# Open Firmware

## Recommended Practice:

## 16-color Text Extension

Version 1.2 (draft)

October 26, 1995 1:57 pm

Published by the Open Firmware Working Group

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## Revision History

Version 1.0 Original.

Version 1.1 Changed "index" references to "number". Reformatted to template.

Version 1.2 changed "light" to "bright" (as per 7/18/95 meeting). minor fixups.

# 1. Introduction

## 1.1. Purpose

IEEE Std 1275-1994 [1] defines a base set of facilities for displaying text on display device packages that supports a simple 2-color model. Most computer systems now implement displays with many more colors, and operating systems desire access to these colors during the booting process (during which Open Firmware is used for access to the "console" display device.)

This document describes an extension to the core Terminal Emulator Support Package (described in section 3.8.4 and Annex B of [1]) that adds support for a 16-color model. This mechanism follows the model defined in ISO 6429-1983 [2], which is the basis for the 16-color model that is common in PC's and in serial terminal emulator packages.

This extension defines additional Terminal Emulator control sequence interpretations (see Annex B of [1]) and two new FCodes (`background-color`, `foreground-color`) for the Open Firmware Terminal Emulator implementation and requirements for "display" device drivers that wish to enable the extension.

The extension mechanism is compatible with the core [1] in that the extension is enabled only when both the Open Firmware implementation and the FCode display device package supports the extension; lack of support by either piece will revert to the behavior of the Terminal Emulator to that of the core document. Means are provided so that each participant can detect the presence of support for this extension in the other. (Client programs can also detect the presence of the support.)

## 1.2. Scope

This extension applies to Open Firmware implementations and to FCode device drivers for display device packages.

# 2. References and Definitions

## 2.1. References

[1] *IEEE Std 1275-1994, IEEE Standard for Boot (Initialization Configuration) Firmware: Core Requirements and Practices*, published by IEEE.

[2] *ISO 6429-1983, Information Processing -- Additional control function for character-imaging devices*, published by ISO.

## 2.2. Definitions

**16-color display package**: A display device package that implements the additional requirements defined in this extension.

**color-number**: a value that represents a color.

**display device package**: An Open Firmware package whose `"device_type"` value is `"display"` and that implements the methods and properties defined in section 3.7.1 of [1].

**effective background color**: the color-number to be used as the background color for text (logo) pixel rendering, depending upon the value of `inverse?`. If `inverse?` is false, it is the value of `background-color`, otherwise it is the value of `foreground-color`.

**effective foreground color**: the color-number to be used as the foreground color for text (logo) pixel rendering, depending upon the value of `inverse?`. If `inverse?` is false, it is the value of `foreground-color`, otherwise it is the value of `background-color`.

## 3. The 16-color Model

IEEE Std 1275-1994 defines the behavior of the Terminal Emulator Support Package (see section 3.8.4 and Annex B of [1]). Annex B assumes that the Terminal Emulator Support Package implements certain escape sequences from the set defined by ANSI X3.64. The extension described here corresponds to ISO 6429-1983, as defined by [2].

The 16-color model adds new FCodes that represent the current foreground (`foreground-color`) and background (`background-color`) colors that are used by the Terminal Emulator Support Package for displaying text. Various support packages use numbers from 0 to 15 to represent colors. The table below defines the sixteen colors in terms of the approximate intensities of red, green, and blue (0 for no intensity and 1 for maximum intensity). The use of these color numbers does not necessarily imply that the hardware uses a color lookup table, nor does the description of the colors imply that the hardware uses an RGB color space.

| Number | Red | Green | Blue | Color |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | Black |
| 1 | 0 | 0 | 2/3 | Blue |
| 2 | 0 | 2/3 | 0 | Green |
| 3 | 0 | 2/3 | 2/3 | Cyan |
| 4 | 2/3 | 0 | 0 | Red |
| 5 | 2/3 | 0 | 2/3 | Magenta |
| 6 | 2/3 | 1/3 | 0 | Brown |
| 7 | 2/3 | 2/3 | 2/3 | White |
| 8 | 1/3 | 1/3 | 1/3 | Gray |
| 9 | 1/3 | 1/3 | 1 | Bright Blue |
| 10 | 1/3 | 1 | 1/3 | Bright Green |
| 11 | 1/3 | 1 | 1 | Bright Cyan |
| 12 | 1 | 1/3 | 1/3 | Bright Red |
| 13 | 1 | 1/3 | 1 | Bright Magenta |
| 14 | 1 | 1 | 1/3 | Yellow |
| 15 | 1 | 1 | 1 | Bright White |

**Table 1. The Sixteen Colors**

The Terminal Emulator Support Packages uses extended Set Graphics Rendition (SGR) parameters to specify changes to the color and intensity of the foreground and background values. The ISO 6429-1983 standard provides parameter values to independently control the color of foreground (30-37) and background (40-47). The intensity is set separately (1-2), and must be issued before the color control; 1 -> color, 2 -> color+8.

The expanded model of the Terminal Emulator Support Package is that there is a "current" background and foreground color (number), the first 16 of which are defined for use by this extension, corresponding to the first 16 entries of the color-table. In positive image mode, pixels corresponding to a font (logo) bit set (1) will be set to the foreground color; pixels corresponding to a font (logo) bit clear (0) will be set to the background color. When in negative image mode, the roles of foreground and background are reversed.

An FCode display driver that supports this extension declares so by defining a new property (**"iso6429-1983-colors"**) that indicates the support of these additional methods. Likewise, an Open Firmware implementation declares its support of this extension by publishing the property within a **/packages/terminal-emulator** node.

## 4. Open Firmware Implementation Requirements

The following sections define the requirements of an Open Firmware implementation to support this extension.

### 4.1. FCode (and User Interface) functions

A system that implements the 16-color text extension *shall* implement the following, as FCode Functions, if the Device Interface is implemented, and as User Interface commands if the FCode Debugging command group of the User Interface is present.

**foreground-color** ( -- color-number ) F 0x168

value, that defines the color table number that is to be used as the foreground color when writing to the display buffer.

**background-color** ( -- color-number ) F 0x169

value, that defines the color table number that is to be used as the background color writing to the display buffer.

The set of permissible values for **foreground-color** and **background-color**, and their meanings, is given in Table 1. **foreground-color** and **background-color** are set by the Terminal Emulator Support Package and used by display device packages and the fb8 support package.

NOTE: these FCodes enable a display driver for a card that does not directly implement an 8-bit display buffer (e.g., a 24-bit-only frame buffer) to work with the color extensions. These drivers need access to the Terminal Emulator's color indices so that they can emulate the extended color behavior of **draw-character**, etc. that they must have overridden.

### 4.2. Terminal Emulator Support Package

The **/packages** node *shall* have a child node named **"terminal-emulator"**. That terminal-emulator package *shall* have the following property:

**"iso6429-1983-colors"** S

Standard *property-name* to indicate 16-color text capability.

*prop-encoded-array:*
None; presence or absence of the property conveys the information.

The presence of this property indicates that the system implements the 16-color text extension. Specifically, it implies that the Terminal Emulator Support Package responds to the color-setting variants of the Select Graphics Rendition (SGR) escape sequence as defined by ISO 6429-1983, that the **foreground-color** and **background-color** values are implemented, and that the fb8 support package responds to those values as defined in this specification.

Absence of this property within a device node named **/packages/terminal-emulator** indicates that the terminal emulator and fb8 support packages do not support 16-color text.

> NOTE: the **"iso6429-1983-colors"** property is intended for the use of client programs that need to determine whether or not the firmware is capable of displaying 16-color text. In addition to the **"iso6429-1983-colors"** property in **/packages/terminal-emulator**, a client program should also look for the **"iso6429-1983-colors"** property in the package corresponding to the console output device, because the fact that the firmware system supports 16-color text does not necessarily imply that the individual display device driver does.

This specification does not require the presence of open and close methods in the **/packages/terminal-emulator** node. Therefore, it is not necessarily possible to open that node (e.g. with **open-package**).

When initialized, the Terminal Emulator Support Package *shall* set the initial state of the following values as follows:

| | |
|---|---|
| **inverse?** | false |
| **inverse-screen?** | false |
| **foreground-color** | 0 |
| **background-color** | 15 |

The Terminal Emulator Support Package *shall* respond to the numeric parameters for the Select Graphics Rendition (SGR) escape sequence shown in Table 2 by setting **foreground-color**, **background-color** and **inverse?** to values corresponding to the interpretation column. Appropriate color-number values for **foreground-color** and **background-color** are given in Table 1. "positive image" corresponds to **inverse?** =true, and "negative image" to **inverse?**=false.

The *default rendition shall* be black foreground (i.e. **foreground-color** =0), bright (bold) white background (**background-color** =15) and positive image (i.e. **inverse?** =false).

The Terminal Emulator Support Package *shall* interpret the parameters of the Select Graphic Rendition (**ESC[#m**) sequence as follows:

parameter 0 affects **foreground-color**, **background-color**, and **inverse?**.
parameters 1 and 2 affect either **foreground-color** or **background-color**,
depending on the following parameter.
parameters 30-37 affect **foreground-color**.
parameters 40-47 affect **background-color**.
parameters 7 and 27 affect **inverse?**.

The following table defines the interpretations of the SGR values:

| Param | Interpretation |
|---|---|
| 0 | default rendition |
| 1 | bold (increased intensity) |
| 2 | faint (decreased intensity) |
| 7 | negative image |
| 27 | positive image |
| 30 | black foreground |
| 31 | red foreground |
| 32 | green foreground |
| 33 | yellow foreground |
| 34 | blue foreground |
| 35 | magenta foreground |
| 36 | cyan foreground |
| 37 | white foreground |
| 40 | black background |
| 41 | red background |
| 42 | green background |
| 43 | yellow background |
| 44 | blue background |
| 45 | magenta background |
| 46 | cyan background |
| 47 | white background |

**Table 2. SGR Parameters**

## 4.3. fb8 support package routines

A system that implements the 16-color text extension *shall* implement the following additional semantics for the fb8 support package routines.

If the package corresponding to the device instance that executed **`fb8-install`** has a property named **`"iso6429-1983-colors"`**, the operations of the fb8 support routines *shall* be performed according to the specifications given below for "16-color mode"; otherwise they *shall* be performed as specified in [1].

**`fb8-draw-character`** and **`fb8-draw-logo`** *shall* set the display pixels corresponding to "zero" bits in the logo or character bitmap image to the effective background color, and display pixels corresponding to "one" bits in the logo or character bitmap image to the effective foreground color.

**`fb8-invert-screen`** and **`fb8-toggle-cursor`** *shall* modify the pixels of the display regions that they affect as follows:

| Existing color-number | New color-number |
|---|---|
| effective foreground color | effective background color |
| effective background color | effective foreground color |
| other | unchanged |

fb8 operations that move portions of the text window to (possibly) different locations within the text window *shall* preserve the existing color indices of the moved regions.

fb8 operations that set portions of the text background to a solid color *shall* set the pixels of the affected regions to the effective background color.

## 5. 16-color Display Package Requirements

A 16-color display package *shall* implement the following property:

**"iso6429-1983-colors"** S

Standard *property-name* to indicate 16-color text (logo) capability.

*prop-encoded-array:*
None; presence or absence of the property conveys the information.

The presence of this property within a package whose **"device_type"** is **"display"** indicates that the package implements the 16-color text extension defined by this document. Specifically, it implies that the package displays text (logo) according to the values of **foreground-color** and **background-color** if the system implements those values.

Absence of this property within a display package implies that the package does not implement the 16-color text extension.

The following additional requirements apply to 16-color display packages:

The package *shall* determine whether or not the system implements **foreground-color**. If not, the package *shall* implement its drawing operations in a manner consistent with the requirements of IEEE Std 1275-1994, including the use of **inverse?** and **inverse-screen?** to determine foreground and background colors. If so, the package *shall* implement its drawing operations so that foreground and background colors are determined by the effective foreground and background indices as defined for the fb8 support routines in 16-color mode, with meanings of those indices as given in Table 1.

NOTE: The preferred method for an FCode Program to determine the presence or absence of **foreground-color** is as follows:

```
h# 168 get-token drop  ['] fcode-error  =   ( absent? )
```

NOTE: In order to use the fb8 support package to assist in implementing the 16-color drawing operations, a display package must setup its color translation mechanism so the correspondence between pixel values in the frame buffer memory and displayed colors is as given in Table 1. This does not necessarily imply that a 16-color display package must use the fb8 support package, nor does it require that the display hardware must use color indices 0…15 directly. The fundamental requirement is that the effective color indices 0…15 (as communicated to the display package by the values **foreground-color**, **background-color**, and **inverse?**) must cause the drawing operations to generate the colors given by Table 1. The mechanism for doing this is the individual driver's responsibility. The fb8 support package is simply a convenient implementation tool for devices that conform to the widely-used hardware model of an 8-bit-per-pixel frame buffer with a color lookup table.