Choosing a sunlight-readable display

The engineer should consider the tradeoffs between power and heat

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Fig. 1. A standard AMLCD display configuration uses an antireflective coating on the front glass.

Recent advances in liquid-crystal displays have created new outdoor applications for sunlight viewing, especially where CRTs are out of the question because of their bulky size. LCDs are finding new applications daily in fast-food and retail-advertising environments.

These applications demand not only sunlight readability, but larger displays. Previously, a display that provided 400 nits with a good reflective surface was acceptable—now the demand has increased to 1,500 nits with a minimum display size of around 15 in. diagonal.

Among all the display technologies available for sunlight readability, liquid crystal holds the dominant place, offering lightweight, compact size, and portability. However, because of the demand for brighter and larger displays, power requirements have also increased.

Displays larger than 10.4 in. pose thermal problems when used in a sunloading environment. To keep costs down, manufacturers have typically used a brutal force method, increasing backlight power to increase display brightness.

This high-power backlight in turn generates tremendous heat that causes an active-matrix LCD (AMLCD) to go above its clearing temperature. Heat is detrimental to AMLCD survivability.

To overcome the heat produced by the backlight, a massive heatsink is needed to cool the system down in an airtight display enclosure. In addition, expensive antireflective and infrared (AR/IR) face glass is laminated onto the AMLCD to block heat generated by sunlight.

Display performance parameters

There are several display parameters to be considered for sunlight readability. Likewise, there are many methods of implementing a sunlight readable display as well. The following list of display performance parameters can be used to sort out the technical tradeoffs, pros and cons:

- *Brightness.* The display must be bright enough to be legible under full sunlight. With good display reflectance, the required brightness ranges between 400 and 1,500 nits.
- *Power consumption.* A 15-in. display can consume as much as 50 W for a brightness of 1,500 nits. A majority of this power translates into heat.
- *Readability.* The display image must be discernable by the naked eye under all viewing conditions from full sunlight to nighttime.
- *Cost.* Cost is tied to display implementation, which is described in more detail in the following section.

Ideally an AMLCD will have a high percentage of light transmission. Four other key components used to construct a display have an effect on the efficiency of the implementation.

Different combinations of these display components will affect the cost of the display and its viewing quality under various lighting conditions. The front glass uses an antireflective coating on the side facing the viewer, while the other side is coated with an infrared coating.

The antireflective coating is used to minimize reflections caused by sunlight, and the infrared coating is used to reject heat due to sunloading. The rejection spectrum is usually in the 700 to 1,100-nm region.

An antireflective film is laminated on front of the AMLCD to minimize the reflection in the air gap between the AMLCD and the front glass rear surface. In this example, a high-efficiency light guide channels the light from four cold cathode fluorescent lamps to the viewer.

An inverter board with dimming capability provides the brightness levels necessary to meet various ambient lighting conditions. In a variation to the foregoing description, a transflective layer could be laminated onto the AMLCD to reflect sunlight, which itself would serve as the light source. The backlight uses two to four cold-cathode fluorescent tubes (CCFLs) for nighttime viewing.

If the backlight is replaced with multiple CCFLs positioned behind the AMLCD, they would provide a brightness of 1,500 nits to the viewer. However, they would also increase backlight power requirements and the backlight used in this way would require system-level heat management.

Recent innovations in backlight technologies have led to some implementations that provide a significant reduction in power consumption. With a reduction in backlight power coupled with good thermal management, lamination of AR/IR glass onto the AMLCD are no longer necessary for sunlight viewing under sunloading conditions.

The *table* summarizes the backlight power for various 15-in. display configurations—the benefits of proper thermal management are obvious. For example, traditionally, a 15-in. display rendering 1,500 nits requires 50 W and a massive heat sink. Harnessing advances in the technology, InSync powers the same 15-in. display running 1,500 nits with only 35 W, allowing a 15-W power cushion to safely operate under heavy sunloading conditions. EP

Backlight Power

Display Configuration	Sunny Day	Cloudy Day	Night Time
Microprism Light Guide	15 W	15 W	8 W
Transflective Film	0 W	15 W	8 W
Multiple Lamp	35 W	15 W	8 W