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PCA8536 and PCF8536 as LCD and backlight driver

Rev. 1 — 11 November 2013   **User manual**

Document information

Info	Content
Keywords	PCA8536, PCF8536, LCD, backlight, PWM
Abstract	NXP has designed the LCD driver family PCx8536 that integrates a PWM controller and up to 6 PWM channels that can be used for LED backlighting, as well as for LED button illumination. The PCx8536 family allows programming the LCD frame frequency and the PWM frequency more than 50 Hz apart to prevent any display flickering.

Revision history

Rev	Date	Description
v.1	20131111	new user manual, first revision

Contact information

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1. LCD illumination

The Liquid Crystal materials emit no light on their own. Therefore the Liquid Crystal Displays (LCDs) need a form of illumination to produce a visible image.

In the "reflective" mode, the ambient light is used to illuminate the display. The illumination is achieved by combining a reflector with the rear polarizer.
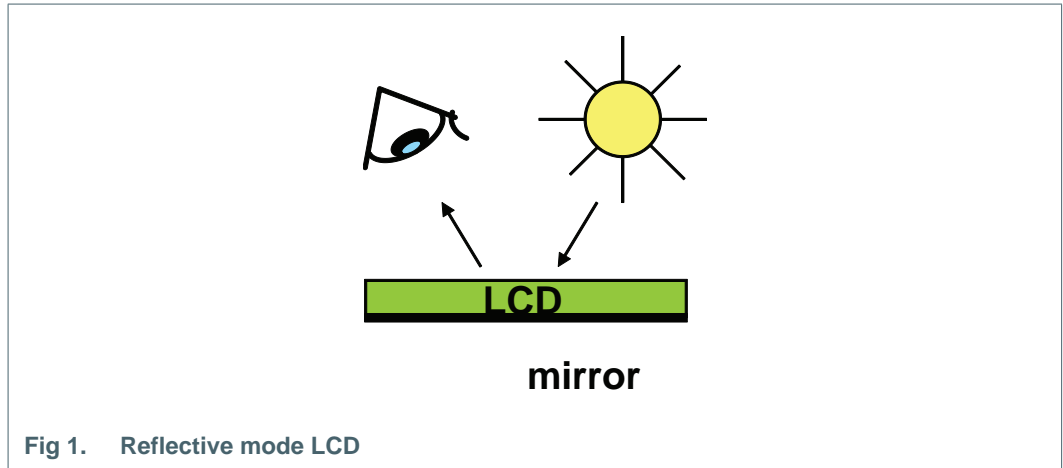
Fig 1.   Reflective mode LCD

In the "transmissive" mode, a special light source is used at the back of the glass, known as a backlight. In combination with a transparent rear polarizer it does not reflect the ambient light.
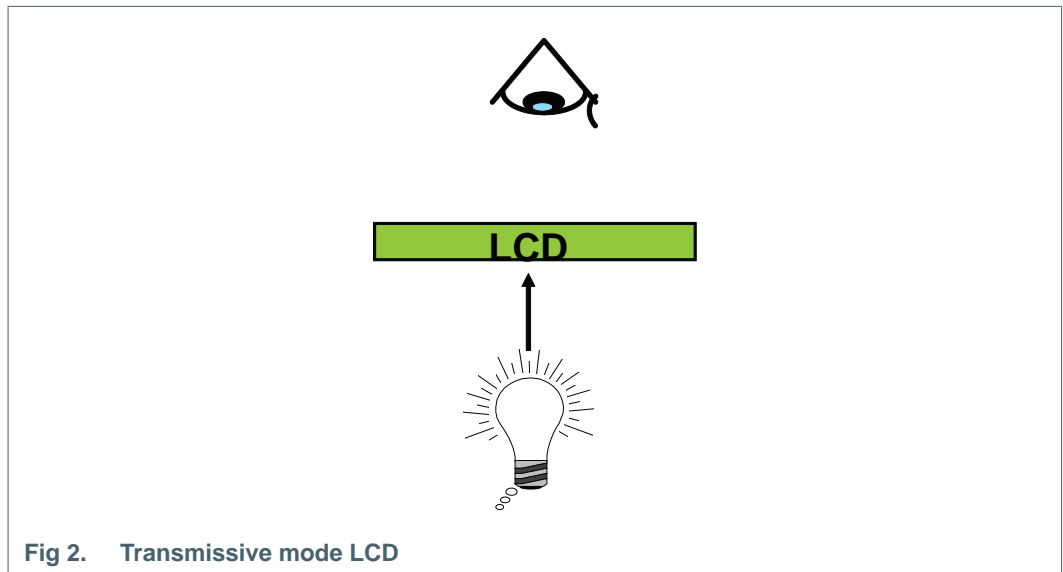
Fig 2.   Transmissive mode LCD

The reflective LCDs work best in an outdoor or well-lit environment; transmissive LCDs work best in low-light conditions, with the backlight continuously on. Transmissive LCDs guarantee much better optical performance but require a backlight, a circuitry to drive the backlight, and this implies higher power consumption.

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There are also "transflective" LCDs that are a mixture of the reflective and transmissive types, with the rear polarizer having partial reflectivity. They are combined with backlight for use in all types of lighting conditions. The backlight can be left off where there is sufficient light, which saves power, and with the backlight on it can provide a bright display in darker environments.

Fig 3.   Transflective mode LCD
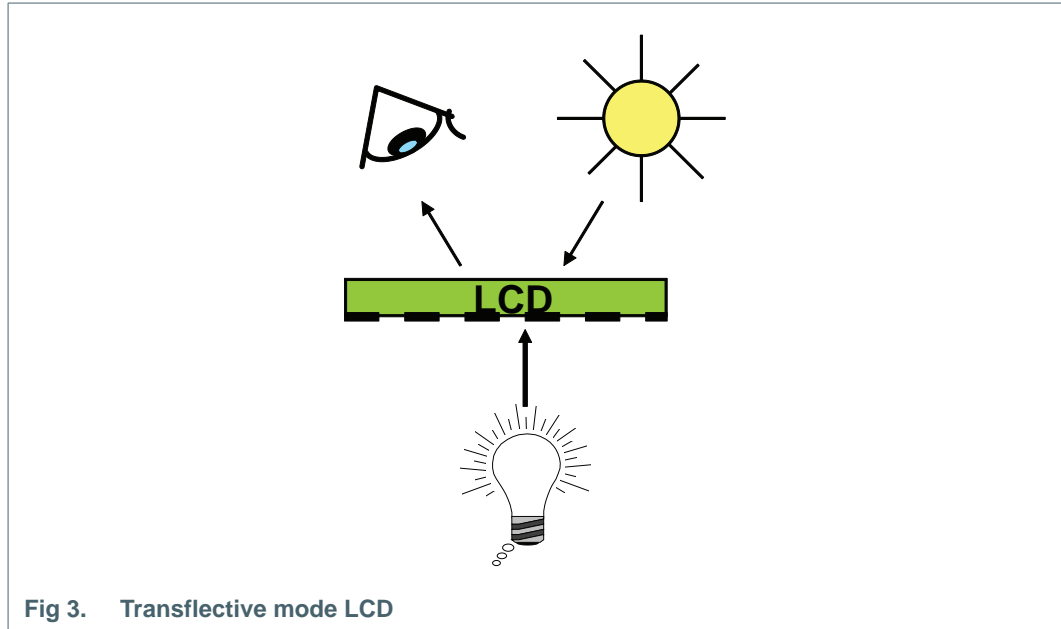
2.   LED backlighting

Today, most LCD displays are designed with LEDs as backlight instead of the traditional cold cathode fluorescent lamp (CCFL) backlight, since they allow a brighter and sharper image while reducing the power consumption. The LEDs could be white for a black and white display or RGB for a chromatic effect.

Fig 4.   LED backlighting

The LEDs could be placed in a row at one or more edges of the screen or could be placed in an array covering a large area of the display. A light diffuser is typically used to spread the light evenly across the whole display. Figure 5 shows a display fitted together with the LED backlight in a plastic frame.
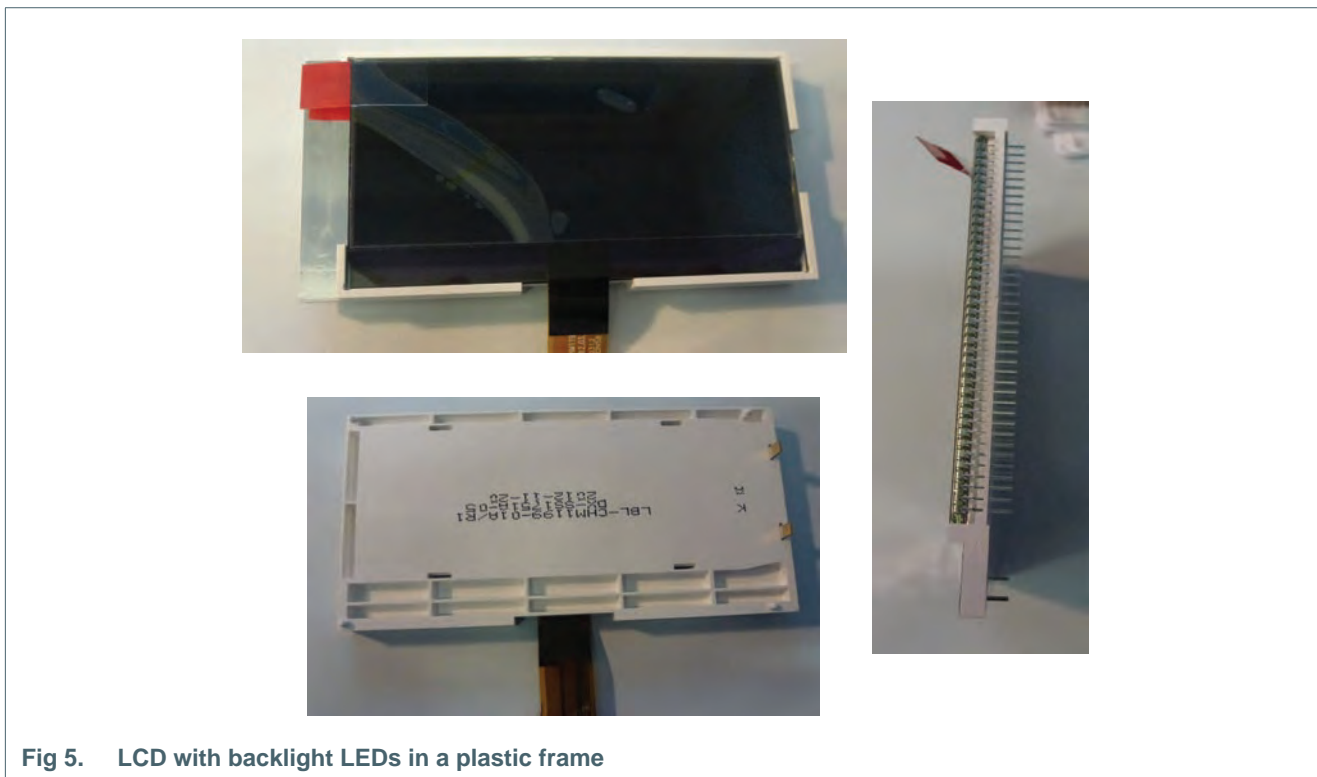

Fig 5. **LCD with backlight LEDs in a plastic frame**

The most common way to control the brightness of an LED is to switch the current, flowing through the LED, on and off by applying a Pulse Width Modulation (PWM) signal, rather than driving the LED with a variable continuous current. As long as the PWM switching frequency is higher than the human flicker fusion threshold, the backlight shows no flicker. In addition, PWM does not cause a color shift, which is the main drawback when using a variable continuous current to dim an LED.
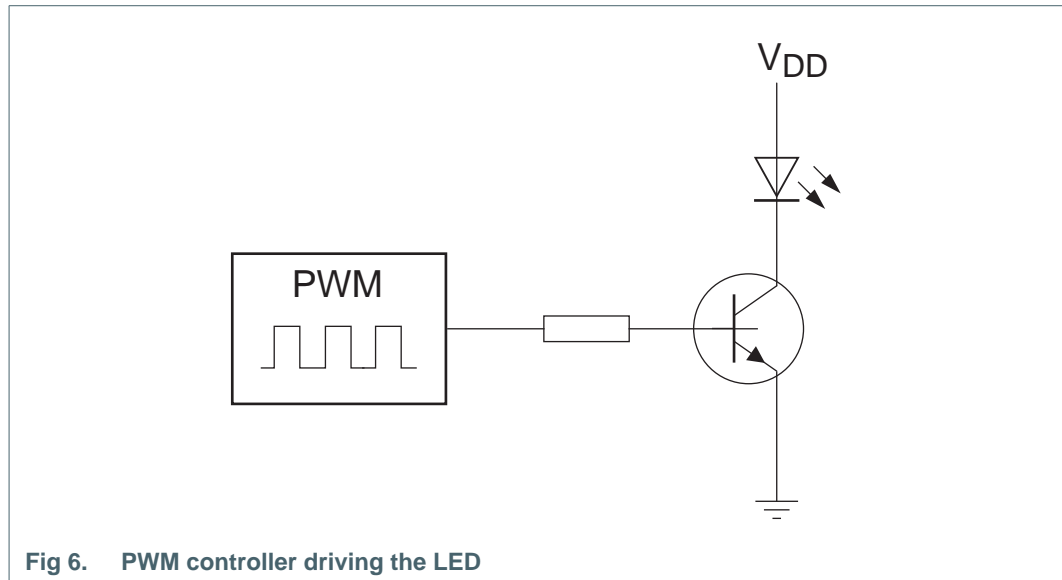
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**Fig 6.** **PWM controller driving the LED**

3. Display flickering

The LCD driving principle also creates flicking. Although the LCD and PWM frequency are both set higher than the human flicker fusion threshold, the combination of these two frequencies generates an intermodulation product or beat frequency. This beat frequency is the sum and difference of the PWM and LCD frequencies. If this beat frequency is below the human flicker fusion threshold, a visible flickering can still occur. This happens when the difference between the LCD frame frequency and the LED PWM frame frequency is too small.

As a consequence, maximum care must be taken when selecting independent LCD and LED drivers for the LCD module design and detailed testing and evaluation is required to avoid any flickering in the application.

The problem can be even more complicated when the clock source for the LED and LCD are not the same. The separate devices will have different responses to temperature and different variations over production life, meaning that even if flicker is carefully avoided during the design phase, it may appear later on during production.

4. PCA8536 and PCF8536 as LCD and backlight driver avoiding flickering

To solve these difficulties, NXP has designed the LCD driver family PCx8536 that integrates a PWM controller and up to 6 PWM channels that can be used for LED backlighting, as well as for LED button illumination.

PWM Controller:

- For LED backlighting

- For LED button lighting

Fig 7.   **Application with PCA8536 or PCF8536**
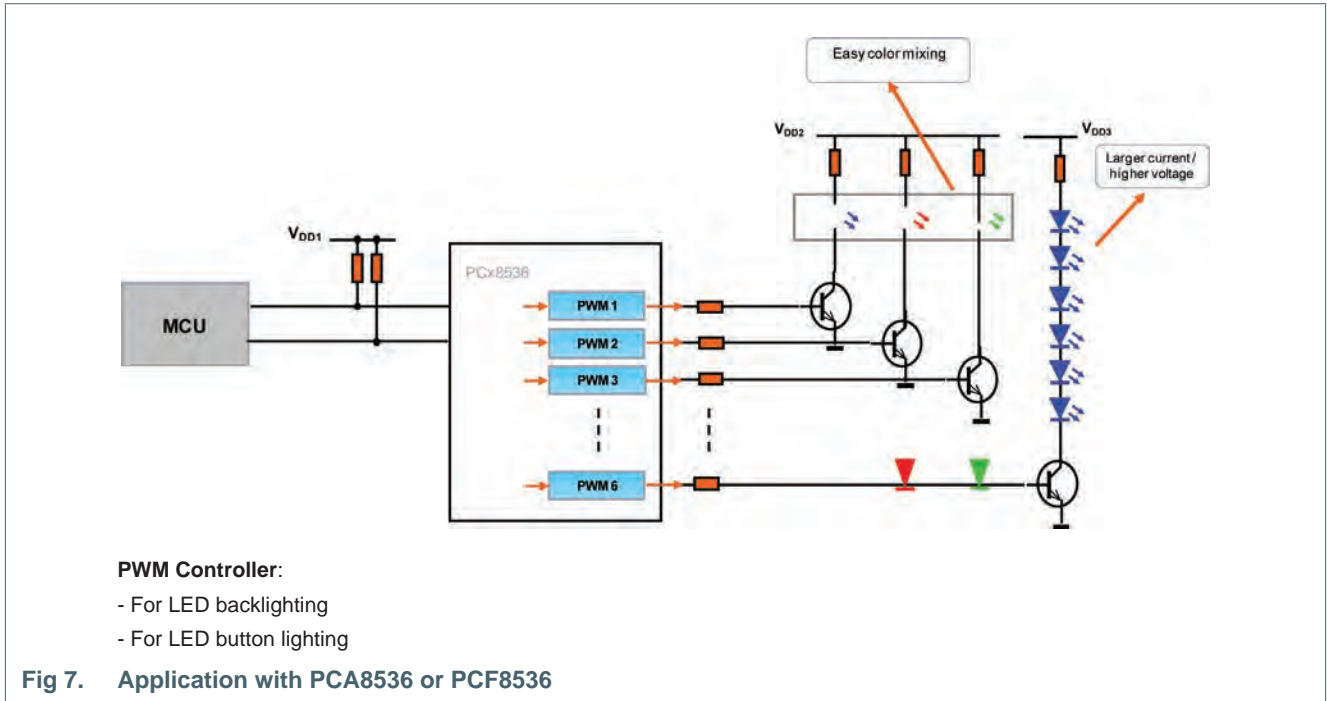
The LCD frame frequency and the PWM frequency are derived from the same clock source and can be programmed independently; it will be enough to program the two frequencies more than 50 Hz apart to prevent any display flickering across the operating temperature range and production spread.

Fig 8.   **Flicker avoidance for LED backlighting**

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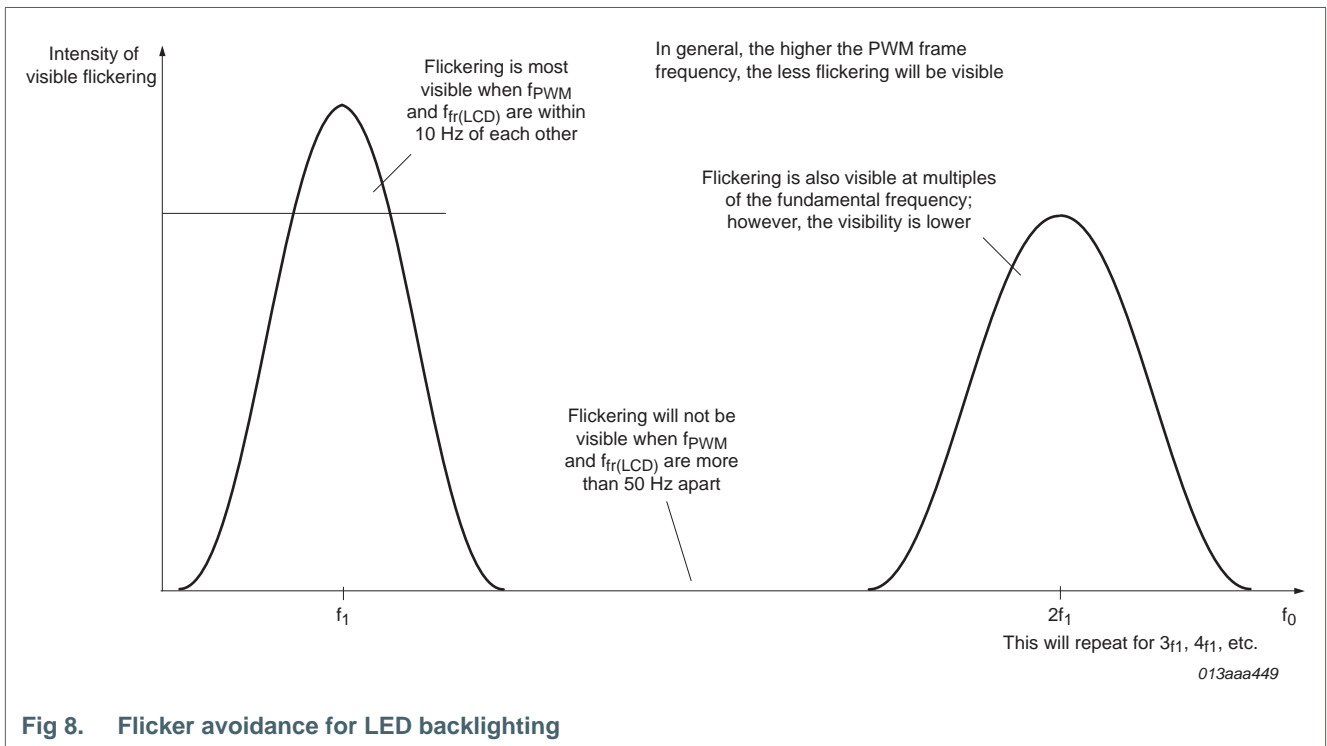
To reduce the BOM as well as testing and evaluation efforts, NXP suggests using the PCx8536 as LCD driver and LED controller.

5. References

[1] **PCA8536 —** Automotive LCD driver for low multiplex rates including a 6 channel PWM generator

[2] **PCF8536 —** Universal LCD driver for low multiplex rates including a 6 channel PWM generator

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