Solar Loading Effects on TFT LCD Displays Part I

Introduction to heat management and control methods

Technical report – Allen Gard and Scott Vahlsing, Planar Systems, Inc. (28 May 2004)

Abstract

Flat panel displays, exposed to ambient sunlight conditions such as those in ATMs and point-of-sale terminals, which are installed outdoors or exposed to direct sunlight are problematic. High ambient sunlight reduces not only the display viewability, due to unwanted light reflections, but also contributes to increased device operating temperatures. This solar heat source combined with the display's drive and lighting electronics heat sources if not properly managed can lead to significantly reduced performance in TFT LCD displays. The major cause of increased display temperature in high ambient sunlight conditions is due to the absorption of the sun's infrared energy. If the exposed LCDs thermal load is not minimized then temporary inhibition of the LCD cells electro optical response function will occur. The end result observed when the LCD cell temperature limit is exceeded is the formation of black areas on the active screen, (in the case of "normally white" constructed LCD cells) and the opposite effect for "normally black" cell configurations. Several control methods can be used to minimize or dissipate unwanted solar and drive electronics heating. These thermal control techniques combine active convection cooling along with front surface polarized infrared reflector film protection.

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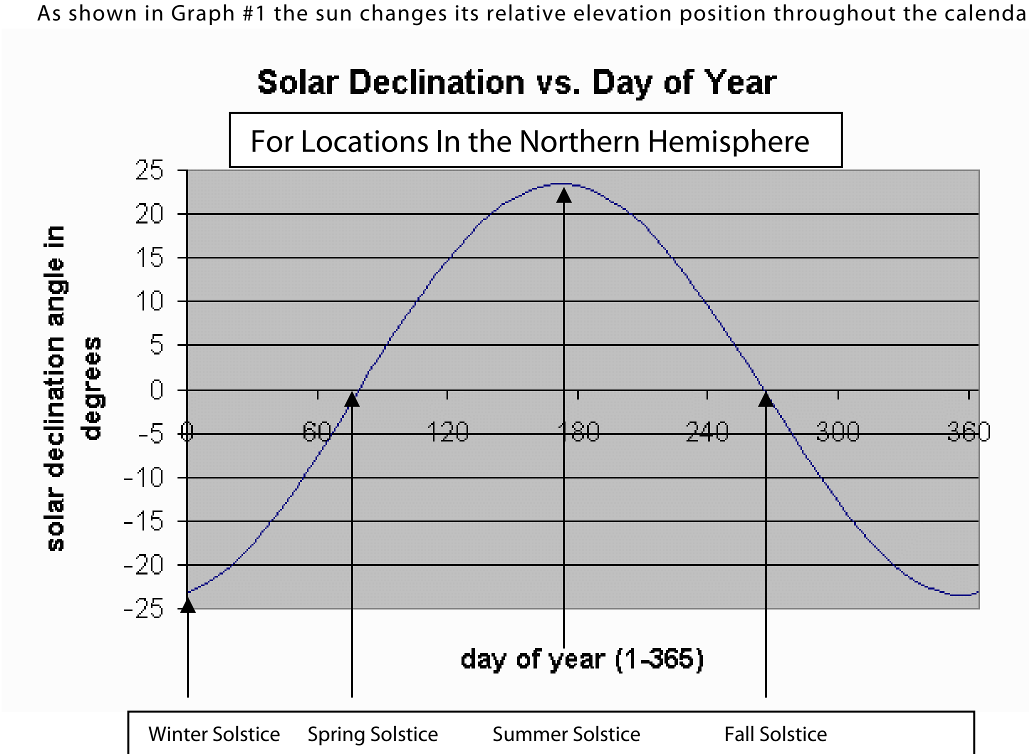
Solar Heating

High levels of solar radiation reaching the display front surface are typically 700-750 W/m^2. For a 15" display size this translates into a possible 50 to 55 watts of power absorbed by the display. The situation is often exacerbated by the addition of another protective layer for those cases of public venue use where protection of the display is needed in the form of a front surface "vandal glass". While protecting the display from physical damage, the vandal glass can also act as a thermal trap of generated and absorbed heat and thereby increase the display temperature.

For cases of fixed terrestrial display installations, understanding the relative position of the sun to the display face can assist the designer / user, techniques to reduce the effects of ambient, internal and absorbed thermal energies.

As shown in Graph #1 the sun changes its relative elevation position throughout the calendar year.



Graph #1

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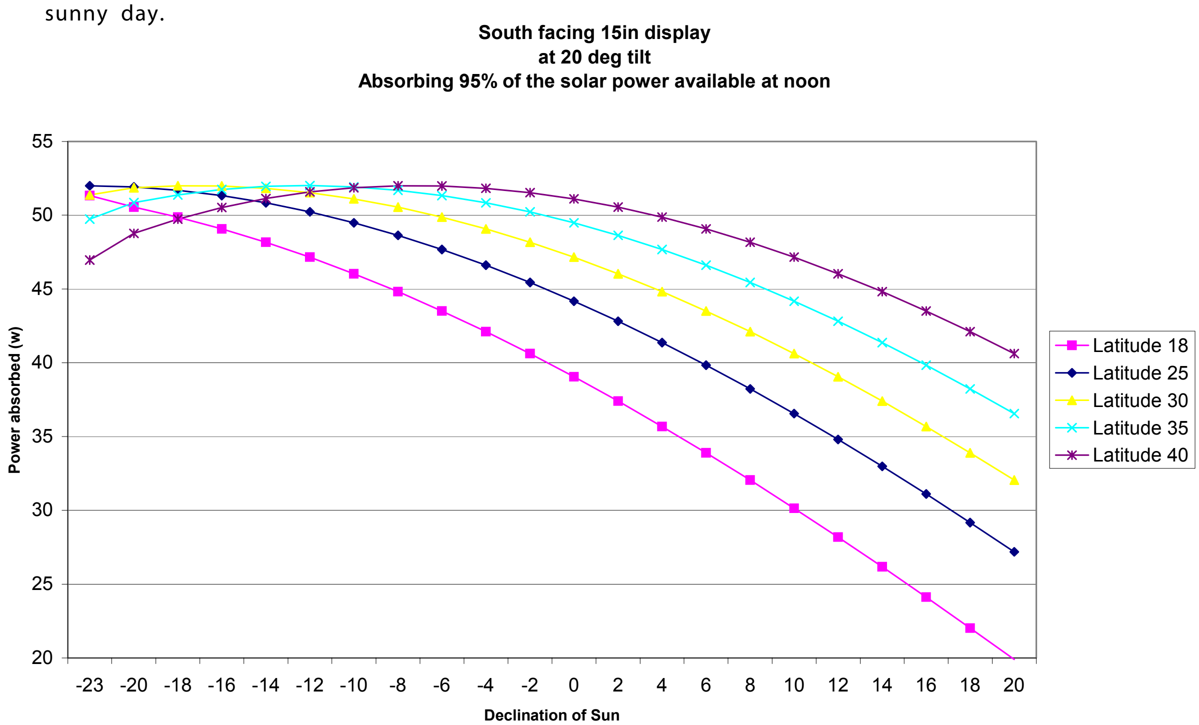
Graph #2below shows the amount of power that is absorbed based on the sun's declination and the display's latitude position. The maximum solar load for a 15" sized display is about 53W with display positioned such that the displays top edge is tilted away from the viewer at a 20 degree angle on a clear sunny day.



Graph #2

The data indicates the display absorbs the most energy in the winter months when temperatures are cooler and the sun is low in the sky. However, for those installations located in the more northern latitudes nearly 80% of the maximum absorbed power occurs during the summer months when ambient temperatures are high.

Heating from the Backlight and Electronics:

TFT LCD displays are generally equipped with high intensity cold cathode fluorescent lamps. For displays used in high ambient sunlight conditions the typical arrangement is with the lights positioned directly behind the LCD cell.

Additionally the supporting drive electronics of video controller and backlight inverter are required. This combined package will typically require 50 to 60 watts of power for 1000 cd/m^2 display brightness. This power adds to the internal temperature rise of the LCD display.

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CCFL lights have their own optimal operating temperature requirements to maintain peak efficiency, maximum brightness and long life, which must be carefully balanced with the LCD cell. CCFL peak efficiency is attained at a temperature of 65° C. This means the typical LCD display is either operating at or above its recommended maximum operating temperature limit.

Efficiency is the key. The more efficient the backlight system, the less power required and the less heat to be removed. It is very easy for a system to get into a downward spiral of adding more power and heat to try to maintain sunlight readability on a hot and sunny day.

Two approaches to effectively manage absorbed or generated heat have been investigated

- Active directed convective cooling via use of forced air fans with thermal sensors
- Use of IR absorbing polarized light control film as part of the display optical system, which includes the cover glass and display.

Combination Convection Cooling and Polarized Light Control Films

Planar has found one the most cost effective means of removing unwanted heat from the LCD cell is through the use of directed forced air cooling fans combined with carefully placed thermal monitoring sensors. When properly installed these fans and sensors maintain backlight temperatures at their optimal points while removing excessive thermal load from the LCD cell. The result is a LCD monitor with substantially extended upper operating temperature limit under bright sunlight conditions.

By directing a curtain of flowing air in front of the LCD cell significant heat reduction can be achieved. When combined with Planar's patent pending CET (Contrast Enhancement Technology) front surface protective layer device, significant temperature reductions are achieved.

Test Results

Tests performed using Planar's LC 15 high bright monitor substantiate that significant improvements can be achieved in maintaining optimal temperature performance with combined cooling fans and CET device.

As shown in Table1 under conditions of very high ambient air temperature condition and very high ambient sunlight illumination condition the monitor performs at essentially its 50°C operating limit with use of the 3 fan external cooling attachment.

When fitted with a front vandal protective screen as used in many outdoor public venues a 30 degree rise above ambient temperature occurs which significantly exceeds the 50°C operating limit of the monitor.

LC 15 Product Outdoor Daylight Solar Load Test Measurements						
Time		2:30 PM				
Ambient temp degrees C		35				
Angle of display (degrees)		20				
Sun angle off Normal (degrees)		58				
Horizontal illumination combined diffuse and glare sources (fc)		11694				
Product Configuration		**LC15 With Cooling Fan Option**		**With Vandal glass**		**CET NoAR/AR**
Front surface display temp degrees C		51		65		50

Table 1

When fitted with Planar's unique CET protective layer option the display temperature is again reduced to its normal operating temperature range. Use of this CET layer does not significantly reduce the display brightness. It retains 85% of the display luminance when measured without the CET layer. It also significantly improves the display contrast by nearly 75% compared to no CET device.

Results Summary

1 Combined forced air cooling and front surface polarized IR reflector significantly removes excess thermal load from the LC 15 display.

2 There is minimal increased power required for the external cooling fan kit (2-5 watts)

3 Use of the CET filter induces essentially no display color shift unlike many IR film reflectors.

4 Nearly 85% of the original LC 15 monitor brightness is retained

5 A 75% improvement in display contrast i.e. viewability is achieved.