of the current firmware levels is lower than the versions of this list, only Color Calibration using the graphics card is possible.

Following is the procedure to check the current firmware levels.

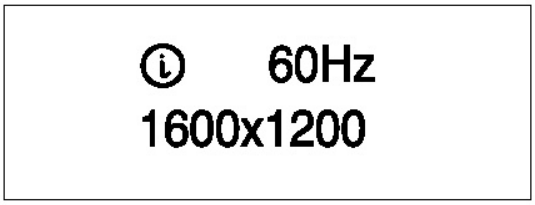
Procedure

1. Setting

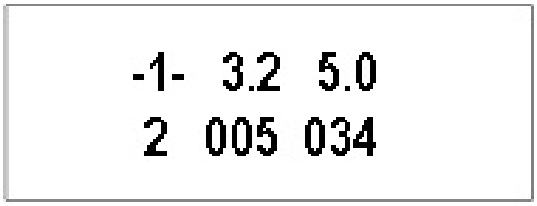
a. Connect the monitor to the desired graphics card in the PC.
b. Turn on the monitor and the PC. Wait until the system has completed its boot process and a stable screen image is displayed. Confirm that the power indicator on the monitor shows green, not amber.

2. Activate the special OSD (on-screen display) menu

a. Press the leftmost OSD button (select/enter) and navigate to the (i) (information) icon by using the "<=" (navigate left) or "=>" (navigate right) buttons. Press the "select/enter" button to access the information screen. The refresh rate and screen resolution will be displayed, as in this example:



b. Press the "navigate left" button three times, and then press the 'navigate right' button three times. The first panel of the special OSD menu will be displayed, as in this example:



In this panel, the firmware versions are shown in the following format:

```
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 -1-      aaa bbb
 c        ddd eee
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where	aaa:	DDC-CPU version
	bbb:	OSD-CPU version
	c:	reserved
	ddd:	USB-CPU version
	eee:	FPGA-Logic version

Note: If the special OSD menu does not appear, press the "select/enter" button to exit from the OSD menu and return to step 2.a. to try again.

3.2. Installation and Usage Guide

There are both Windows and Macintosh versions of the Color Management Utility. The installation procedures and user interfaces are slightly different.

(1) Windows Version - Installation and Usage Guide

- Click on "Windows Version - Installation Package" to download the installation package to an appropriate folder in the PC.

- Click on "Windows Version - Installation and Usage Guide" to view a text file for the installation procedure, and perform the installation according to the instructions in this document. A brief usage guide is also included in this file.

- For the detailed usage instructions, please refer to the online "User's Manual" document that can be accessed via "Start" => "Programs" => "Color Management Utility" => "Users Manual".

(2) Macintosh Version - Installation and Usage Guide

- Click on "Macintosh Version - Installation Package" to download the self-extractive format file to an appropriate folder in the PC. Extract the file after the download is

complete.

- Click on “Macintosh Version - Installation and Usage Guide” to view a text file for the installation procedure, and perform the installation according to the instructions in this document. A brief usage guide is also included in this file.

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