Electromagnetic Compatibility (EMC)

Introduction about Cables, Connectors and Gasket
Agenda

- EMC Cables
  - Coaxial Cables
  - RF Absorptive Cables
  - Ribbon Cables
  - Other Cables

- EMC Connectors
  - Pigtail Effect
  - Connector Shielding

- EMC Gaskets
Coaxial Cables

- Shielded cables are of two general types
  - The shield is the return conductor for the signal (i.e. coaxial)
  - The signal return is within the cable, and the shield is only used to control noise and interference.
Coaxial Cables

MIL中的屏蔽密度大都96~97%，但市售屏蔽線大都只有60~70%。

- 屏蔽密度越高者，線質越缺乏彈性，過度彎曲時屏蔽容易斷裂
- 屏蔽密度低者，屏蔽間隙大，對高頻雜訊的屏蔽效果差
- 若要防治低頻磁雜訊，第二層屏蔽可採用低磁阻材料

![Coaxial Cables Diagram](image)
Coaxial Cables
Braided (編織的) Shields

The advantages of braid are flexibility, durability, strength, and long flex life.

Braided shields usually provide just slightly reduced electric field shielding but greatly reduced magnetic field shielding.

At higher frequencies, the shielding effectiveness of the braid decreases further.
Coaxial Cables
Braided (編織的) Shields

Figure 2-32. Normalized transfer impedance of a braided-wire shield, as a function of percent braid coverage (from Vance, 1978, © Wiley).
RF Absorptive Cables

- Using RF absorptive compounds
  - Elastomeric materials mixed with lossy ferrite powder
  - RF energy is dissipated by way of conversion into heat, because of magnetic losses in the ferrite powder.

- These cables can protect from both CM and DM interference.

- The transmission bandwidth of RF absorptive low-pass cables is more restricted when compared to cables using normal construction.

  - The typical pass-band of these cables is from DC to about 10MHz.
RF Absorptive Cables
Low-pass power cable

RF-absorptive material is between conductors.
RF Absorptive Cables

CM suppression signal cable

RF-absorptive material is between conductors and outside environment
RF Absorptive Cables

**Low-transfer impedance coaxial cable**

RF-absorptive material is between inner conductor and 2\textsuperscript{nd} braid.
Ribbon Cables (Flat Cables)

- Ribbon cables are widely used in multi-connection applications such as a computer bus or control circuits, which required low-cost multiple paths.

**Advantages**

- Allow low-cost multiple terminations
- Controlled cables, not random cable
  - The position and orientation of the wires in the cable is fixed

**Major problems**

- The way that the individual conductors are assigned with respect to signal leads and grounds.
Ribbon Cables (Flat Cables)

- **Ribbon Cables:**
  - **All conductors use just a signal ground return.** The current loop area, CM coupling and cross-talk will be worse.

- **Each conductor has a separate signal ground return.** The current loop, CM coupling and cross-talk should be reduced, but the number of conductors also decreases.

- **Two conductor share a separate signal ground return.** The current loop, CM coupling and cross-talk should be higher than above configuration.

- **Best:**
  - **All conductors use a signal ground plane across the width of the cable, so the loop area is very small.**
Ribbon Cables (Flat Cables)

The capacitor of the ribbon cables with shield will increase and the characteristic of the transmission line will decrease.
低靜電雜訊 同軸電纜
Multipair Cables

(a) 未加屏蔽之多对电缆线

(b) 附加屏蔽之多对电缆线
Twisted Cables

- Twist pair are good for EMI
  - Low emission and low loop area

- Transmission line pair are good to prevent noise coupling
Twinaxis Cables

(a) 對絞線對電纜線
(b) 双晶軸對絞電纜線
(c) 二重屏蔽双晶軸對絞電纜線
EMC Cables
Useful Frequency Range for Various Transmission Line

![Graph showing the useful frequency range for various transmission line types. The graph includes labels for different frequency bands and cable types such as coaxial cable, twisted pair, and special applications.]
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- EMC Gaskets
Pigtail Effect

Pigtail connections cause the shield current to be concentrated on one side of the shield, and therefore maybe degrade shielding effectiveness.

- Short pigtail does not itself radiate at low frequency, but it can excite external currents on the outside surface of a coaxial line which result in RF leakage and cross-talk.
- It still can be a source of RF leakage at high frequencies

The inductance of the pigtail can resonate with the capacitance between shield and chassis ground.

- At resonance, most of the interference voltage appears across the shield and it results in very poor shielding effectiveness.
Pigtail Effect

Pigtail shield connection concentrates current on one side of shield.

One method of terminating a cable with 360° contact to a shield.

( Like BNC connector )
Figure 2-36. Coupling to a 3.7-m shielded cable with an 8-cm pigtail termination. Circuit termination equals 50 Ω (from Paul, 1980, © IEEE).
The most effective shielding integrity is to bond a heavy metal cap from the cable shield to the equipment shield, like the D-subminiature connector.
Connector Shielding

(註) ①電纜線端的連接器：57FE-30360-20
②面板端的連接器：57LE-40360-2700
③面板端的連接器之接地連接方式：連接金屬
殼體於面板後面
④面板安裝孔尺寸：15.8 mm (W) ×
59 mm (L)

根據電纜線端連接器之接地連接方式的屏蔽效果
Connector Shielding

根據電纜線端連接器之接地連接方式的屏蔽效果

(A) 以捲附鋁箔後用夾子連接。
(B) 7/0.18 φ ( l = 35 mm) 引線兩端連接前殼
(C) 7/0.18 φ ( l = 35 mm) 引線單端用夾子連接
(D) 7/0.18 φ ( l = 105 mm) 引線兩端用夾子連接
(E) 7/0.18 φ ( l = 105 mm) 引線單端連接前殼
(F) 7/0.18 φ ( l = 35 mm) 引線單端連接前殼
(G) 7/0.18 φ ( l = 105 mm) 引線兩端連接前殼

注：(1) 電纜線端的連接器：57E-30360
(2) 面板端的連接器：57LE-40360-2700
(3) 面板端的連接器之接地連接方式：連接金屬殼體於面板後面。
(4) 面板安裝角孔的尺寸：
   15.8 mm (W) × 59 mm (L)
Connector Shielding

根據面板端連接器之接地方式的屏蔽效果

( 註 ) ①面板安裝角孔尺寸：19.5mm(W)×59mm(L)
②電纜線端連接器：57FE-30360-20
③面板端的連接器：57LE-40360-2700

(A) 連接金屬殼體於面板後面
(B) 以接地板連接兩端
(C) 7/0.18ϕ(l =35 mm)連接引線兩端
(D) 7/0.18ϕ(l =105 mm )連接引線單端
(E) 30/0.18ϕ(l =35 mm)連接引線單端
(F) 7/0.18ϕ(l =35mm)連接引線單端
Connector Shielding

Graph showing the relationship between frequency (MHz) and absorption rate (dB) with different values of W:
- W = 15.8mm
- W = 19.5mm

Additional text in Chinese:
根据面板安装孔的尺寸法之屏蔽效果

Date: 6-1-27
Connector Shielding

- Connector
- Seal
- Adapter
- Compressible contact
- Seal
- Collar
- Nut
Agenda

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- EMC Gaskets (http://tecknit.com/emihome.html)
EMC Gaskets

- It is a shielding arrangement used to reduce the leakage of electromagnetic energy at metal-to-metal joints.

- It’s electrical properties are selected to be nearly identical to those of the shield in order to maintain a high conductivity and to avoid air or high resistance gaps.

- They are capable of controlling electromagnetic leakage in the frequency range from a few KHz to tens of GHz with typical $SE \approx 80\sim100\text{dB}$. 

6-1 -30
EMC Gaskets
Knitted Wire-Mesh Gaskets

- **Knitted** (編織的) **Wire-Mesh** (金屬線羅網) **Gaskets** (織線網榦墊材料)

  - Standard product is available in Monel Sn/Cu/Fe, Aluminium, Phosper Bronze & silver plated brass wire. The material is manufactured into square, round, round with fin, and double round sections.

  - *Mesh Strips* provide EMI shielding for joints and seams of electronic enclosures.

  - Knitted wire mesh is also available in the form of flat *EMC Shielding Tape* which is ideal for shielding electronic cables and cable assemblies.

  - Mesh products can also be customized in the form of *Die Compressed Mesh* gaskets to suit requirements as washers (墊圈) or rectangular gaskets.
EMC Gaskets
Knitted Wire-Mesh Gaskets
EMC Gaskets
Mesh & Elastomer Combination Gaskets

- **Mesh & Elastomer (合成橡胶) Combination Gaskets**
  - Custom Strips combine the resilience (弹性) and conductivity of knitted mesh with the excellent compression (可压缩性) and deflection (可卷绕性). *Solid or sponge (海绵) cores are available as well as hollow tubes.*
  - A knitted wire mesh bonded to an elastomer section means that Duogaskets and Duostrips offer an excellent shielding and environmental seal (密封).
EMC Gaskets
Conductive Shielding Gasket (導電泡棉)
Wire-Screen (金屬線紗網) / Metal-Screen and Fiber (纖維) Gaskets

Flat die cut gaskets can be formed from Duolastic, Conmax, Teckspan & Teckfelt, a range of materials formed from woven and expanded metals or metal fiber products.

Some products are available purely as a metal material or neoprene or silicone filled.
**EMC Gaskets**

**Oriented Wire-Mesh Gaskets**

- **Oriented Wire-Mesh** (有向線網條和襯墊)
  - Elastomet and Elastofoam are solid silicone and silicone sponge materials that are supplied *with oriented wires*.
  - This product offers excellent environmental and shielding protection and is available in standard sheets and strips as well as custom manufactured solutions.
EMC Gaskets
Conductive Silicon Elastomer

Conductive Silicone Elastomer (導電性矽樹脂材料)

- Silicone gasket/elastomer materials supplied with a variety of conductive fillers (like silver, nickel, and aluminum) offer a group of materials with a wide choice of shielding performance.
- These materials are available in standard sheets and extrusions, custom die cut, custom extrusion, compression and injection molded parts.
EMC Gaskets
Transparent Conductive Windows

Transparent (透明) Conductive Windows
- Produced by vacuum depositing a very thin electrically conducting transparent coating
EMC Gaskets
Conductive Adhesive

Conductive Adhesive (黏著劑), Conductive Grease (油脂), Epoxy (環氧樹脂), Grease (潤滑劑), Caulking (填隙材料) and Conductive Coatings
The gasket should be in a slot and on the inside of the screw to protect against leakage around the screw hole.

Figure 6-28. EMI gaskets, correct and incorrect installation.
EMC Gaskets

Gasket Fabrication

(a) Located in groove

(b) Adhesive bonded

(c) Friction retention

(d) Nut and bolt (or self-tapping screw)

(e) Riveted (using a stiffening plate or strip)

(f) Spot welded (These double P sections can alternatively be riveted into position or retained by adhesive on fin.)

(g) Spot welded between flanges

(h) P section entrapped in extrusion (The extrusion, normally in aluminium, provides a rigid mounting strip for the gasket fin.)

Extension
EMC Gaskets
http://williamson-labs.com/

- Custom conductive gasket
- Solderable & snap-in metal shields
- "O" Ring
- Connector gaskets
- Compressible gasket
Summary

- The key to magnetic shielding is to decrease the area of the current loop.
- To prevent radiation from a conductor, a shield grounded at both ends is useful above the shield cutoff frequency.
- Only a limited amount of magnetic shielding is possible in a receptor circuit grounded at both ends, due to the ground loop formed.
- The shielding effectiveness of twisted pair increases as the number of twists per unit length increase.