Effective Use of Pictiva™ OLED Displays: Power, Image and Lifetime Optimization

Application Note AN008

Basic Considerations

OLED technology is an emissive technology. This means that unlike LCDs, power consumption is not a fixed value; it varies with image content. The driving of an LCD with changing images consumes little power because there is almost no current flow in the LCD cell. The main contributor to LCD power consumption is the backlight which always illuminates the whole viewing area. For an OLED, this is comparable to an *All-Pixels-ON* scenario, but this image conveys no information. Therefore, an OLED with a typical image that consists of ON and OFF pixels has lower power consumption because the dark OFF pixels consume negligible power.

Influence of Picture Mode

Basically, there are two modes to display information. Figure 1 shown below indicates the difference between negative mode (bright characters on dark background) and positive mode (dark characters on bright background), using dark ink on white paper as a reference.

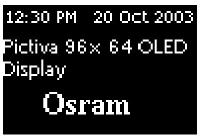


Figure 1.a: Negative Mode Image

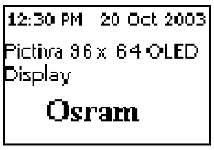


Figure 1.b: Positive Mode Image

The information content shown in Figures 1.a and 1.b is the same. However, the left image has only 10 % of the pixels ON, whereas the right image has 90 % of the pixels ON. In a first approximation, the positive mode image consumes 9 times more power. In many applications, less than 10% of the pixels are required to generate images so this difference is even more dramatic. It is evident that image design can significantly help reduce power consumption.

Influence of Color Choice

OSRAM Opto Semiconductors offers different colors for its Pictiva™ display products. As a consequence the display's **efficacy (= luminance output / power input)** is a parameter that is highly dependent on the chosen materials. In each Pictiva™ datasheet there is a table which determines the module power consumption based on several picture and luminance scenarios. A comparison shows that the yellow or green color OLEDs deliver the highest luminance values with lowest power consumption. If power consumption is the main priority for the application, it is recommended to use a yellow or green display to save power. Details can be found in the datasheets.

Influence of Luminance Level

In an OLED device, luminance is dependent on the current density. A higher current results in a higher luminance or brighter display. Thus, brighter pixels consume more power than darker ones. The relationship is not completely linear, but for a first estimation it is reasonable to assume this is the case. Consequently, the luminance level of the OLED display should always be optimized for operation in ambient illumination conditions. In darker ambient conditions the brightness of the display can

be dimmed down to as low as 10 cd/m² and still maintain good viewability.
An overview of different scenarios for a few Pictiva™ display formats is given in Table 1, as shown below. It should be noted that the given values are based on actual measurements with an OLED drive voltage of 12-12.5 V and a frame rate of 75 Hz.

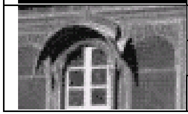
Sample Picture	Pixels ON	Luminance / Cd/m²	Power Consumption / mW 128x64	96x64	80x48
	2 %	15	5	5	3
	2 %	50	8	7	3
	2 %	100	12	9	4
	5 %	15	8	6	3
	5 %	50	15	10	5
	5 %	100	20	16	8
	10 %	15	10	8	4
	10 %	50	24	16	8
	10 %	100	40	26	13
	~ 45 %	15	55	40	17
	~ 45 %	50	110	69	27
	~ 45 %	100	175	104	40

Table 1: Example of power consumption scenarios for Yellow Pictiva™ Displays

Obviously it is very helpful to use dimming functions to reduce power consumption. Another positive effect of dimming is an elongation of the display lifetime. Especially for indoor applications it should be considered not to fix the highest luminance level to the maximum possible, but to something lower. **With half the value of initial brightness, the OLED operational life can be roughly doubled.** As an example, with an initial luminance of 200 cd/m² the lifetime of a yellow Pictiva™ product is nearly 15,000 hours. By setting the initial value to 50 cd/m² a lifetime of more than 60,000 hours can be achieved.
An easy way to adjust the luminance to optimize for varying ambient illumination conditions is to use a photodiode (e.g. SFH3710 from OSRAM Opto Semiconductors). Using an OLED driver IC such as the SSD0323, there are two commands that control the luminance of the display; one command sets the current range and the other sets the contrast ratio. Both commands control the amplitude of the current drive pulse rather than the pulse width. Refer to individual product specifications for the correct setting of these parameters.

Influence of Voltage Multiplier

Some Pictiva™ products are offered with an optional DC-DC-converter (voltage booster) on board. The driver IC usually requires 2.4 to 3.5 V VDD input (logic power supply), but the OLED drive voltage VCC should be in the range of 12 to 13 V. For many applications, only a low battery voltage is available. The voltage booster on board (inductor / Mosfet combination) has an 80% efficiency in the best conditions with a power supply of ~ 3 V. Therefore, if the DC-DC-converter is used the power consumption rises by 20 to 25 %. Thus, it is recommended to make use of an existing voltage supply in the range of 12 to 13 V whenever possible. In general, a voltage booster circuit on a PCB is more efficient than the version on the flex of a display module.

Influence of Frame Frequency

The frame frequency or refresh rate should be set at a nominal rate of 75 Hz. During initialization it can be adjusted to the desirable rate by varying the software settings for the oscillator frequency, clock divide value D, and row period K (optimized at 70) for a given multiplex ratio. For more details refer to the driver specification. A low frame frequency (< 60 Hz) leads to visible image flickering. A very high frame frequency causes the display to dim due to a shorter pixel charge time during each refresh period. The contrast setting can be increased to restore the required luminance, however, this results in higher power consumption. Even without readjusting the contrast setting, the power consumption increases at higher frame frequencies. This is due to the capacitive characteristics of the OLED pixels. Under multiplex drive conditions the pixels are always charged and discharged. For a higher frame rate the number of charging cycles increases, and as a result the power consumption also increases. Thus, the frame frequency should be set as low as possible without affecting the picture quality (flickering).

Influence of Time Out Modes

In many applications the display is not required all the time. A standard user profile – especially for portable applications – indicates limited viewing time. In such an application, for example the display could light up and show some information when the complete device is operated via a keypad. After this operation a time-out period could be defined, after which the display switches OFF or goes into a dim Standby state. The switch OFF could also be achieved by using a fade out function. When the display is needed again, it could be easily activated by pushing a button. The ON-time of the display is essential for the overall power consumption and a time-out scheme can significantly increase battery life.

Influence of Screen Savers

An additional advantage of the above mentioned time-out mode is the lifetime enhancement of the display itself. Since OLED is an emissive technology, very slow degradation is observable with continuous use. Static text in particular results in differential aging or burn-in, similar to that observed in Cathode Ray Tubes or Plasma Displays. This is a result of frequently used pixels appearing darker than rarely used ones. To avoid this effect there are also other highly recommended options besides the time-out or standby modes. Screen saver or scrolling modes can assure that the pixels are equally stressed, thus providing constant image quality. Again, when defining the screen saver design the luminance level and picture mode recommendations should be considered. A variant of such a screen saver could be very slow moving of static pictures within a few pixels confine. This can be realized without being noticeable to the user.

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