



Electromagnetic Interference (EMI) Shielding

White Paper

A D Metro

1390 Star Top Road
Ottawa, Ontario, Canada K1B 4V7

Website

<http://www.admetro.com/>

For technical questions

Dominic Zborowski

Dominic.zborowski@admetro.com

1-800- 463-2353 ext. 104

For other questions

Sebastian Coloma

sebastian.coloma@admetro.com

1-800- 463-2353 ext. 106

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Introduction

A D Metro was established in 1993 in Ottawa, Canada. The company's expertise is in touch screens and currently, it is one of the few remaining North American based touch sensor manufacturers. A D Metro is a world leader in the production of ULTRA, a patented glass/film/glass resistive touch screen. EMI shielding is one of the modifications that can be applied to the ruggedized ULTRA touchscreen.

All electronics emit some level of radio frequency known as electromagnetic radiation. A number of products have been developed over the years to combat these undesired signals. Currently, there are two types of EMI shielding: transparent conductive coating and EMI mesh. Transparent conductive coating is available on: 1) Film or 2) Glass. EMI mesh includes: 1) Wire Mesh, 2) Micromesh, and 3) Lasermesh. Each option offers varying levels of light transmission, attenuation, and sheet resistance.

Traditionally, coated glass offered higher light transmission than EMI mesh. Due to recent advances in the field current EMI shielding products do offer higher light transmission than traditional products. EMI mesh offers a wider effective attenuation range than coated glass. Also, sheet resistance is significantly lower in EMI mesh filters compared to coated conductive coatings. Fundamental factors for mesh size and colour include: openings per inch and blackening of the mesh. Other factors to contemplate when considering EMI shielding include: 1) Grounding options such as bus-bars and conductive tape, 2) Mesh angle, 3) Enhancement options.

The purpose of this document is to define the different EMI shielding options available in the market. First, the document provides a brief background on EMI shielding. Second, the document gives a technical overview of EMI filters and their specifications. Third, the document lists the different A D Metro design options and the new possibilities and parameters resulting from the innovative incorporation of EMI filters into A D Metro's ULTRA touch screen.

Background Information

Electromagnetic compatibility of a touch screen is one of the determining factors of the ability of the touch screen to function within its operational specifications without emitting or being sensitive to unacceptable levels of electromagnetic radiations. EMI filters are used to equip touchscreens with the capability to function in a number of industries that must restrict some level of EMI emissions such as:

- 1) Military displays
- 2) Avionics
- 3) Marine
- 4) Mobile applications
- 5) In-flight entertainment displays
- 6) Medical equipment

EMI filters can be tuned for a specific frequency. The effectiveness of the shield is determined by testing the level of the signal passing through the aperture (measured in decibels [dB]) before and after fitting the shield then comparing the difference. There are two types of EMI filters:

1) Transparent Conductive Coating

This typically offers less than 40 [dB] EMI emission attenuation with a sheet resistance from 1 to 100 [Ω /sq]. This option can be obtained at a low cost and provide high light transmission and excellent optical properties. However, it provides only moderate EMI shielding as there is an inverse relationship between light transmittance and sheet resistance.

2) EMI Mesh

This option usually offers 60-80 [dB] of EMI emission attenuation and conductivity of less than 0.3 [Ω /sq]. The conductive grid pattern is made of a combination of conductively coated woven polyester, plated woven stainless steel, and aluminum (or copper) mesh or simply with a patterned metal coating on the surface of a substrate. Most EMI filters available in the market offer moderate to good optical properties. A D Metro's EMI filters have a high shielding mesh window that have been optimized for high light transmission, while eliminating the optical distortion patterns often associated with mesh windows.

Technical Overview

Transparent Conductive Coating

A transparent conductive coating is used to trap a number of EMI emissions.

1) **Coated Glass** offers low to moderate EMI shielding and good optical properties. An example of transparent conductive coatings a transparent conductive oxide such as indium tin oxide (ITO). This is an ideal option for electronic displays requiring high quality optical properties. The addition of an ITO coating will aid any device in meeting the Federal Communications Commission Class A (electrical equipment used in offices) and Class B (in homes) requirements. ITO is an imperfect conductor, thus it is classified as a resistor. ITO has low resistance and the conductive coating resistance or sheet resistance is measured in Ω/sq .

2) **Coated Film** offers low to moderate EMI shielding, depending on the range of the EMI emissions, as well as good optical properties. Coated films are more susceptible to ITO cracks and surface abrasions than coated glass because the substrate layer is usually composed of polyethylene terephthalate (PET). It has a typical sheet resistance of 15 [Ω/sq]. Decreasing the resistance will not improve the shield effectiveness, but it will degrade the optical quality.

EMI Mesh

EMI mesh filters offer excellent EMI shielding. There is a slight difference between mesh types. The shielding effectiveness is typically driven by the sheet resistance of the conductive material. The more conductive the material, the better the shielding effectiveness across the RFI/EMI spectrum. Factors that affect the mesh performance are:

- 1) **Openings per Inch** - A typical mesh filter is made of fine copper, aluminum or stainless steel wires (0.0005 to 0.002 inches thick) woven into a matrix pattern with high open areas and excellent conductivity. To count an opening per inch, start from the centre of one wire and count the number of openings to one inch away. As an example: an OPI of 60 means there are 60 openings/inch. The mesh optical properties are determined by OPI. As such, having an OPI of 60 results in a considerably higher light transmission compared to mesh with an OPI of 80 or higher where the mesh wires tend to be more visible.
- 2) **Mesh Blackening** - Non-blackened copper can be highly reflective, which can result in impeding the view of the LCD image behind it. To improve the optical performance and galvanic stability of the touch screen the mesh is blackened with a conductive element such as carbon or silver oxide. From an optical perspective, blackened copper mesh has better optical properties than non-blackened copper mesh because it reflects less light. Oxidation changes the state of the metal to powder, which can clog the openings in the mesh construction. Improving galvanic stability prevents oxidation. So by blackening the mesh the corrosion of metal is prevented.

Currently, there are a wide range of EMI shielding options, they include:

1) **Wire Mesh**

This is a woven metal mesh that offers 80% visible light transmission and attenuation over a frequency of 60-80 [dB]. The optical clarity of this mesh is higher than ITO shields and lower than micromesh. Since it is composed of blackened copper or blackened aluminum, it has less reflectivity but the conductive coating maximizes the shielding application. As a result, the blackened metal has higher conductivity and also galvanic stability, which reduces the probability of oxidation. The wire mesh can be attached with different processes and a common process is to bond the wire mesh to the back of the touch screen with an optically clear adhesive.

2) **Micromesh**

This is a woven wire mesh composed of copper that uses a deposition process to photo-etch the wire. This allows for a combination of optimal optical properties and shielding effectiveness. It has a light transmission of at least 85% and has an attenuation of 20 to 60 [db] (for an 8 μm mesh width x 300 μm pitch). Since it uses a different process from traditional micromesh, it eliminates the requirement of a secondary lamination to make it more optically clear.

3) **Lasermesh**

This is a directly applied conductive grid that provides EMI. A pen entry polyester base film is used. The film includes a laser aided patterned EMI shielding a 7 μm copper mesh that requires no secondary optical lamination to make it optically clear. This option offers a sheet resistance of 0.2 [Ω/sq] and a typical visible transmission of 76% (with one AR layer) or 80% (laminated between two AR layers) for 30 μm mesh width x 300 μm pitch.

Refer to Table 1 for a comparison chart of transparent conductive films and EMI mesh.

Table 1: EMI Shield Comparison Chart*

EMI Shield Type	Transmissivity (%)	Attenuation (db)	Sheet Resistance (Ω/sq)	Effective Attenuation Range (MHz)
Coated Conductive ITO Film	82	20-30	15	200-500
Coated Glass	90	25-60	12	1-10000
Wire Mesh	70	40-50	0.15	200-1000
Lasermesh	76-80	30-70	0.3	10-10000
MicroMesh	≥85	20-60	≥0.25	10-10000

*Based on values reported by multiple suppliers

Installation Considerations and Enhancements

There are multiple ways to ground the EMI shield to a display including: conductive silver bus bars, conductive gaskets, a conductive adhesive, or a mesh extension. The most efficient termination option is using a mesh extension because it eliminates interface losses from various gasket options.

Available Mesh Grounding Options:

1) Conductive Tape

Conductive tape is a more cost-effective method that provides good conductivity. However, it can result in leakage, leading to EMI emissions. In addition, there are a few ohms of internal resistance in conductive tape affecting its ability to absorb EMI emissions. Another issue with using conductive tape is that the tape can touch the touch screen ITO layers at the edges of the sensor, which can cause the sensor to stop working or affect the EMI shielding effectiveness. This problem can be alleviated by applying an insulator around the edge first such as a Kapton tape.

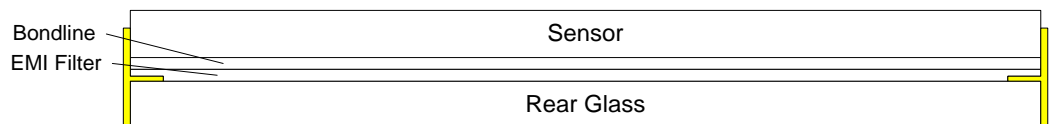
2) Bus bars

Bus bars provide better grounding than conductive tapes. Bus bars are applied to all sides of the sensor to eliminate emission signal leakage, so good contact is needed between both the EMI shield and the EMI gasket used. Determining how the bus bar should be wrapped depends on the design of the overall project.

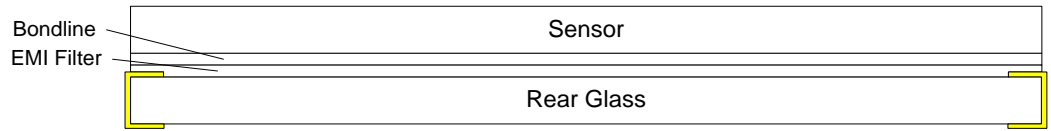
It must initially be considered that bus bars are not ideal for wrapping to the front or the sensor. If applied around the edges, it must be painted on by hand, which can be expensive. An issue with bus bars is EMI emission leakage which can occur around the edges of the bus bar paint. Edges and sharp corners should be avoided because the bus bar paint can become too thin and crack, or be rubbed off easily; this leaves gaps in the EMI shield. Another issue with bus bar material is that painting it around the edge can interfere with the ITO in the sensor and cause short-circuiting.

Below are options for how Bus bars can be applied:

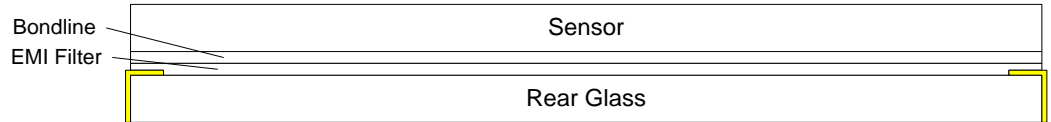
T-Shape – Side Grounding



C-Shape – Side and/or Back Grounding



L-Shape – Alternate Side Grounding



In determining the best method to employ, the integrator has to take into consideration the specifications that need to be met including the design of the mounting, the cost, and angling of the mesh. Most meshes have to be rotated at a 22.5, 30, or 45 degree angle because most displays have a pixel orientation of 90 degrees. In order to reduce a moiré or rainbow effect, this rotated orientation is typically necessary. Other processes can be done to minimize this effect including altering the mesh pitch and the mesh depth within the substrate or to add a surface finish such as AG on the substrate in order to break up the formation of moiré anomalies.

Enhancement Options

A D Metro touch screens can support a number of design modifications. Many of the current available features offered in our products were developed to meet customer's specifications. These modifications include:

Optical Enhancements:

- Anti-reflective coating - AR
- Anti-smudge coating – AS

Strengthened Substrates:

- Chemically strengthened back glass lamination
- Sizes Available: 1.6, 2.0 & 3.0 [mm]

Armor Microglass Thickness:

- 0.1[mm] – AG & AS options available
- 0.145[mm] – AG, AR & AS options available
- 0.2[mm] – AG, AR & AS options available

Glossary

Blackened Copper – Copper that is coated with black oxide in order to add mild corrosion resistance. Maximum corrosive resistance involves requires impregnating with oil or wax.

Bus Bars – A bar or strip composed of a conductive metal such as silver or conductive UV ink (silver UV ink) that conduct a substantial current of electricity.

Conductive Tape – A strip composed of conductive metal, such as tin-plated aluminum foil or copper foil, taped around the edges of a screen to increase conductivity.

Electromagnetic Interference (EMI)/ Radio Frequency Interference (RFI) – A disturbance that interferes with an electrical circuit due to electromagnetic induction or electromagnetic radiation emitted from an external source, which can affect the performance of a circuit.

Galvanic Stability – A property of a metal, such as copper or aluminum that has undergone an electrochemical process in order to prevent oxidation of the metal.

Indium tin oxide (ITO) – A coating used on glass or film to make it electrically conductive and maintain good optical properties.

Moiré Effect – In wire mesh, it is the secondary or superimposed pattern that creates a rainbow effect when the mesh pattern interferes with an LCD pixel image.

Optically Clear Adhesive – A type of pressure-sensitive optically clear adhesive allowing for two optical layers to be attached to each other.

Pressure-Sensitive Adhesive – An adhesive film, usually acrylic based, that bonds two surfaces together when pressure is applied.

Refractive Index Matching – The process of matching the index of refraction to a material such as glass to reduce the reflectivity on that surface.