Shielding touchscreens from EMI

There are pros and cons of thin-film conductive coatings and fine wire mesh solutions

BY BRIAN E. HERR
Dontech
Doylestown, PA
http://www.dontechinc.com

Electronic displays are now commonplace in many demanding environments where both high-ambient-light readability and EMC can only be achieved through enhancements to COTS components. It is also common for touchscreens to be integrated into display systems as they are a very efficient user interface, especially in the case of portable electronics.

The dilemma for system designers is that COTS touchscreens typically degrade the high-ambient readability of high-performance displays to an unusable level. However, the technology to modify display systems for high-ambient-light readability is readily available. Resistive touchscreens integrated into display assemblies can be configured with an EMI-shielding conductive ground plane (CGP) to maintain readability while controlling EMI.

EMI shielding

A typical touchscreen-enabled display assembly is constructed with a Faraday cage. Metalized enclosures form most of a Faraday cage in typical display assemblies, but inherently must leave the display face open and viewable.

Therefore, CGPs with satisfactory transparent properties must be installed in the display optical path to complete the Faraday cage and function as an EMI shield. If this element of the Faraday cage is not properly terminated (for example, the shielded touchscreen is only terminated on one or two corners), this portion of the shield could act as an antenna and reradiate an undesired field.

Two common techniques for adding conductive properties to an optical substrate and controlling EMI in a touchscreen display include vacuum-deposited transparent conductive coatings and integration of a fine grid of a conductive opaque metal with a high open area. Each method has its advantages and disadvantages, so it is important to understand both approaches to meet your application's needs.

Table 1. Typical shielding effectiveness

Frequency	10 Ω/sq ITO	80 Mesh-Plated
H Field		
100 kHz	0 dB	15 dB
1 MHz	1 dB	32 dB
E Field		
100 kHz	72 dB	86 dB
10 MHz	36 dB	81 dB
Plane Wave		
100 MHz	24 dB	71 dB
1 GHz	25 dB	58 dB
10 GHz	18 dB	34 dB

Transparent thin-films

Transparent thin-film conductive coatings offer excellent optical and moderate EMI shielding properties (see *Tables 1 and 2*). A transparent thin-film conductive coating is typically deposited onto an optical medium using a high-vacuum coating process (for example, ion=enhanced e-beam evaporation or dc magnetron sputtering).

These high-energy processes can create very dense films. The durability of a specific coating is greatly dependent upon the optical substrate, the specific materials deposited, and the deposition method. The base material of optical plastic substrates often must be hard-coated for the conductive coating to have adequate durability and conductivity properties.

Typical transparent conductive films include transparent conductive oxides (TCOs) such as indium tin oxide (ITO), and metal alloyed films (for example, alternating layers consisting of Ag & ITO). Increasing the conductivity of the coating will increase the average EMI attenuation level over the frequency range of 100 kHz to 20 GHz.

Typical conductivities for transparent thin-film conductive coatings for this purpose range from 1 to 100 Ω/sq. Unfortunately, there is an inverse relationship between light transmittance and conductivity.

Metal-alloyed films offer better cost/performance options over TCOs, especially when applied to plastics. They can be cost effectively deposited in resistances down to 2 Ω/sq, while maintaining moderate total luminous light transmittance performance (>68% T_L).

The photopic transmission of metallic coatings quickly decreases as the conductivity increases. Additionally, metal alloys have an inferior mechanical and galvanic durability.

By contrast, TCOs become costly to apply to plastics for resistances below 30 Ω/sq, but can be applied to glass to values below 1 Ω/sq. A low-resistance coating on glass will offer high performance, but cost more because it is deposited in a batch vacuum process rather than a web or continuous process.

Additionally, most TCOs can be

fully integrated into a multilayer dielectric stack as part of a broadband antireflection (AR) coating. An AR coating reduces surface reflection losses and increases transmitted light.

A fully enhanced TCO can have a total luminous reflection of a broadband white light source (for example, illuminant D_{65}) of less than 0.5%. Furthermore, the photopic absorption of TCOs tends to be very low, often less than a few percent at fairly high conductivities (that is, <10 Ω/sq).

EMI shield construction

The EMI shield can be applied to the front, rear, or both surfaces of the touchscreen. Care must be taken not to interfere with the resolution or sensitivity of the touchscreen if the touchscreen itself must be shielded (that is, the CGP is on the outer most surface).

Thin-film conductive coatings applied to the rear surface of the touchscreen offer a simple cost-effective way to achieve EMI attenuation. The degree and type of index matching of the rear surface is dependent upon the desired contrast and assembly technique used to construct the display (i.e., air gap or optical bonding).

Fine conductive grid

Fine-grid CGPs offer excellent EMI shielding and good optical properties (see *Tables 1 and 2*). Fine conductive grid pattern is typically made of woven stainless steel or copper mesh, or with a printed/patterned metal coating on a surface of the substrate. Both technologies have high open areas and excellent conductivities (100 mΩ/sq to < 3 mΩ/sq).

For higher shielding applications, the mesh is created by weaving fine wires (0.0008 to 0.002 in.) in a plain weave format. Plain weave mesh is constructed with wires crossing alternately over and then under one another with adjacent wires 180° out of phase.

The mesh is created by weaving fine wires (0.0008 to 0.002 in.), and for highest shielding applications the mesh must be conductively plated (silver conductive plating) to fuse the wire crossovers. The mesh can then be blackened with a black conductive corrosion-resistant plating to improve galvanic stability and optical performance (by reducing reflections).

Table 2. Thin-film conductive coatings vs. fine conductive grid

CGP	Transmittance (%)	Reflection (%)	Shielding
10 Ω/sq Metal Alloy	80	7 to 8	Low
10 Ω/sq ITO	88	7 to 8	Low
10 Ω/sq IMITO	96	<0.5	Low
2 Ω/sq ITO	78	10	Fair
2 Ω/sq IMITO	87	<1.0	Fair
50 Mesh	80 to 85	0.15 to 0.35	Good
MEM 100 Printed Mesh	79 to 82	<1	Good
80 Mesh	77 to 83	0.15 to 0.35	Very Good
100 Mesh	66 to 69	0.15 to 0.35	Very Good
255 Mesh	40 to 44	0.15 to 0.35	Superior

Fine wire mesh is typically specified by the number of strands per inch in the x and y directions (for example, 100 x 100 mesh) or openings per inch (OPI). Often the number of strands per inch is stated only once (for example, 100 mesh) because most of the weaves used in the optical industry are square (that is, the same number of wires per inch in both x and y directions).

The minimum wire diameter and the number of strands per inch will vary with the physical properties of the base material. Standard mesh counts range from 50 to 255 strands/in., and different mesh count options are available for increased shielding needs and for moiré control options.

Moiré control

Whenever two light-transmitting matrices are overlaid there is a potential for a moiré pattern to be generated. The moiré pattern will hinder display readability if the mesh interferes with active-matrix display pixels.

Therefore, a touchscreen with a fine-grid CGP must be optically fitted to the specific electronic display to minimize or eliminate this phenomenon. EMI/EMC performance will not change when the grid orientation is adjusted.

The need to optically fit mesh products makes it more challenging to design remotely than transparent thin-film products.

Fine-wire-mesh construction

Touchscreen designs with fine wire mesh shielding must take into account mesh encapsulation, mesh orientation, and mesh termination. Applying the mesh to the rear surface of the touchscreen offers the simplest and a very cost effective way to achieve EMI attenuation.

The first step is to treat the outer surfaces with AR coatings and then apply the properly oriented mesh under tension to the rear surface of the touchscreen. The drawback of this approach is that the mesh must be handled with extreme care to prevent damage during installation. The product should be assembled in a cleanroom environment because of the difficultly in cleaning exposed mesh.

Encapsulating the mesh is strongly recommended to ease handling. This can be done in conjunction with the optical enhancement to the rear surface of the touchscreen.

Extended mesh would allow for the highest shielding as the transfer impedance to adjacent conductive surfaces would be minimized. However, this technique poses more difficulties in the packaging of the touchscreen display assembly and should be considered early in the design. Again, if the mesh shield were required to be on the front of the touchscreen it would have to be embedded in a thin flexible membrane. ■

For more on shielding, visit http://www.electronicproducts.com/packaging.asp.