



Electromagnetic Compatibility (*EMC*)

Introduction about
Cables, Connectors and Gasket





Agenda

☛ EMC Cables

- ☛ Coaxial Cables

- ☛ RF Absorptive(有吸引力的) Cables

- ☛ Ribbon(緞帶狀) Cables

- ☛ Other Cables

☛ EMC Connectors

- ☛ Pigtail Effect

- ☛ Connector Shielding

☛ EMC Gaskets (襯墊)





Coaxial Cables

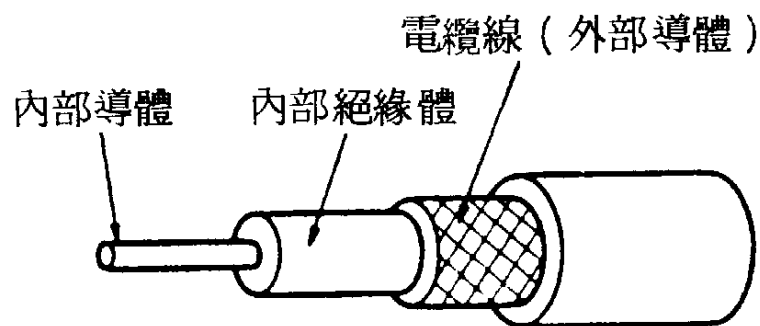
- ☒ Shielded cables are of two general types
 - ☒ The shield is the return conductor for the signal (i.e. coaxial)
 - ☒ The signal return is within the cable, and the shield is only used to control noise and interference.



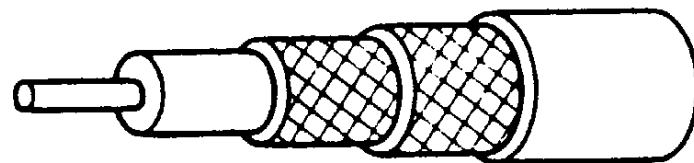


Coaxial Cables

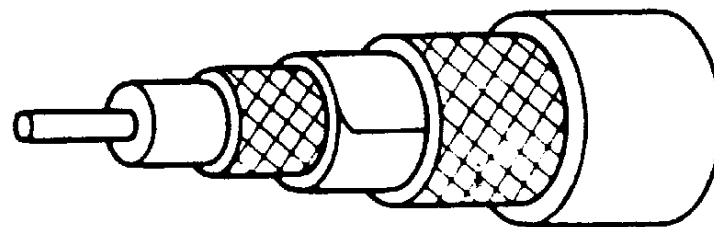
- MIL中的屏蔽密度大都96~97%，但市售屏蔽線大都只有60~70%。
 - 屏蔽密度越高者，線質越缺乏彈性，過度彎曲時屏蔽容易斷裂
 - 屏蔽密度低者，屏蔽間隙大，對高頻雜訊的屏蔽效果差
- 若要防治低頻磁雜訊，第二層屏蔽可採用低磁阻材料



(a) 一般的型式



(b) 二重屏蔽型



(c) Triakishel 型



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

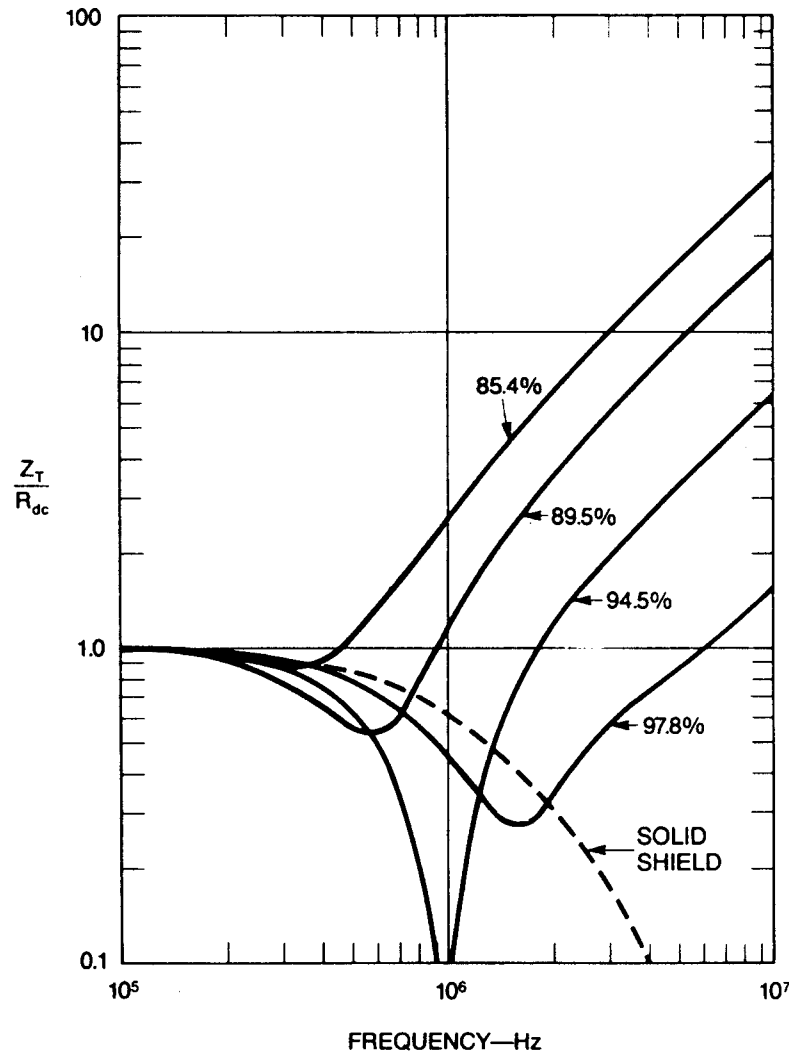


Figure 2-32. Normalized transfer impedance of a braided-wire shield, as a function of percent braid coverage (from Vance, 1978, © Wiley).





RF Absorptive Cables

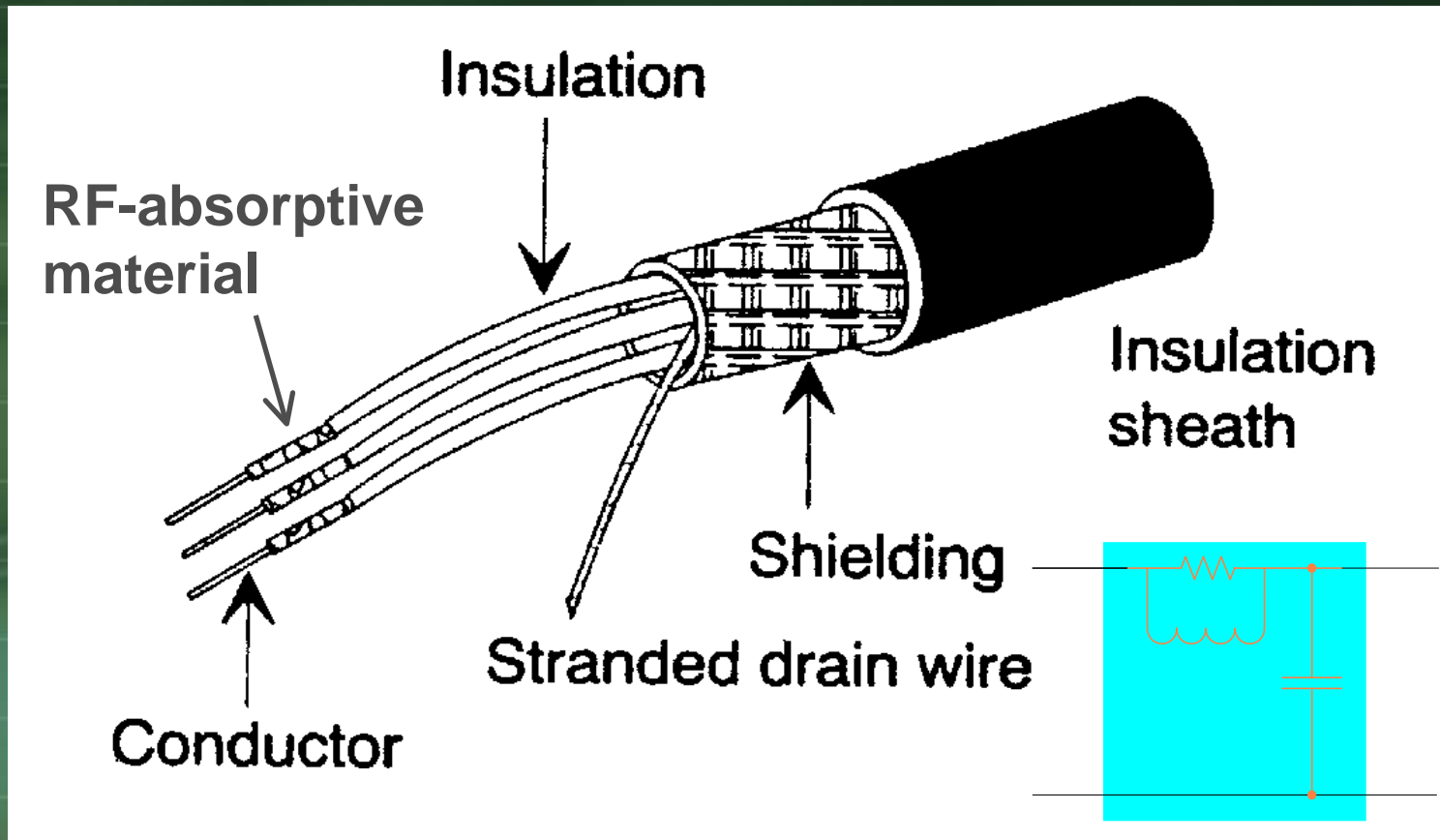
- Using RF absorptive compounds(混合物)
 - Elastomeric(合成橡膠) materials mixed with lossy ferrite powder(粉末)
 - RF energy is dissipated by way of conversion into heat, because of magnetic losses in the ferrite(亞鐵鹽) powder.
- These cables can protect from both CM and DM interference.
- The transmission bandwidth 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



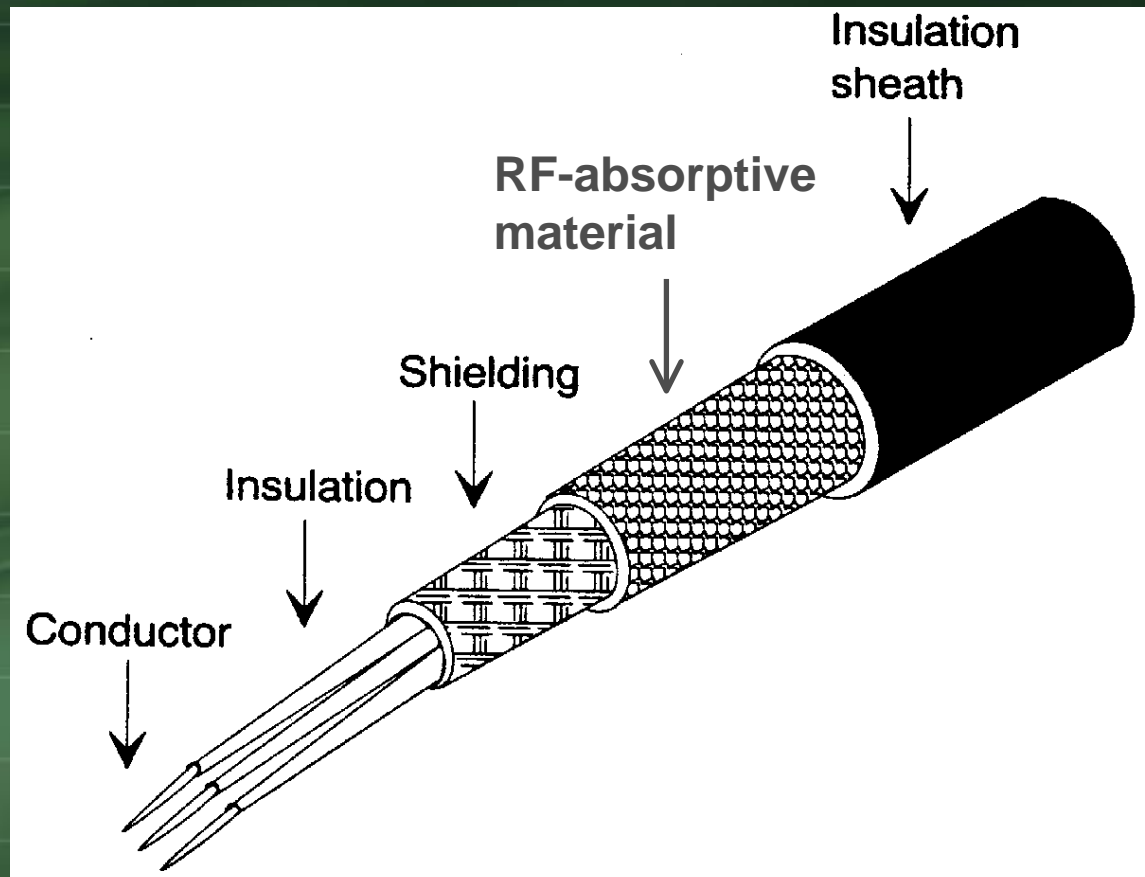
RF-absorptive material is between conductors





RF Absorptive Cables

CM suppression signal cable



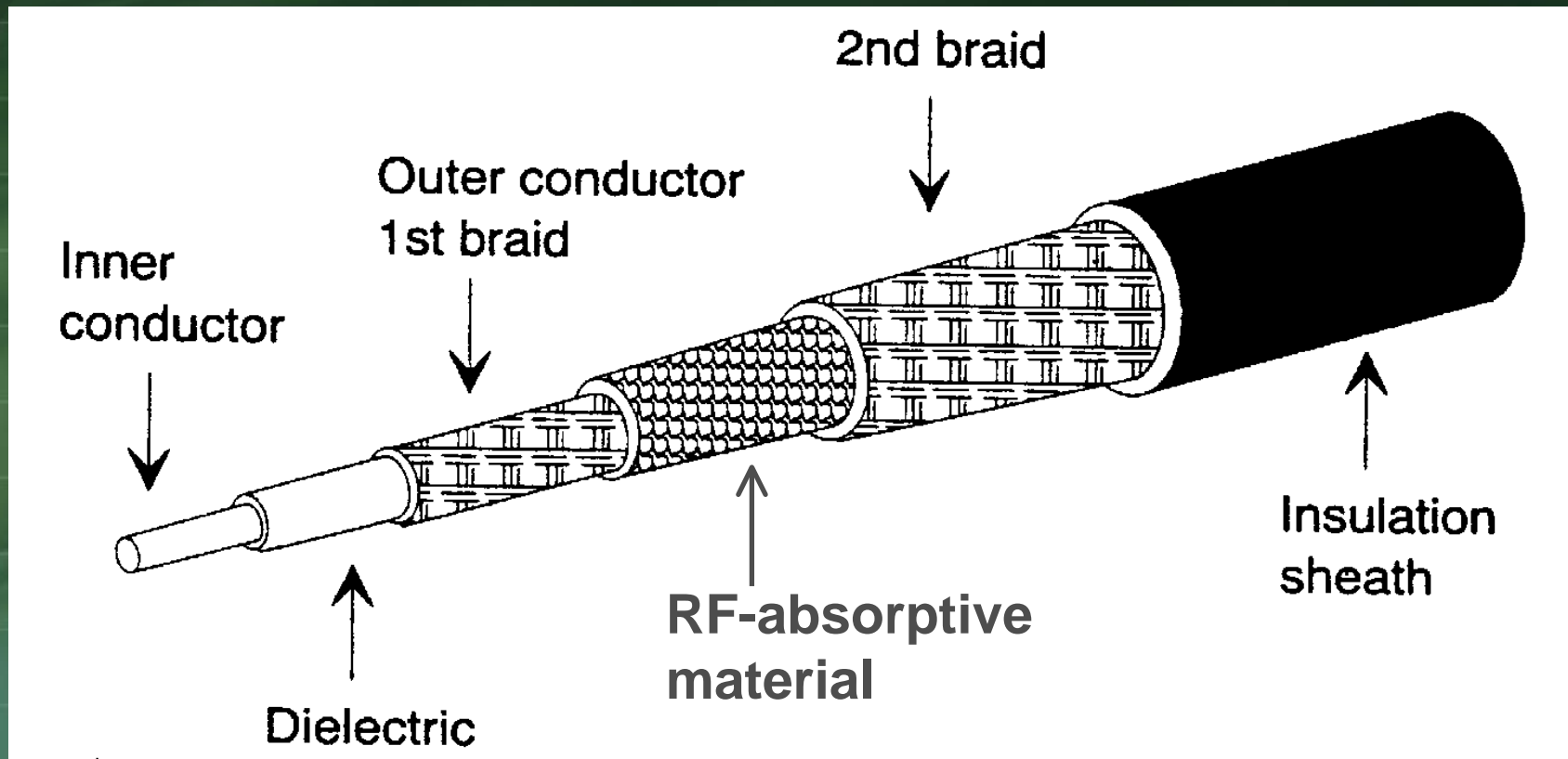
RF-absorptive material is between conductors and outside environment





RF Absorptive Cables

Low-transfer impedance coaxial cable



RF-absorptive material is between inner conductor and 2nd 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)



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

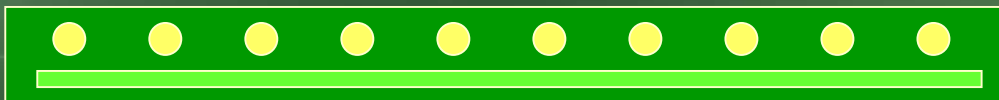


Each conductor has a separate signal ground return. The current loop, CM coupling and cross-talk should be reduced, but the number of conductors also decreases.



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.

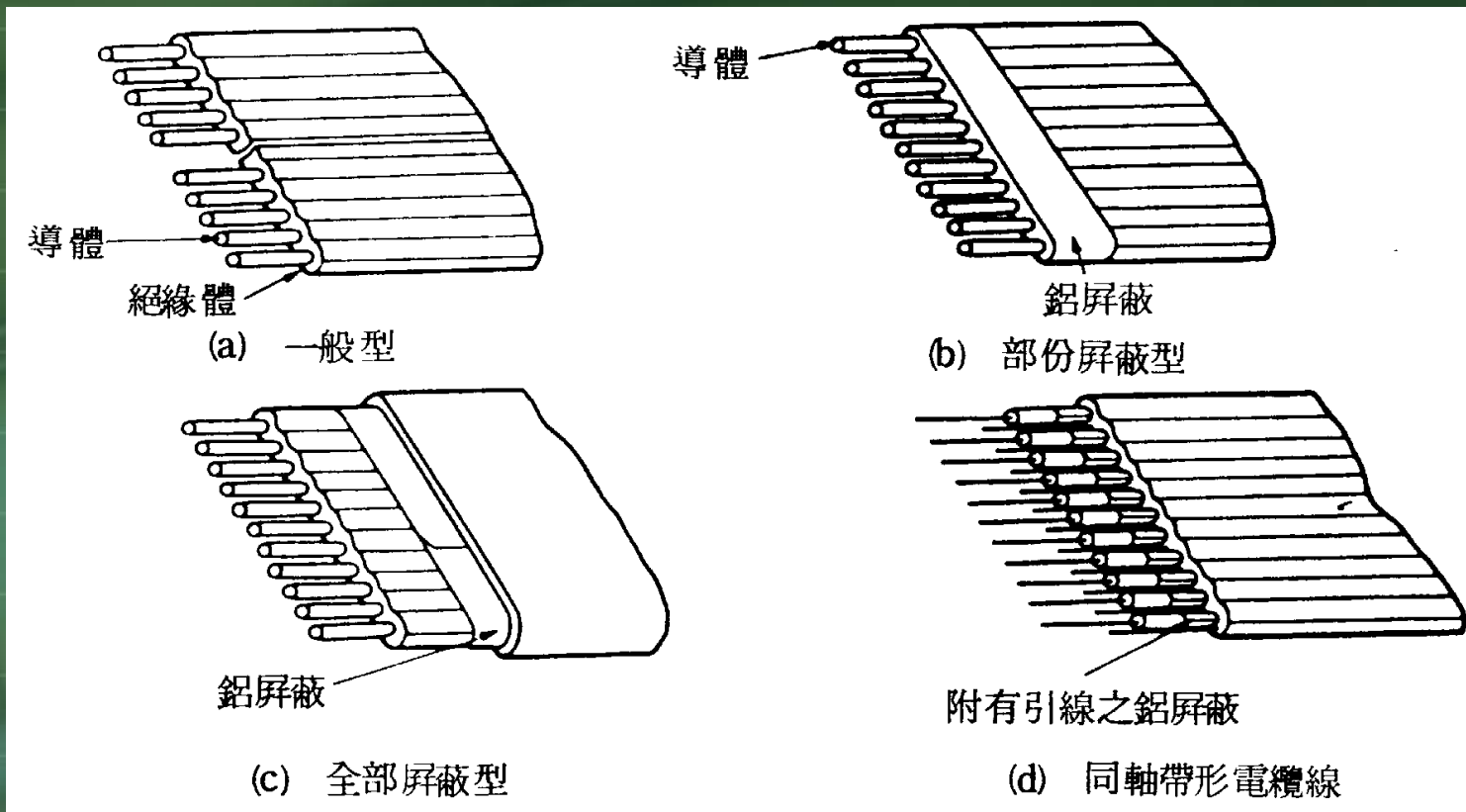
- Ground
- Signal line





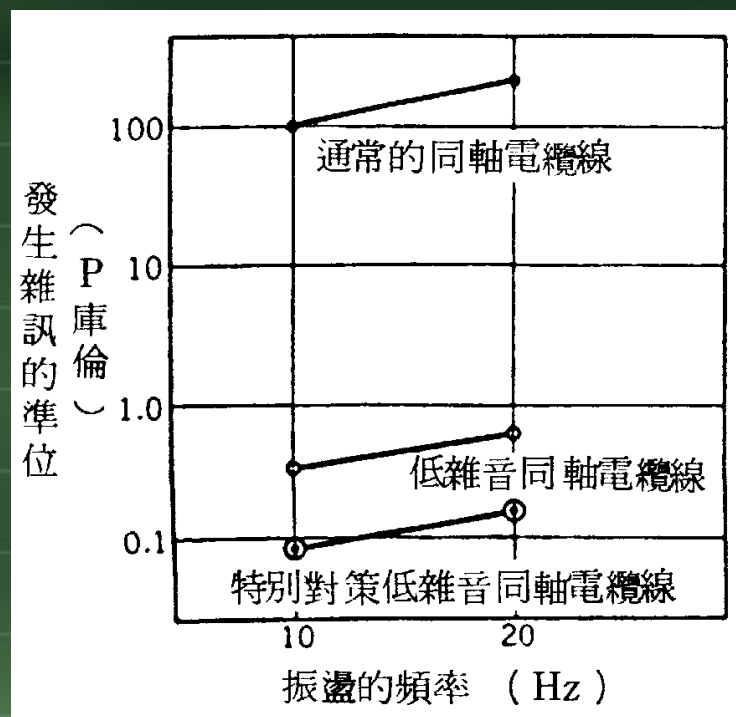
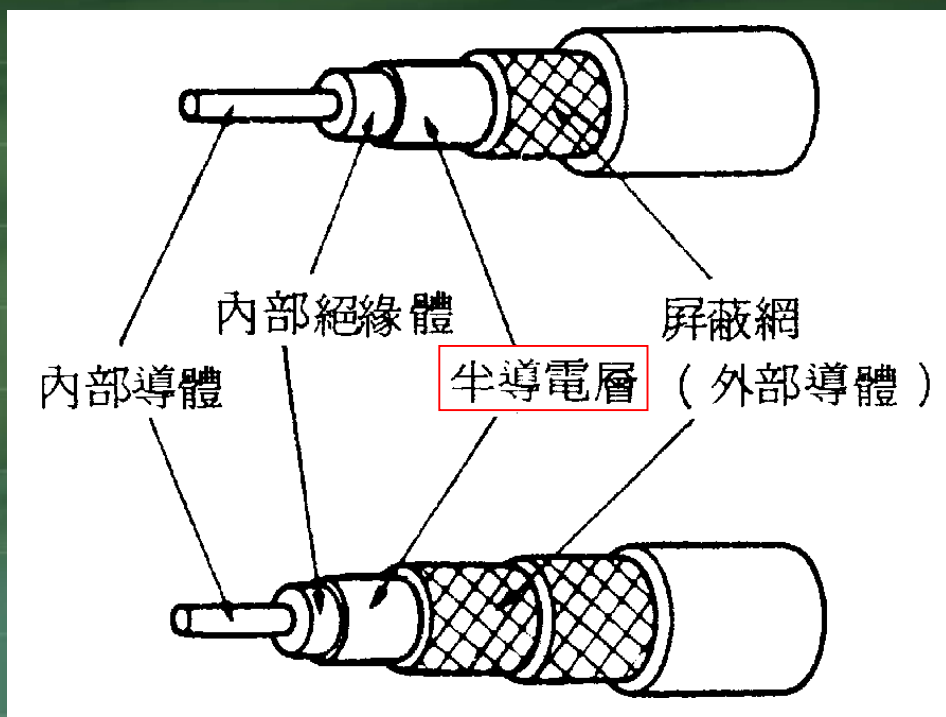
Ribbon Cables (Flat Cables)

- The capacitor of the ribbon cables with shield will increase and the characteristic of the transmission line will decrease.



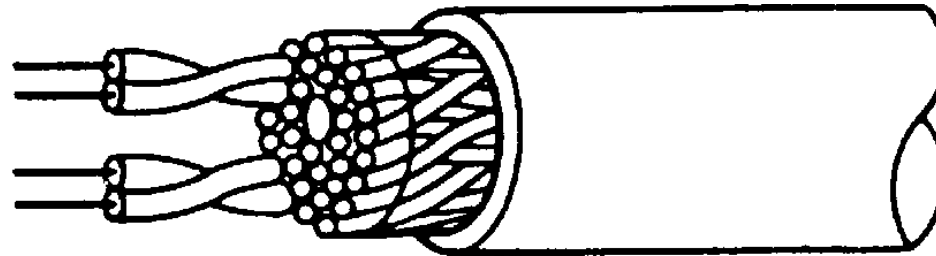


低靜電雜訊 同軸電纜

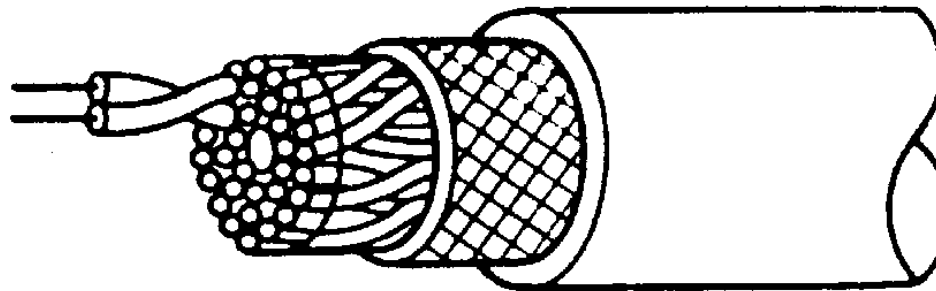




Multipair Cables



(a) 未加屏蔽之多對電纜線



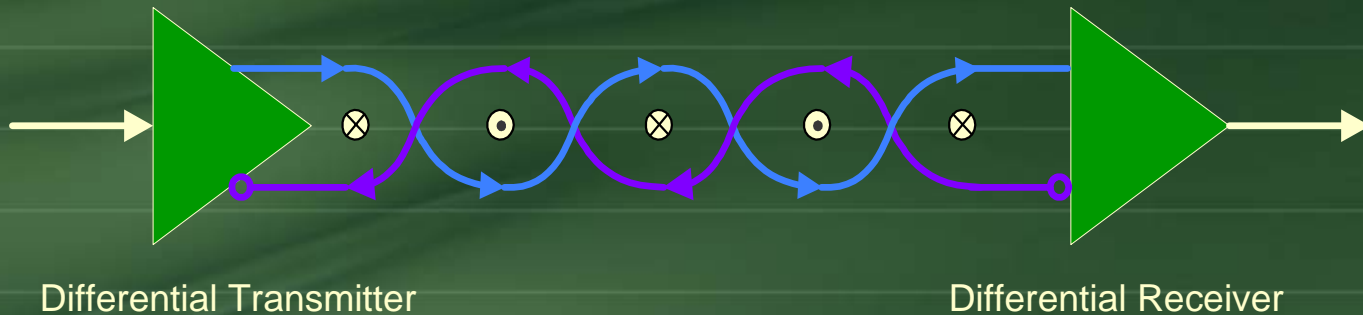
(b) 附加屏蔽之多對電纜線



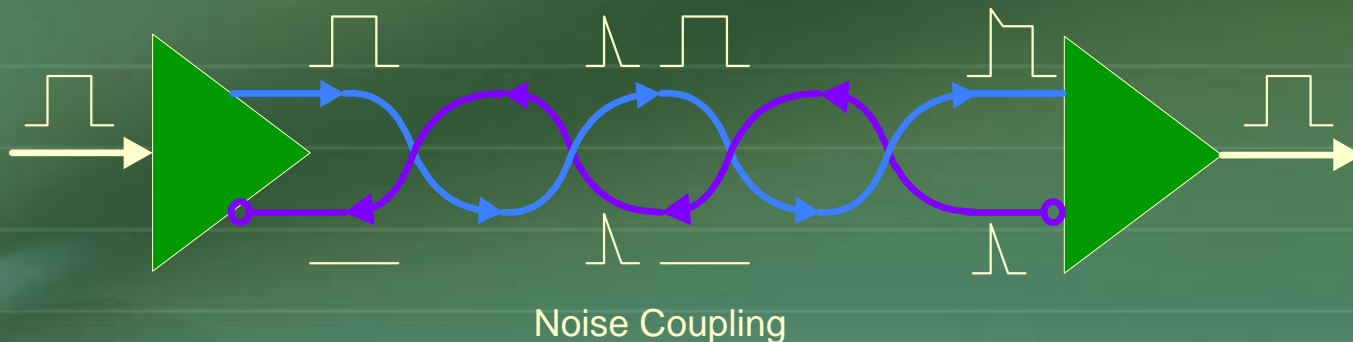


Twisted Cables

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



- Transmission line pair are good to prevent noise coupling

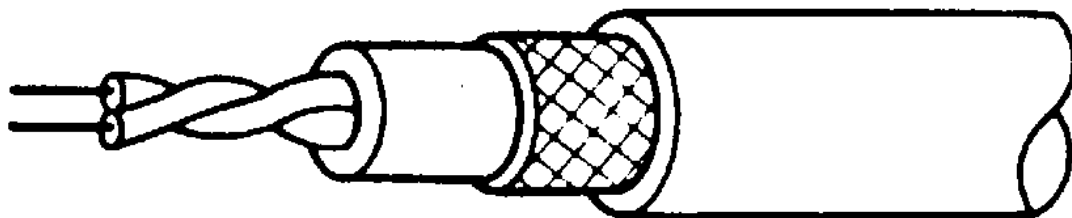




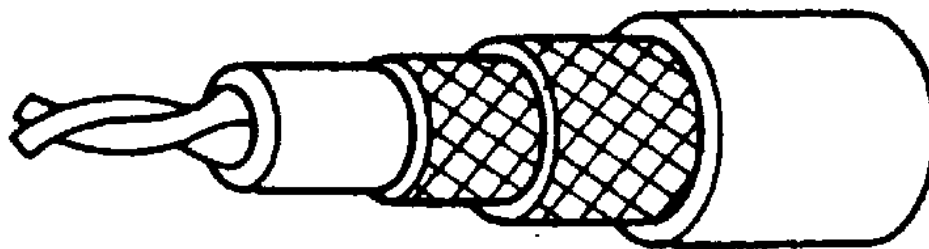
Twinaxis Cables



(a) 對絞線對電纜線



(b) 双晶軸對絞電纜線

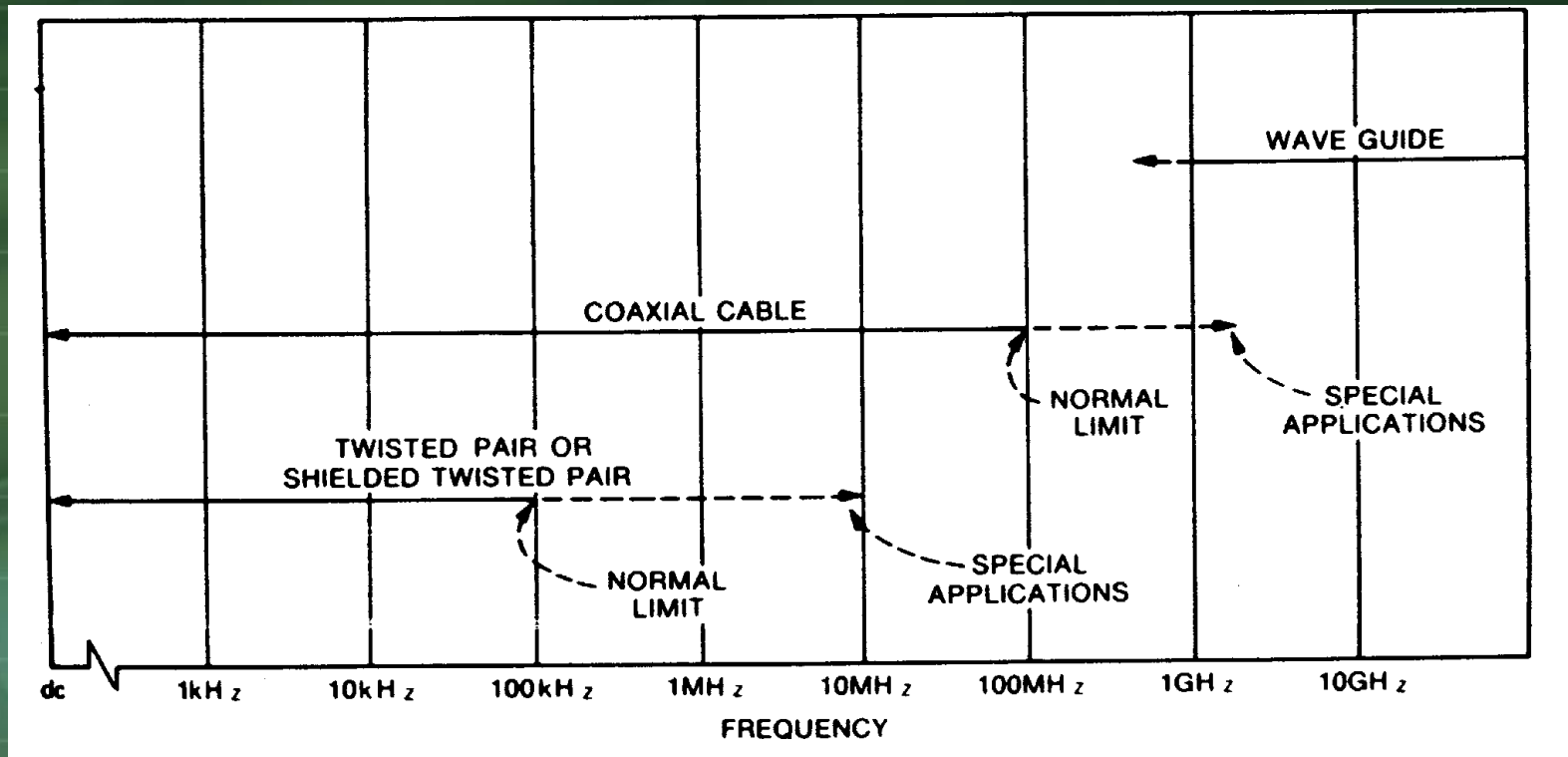


(c) 二重屏蔽双晶軸對絞電纜線



EMC Cables

Useful Frequency Range for Various Transmission Line





Agenda

- ✦ EMC Cables
 - ✦ Coaxial Cables
 - ✦ RF Absorptive(有吸引力的) Cables
 - ✦ Ribbon(緞帶狀) Cables
 - ✦ Other Cables
- ✦ EMC Connectors
 - ✦ Pigtail Effect
 - ✦ Connector Shielding
- ✦ EMC Gaskets





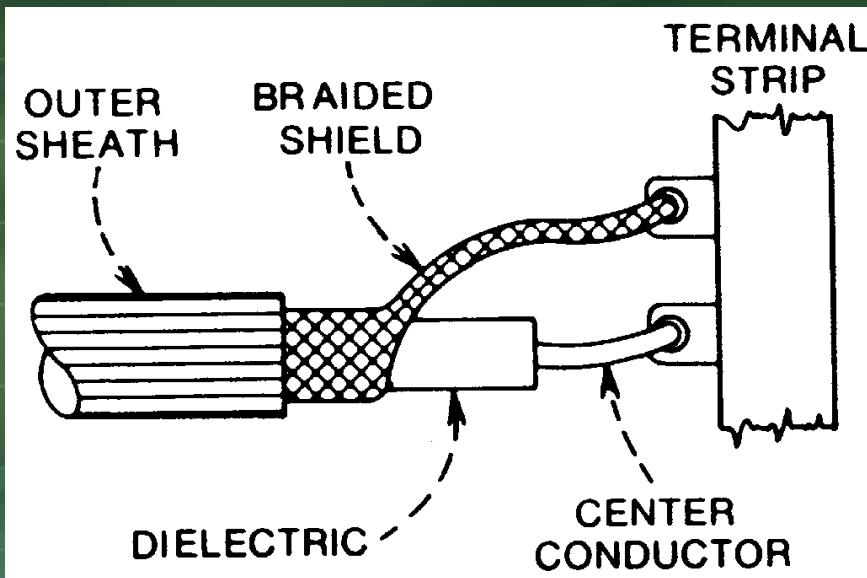
Pigtail Effect

- 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.

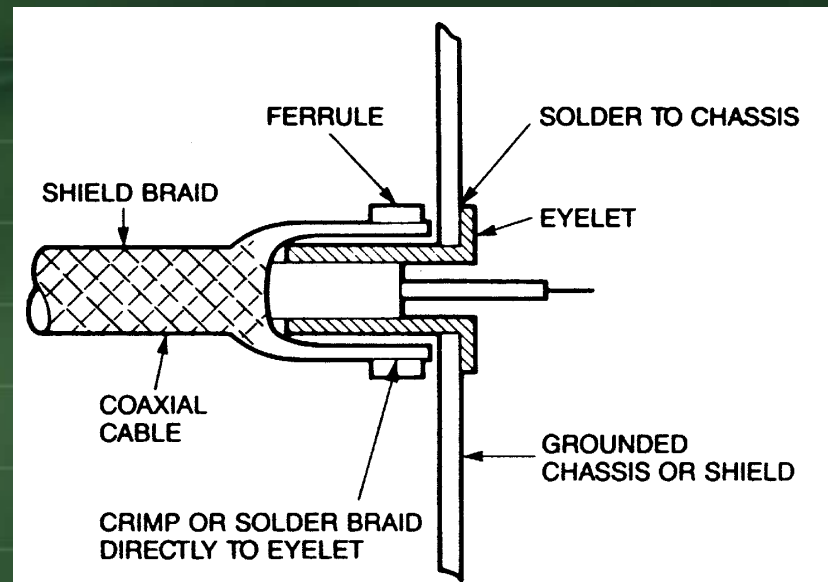




Pigtail Effect



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)





Pigtail Effect

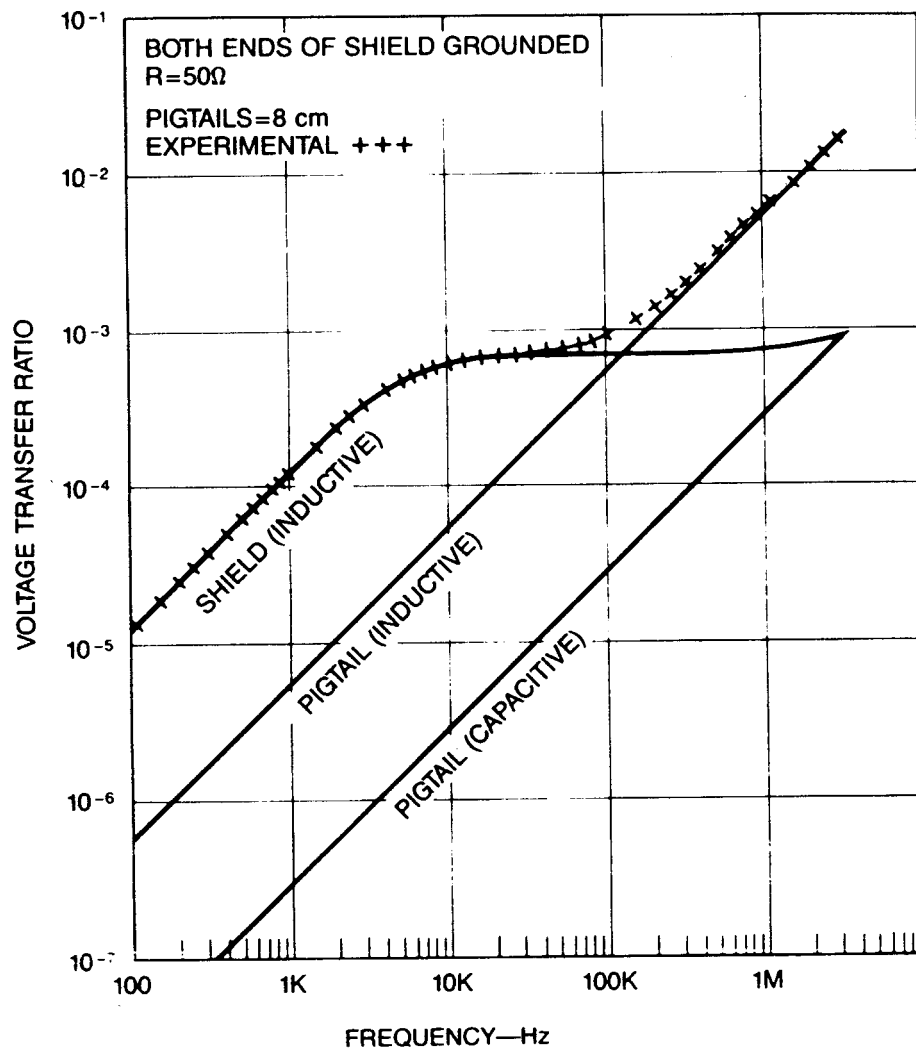


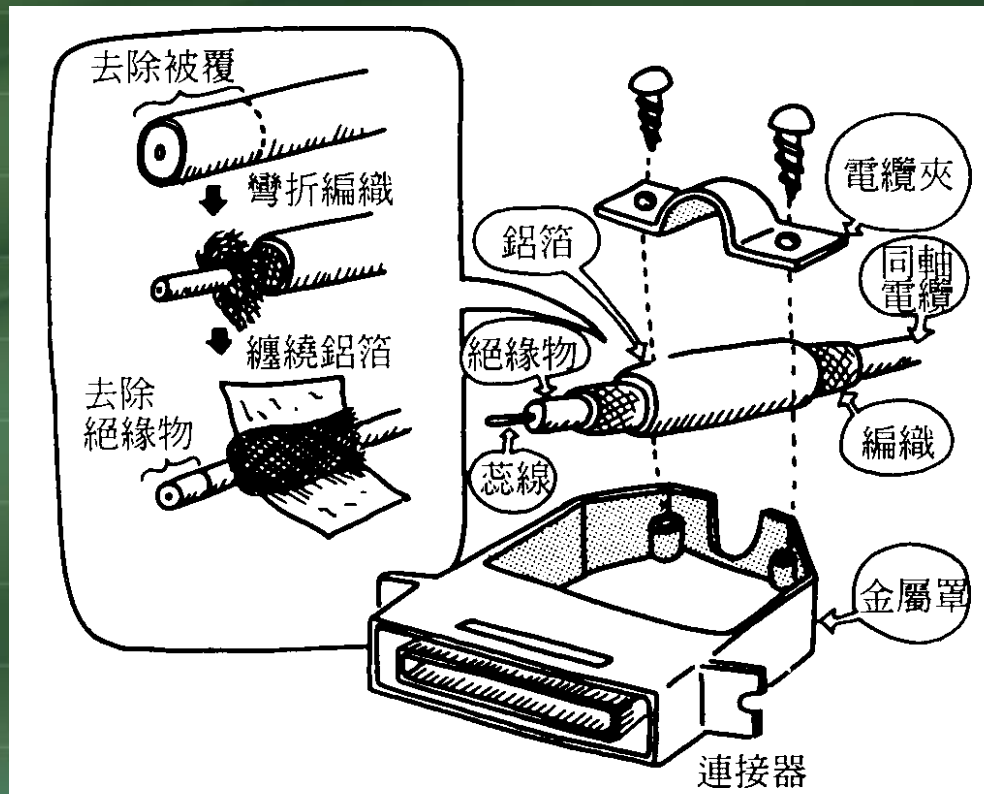
Figure 2-36. Coupling to a 3.7-m shielded cable with an 8-cm pigtail termination. Circuit termination equals 50Ω (from Paul, 1980, © IEEE).





Connector Shielding

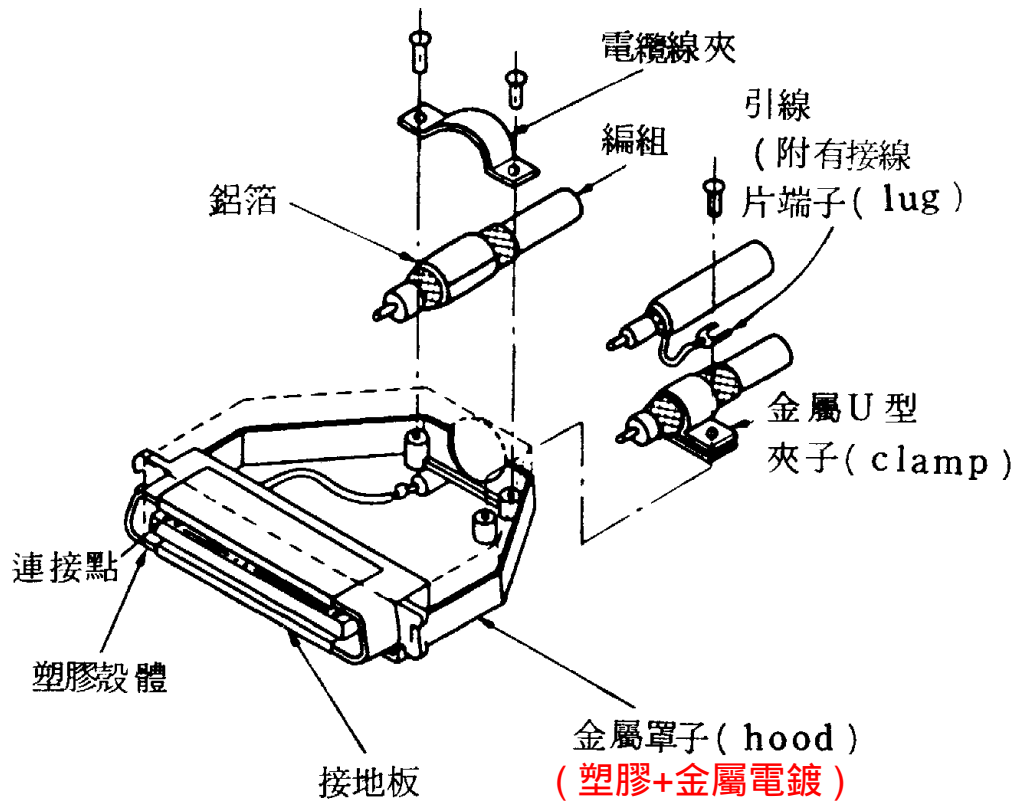
- The most effective shielding integrity is to *bond a heavy metal cap* from the cable shield to the equipment shield, like the D-subminiature connector.



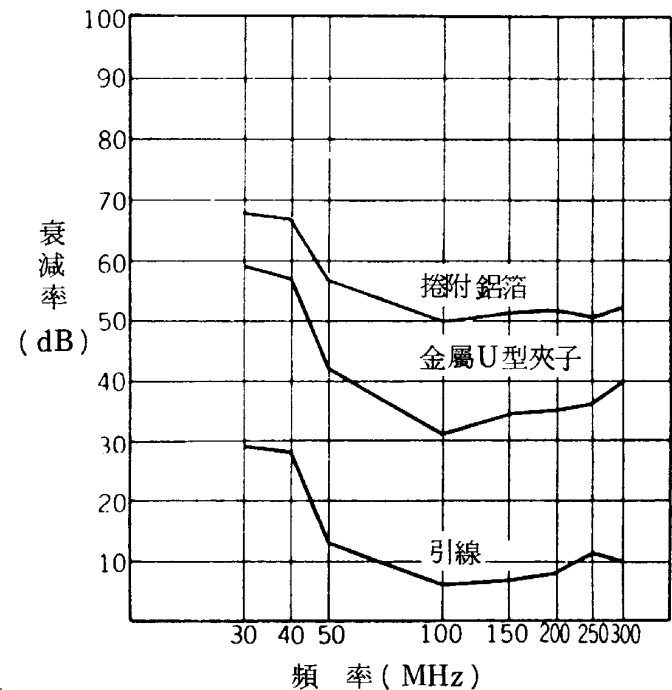


Connector Shielding

- (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面板安裝角孔尺寸：15.8 mm (W) × 59 mm (L)

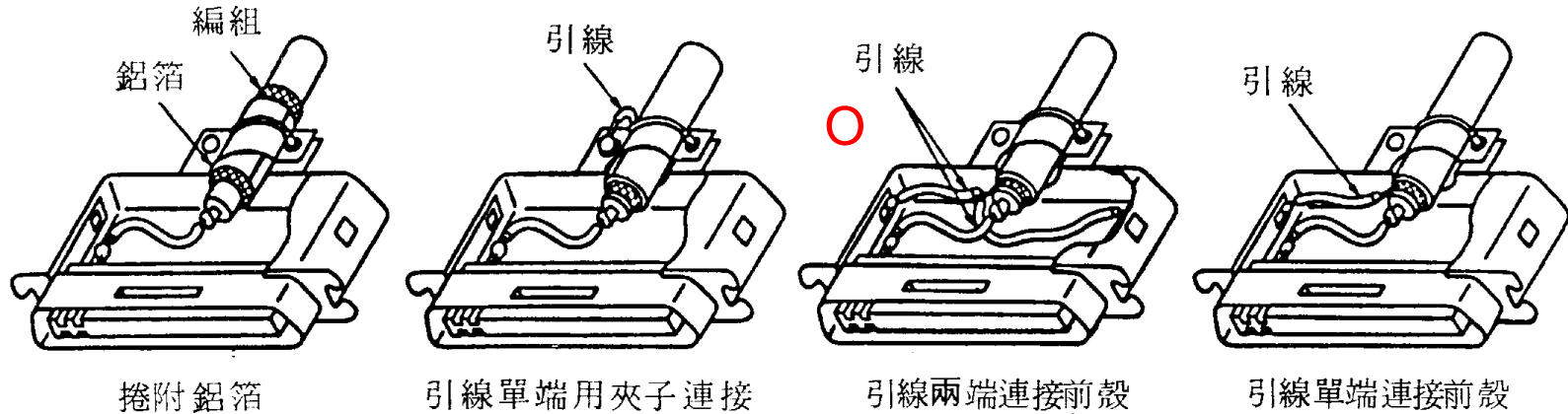


根據電纜線端連接器之接地連接方式的屏蔽效果

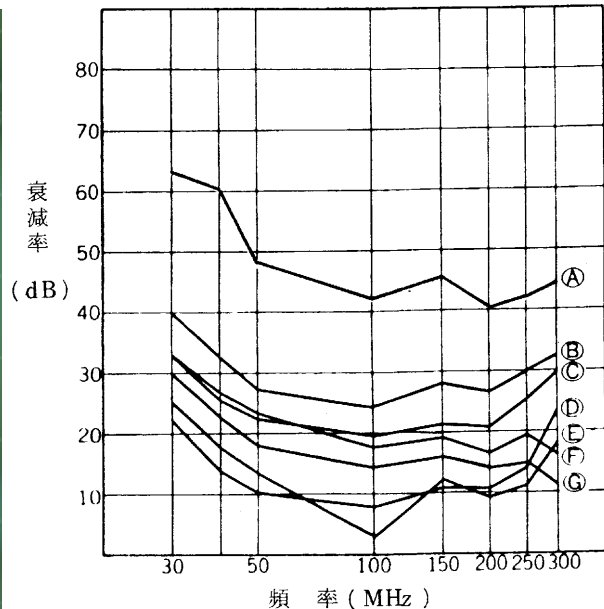




Connector Shielding



根據電纜線端連接器之接地連接方式的屏蔽效果

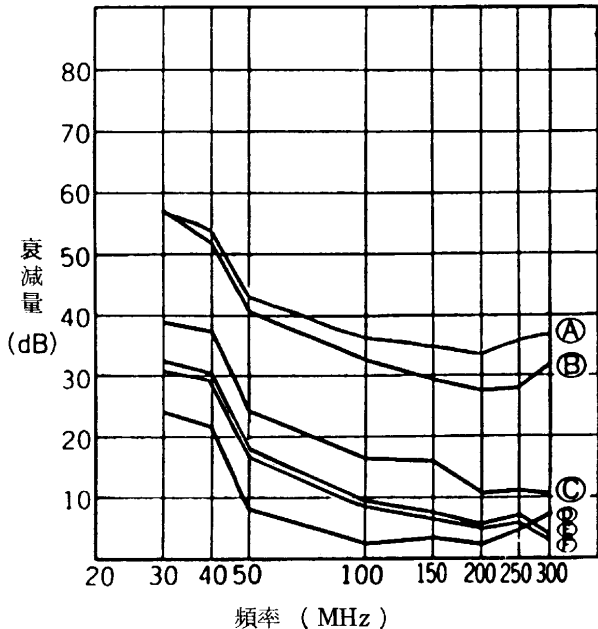
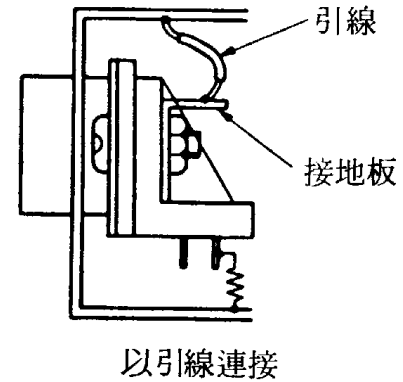
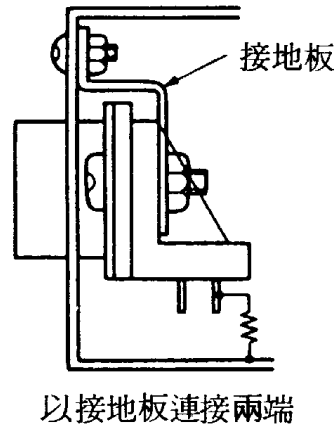
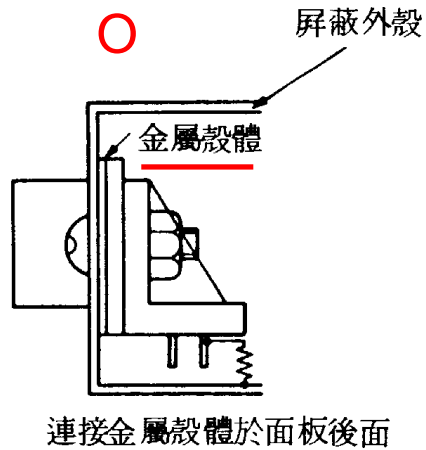


- (註) ①電纜線端的連接器：57E-30360
 ②面板端的連接器：57LE-40360-2700
 ③面板端的連接器之接地連接方式：連接金屬殼體於面板後面。
 ④面板安裝角孔的尺寸：
 15.8mm (W) × 59 mm (L)

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



Connector Shielding



根據面板端連接器之接地方式的屏蔽效果

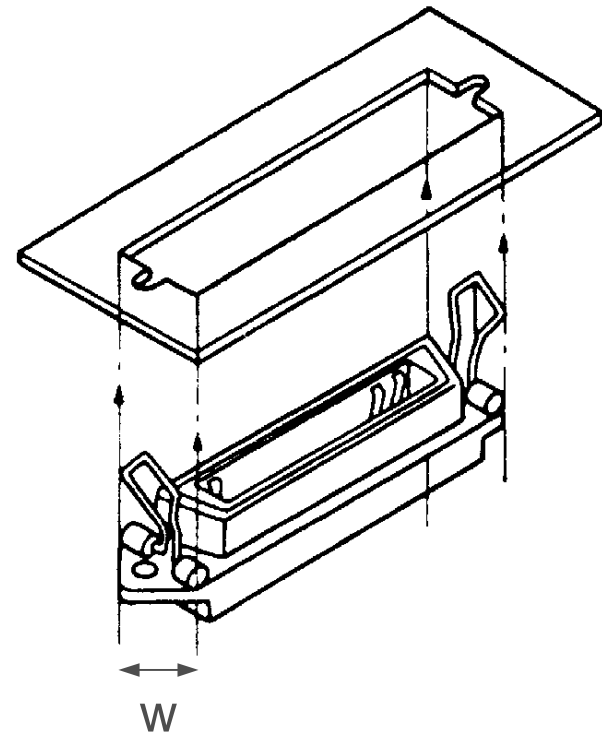
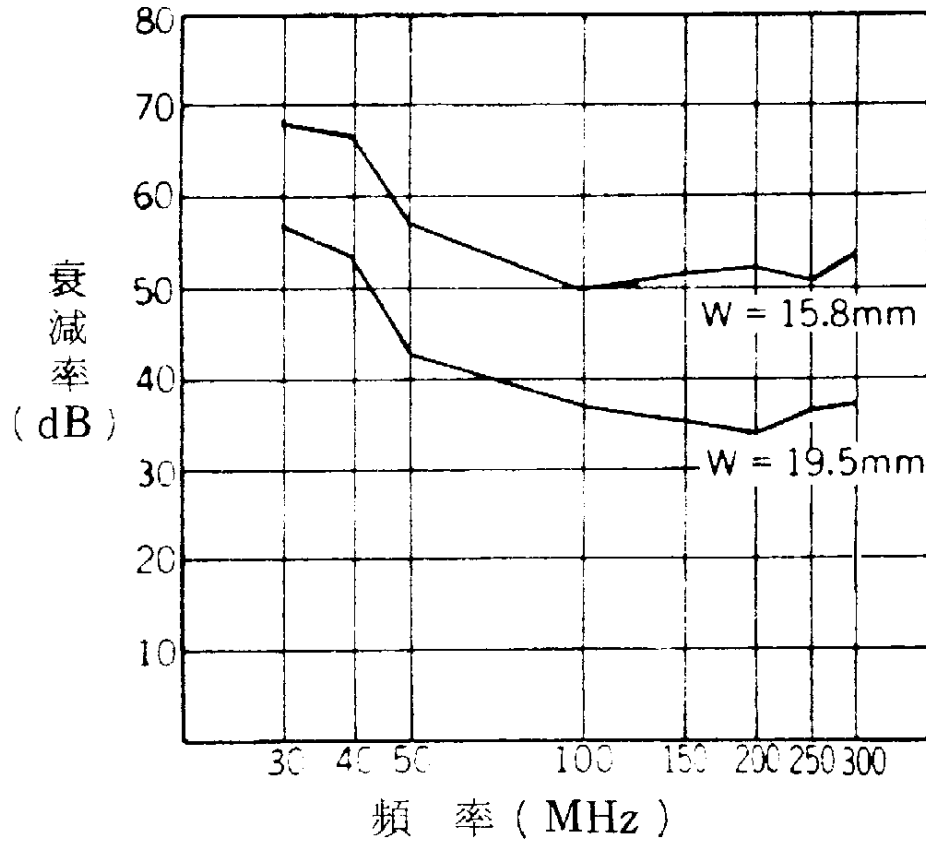
- (註) ①面板安裝角孔尺寸；19.5 mm (W) × 59 mm (L)
 ②電纜線端連接器；57FE-30360-20
 ③面板端的連接器；57LE-40360-2700

- (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 = 35 mm) 連接引線單端





Connector Shielding

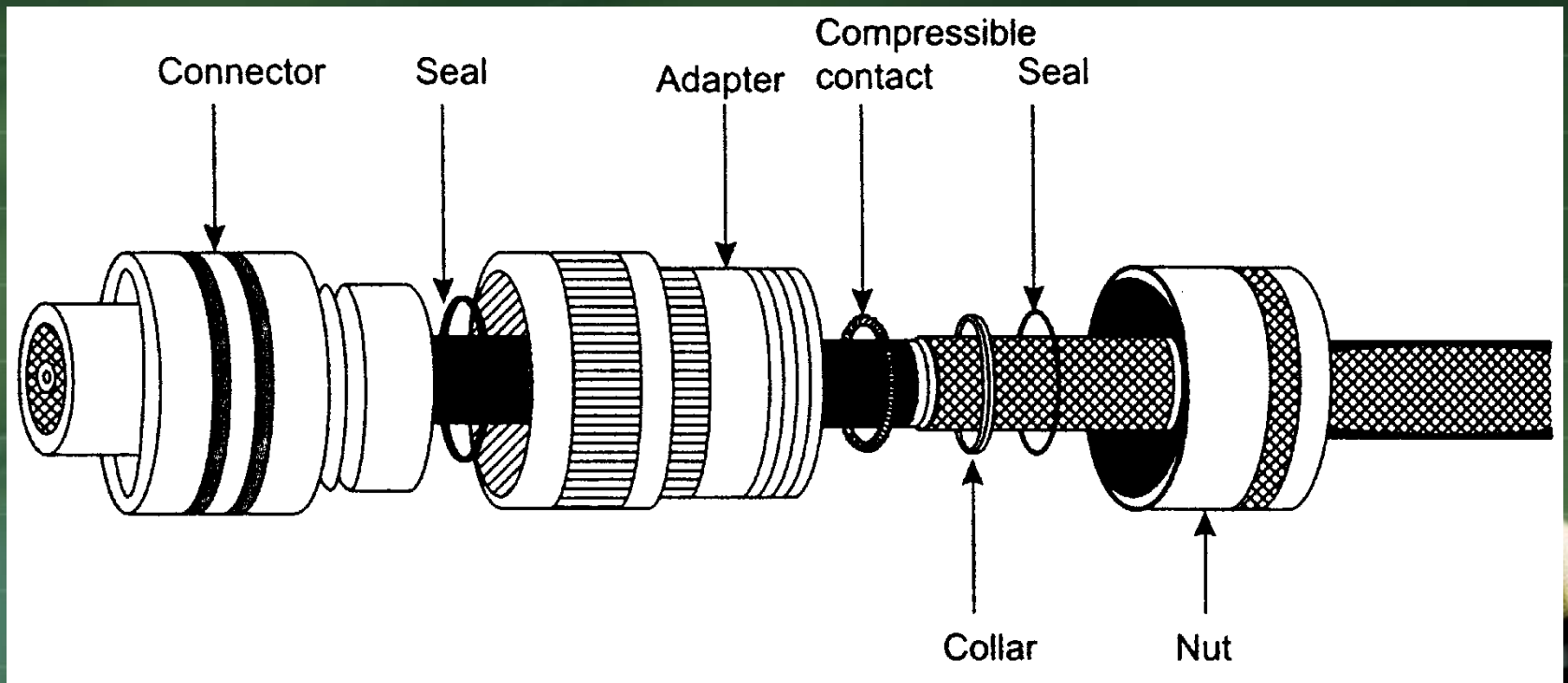


根據面板安裝角孔的尺寸法之屏蔽效果





Connector Shielding





Agenda

- ✦ EMC Cables
 - ✦ Coaxial Cables
 - ✦ RF Absorptive(有吸引力的) Cables
 - ✦ Ribbon(緞帶狀) Cables
 - ✦ Other Cables
- ✦ EMC Connectors
 - ✦ Pigtail Effect
 - ✦ Connector Shielding
- ✦ *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 80~100dB.





EMC Gaskets

Knitted Wire-Mesh Gaskets

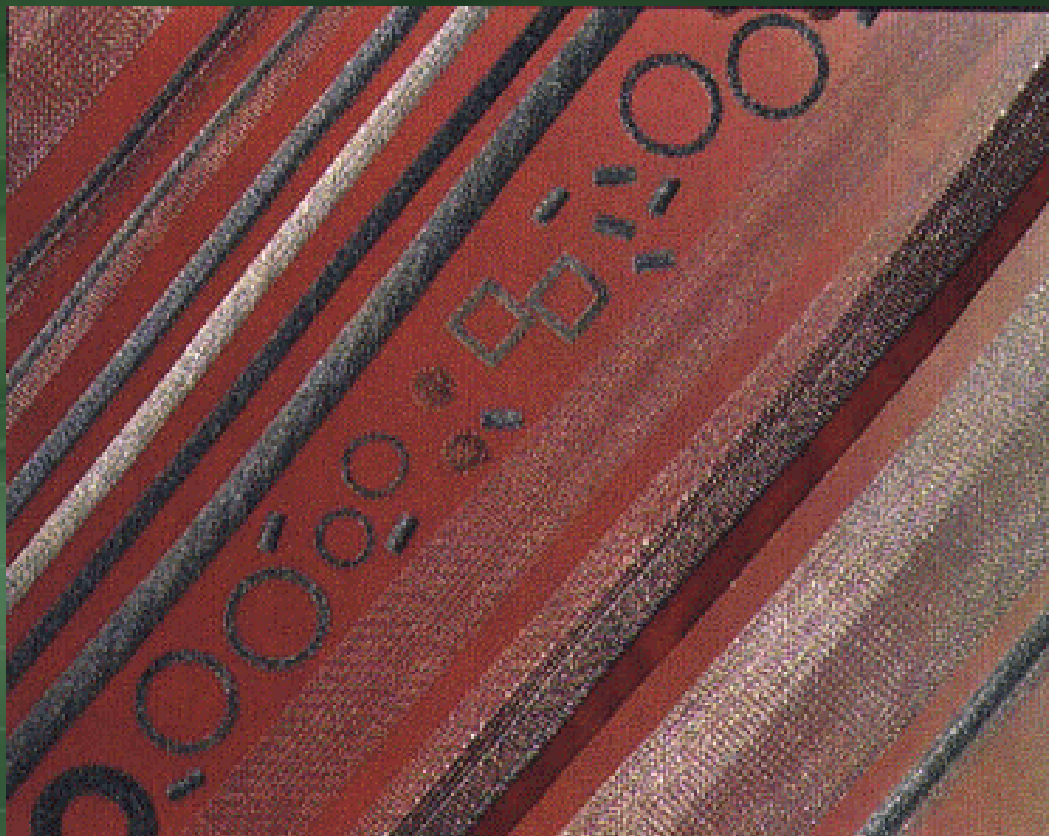
- Knitted(編織的) Wire-Mesh(金屬線羅網) Gaskets (織線網襯墊材料)
 - Standard product is available in Monel Sn/Cu/Fe, Aluminium, Phosper Bronze & silver plated brass wire. The material is manufactured into square, round, round with fin, and double round sections.
 - Mesh Strips provide EMI shielding for joints and seams 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

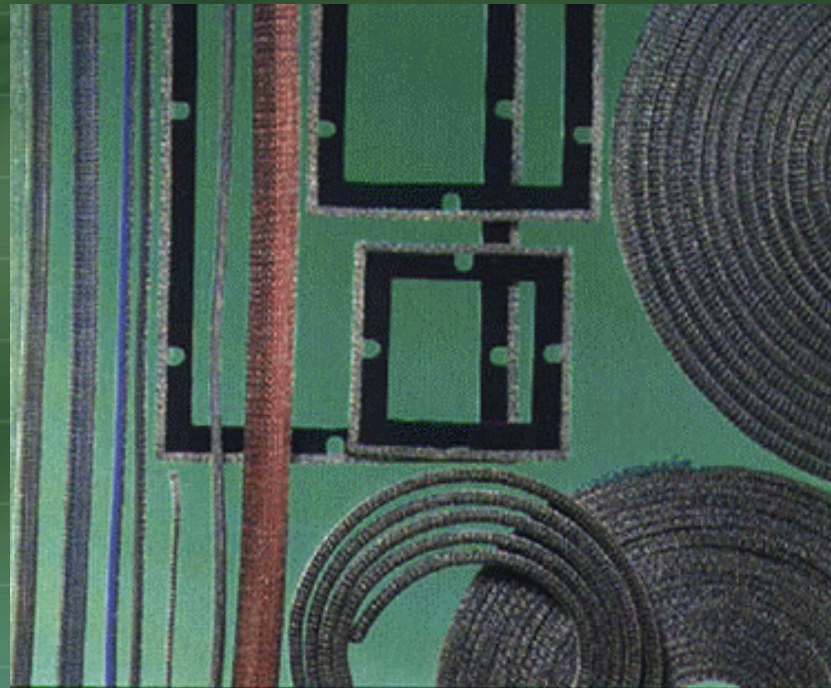




EMC Gaskets

Mesh & Elastomer Combination Gaskets

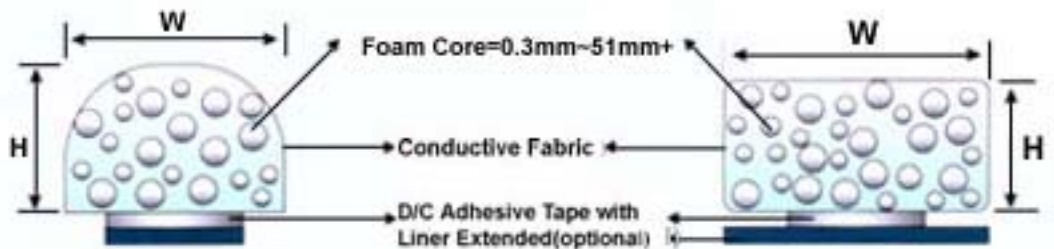
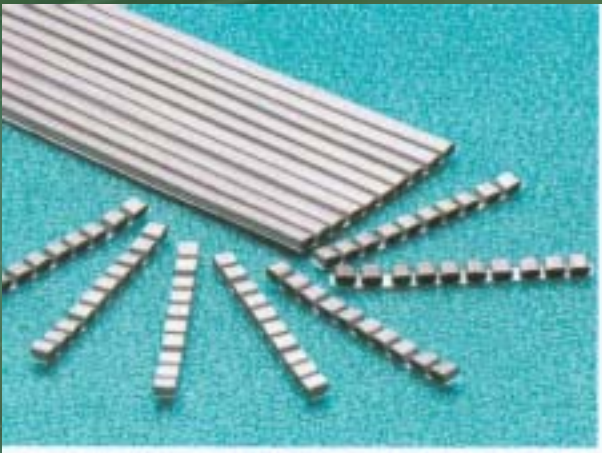
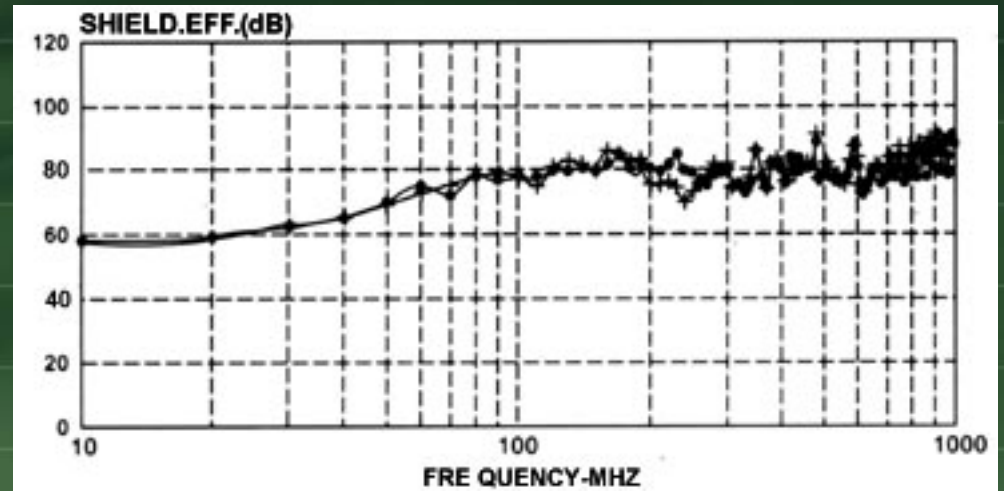
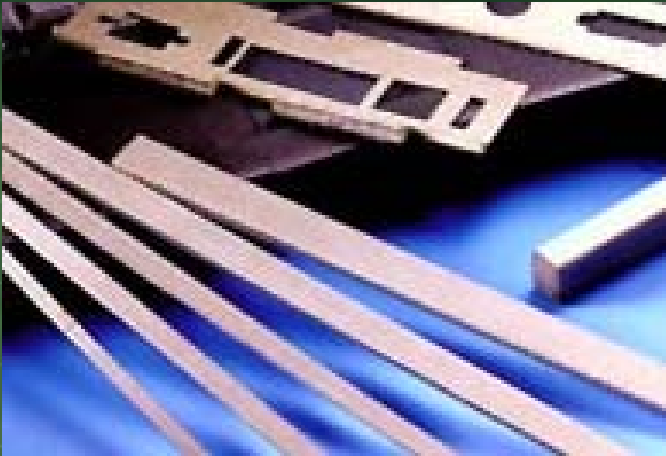
- Mesh & Elastomer(合成橡膠) Combination Gaskets
 - Custom Strips *combine the resilience(彈性) and conductivity of knitted mesh with the excellent compression(可壓縮性) and deflection(可捲繞性). Solid or sponge(海綿) cores are available as well as hollow tubes.*
 - A knitted wire mesh bonded to an elastomer section means that Duogaskets and Duostrips offer an excellent shielding and environmental seal(密封).





EMC Gaskets

Conductive Shielding Gasket (導電泡棉)

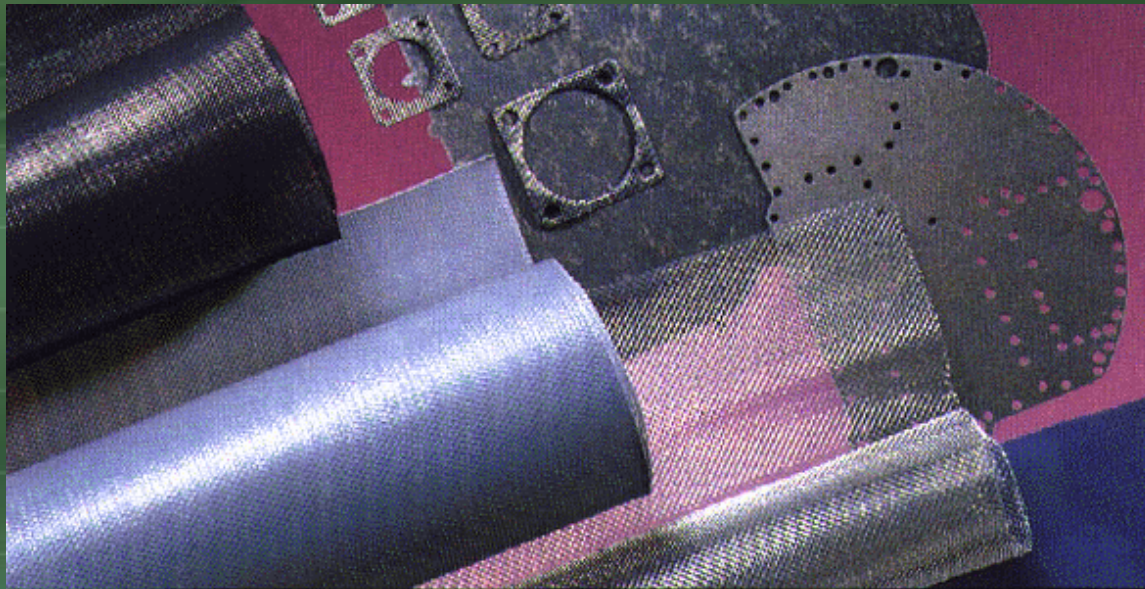




EMC Gaskets

Wire-Screen Gaskets

- 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.

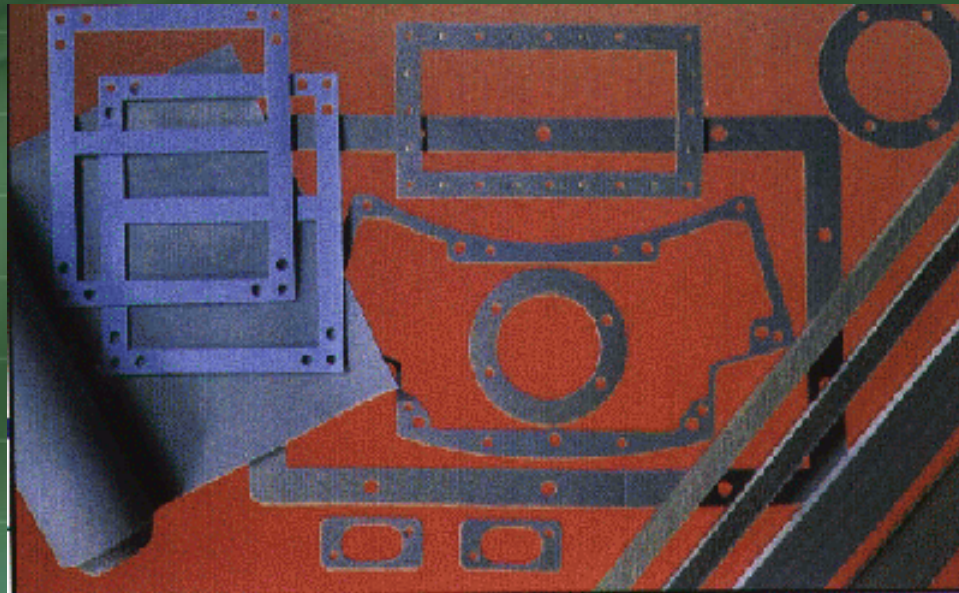




EMC Gaskets

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.

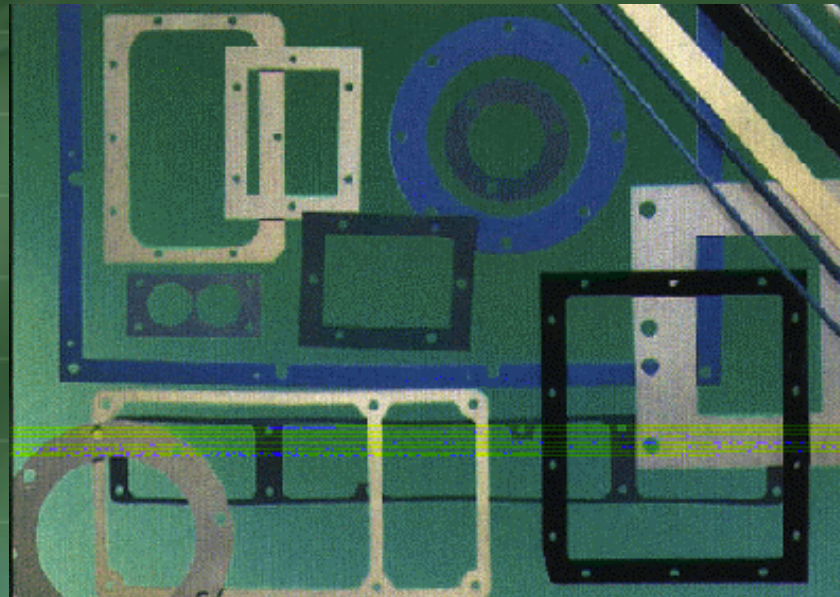




EMC Gaskets

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





EMC Gaskets

Gasket Fabrication (構造)

- The gasket should be in a slot and on the inside of the screw to protect against leakage around the screw hole.

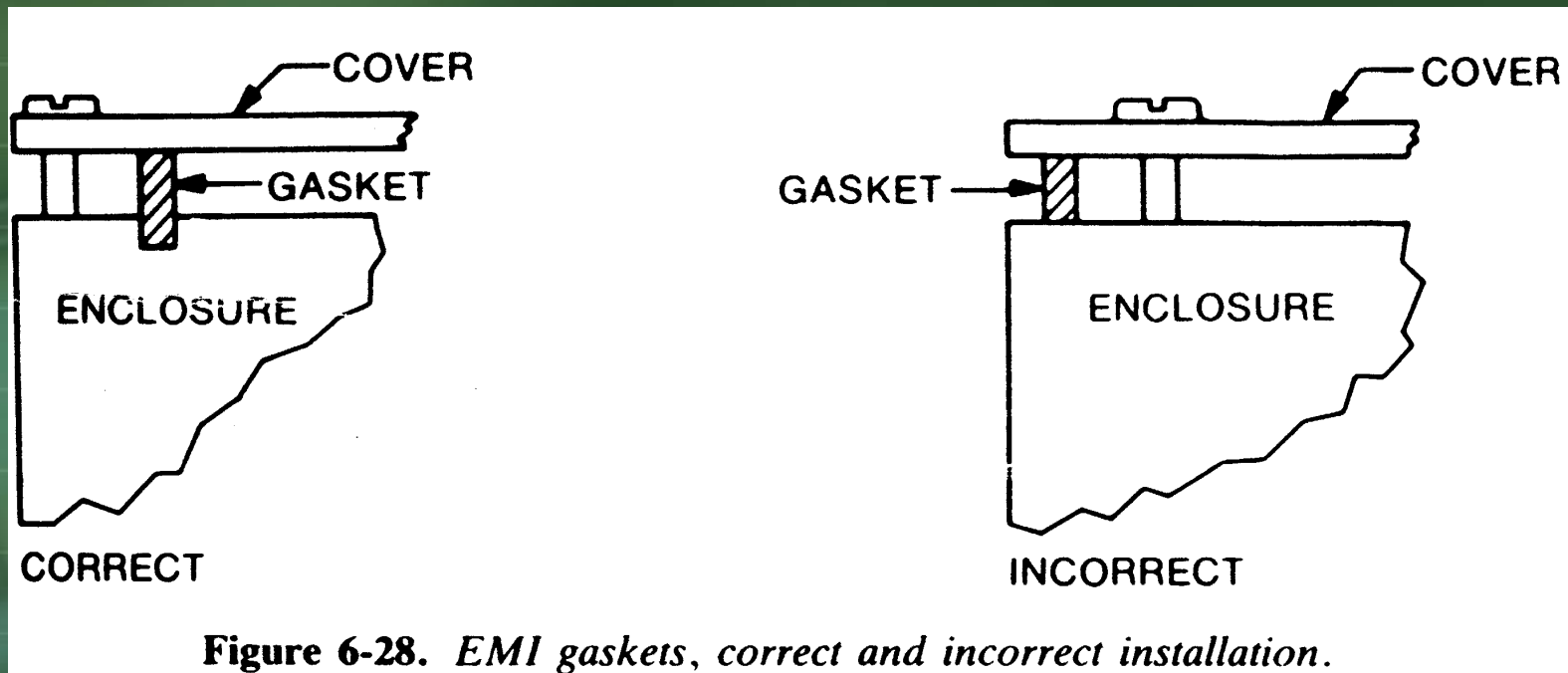
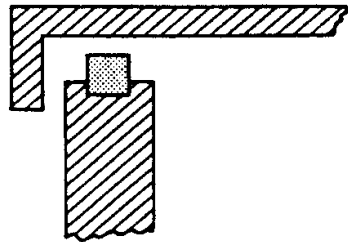


Figure 6-28. EMI gaskets, correct and incorrect installation.

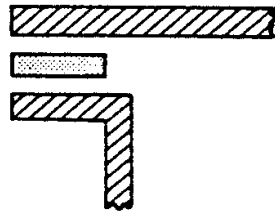


EMC Gaskets

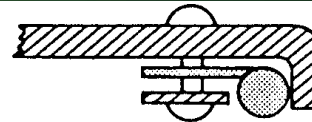
Gasket Fabrication (構造)



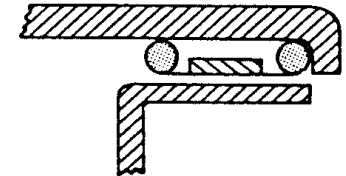
(a) Located in groove



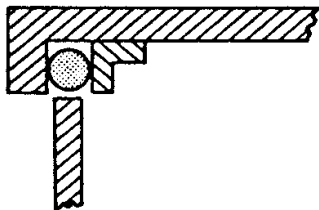
(b) Adhesive bonded



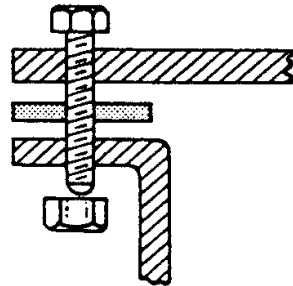
(e) Riveted
(using a stiffening plate or strip)



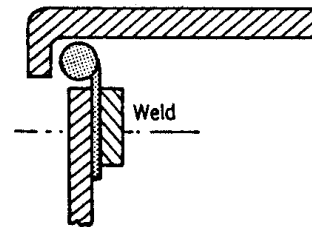
(f) Spot welded
(These double P sections can alternatively be riveted into position or retained by adhesive on fin.)



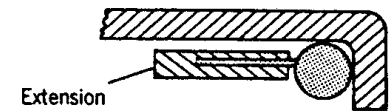
(c) Friction retention



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



(g) Spot welded between flanges

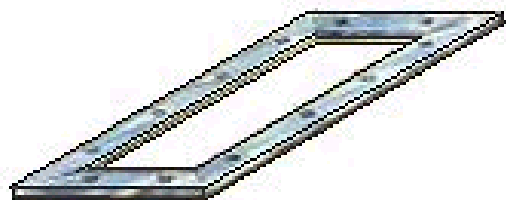


(h) P section entrapped in extrusion
(The extrusion, normally in aluminium, provides a rigid mounting strip for the gasket fin.)



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.

