Development of LCD Controller/Driver ICs with an On-Chip Automatic Backlight Brightness Control Function (Mobile AGCPS)

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Abstract

The cellular phone has become an indispensable tool in daily life and its display is always required to "offer appealing images" and to "consume less power." NEC Electronics has commercialized an LCD controller/driver IC product that incorporates our original backlight control technologies (Mobile AGCPS). These are technologies that enable a reduction of power consumption while maintaining a high display quality. Our developed driver IC has all needed functions for display driving and for backlight brightness control.

It contributes thus to the implementation of low power consumption for cellular phones without requiring any important modifications to the system design.

Keywords

LCD, driver IC, backlight, power consumption, display quality

1. Introduction

Mobile devices such as cellular phones have recently been subject to functionality enhancements, e.g. by incorporating still and video camera functions. In particular, mobile digital broadcasting enables high quality TV viewing even when moving about such as during commuting. As seen above increases in cellular phone functions have imposed a need for reduced power consumption as well as for improved LCD display definition and color quality. In particular, one of the most frequent requests from users of cellular phones with a TV viewing function is for an extension of the "viewing time." The result of this has been to make it an urgent task to minimize the power consumption of the LCDs that are used for TV viewing over lengthy periods.

NEC Electronics has developed Mobile AGCPS (Mobile Auto Gamma Control and Power Saving), which is an NEC-original backlight control technology for reducing power consumption without adversely affecting the display quality and have commercialized LCD controller/driver ICs that incorporate it. The purpose of this paper is to introduce the LCD controller/driver ICs with on-chip Mobile AGCPS.

2. Basic Principles of Mobile AGCPS

Traditionally, about 90% of the power consumed by the LCD module has been that for the backlight and the power consumed by the LCD panel and driver IC has been only around 10%. The power consumed by the LCD panel and driver IC varies according to the displayed images. The backlight always illuminates at the full luminance regardless of the displayed images, so the latter always consumes most of the power in the LCD module. In addition, as the improvement of definition of LCD panels has increased, the number of LEDs used in the backlight and consequently the power consumption of the backlight has tended to increase.

Our newly developed Mobile AGCPS technology can reduce the power consumed by the backlight, which occupies the largest share in the power consumed by an LCD module. **Fig. 1** shows the comparison between the system configuration using a conventional driver IC and that using an LCD controller/driver IC with on-chip Mobile AGCPS. **Fig. 2** shows the operating principles of an LCD module using an LCD driver IC with an on-chip Mobile AGCPS. The driver IC for the on-chip Mobile AGCPS recognizes the characteristics of the input image data automatically and adjusts the backlight brightness accordingly. When the input image data indicates a dark image the backlight brightness and the power consump-

tion is reduced. At the same time, the Mobile AGCPS also adjusts the gradation voltage (γ curve) characteristic applied from the driver IC to the LCD panel, which with the conventional configuration was fixed optimally according to the result of the backlight brightness control.

Since simply reducing the backlight brightness would dim the displayed image, the LCD display image brightness is corrected for the same amount as the backlight brightness reduction in order to enable a reduction in power consumption without adversely affecting the display quality of the LCD. As the TV images for news, animations and movies are often dark, a reduction of the backlight brightness becomes especially possible for such programs.

The characteristics of image data are recognized on a per-frame basis, and the backlight brightness and γ curve are finely adjusted for every frame. With the on-chip Mobile AGCPS the backlight brightness is controlled based on the PWM (Pulse-Width Modulation) signal output from the driver IC. Fine adjustment of the backlight brightness in 256 steps (The accuracy of the PWM signal is 8 bits) enables smooth brightness adjustment without causing image quality deterioration such as flickering, even during the display of moving images.

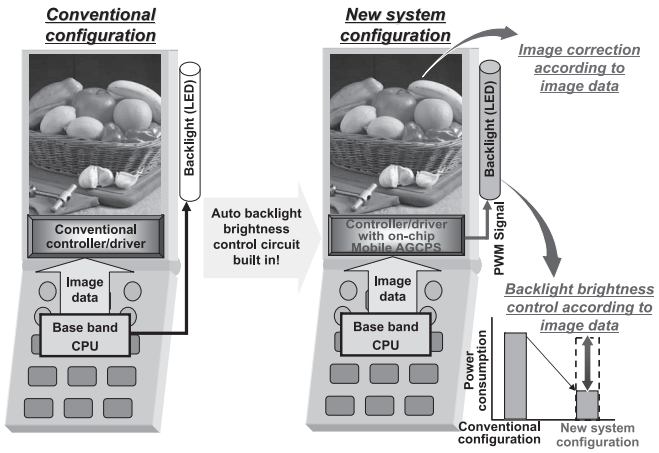

Fig. 1 Comparison of system configuration between the previously used driver IC and the new driver IC with the on-chip mobile AGCPS.

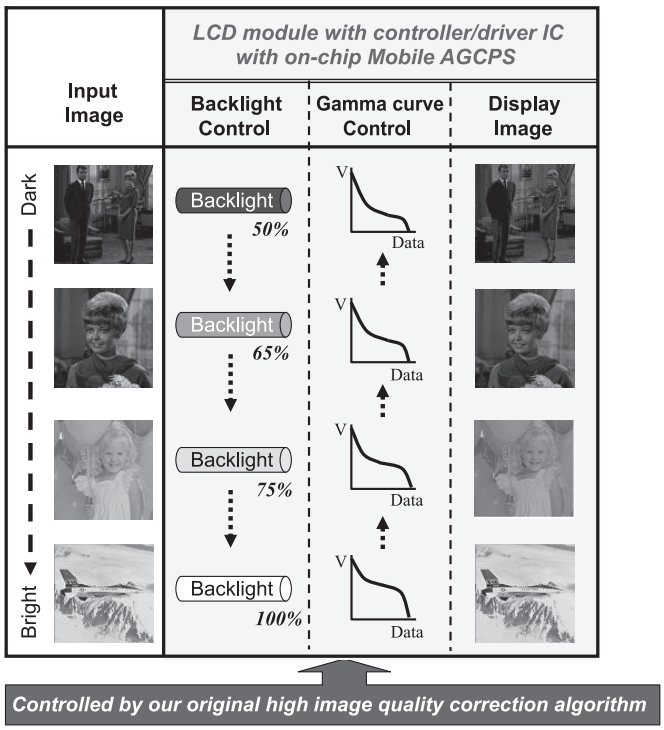

Fig. 2 Operating principles of LCD driver IC with on-chip mobile AGCPS.

3. Features of Drive ICs with On-Chip Mobile AGCPS

We have developed successfully the driver ICs with Mobile AGCPS almost in the same chip size with conventional driver IC. **Photo 1** shows the μPD161707 chip, which is the QVGA display-compatible LCD controller/drive IC for the on-chip Mobile AGCPS and the μPD161708, which is the WQVGA display-compatible model. **Table** shows the specifications of the μPD161707 and μPD161708.

The μPD161707/708 is incorporated in the Mobile AGCPS circuit for use in image data recognition, backlight brightness adjustment and image quality improvement (γ curve adjustment). This is in addition to the conventional circuit used

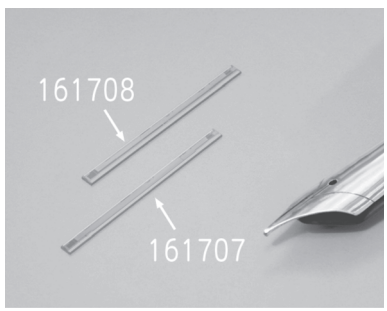

Photo 1 μPD161707 / μPD161708 chips.

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Table Basic specifications of µPD161707/µPD161708.

Item	µPD161707	µPD161708
Panel resolution	QVGA :240(RGB)×320	WQVGA : 240(RGB)×432
Outputs	Source: 720 outputs Gate: 320 outputs	Source: 720 outputs Gate: 432 outputs
Display memory size	1,382,400 bits (240 pixels×18 bits ×320 lines)	1,866,240 bits (240 pixels×18 bits ×432 lines)
Drive methods	Line-inversion drive Frame-inversion drive	
Colors	262,144 colors/pixel 8 colors/pixel	
Interfaces	8/16/18-bit parallel I/F, 16/18-bit serial I/F, 6/16/8/18-bit RGF IF	
Supply voltages	Interfaces: 1.65-3.3 V Source driver: 4.0-5.5 V	
Other functions	• RGB independent γ correction • Auto backlight brightness adjustment (Mobile AGCPS) • Nonvolatile memory (Fuse): For use in VCOM value storage	

in driving the LCD panel such as the gate circuit, source circuit, display memory and power circuit. With all of these functions being accommodated in a single chip, the driver IC does not increase the data processing load of the CPU or need modification of the interfaces between the CPU and the driver IC. As the number of chips is not increased from the conventional system configuration, it can implement cellular phone terminals with a Mobile AGCPS function without concerns regarding the cost and mounting space. The features of the driver ICs with on-chip Mobile AGCPS are as follows.

1) Reduction of power consumption without affecting the display quality (Reduction of backlight power consumption by more than 50%).
2) Moving image display capability thanks to the high-speed processing circuit (Compatible with 60Hz frame frequency).
3) No increase in the CPU processing load.
4) No change in the interfaces (between CPU and driver IC).
5) No increase in the number of chips (No need for reserving more mounting space).

4. Effects of Mobile AGCPS

Photo 2 shows the images displayed on an LCD panel incorporating µPD161707, with (A) showing the image when Mobile AGCPS is ON and (B) showing the image when it is OFF (i.e. in normal display mode, which is identical to the operation of conventional driver ICs). The figures below the displayed images indicate the amount of current consumed by the backlight LEDs (Current unit: mA, Voltage for LEDs: 12V). The images and data show that the use of the Mobile AGCPS function can significantly reduce the backlight power consumption and that the LCD display during use of Mobile AGCPS maintains similar display quality to the normal display mode despite its reduced backlight brightness.

LCD panel provided by
NEC LCD Technologies, Co., Ltd.

(A) Mobile AGCPS: ON
(Backlight: Auto brightness controlled)
(γ curve: Auto corrected)

(B) Mobile AGCPS: OFF
(Backlight: Fixed)
(γ curve: Fixed)

Photo 2 Display on LCD panel incorporating µPD161707.

5. High Image Quality Display Function

In addition to the low power consumption mode (Mobile AGCPS) for the backlight brightness control, the µPD161707/708 also have functions for improving the LCD display quality. One of them is the RGB independent γ control function that can adjust the γ curves of Red, Green and Blue independently. Setting the γ curve correction registers provided for R/G/B makes it possible to correct the traditional problems with LCD panels such as coloring in the medium gradations and color shifting in white points.

Another function is the image enhancement function that can improve the LCD panel display quality automatically. When

the image data input to the driver IC is a dark or low-contrast image, this function adjusts the γ curve automatically to improve the view of the LCD panel display image. **Photo 3** shows the comparison of LCD displays in the normal display mode and in the image enhancement mode. The displayed image of the image enhancement mode is enhanced in order to improve the display quality. Note that the backlight brightness in the image enhancement mode is identical to that of the normal display mode, so the power consumption reduction effect cannot be obtained.

Photo 4 shows that the enhancement of only a part of the display image is possible, which enables for example, the enhancement of only the area corresponding to the digital TV display area when the LCD screen is split into digital TV display and character display areas. The degree and area of the display image enhancement can be set with the quality correction registers and the display quality can be adjusted as required by the user.

(A) Normal display mode (B) Image enhancement mode

Photo 3 Comparison of LCD displays between the normal display and image enhancement modes.

(A) Normal display mode (B) Image enhancement mode (Area designated)

Photo 4 Comparison of LCD display between the normal display mode and the area-designated image enhancement mode.

6. Conclusion

We believe that driver ICs with on-chip Mobile AGCPS have the potential of greatly contributing to a reduction in power consumption, improvement of image quality and a decrease in the chip mounting area of mobile devices such as cellular phones. Moreover, it is expected that they will also be able to offer optimum solutions for cellular phones that have a digital TV broadcasting reception capability.

In the future, we are planning to expand the lineup of driver ICs with on-chip Mobile AGCPS and to develop new driver IC products that can improve the performances of mobile devices by taking full control of image processing, driver circuits and the associated LSI technologies.

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