NXP UM10782 LPC User manual

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Assumed an LCD with a certain resolution, a defined LCD drive mode (commonly called multiplex rate) and a defined LCD bias configuration (commonly called bias system), the display contrast depends on the VLCD voltage, also called operating voltage of the display.

UM10782

The NXP LCD driver with on-chip charge pump for the LCD supply voltage generation

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Document information

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Keywords	Contrast, LCD driver, charge pump, PCA8547, PCA8543, PCA8537, PCA9620, PCA8538, PCA8539, PCF2119, PCF21219
Abstract	The most important parameter to assess the optical performance of a passive monochrome LCD is the display contrast. Therefore the V_{LCD} voltage must be set properly to gain an optimum contrast.

Revision history

Rev	Date	Description
v.1	20140220	first revision

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1. Introduction

The most important parameter to assess the optical performance of a passive monochrome LCD is the display contrast.

2. Display contrast

Assumed an LCD with a certain resolution, a defined LCD drive mode (commonly called multiplex rate) and a defined LCD bias configuration (commonly called bias system), the display contrast depends on the V_{LCD} voltage, also called operating voltage of the display.

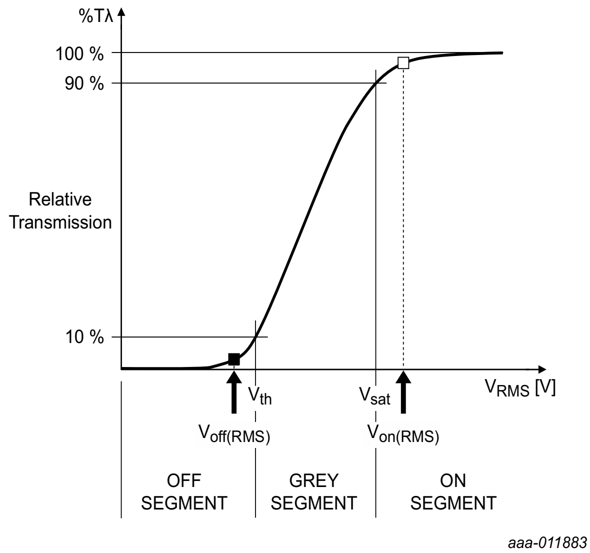
For an optimum display contrast, the V_{LCD} voltage must be set in order that the following two conditions are met (see Figure 1):

1. **$V_{off(RMS)} \leq V_{th}$**

   where V_{th} is the threshold voltage of the display, defined as the RMS voltage corresponding to 10 % relative transmission, and V_{off} is the voltage supplied to drive the pixel OFF; the condition $V_{off(RMS)} \leq V_{th}$ means that the pixel is really driven OFF.

2. **$V_{off(RMS)} \geq V_{sat}$**

   where V_{sat} is the saturation voltage of the display, defined as the RMS voltage corresponding to 90 % relative transmission, and V_{on} is the voltage supplied to drive the pixel ON; the condition $V_{on(RMS)} \geq V_{sat}$ means that the pixel is really driven ON.



$$V_{on(RMS)} = V_{LCD}\sqrt{\frac{a_{bias}^2 + 2a_{bias} + n_{MUX}}{n_{MUX} \times (1 + a_{bias})^2}}$$

$$V_{on(RMS)} \geq V_{th(on)}$$

$$V_{off(RMS)} = V_{LCD}\sqrt{\frac{a_{bias}^2 - 2a_{bias} + n_{MUX}}{n_{MUX} \times (1 + a_{bias})^2}}$$

$$V_{off(RMS)} \leq V_{th(off)}$$

With a_{bias} = 1 for ½ bias, a_{bias} = 2 for ⅓ bias etc. and n_{MUX} = 1 for static drive mode, n_{MUX} = 2 for 1:2 multiplex drive mode etc.

Fig 1. Proper V_{RMS} values switching a pixel fully on and off

Higher values of V_{LCD} lead to a loss of contrast since the pixel cannot be really driven OFF ($V_{off(RMS)} \geq V_{th}$), see Figure 2.

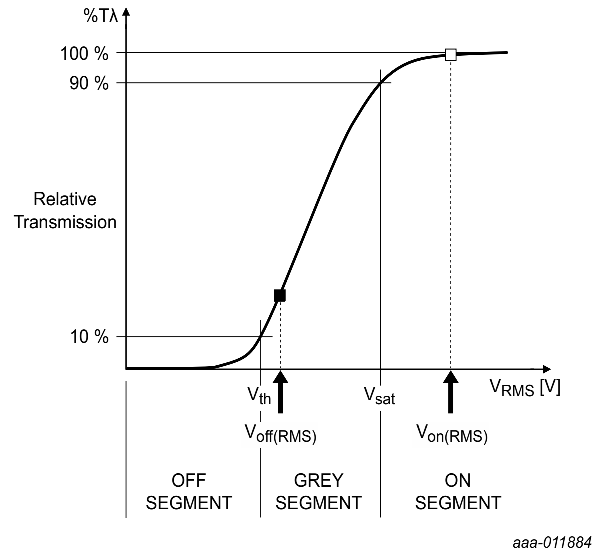


Fig 2. A too high V_{LCD} causing that $V_{off(RMS)} \geq V_{th}$

Lower values of V_{LCD} lead to loss of contrast since the pixel cannot be really driven ON ($V_{on(RMS)} \leq V_{sat}$), see Figure 3.

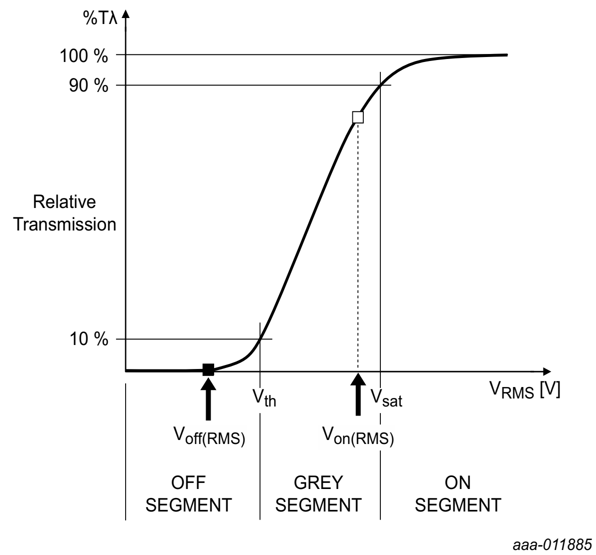
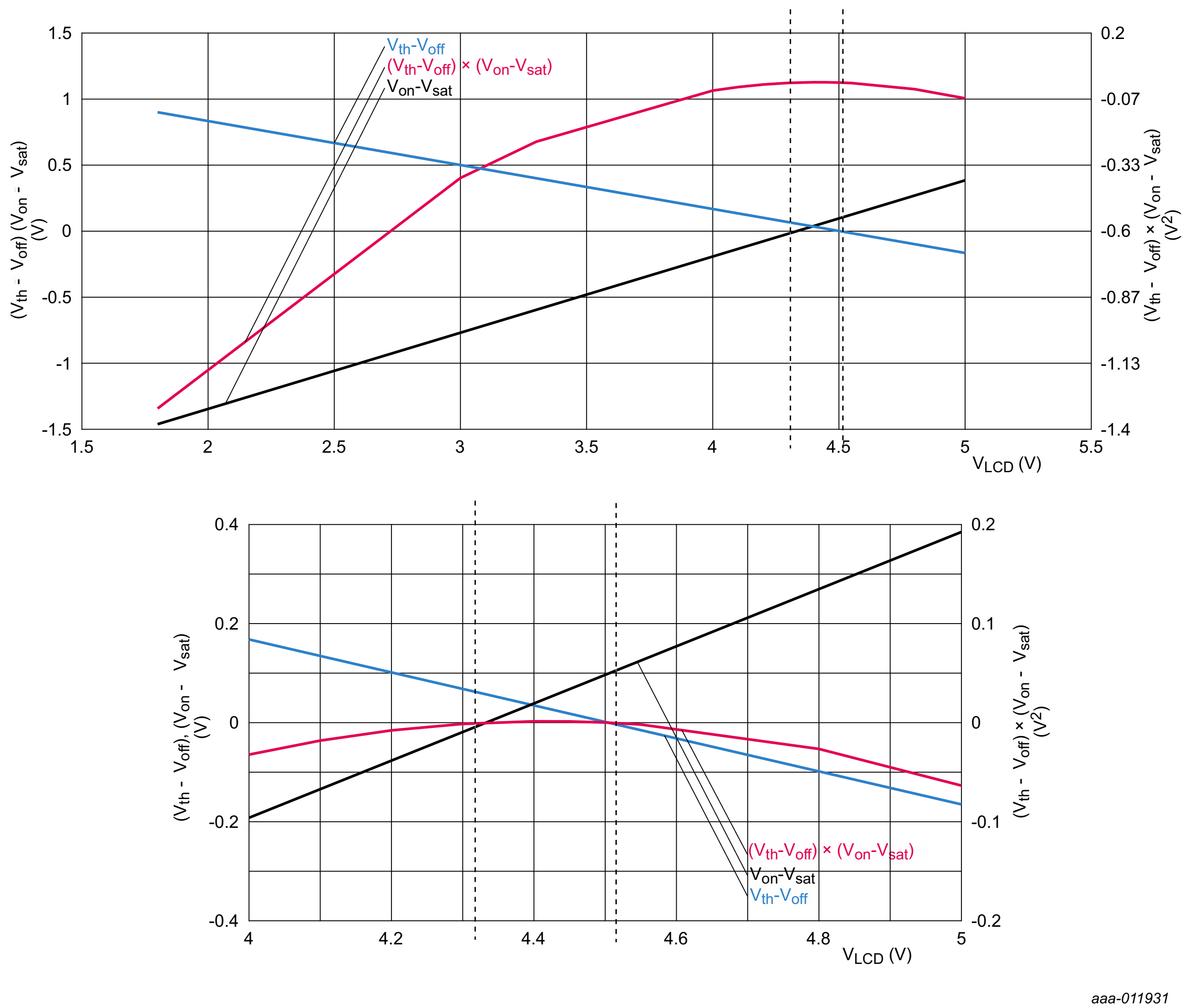


Fig 3. A too low V_{LCD} causing that $V_{on(RMS)} \leq V_{sat}$

There is only a strict range of V_{LCD} values that lead to an optimum contrast: the optimum value is that one, that maximizes the product $(V_{th} - V_{off}) \times (V_{on} - V_{sat})$. This product has always to be positive.



V_{th} = 1.5 V; V_{sat} = 2.5 V; MUX 1:4; bias ⅓.

Fig 4. Optimum V_{LCD} value to optimize the display contrast

In summary, to optimize the contrast:

1. **V_{LCD} must be independent from the V_{DD} supply**

   To be able to select the LCD voltage value and then optimize the display contrast independently from the V_{DD} supply.

2. **V_{LCD} must be programmable in a wide range**

   To be able to optimize the display contrast for a wide selection of LCDs with different V_{th} and V_{sat}.

3. **V_{LCD} must be programmable with a small programming step and very accurate**

   To guarantee that the programmed LCD voltage value is as much as possible close to the optimum value also across process variations.

4. **V_{LCD} must be compensated over temperature to keep a high and stable contrast over the temperature range**

   Since the display characteristics change over temperature, V_{LCD} should also change to maintain the best contrast over temperature.

Different solutions can be implemented by using discrete components.

In order to reduce the BOM and the overall system cost, NXP has developed a wide portfolio of LCD drivers with an integrated charge pump and regulator to generate the V_{LCD} on-chip and allow programming the V_{LCD} value accurately in a wide range, by simply programming a register through the interface. The capacitors of the charge pump are also integrated on-chip, allowing reducing the number of external components to a minimum. Further, NXP has integrated a temperature sensor and a V_{LCD} temperature compensation circuitry in order to compensate the V_{LCD} value with the temperature and to reach an optimum contrast all over the operating temperature range, from –40 °C to 85 °C for the industrial and consumer LCD drivers and from –40 °C to 95 °C or even 105 °C for the automotive qualified LCD drivers.

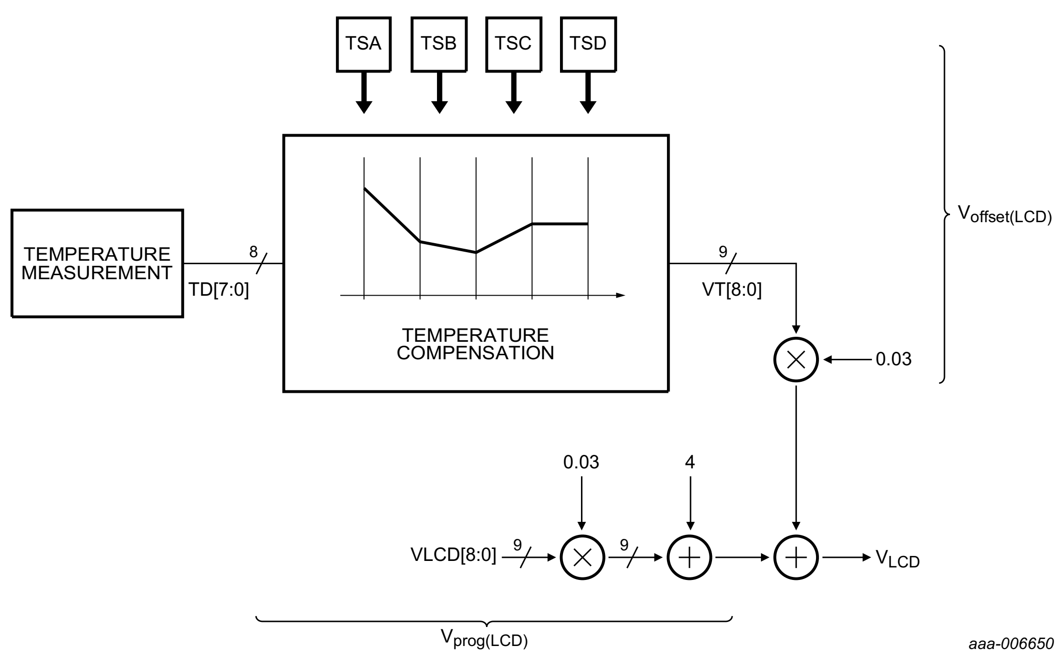


Fig 5. V_{LCD} generation including temperature compensation

3. LCD drivers with integrated charge pump

Table 1. List of LCD drivers with integrated charge pump

Product type	Maximum resolution	Package	V_{LCD} programmable range	Max. charge pump multiplication factor	Temperature range
Packaged LCD segment drivers					
PCA8547	4 × 44	TQFP64	2.5 V to 9.0 V	3 × V_{DD2}	–40 °C to 95 °C
PCA8543	4 × 60	LQFP80	2.5 V to 9.0 V	3 × V_{DD2}	–40 °C to 105 °C
PCA8537	8 × 44	TQFP64	2.5 V to 9.0 V	3 × V_{DD2}	–40 °C to 95 °C
PCA9620	8 × 60	LQFP80	2.5 V to 9.0 V	3 × V_{DD2}	–40 °C to 105 °C
Chip-On-Glass LCD segment drivers					
PCA8538	9 × 102	bare die	4.0 V to 12.0 V	5 × V_{DD2}	–40 °C to 105 °C
PCA8539	18 × 100	bare die	4.0 V to 16.0 V	4 × V_{DD2}	–40 °C to 105 °C
Chip-On-Glass LCD character drivers					
PCA2117	1 line × 40 characters or 2 lines × 20 characters	bare die	4.0 V to 16.0 V	4 × V_{DD2}	–40 °C to 105 °C
PCF2119	2 lines × 20 characters	bare die	2.2 V to 6.5 V	4 × V_{DD2}	–40 °C to 85 °C
PCF21219	2 lines × 20 characters	bare die	2.5 V to 6.5 V	4 × V_{DD2}	–40 °C to 85 °C

Choose the NXP LCD drivers with integrated charge pump that allow both, high performance and low cost!

4. References

[1] **AN10170 —** Design guidelines for COG modules with NXP monochrome LCD drivers

[2] **AN11267 —** EMC and system level ESD design guidelines for LCD drivers

[3] **PCA8547 —** 4 x 44 automotive LCD driver with integrated charge pump, product data sheet

[4] **PCA8543 —** 4 x 60 automotive LCD segment driver with integrated charge pump, product data sheet

[5] **PCA8537 —** Automotive LCD driver for multiplex rates up to 1:8, product data sheet

[6] **PCA9620 —** 60 x 8 LCD high-drive segment driver for automotive and industrial, product data sheet

[7] **PCA8538 —** Automotive 102 x 9 Chip-On-Glass LCD segment driver, product data sheet

[8] **PCA8539 —** 100 x 18 Chip-On-Glass automotive LCD dot matrix driver, product data sheet

[9] **PCF2119 —** LCD controllers/drivers, product data sheet

[10] **PCF21219 —** LCD driver for character displays, product data sheet

[11] **R_10015 —** Chip-On-Glass (COG) - a cost-effective and reliable technology for LCD displays

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