

Optimizing flat panel displays for 21st century applications

A successful configuration must meet the expectations and attitudes of end users as well as the rigors of the application.

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HIGH TECHNOLOGY PRODUCTS pervade everyday life, and displays ranging from small EL (electro-luminescent) and LCD (liquid crystal display) dot matrix readouts to large TFT (thin-film transistors)-LCDs and plasma panels are becoming commonplace items. Size, cost, and energy consumption dominate the selection criteria, but further measures are frequently required to maximize optical performance, achieve electromagnetic compliance, add touch-screen capability, or implement demisting or even de-icing. How does the designer negotiate these options to configure a display that will meet all of the requirements of the target application?

INTRODUCTION

A glass or acrylic window fitted to the front of the display provides protection and also allows the application of various filters and surface treatments, which may support a combination of optical filtering, shielding, touch-screen, or heating features. Selection of the most suitable window material and surface treatments is largely determined by the requirements of the application. Still, designers' subjective opinions also have a profound influence on the overall specification, performance, and appearance of the display.

WINDOW MATERIALS

If security, vandal resistance, or durability in harsh environments (*e.g.*, outdoors or the factory floor) is required, a protective window may be necessary. Common materials include toughened glass, polycarbonate, or laminates comprising one or both materials. For touch-screen panels using projected capacitance, the active component of the sensor can be encapsulated within a multi-laminar screen of polycarbonate or heat-treated or chemically strengthened glass for maximum durability and optical clarity. These protective measures are particularly important in retail kiosk applications, where screens that are easily damaged are expensive to replace and may become dangerous to users. Both glass and polycarbonate can provide an excellent flammability rating, as well as safety and impact resistance. However, if a lightweight solution is required for a portable product or if the assembly is to be suspended from a bracket, then a polycarbonate window provides a lightweight solution.

On the other hand, glass typically provides higher abrasion and scratch resistance; but clear or anti-glare hard coat anti-scratch coatings may be applied to a polycarbonate window. Glass and polycarbonate both offer similar optical performance when combined with coatings or when etched.

DEALING WITH REFLECTIONS: ETCHING OR COATING?

The crucial requirement of visibility neces-

sitates dealing with unwanted reflections. When the ambient light level reflected from the surface of the screen exceeds the intensity of the displayed image, the display cannot be read. This problem can be countered either by treating the surface of the panel to disperse the reflected light in many directions or by applying a filter to attenuate a specific set of wavelengths. The former technique is known as anti-glare filtering. The surface of the screen is finely etched by chemical treatment or by sandblasting. The technique is relatively low cost and robust. Unfortunately, there is a trade-off in terms of reduced image clarity. Ensuring that the etched surface is located at an optimal distance from the image can minimize this effect. More recently, a high resolution etch has allowed designers to enhance display performance while maintaining the cost benefits of anti-glare etching.

Generally, etches are characterized by their gloss level—a reading that is typically measured at a 60° angle of incidence. A gloss meter measures specular reflection to determine light intensity or gloss. Typical etches for glass range from 75 ± 15 gloss units to 90, 120, and 140 ± 10 gloss units. Lower gloss levels, between 90 and 12 ± 10 gloss units, are more suitable for polycarbonate. Acrylics require a different level of gloss. Suitable glosses range from 40 to 80 gloss units for cast acrylic up to 140 gloss units for extruded acrylic.

To create an anti-reflection coating, a series of ultra thin metallic coatings are deposited onto the surface. Each layer absorbs a specific wavelength, reducing reflection to less than 4% from each “face.” The composition of the coating determines the wavelengths it will filter. This technique reduces the interference from reflections but does not compromise image sharpness as anti-glare etching does. Typically, these coatings have been more expensive than etching and used primarily for military applications and other high quality systems in which optical image quality is of paramount importance. However, economical, robust quality coatings are now available for general-purpose applications.

Applicable standards for coatings in outdoor applications can be found in BS ISO 9211-4, BS 9022-2, and BS 2011. For military applications MIL-C-675A/B, MIL-C-48497, MIL-E-12397B, and MIL-STD-810C also set forth standards for anti-reflection coatings.

CONTRAST ENHANCEMENT

There are several methods of enhancing the contrast between the displayed image and the background or surround. An interlayer within the glass or polycarbonate window, which may be of neutral density or tinted to match a colored background, improves contrast by darkening the background, thus making the image appear brighter. Circular polarizers are another solution, while anti-glare or anti-reflection treatments also provide some contrast enhancement.

A circular polarizer maximizes the light output from the display while blocking reflected ambient light. It

combines a linear polarizer with a quarter-wave retarding filter. The retarding filter effectively rotates reflected ambient light through 90° to prevent its passing back through the linear polarizer. This combination not only traps reflections from the surface of the screen but also makes the background to the display appear dark blue or black, further enhancing contrast between the bright image and dark background.

An infrared (IR) filter for eliminating solar gain may also be included with various contrast-enhancing substrates or interlayers. The filter reflects more than 50% of invisible IR while transmitting more than 70% of visible light.

FILTERING EMI AND RFI

To meet electromagnetic compatibility (EMC) laws in force throughout most of the world, electromagnetic or RF interference (EMI/RFI) emitted from the display must be shielded. Interference is generated by the internal electronic circuitry of an LCD or EL display or by the surface of the display itself in the case of plasma panels. There are two common techniques to prevent EMI/RFI escaping through the open display.

Frequently, a very fine coating of Indium Tin Oxide (ITO), deposited by vacuum onto the surface, is sufficient to attenuate the interference signals. The resistivity of the layer determines its shielding properties and typically varies from 5 Ω/sq. to 300 Ω/sq. However, the level of signal attenuation possible is limited since the coating must be very thin to allow high light transmission.

A shielded window delivers higher signal attenuation and better optical performance. It comprises a very fine metallic woven mesh laminated between the layers of glass or polycarbonate. The mesh is usually blackened copper or stainless steel that has been silver-plated and blackened. Blackening the mesh makes it less visible to the end user, thus enhancing the image quality.

The EMI attenuation of a given window is a function of the mesh characteristics—*i.e.*, the size of the apertures and the thickness of the filaments. Table 1 shows some typical mesh characteristics, with the expected EMI filtering performance and effect on image brightness.

The shielded window must also be grounded to the display. Usually, the mesh is extended so that it can be grounded directly onto the bezel or frame. Alternatively, the window may be terminated to a conductive silver busbar and then clamped to a conductive bezel. There are drawbacks to this latter method, particularly in cases in which connecting the silver busbar to the bezel proves problematic. In such instances, a conductive gasket or silver-loaded epoxy may be used although the mesh extension approach is usually more effective.

DE-MISTING AND DE-ICING

In some applications it may be necessary to prevent the display from misting. Examples include kiosks stationed outdoors, where rapid changes of temperature can cause

MESH	OPENINGS PER INCH	WIRE Ø (INCH)	ELECTRIC FIELD		PLANE WAVE				TRANSMISSION (%)
			1 MHz	10 MHz	100 MHz	400 MHz	1 GHz	10 GHz	
Copper	70	0.003	110	111	98	68	64	38	62
Copper	100	0.001	>120	>120	100	67	54	50	81
Copper	100	0.002	107	111	85	70	58	-	64
Copper	145	0.002	128	112	106	84	82	64	51
S. steel	+50	0.001	100	100	75	60	50	37	90
S. steel	50	0.002	94	90	82	58	55	28	81
S. steel	+80	0.002	106	88	82	64	60	34	71
S. steel	+80 x 60	0.001	102	105	103	75	60	43	84
S. steel	+100	0.001	128	112	92	80	86	74	81
S. steel	+165	0.002	137	124	106	100	81	61	45
S. steel	+200	0.0016	128	108	98	88	86	68	46
S. steel	+230	0.001	140	120	95	94	80	60	46

Table 1. Typical mesh properties for shielded windows.

moisture to form on the surface of the screen. A transparent conductive coating such as ITO may be used. Alternatively, a newly developed technique embeds fine conductors within the laminated window, thus creating both rapid de-misting and de-icing capabilities while ensuring high optical performance.

CONCLUSION

Choosing an LCD display is fairly straightforward when considering size, resolution, and some other basic features. However, where the application demands fine-tuning of the display to meet specific visibility criteria, additional, more subjective, factors come into play. In creating a successful configuration, designers must consider the expectations and attitudes of end users as well as the rigors of the application.

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