

## GenFlective™ Passive Optical Enhancement

As more and more LCDs find their way into outdoor applications, the need becomes far greater for them to not only be able to withstand severe temperature extremes (heat and cold) and solar radiation, but the LCD must also be readable when exposed to extreme optical conditions such as direct and indirect sunlight, glare and reflection.

Most off-the-shelf LCDs are not properly equipped to handle all of these requirements. The traditional approach demands installation of value-add backlights to boost brightness and incorporation of thermal management solutions to dissipate the heat generated by the backlights.

Additionally, although transmissive panels are now available with a seemingly bright white luminance, they do not provide adequate brightness or contrast to be considered practical in high ambient lighting conditions or direct sunlight.

### The Myth

It is a common myth that increasing an LCD's backlight brightness alone will make an LCD usable in high brightness environments (i.e., sunlight readable). The reality is that the increase in brightness is only a benefit if it does not adversely affect the contrast at the same time.

For example, imagine that a value-add backlight is used to increase the luminance of an OEM LCD that has a white luminance of 200 nits and a contrast ratio of 300:1 (black luminance of 0.66 nits) by ten-fold to a white luminance of 2,000 nits. While the display is unarguably brighter, the increased brightness will not be of much value in direct sunlight if the "black luminance" is correspondingly increased from 0.66 nits to 660 nits (contrast ratio of 3.03).

These factors, as well as other integration issues (e.g., power consumption and heat dissipation), must be considered as a collective when designing LCDs for true sunlight readability.

General Digital Optical Bonding Laboratories (GD-OBL) offers three types of sunlight readable solutions. The first is the traditional value-add backlight solution. The second approach is to provide a transmissive display, which incorporates a highly reflective backlight that reflects ambient light back out of the display. Our third offering, and generally the most efficient and cost-effective solution, is the **GenFlective** display, a hybrid of transmissive and passive enhancements.

### Value-Add Backlights

Traditionally, value-add backlights have a short life expectancy; bulbs generally have a brightness half-life of 20,000 hours, which means that the backlight will only be able to

### QUICK LOOK

- » Can Enhance Transmissive Brightness
- » Can Provide Additional Reflective Performance
  - › Uses Sunlight to Increase Backlight Brightness
- » Low Power Usage (No More than Conventional LCDs)
- » Low Heat Emission (No More than Off-The-Shelf LCDs)
  - › Easily Integrated into Sealed Enclosures in Extreme Environments
- » Can be Combined with Low-Power Active Enhancements
- » Contrast Enhancements
- » Index-Matching Films or Coatings
- » Minimize Internal and Surface Reflections
- » Cost of Ownership Reduced Due to Increased Bulb Life and Simpler Integration Compared to Conventional Solutions
- » Eliminates Expensive Semi-Custom Inverters
- » Eliminates Expensive Multi-Bulb Backlights
- » Can be Applied to Virtually Any Size LCD
- » Optical Bonding Available Optionally to Further Augment Performance



produce approximately half of its original brightness after 20,000 hours. Compared to this, current OEM backlights often are rated for 50,000 hours.

A typical 2,000 nit backlight for a 10.4" display will require as much as 20 watts, while a 600 nit 20" backlight uses greater than 60 watts. Because of this high power consumption, heat dissipation is of paramount importance.

Integration of thermal management such as heat sinks, cooling fans, heat exchangers, heat pipes, etc. is necessary to maintain safe operating conditions.

Although most recent value-add backlight designs do not add significant depth to the OEM LCD, they typically require more space in the integrated enclosure due to the necessity to provide thermal management.

By themselves, value-add backlights can be quite costly. In addition to the expense of the backlights and their associated electronics and packaging, most displays also require some optical films as well. When considering the integration of a value-add backlight, one must also consider the expense of the thermal management solution (typically required) as well as the increased cost of ownership resulting from shortened lamp life. And don't forget about the special inverter(s) required to drive the backlights.

### Transflective Panels

Although they are designed to reflect ambient light back out the display to augment its performance in direct sunlight, transflective panels have insufficient transmissive luminance (typically ~200 nits) to be considered usable in diffuse lighting conditions where direct sunlight is not available (e.g., cloudy or rainy days).

Additionally, transflective panels are only available in a limited range of display sizes and resolutions.

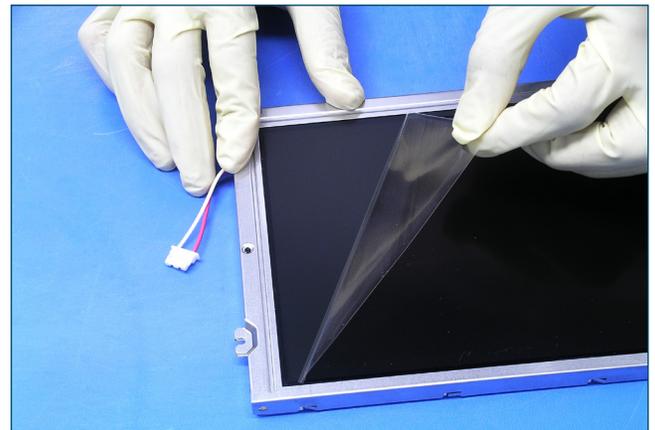
### GenFlective Technology

A GenFlective-enhanced LCD is a display that GD-OBL has altered, using passive enhancements, to improve the brightness (transmissive and/or reflective) and/or the contrast of a display. Although each display has its own personality, due to differences in design, manufacturing techniques and in the stock film stack, we can typically enhance the performance of an OEM panel utilizing Optical Management Films, Polarizers and Diffusers, and a multitude of films and coatings (Contrast Enhancement, Index Matched, Antireflective, etc.).

In contrast to value-add backlights, LCDs enhanced with GenFlective technology do not require any additional power since we have not modified the OEM bulbs or backlights. In addition to reduced power consumption, this benefits the end user with cooler running units, which in turn negates the need for bulky, complex and/or expensive cooling systems (fans, heat exchangers, heat pipes, etc.) that traditional value-add backlights typically require. Another benefit resulting from these factors is improved reliability (reduced piece count).

Since the LCD's lamps are not being overdriven, the GenFlective enhancements do not adversely affect the brightness half-life of the bulbs. A direct correlation exists between the brightness half-life of the bulbs and the suitability and cost of ownership of the integrated solution. For example, most bulbs are rated for 50,000 hours when operated at their intended drive current. As a rule of thumb, the bulbs will lose 10% of their initial brightness during their first 500-2,000 hours and 1-5% for every 1,000 hours of use thereafter. Longer brightness half-life also reduces the cost of ownership by reducing the frequency of backlight replacement.

In theory, candidate displays for GenFlective enhancement can be of any size, resolution or manufacturing origin. The success of the candidate display is most influenced by the display's aperture, transmissivity and the "personality" (OEM film recipe).



### Combining GenFlective with Other Technologies

To further enhance LCD performance and improve its ruggedness, GenFlective technology can be combined with optical bonding, provided by GD-OBL.

Optical bonding of an LCD reduces internal reflection and increases brightness and contrast by index matching internal surfaces. It also creates a shatterproof construction similar to the properties of automotive windshields. An additional benefit is the optical-friendly integration of other options, such as heaters, EMI filters, hot mirrors (IR filters) and more.

Another combination utilizes low power active enhancement, which allows overdriving of cold cathode fluorescent tubes and multiple tube edgelight replacements.

Overdriving the bulbs, or using a drive current that is greater than recommended by the OEM manufacturer, will increase display brightness but will also reduce the brightness half-life expectancy of the bulbs. Increasing the number of bulbs will also increase the luminosity of the panel and add less than 10 watts of additional power consumption.

In some instances, GenFlective technology can also be combined with traditional value-add backlights for a “best of both worlds” solution.

### Integration Decisions and Influences

To optimize the benefits and performance of the GenFlective-enhanced LCD panels, GD-OBL recommends that an index-matched-to-air antireflective coating be included on the outer viewing surface to improve contrast. Customers should note that special handling and cleaning instructions are required for the care of antireflective coatings.

Introduction of overlays that adversely affect light transmission, such as vandal shields, touch screens, EMI filters, hot mirrors, etc., will diminish the performance of the GenFlective-enhanced LCD.

### For More Information

Determining the best solution for your particular application can be a daunting task. We invite you to visit our Web site at <http://www.GDOptiLabs.com> to explore the latest information available on GenFlective LCD optical enhancements. Or call 800.952.2535 to speak with a Sales Engineer.



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