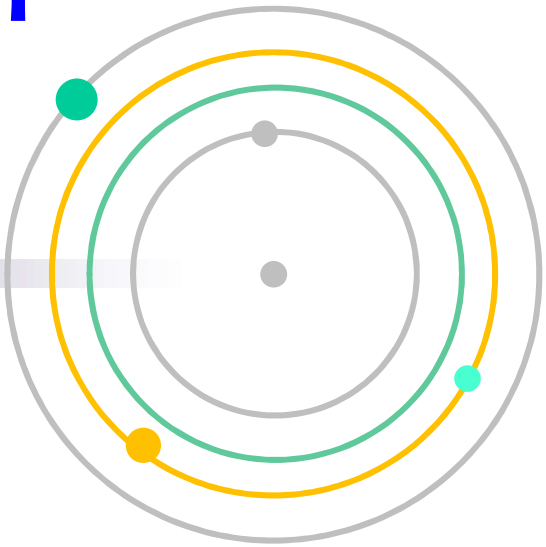
EMC Technical Seminar



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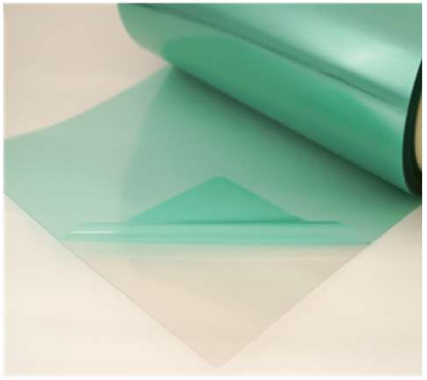
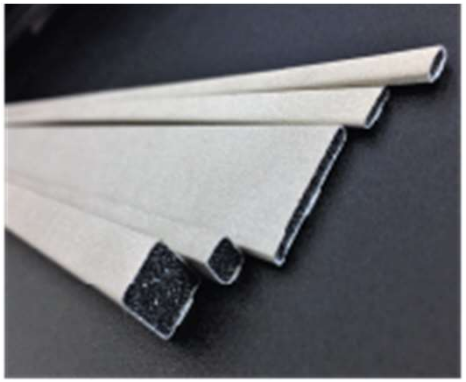
Contents

Shielding with Low Impedance Material



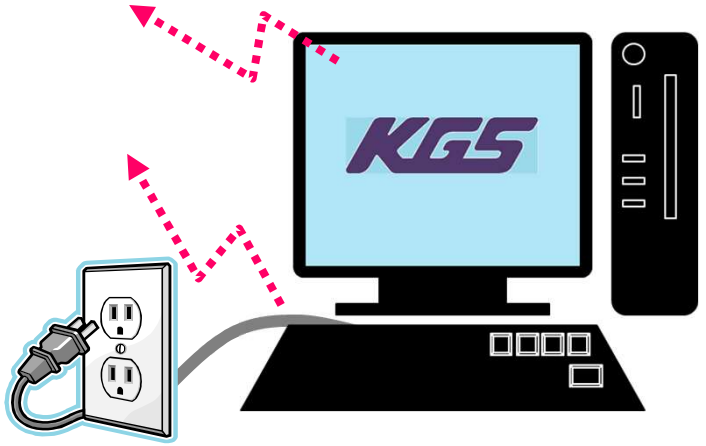




Radiation of Electromagnetic Waves

- Openings of enclosure
- Cables
- PCB

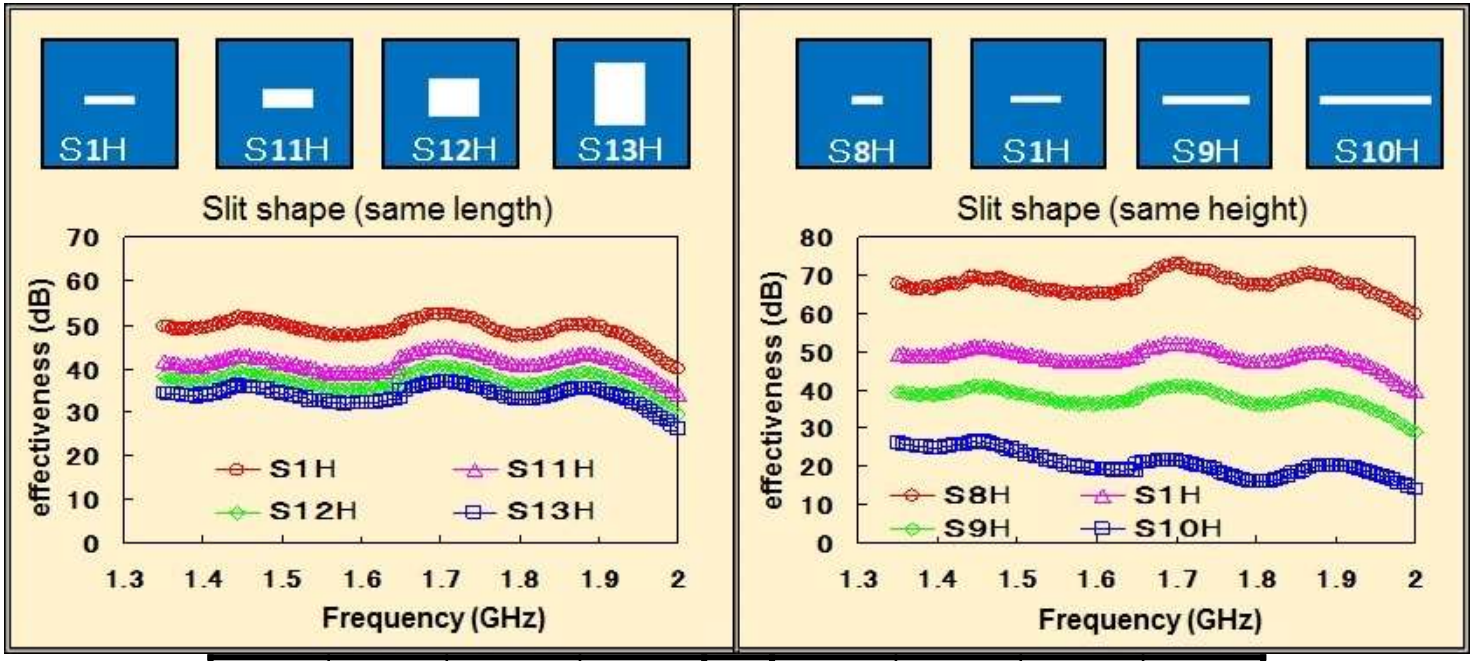
Reduce radiation by Shielding



Shielding helps prevent electromagnetic waves from exiting or entering the enclosure.

Aperture size affects Shielding Effectiveness

Shielding Effectiveness Comparison



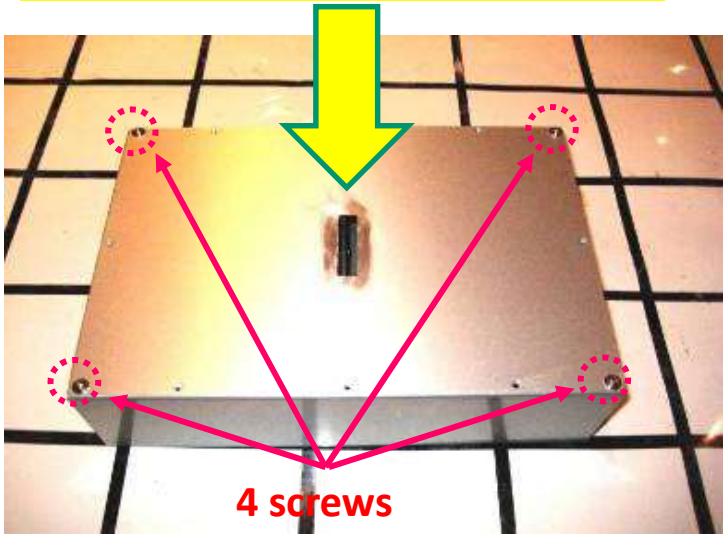
	Length (mm)	height (mm)	size (cm^2)			length (mm)	height (mm)	size (cm^2)
S1H	34.0	2.0	0.7		S8H	17.0	2.0	0.3
S11H	34.0	10.0	3.4		S1H	34.0	2.0	0.7
S12H	34.0	20.0	6.8		S9H	50.0	2.0	1.0
S13H	**34.0**	**34.0**	**11.6**		**S10H**	**75.0**	**2.0**	**1.5**

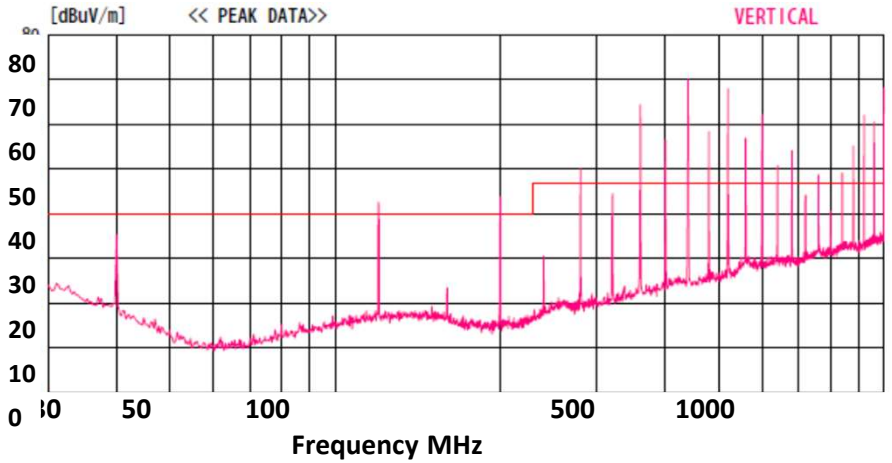
The maximum dimension has more influence on shielding effectiveness.

Aperture size affects Shielding Effectiveness

Test box:
1. Aluminum case
2. Dimensions: W250✕D180✕H70 (mm)
3. Surface treatment: alumite (non-conductive)

Cutout (5cm✕1cm)

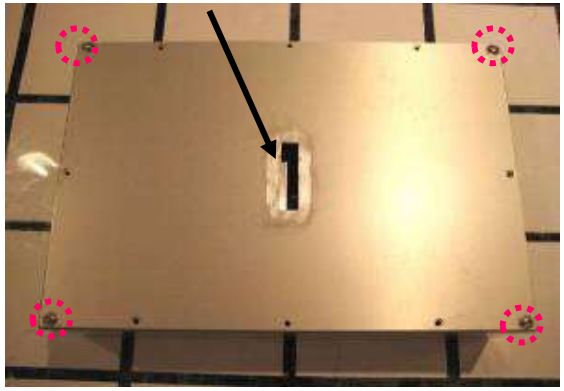




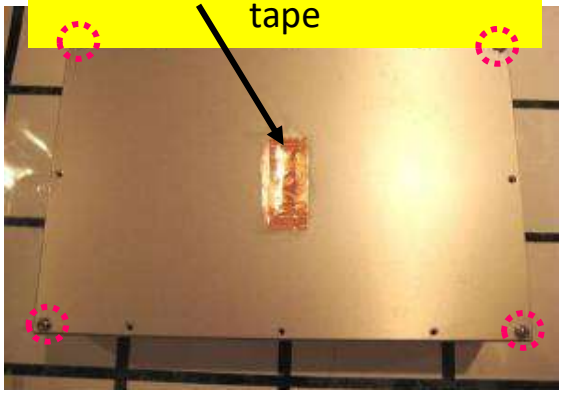
Noise emission in vertical polarization without a lid

Aperture size affects Shielding Effectiveness

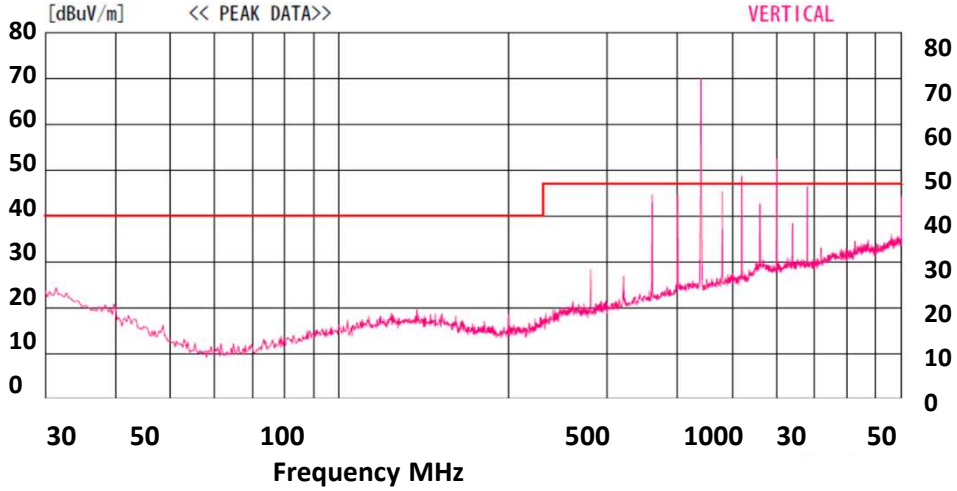
Cutout size (5cm✕1cm)

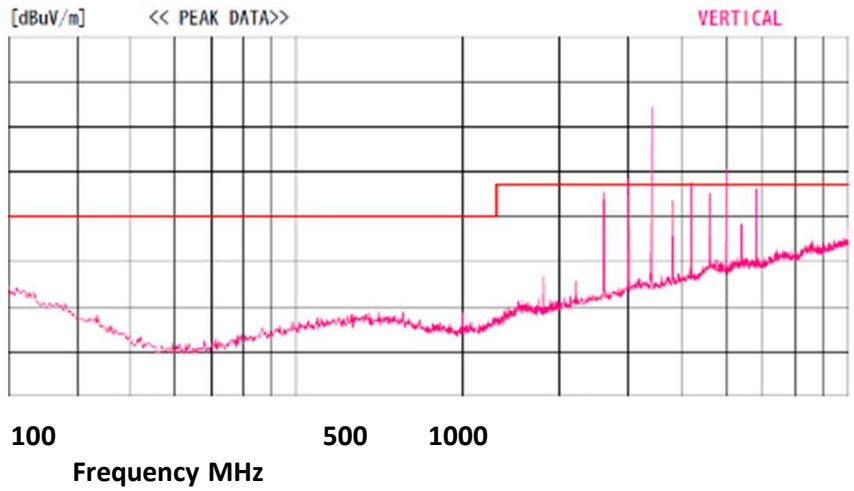


Cutout covered with copper tape

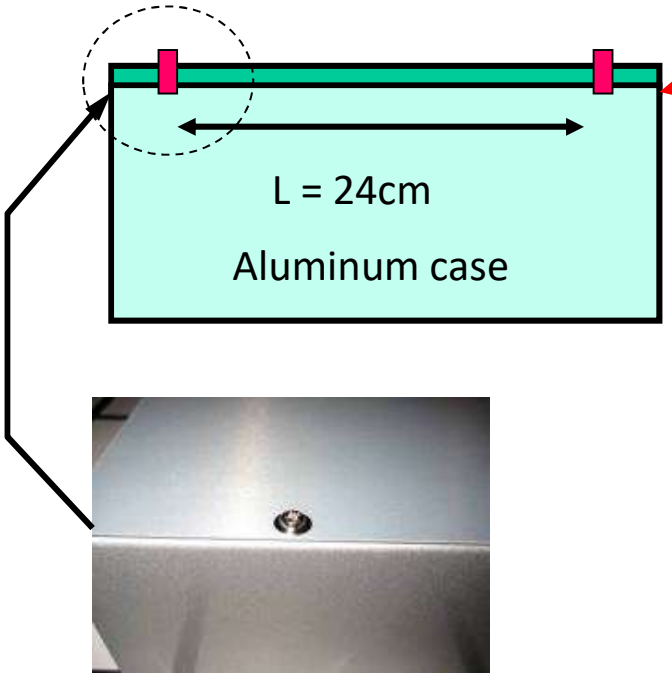


No significant improvement





Aperture size affects Shielding Effectiveness



Joint at the lid formed a longer slit than the cutout on the lid.

Since the cover is coated with alumite, electrical conductivity through the lid is only at screw points.

↓

Long slits are created between the screws.

↓

Shielding effectiveness is greatly reduced.

Shielding effect of a slit

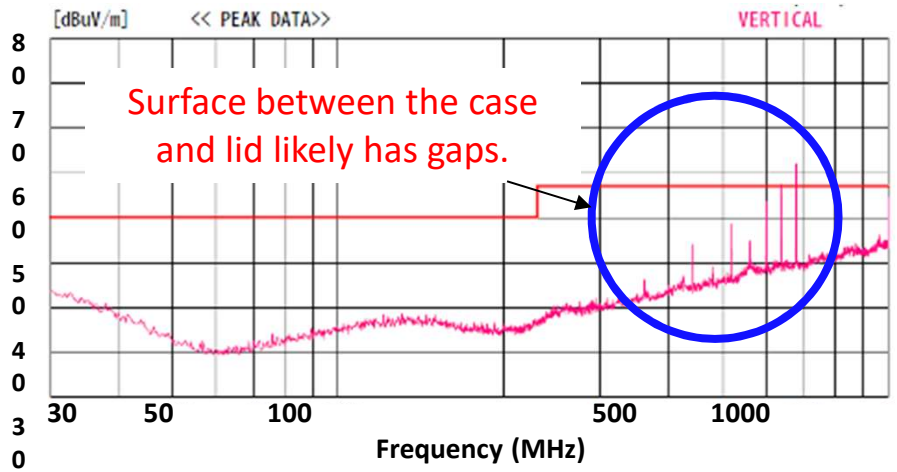
$$SE(dB) = 20Log(\frac{\lambda}{2L})$$

λ：Wave length (m)

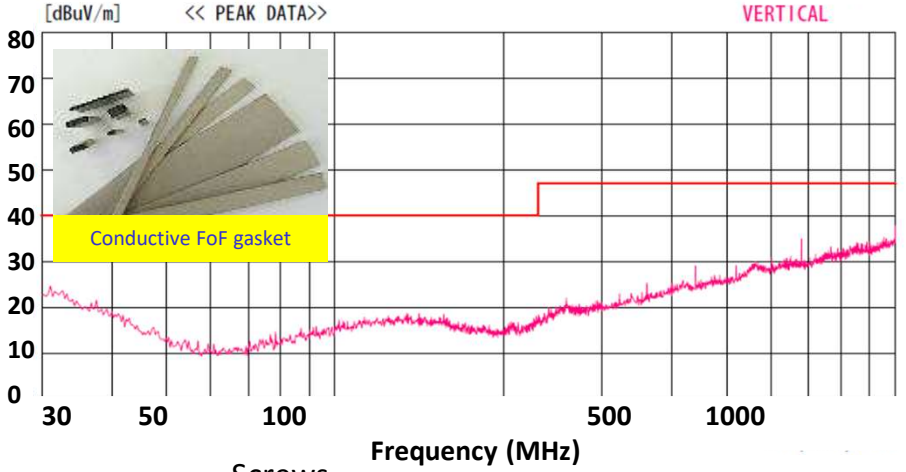
L:largest opening measurement (m)

Sealing Slits on Enclosures with Shielding Gaskets

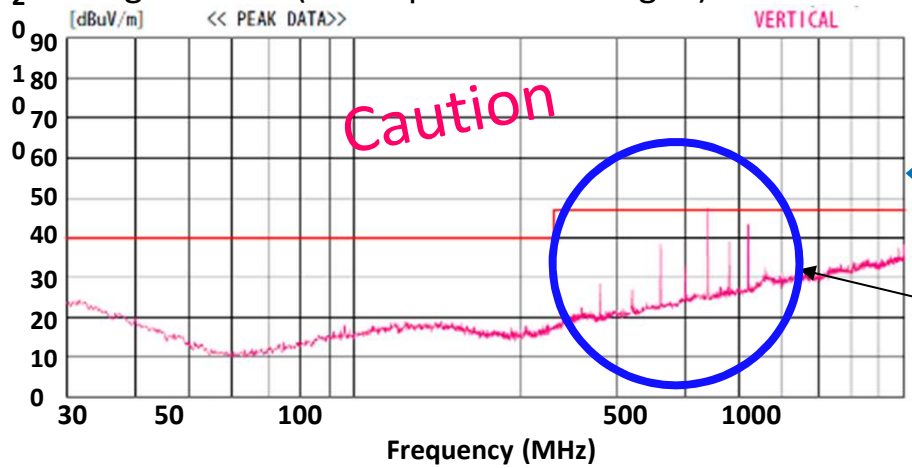
Non-conductive coating removed

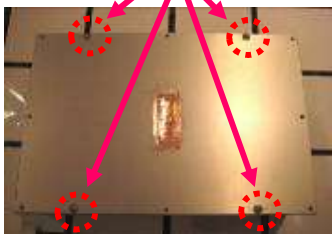


Using Gaskets (entire slit)

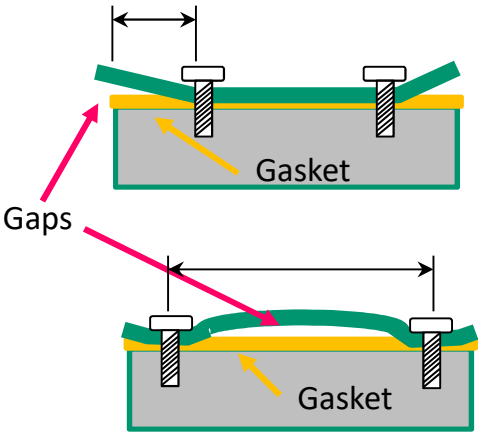


Using Gaskets (screw positions changed)



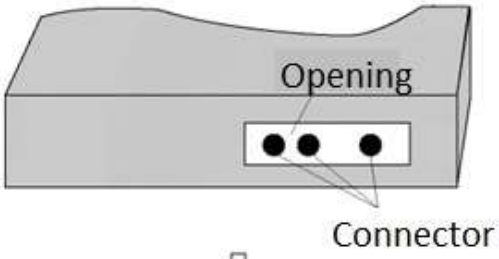


Due to repelling force of the gasket, it does not attach well to the lid and can potentially warp and create gaps around the screws.

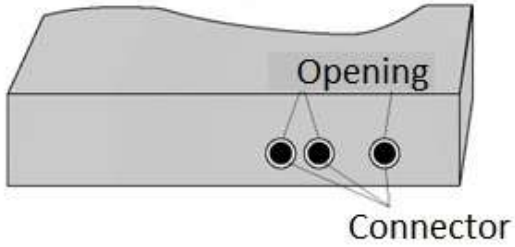


Recommended Shielding Design

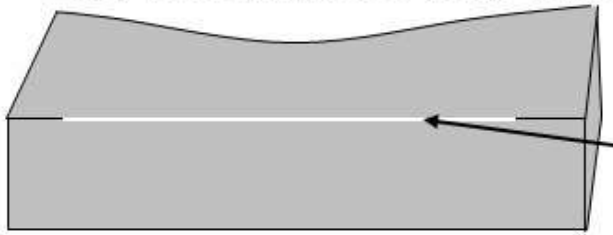
Bad: overall opening is large



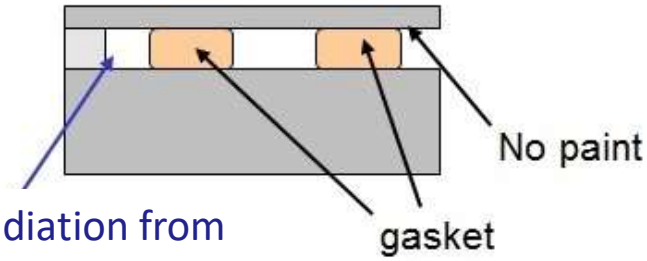
Good: overall opening is small



Bad: Non-conductive paint forms a long slit



Good: paint removed, gasket used

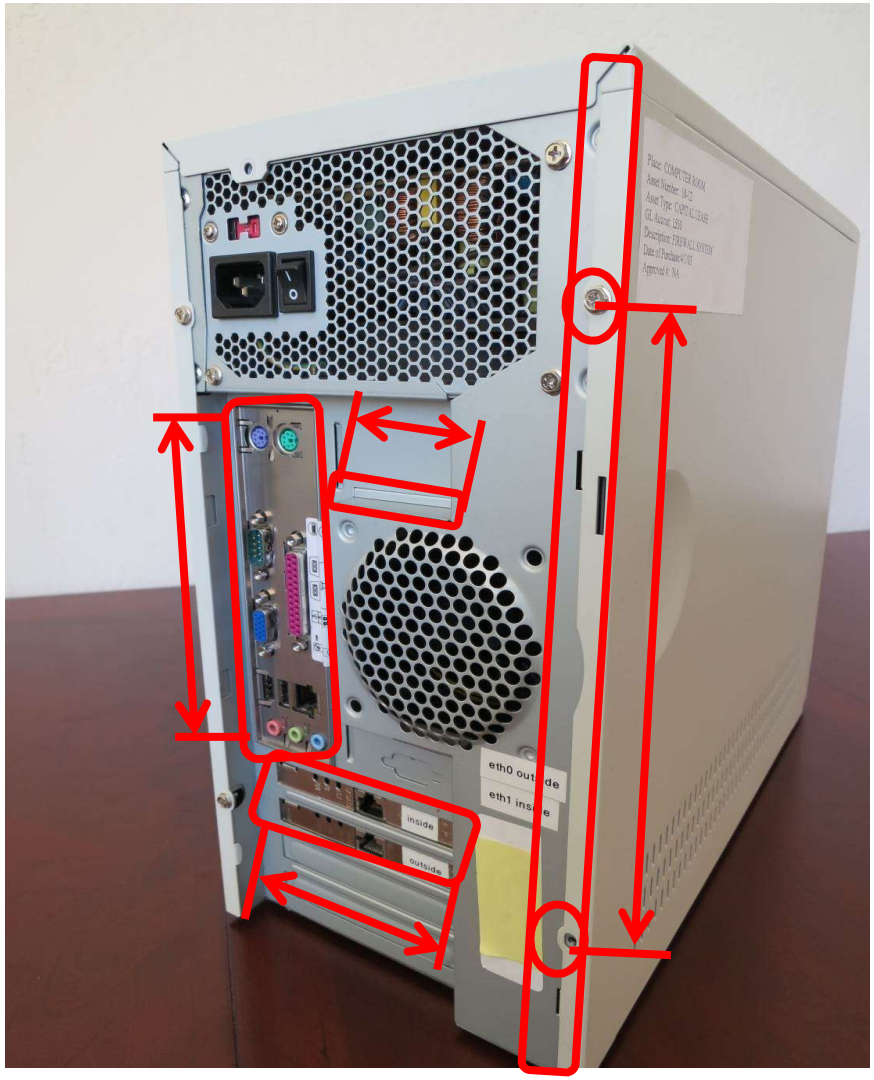


Prevents radiation from apertures

Slit should be less than 1/10 of the wavelength

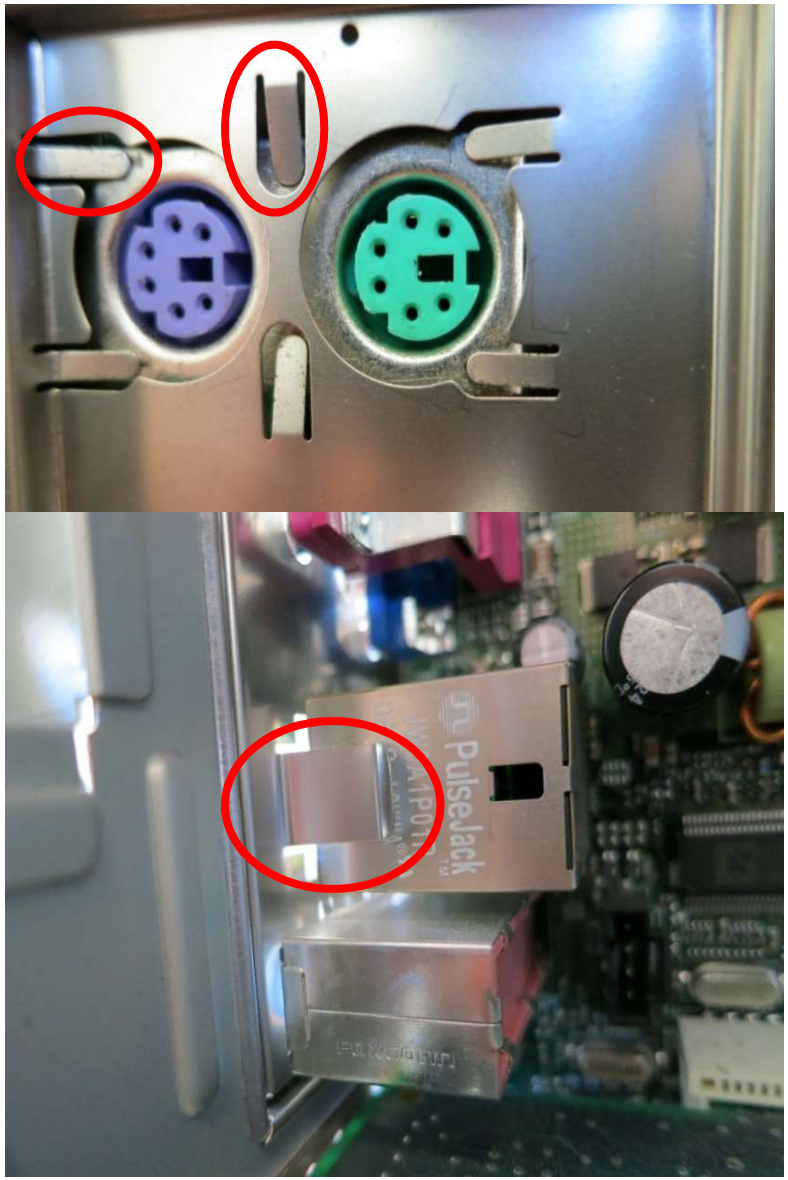
$$\lambda(m) = 300 / f(MHz)$$

In this example of a desktop computer, one could assume that the noise would leak from the blue areas, as there are many holes for the noise to escape from.



However, the areas in red would be the real points of concern.

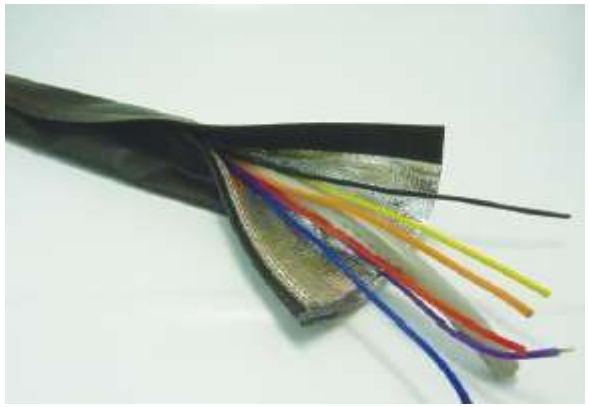
Taking a closer look by removing the side wall, we can see that contact points were built in, with a small pitch bedween each point, to ensure the length is no over 1/10th the distance of the wave length.

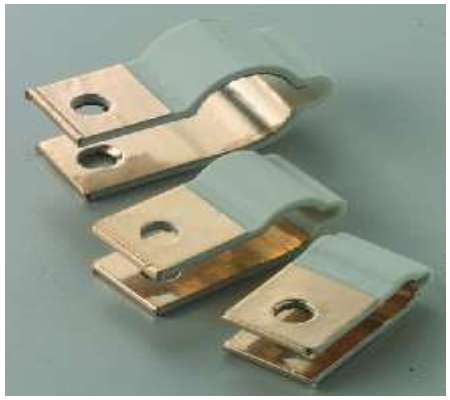


Same care was taken when designing the face plate for the I/O area and the small fingers, ensuring there is a contact and frame ground.

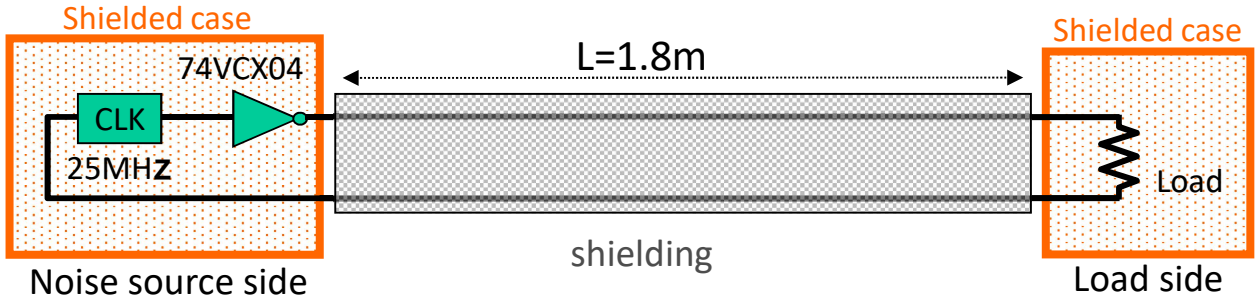
If noise is still leaking, it would most likely be from these two points, where such care was not taken in the design.

Cable Shielding





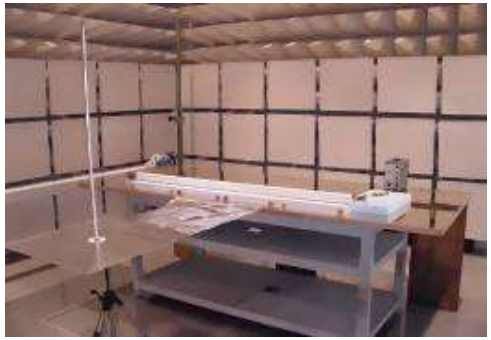
Cable Shielding Test



Noise Emission comparison among different grounding methods

- Shielded but not ground
- Shielded and ground to noise source side only
- Shielded and ground to load side only
- Shielded and ground to both sides with grounding wires
- Shielded and ground to both sides with grounding clamps

Site setup 150kHz-30MHz

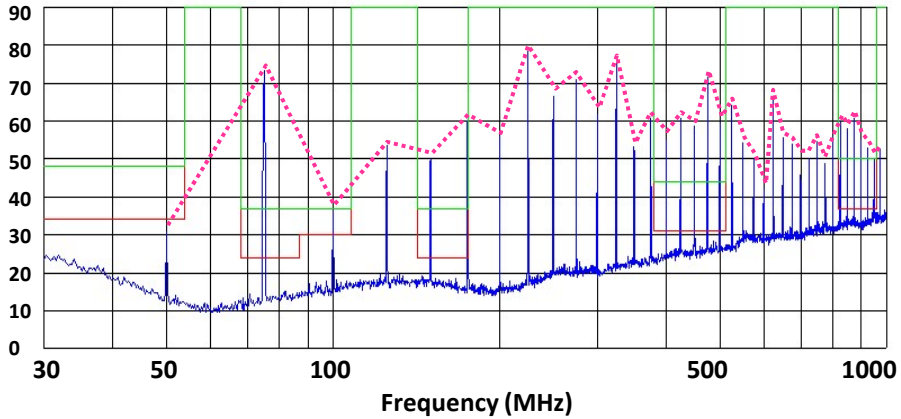


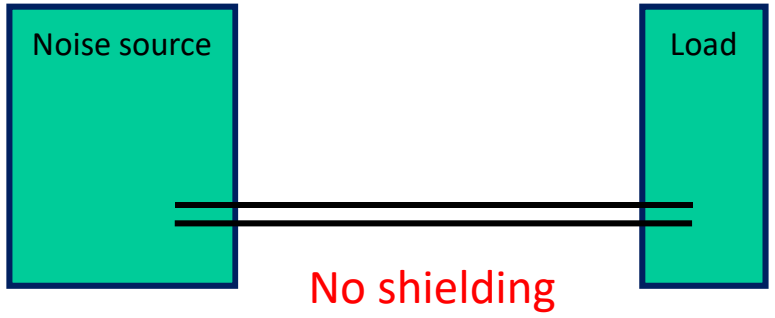
Site setup 30MHz-300MHz

※ Tested by CISPR25 Class3 method
(for over 30MHz, measured with horizontal polarization only)

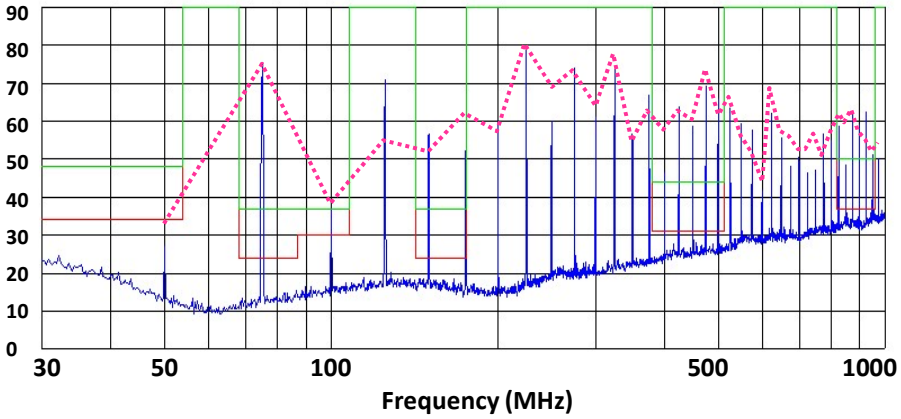
Cable Shielding Effectiveness: 30MHz ~ 1000MHz

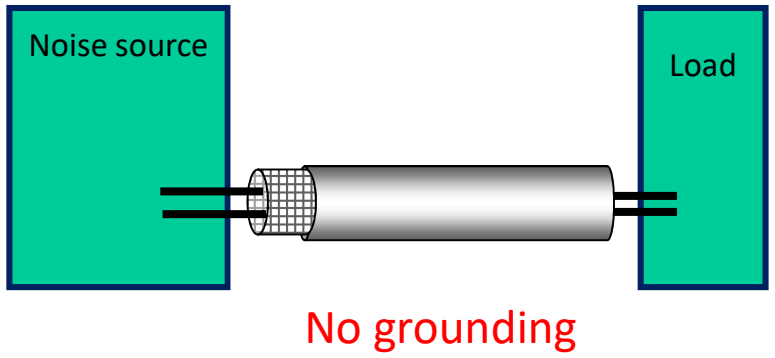
No shielding





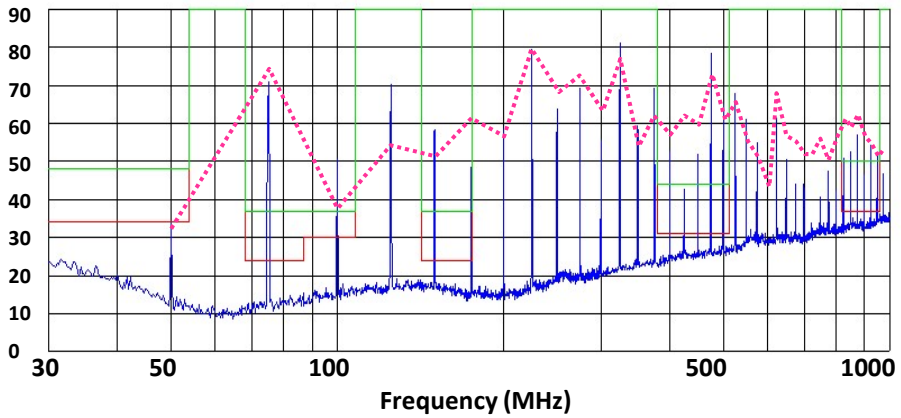
Shielded but not ground





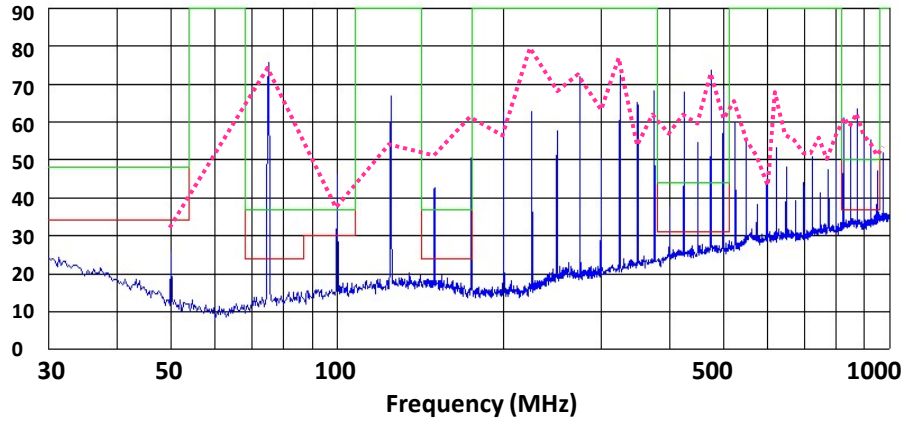
Cable Shielding Effectiveness: 30MHz ~ 1000MHz

■ Shielded and ground to noise source side only



Ground with 360˚ clamp
Noise source side

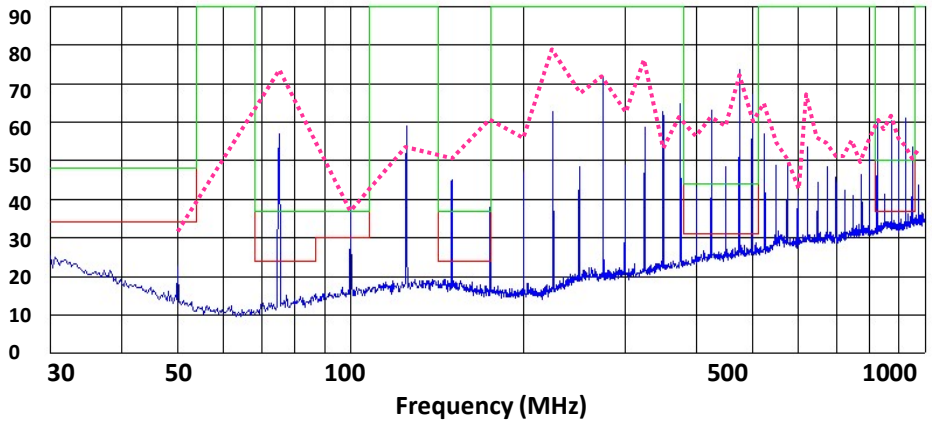
■ Shielded and ground to load side only

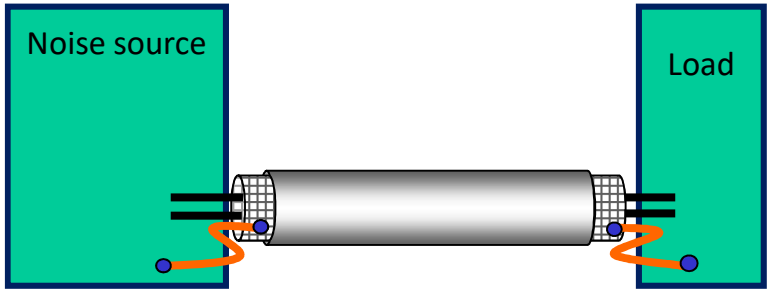


Ground with 360˚ clamp
Load side

Cable Shielding Effectiveness: 30MHz ~ 1000MHz

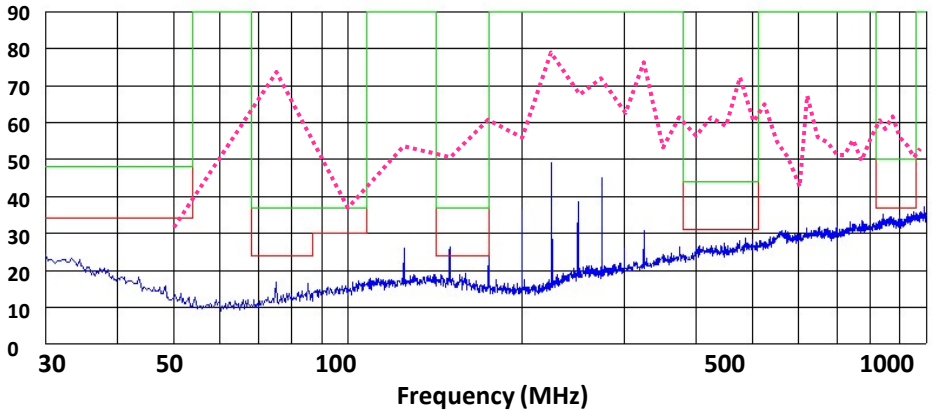
Shielded and ground to both sides with grounding wires





Ground with pigtail wires

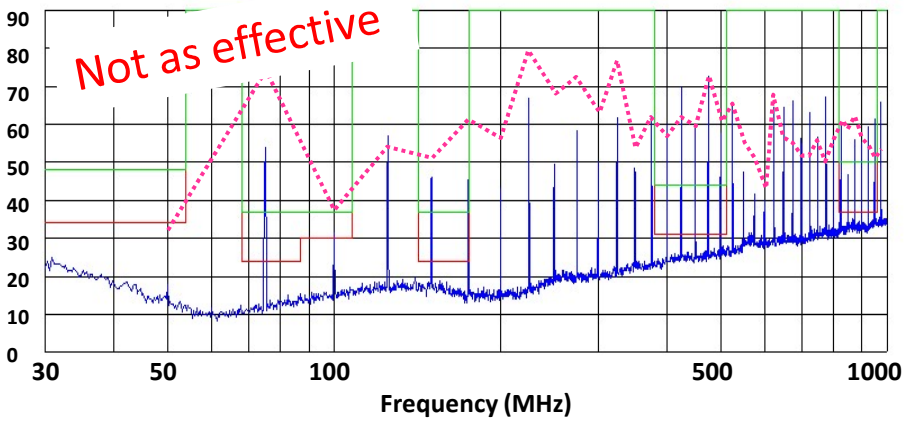
Shielded and ground to both sides with grounding clamps

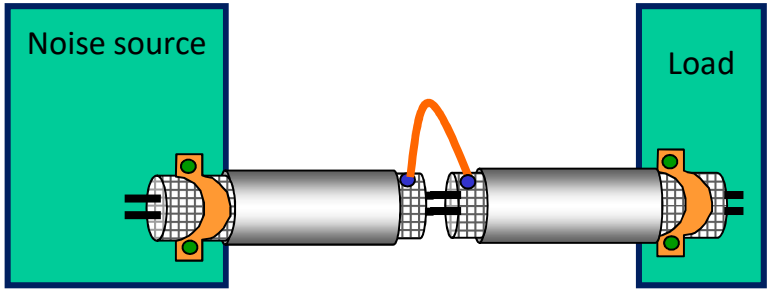


Ground with 360˚ clamps
Both sides

Cable Shielding Effectiveness: 30MHz ~ 1000MHz

■ Two shields ground at either end and connected with wire



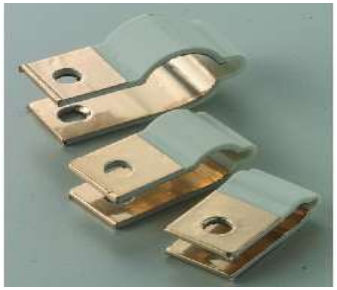


Ground with 360˚ clamps with center break connected with a wire

Plastic Cable Grounding Example:

- Grounds and fixes cables at the same time
- Does not damage cables (compared to metal clamps)

Cable grounding clamps

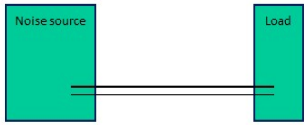


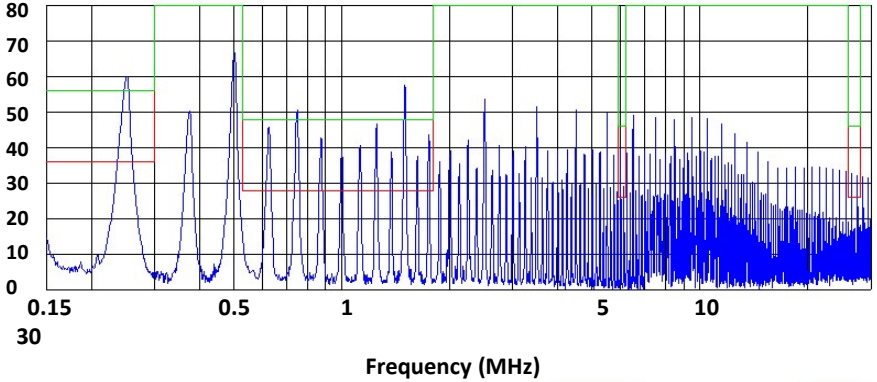
Screw-mount

Snap-mount

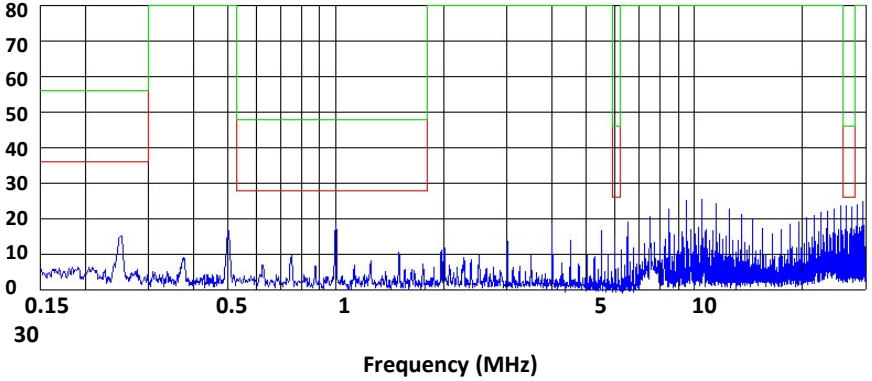
Cable Shielding Effectiveness: 150kHz ~ 30MHz

No shielding

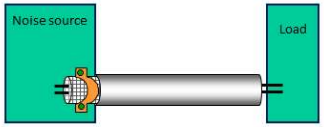


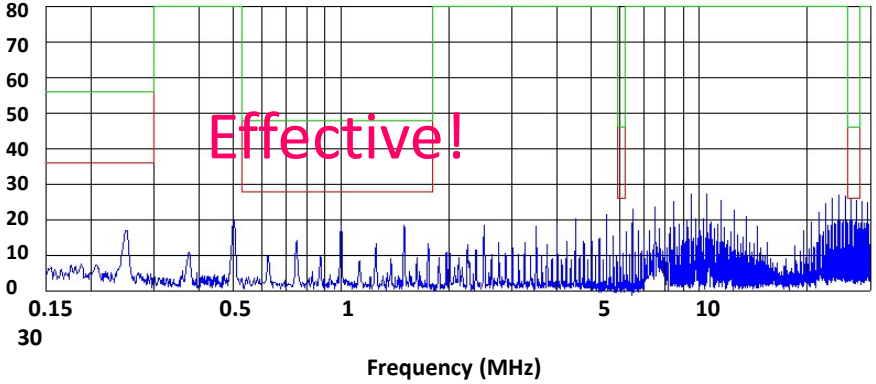


Shielded & ground on both sides

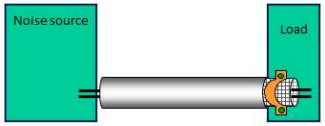


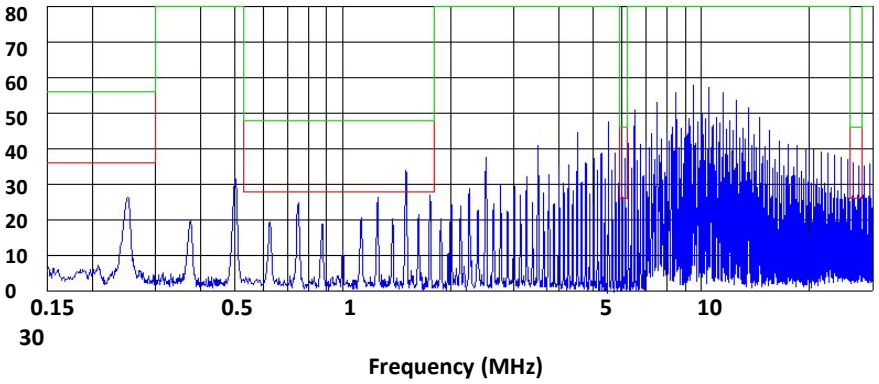
Shielded & ground on noise source side only





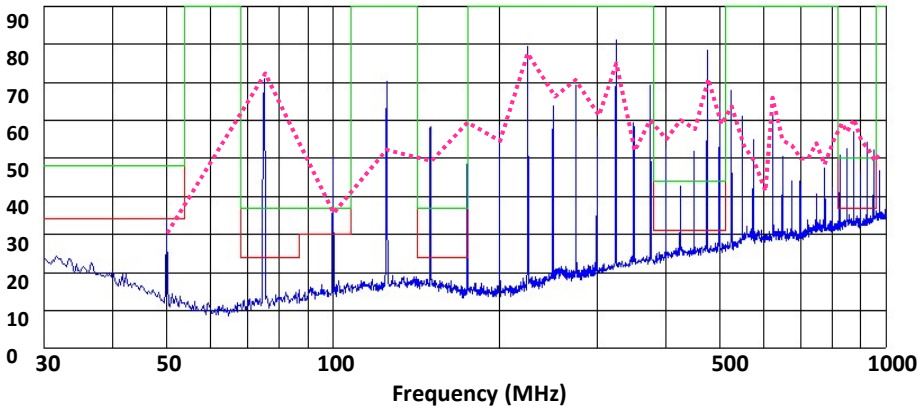
Shielded & ground on load side only



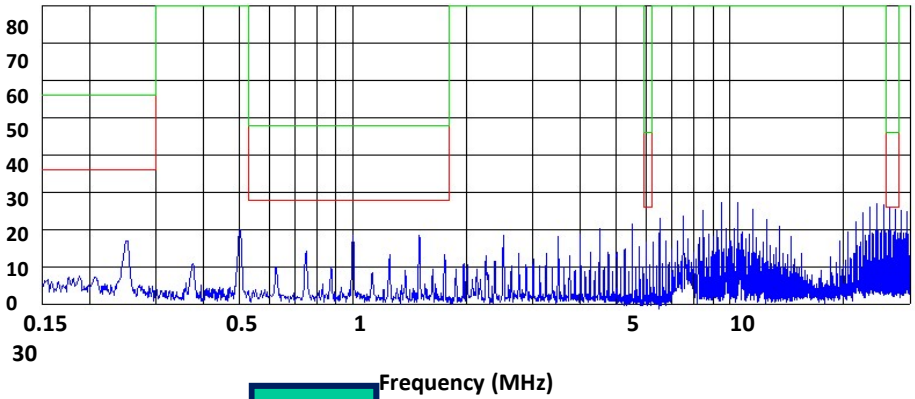


Ground to Noise Source Side

■ High Frequency (30MHz ~ 1000MHz)



■ Low Frequency (150kHz ~ 30MHz)



Ground with 360˚ clamp

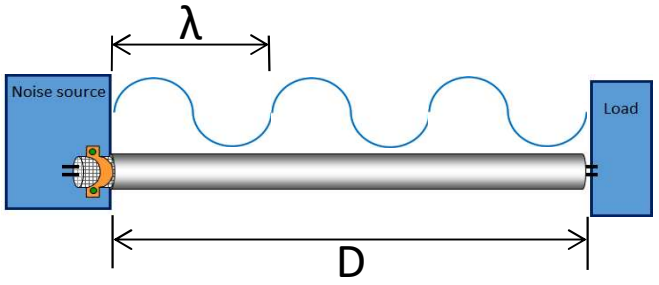
Noise source side

Why did grounding only on the noise source side of the cable work for low frequency test?

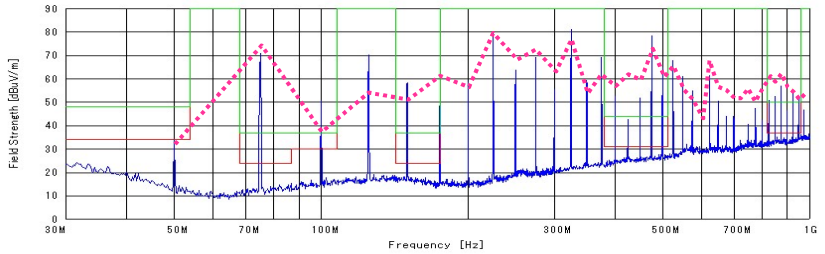
Wavelength vs Cable Length

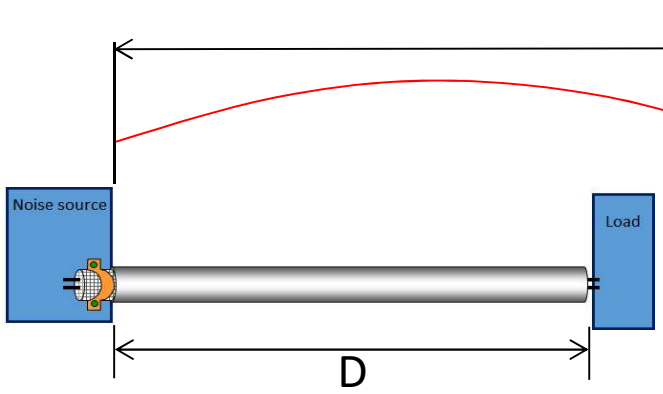
Ground with 360˚ clamp (noise source side)

Relationship between the cable length (D) to the problem frequency's wavelength (λ) directly affects the cable shield's effectiveness.

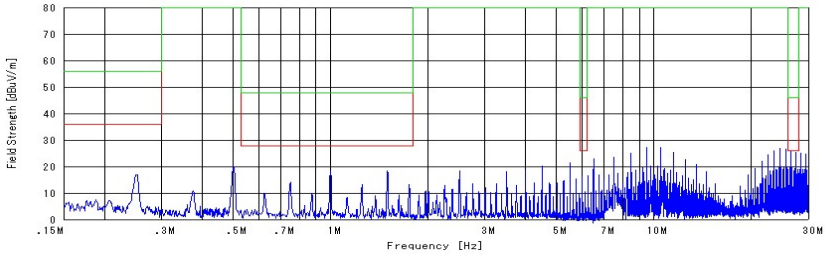


If D > λ, shielding effectiveness is poor





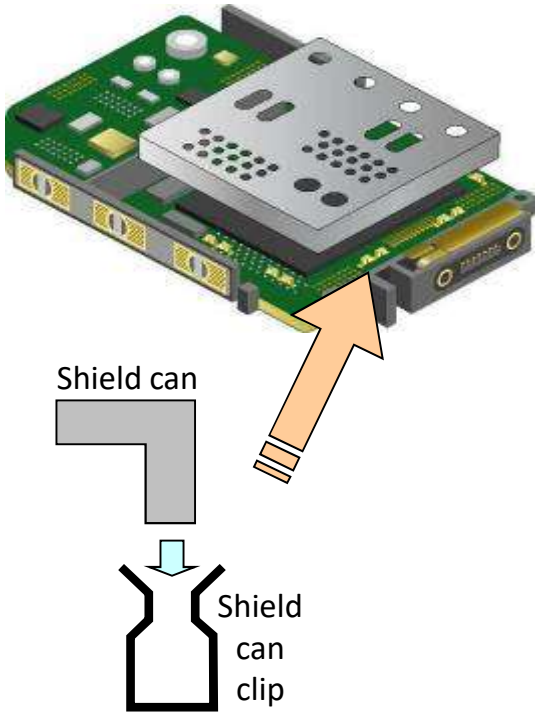
If D < λ, shielding effectiveness is GOOD



On-Board Grounding Clips for Shield Cans

Shield cans prevent:

- EM radiation from the IC
- Susceptibility to EM emissions from other sources

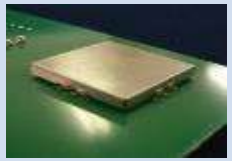


Board-level grounding clips

Features

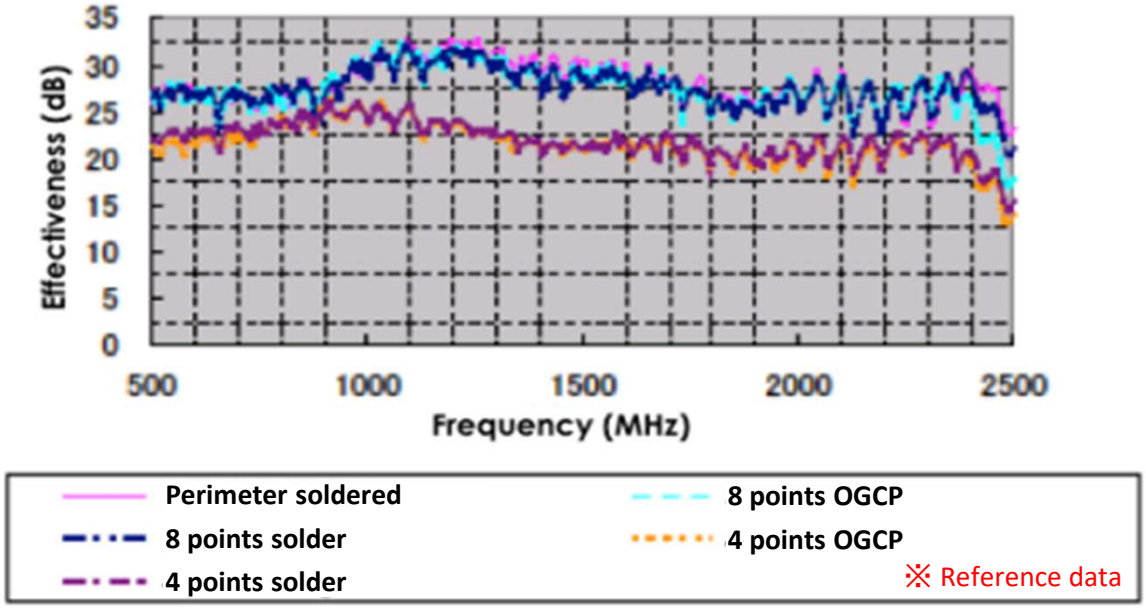
- Same effect as soldering
- Easier maintenance, including mounting check
- Maximize use of PCB space
- Small footprint

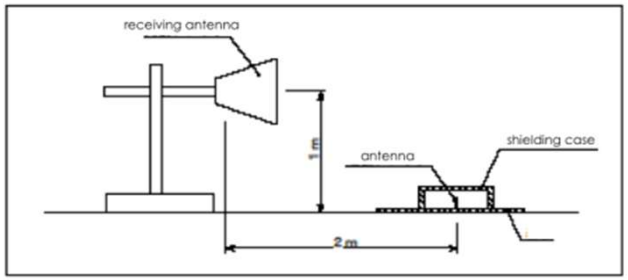
Options for Attaching Shielding Can

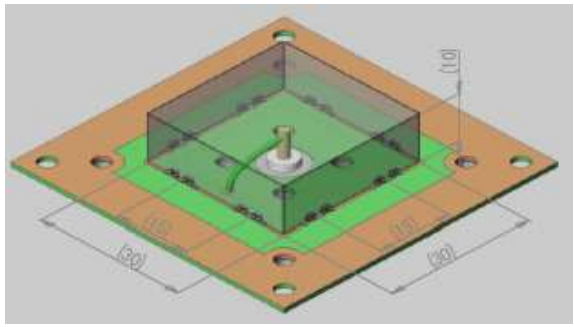
Shield Can + Mounting Options	Image	Advantages	Disadvantages
Shield Can + Shield Can Clip		1) Easy inspection and maintenance 2) Low manufacturing and parts costs 3) Effective use of available space on PCB (less dead space) 4) No added tooling cost	1) May increase number of pieces required
Shield Can + Perimeter Solder		1) Fewer parts to track 2) Best shielding performance if can is 100% perimeter soldered	1) Requires special coating on shield can for soldering process 2) Solder must broken for maintenance, high potential for board/ component damage 3) Can take long time for service and maintenance
Shield Can + Fence		1) Easy maintenance and inspection	1) Two tooling charges 2) Poor use of space 3) Difficult to rework 4) Difficult to reduce product height

Shielding Effectiveness Comparison

- Compare solder vs. shield can clips (OGCP) between 500MHz ~ 2.5 GHz
- 4 pts of solder vs 4 pts of OGCP yield similar shielding effectiveness
- Perimeter solder vs 8 pts OGCP yield similar results



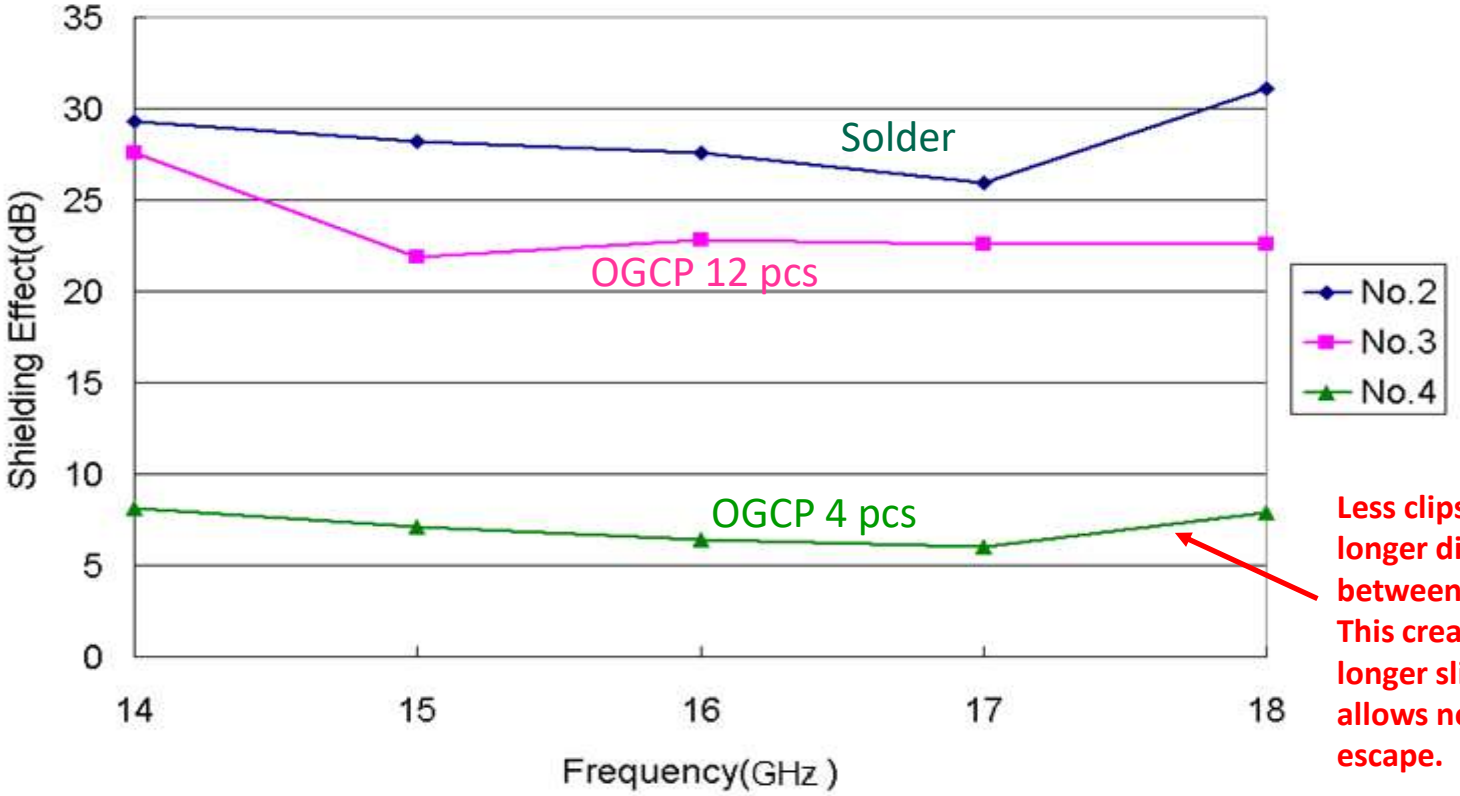




When connected at same contact point, soldering and OGCP have the same shielding effect.

Shielding Effectiveness at 16GHz

λ = 18.75mm @16GHz

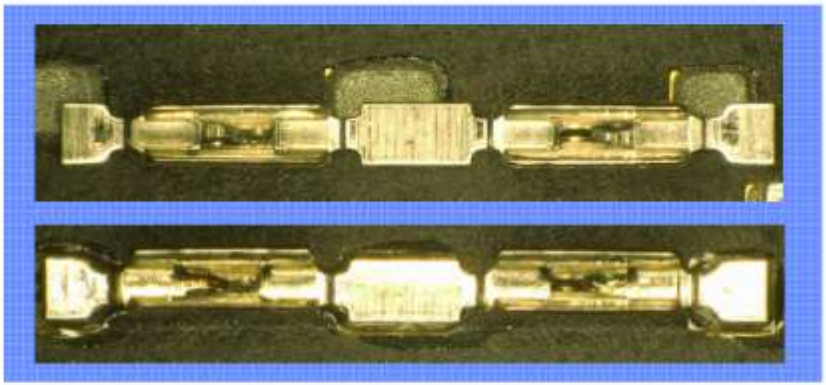


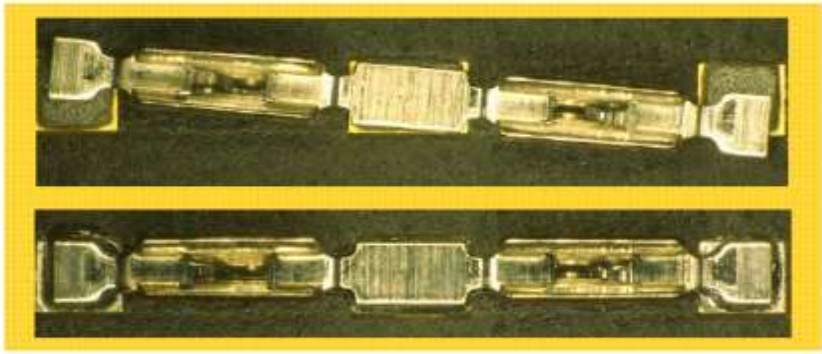
Less clips means longer distance between clips. This creates a longer slit which allows noise to escape.

Recommended distance between grounding points is less than 1/10 wavelength (λ).

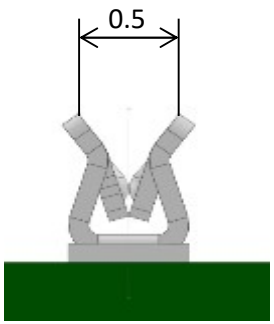
Reflow Process

- Clips are designed to be self-aligning.
- Even if the placement is off-center or tilted, the clips self-correct onto the solder pad during the reflow process.

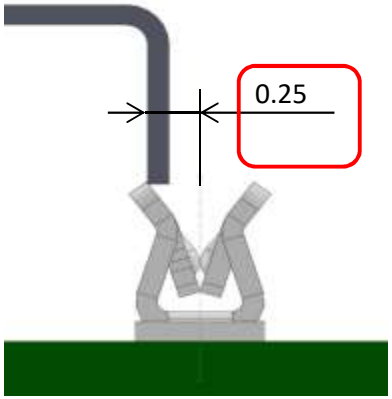




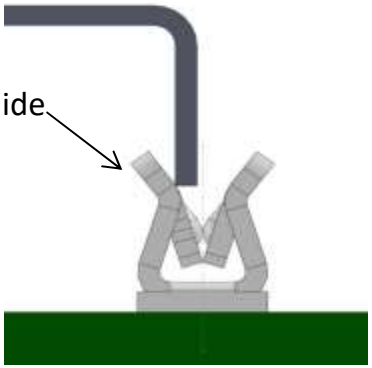
Shielding Can Clip Design



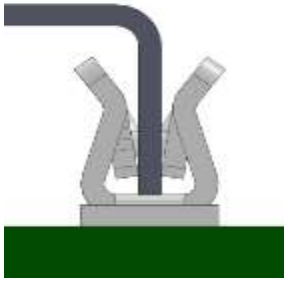
Insertion (top) dimension



Insertion clearance



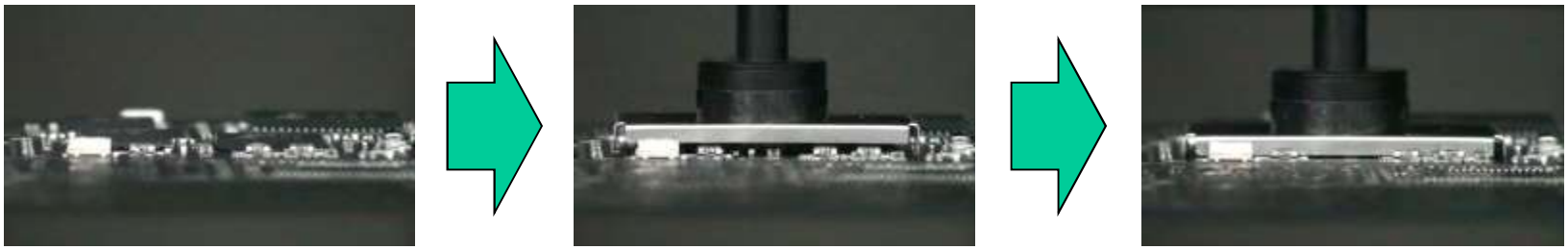
Shield can is guided into place



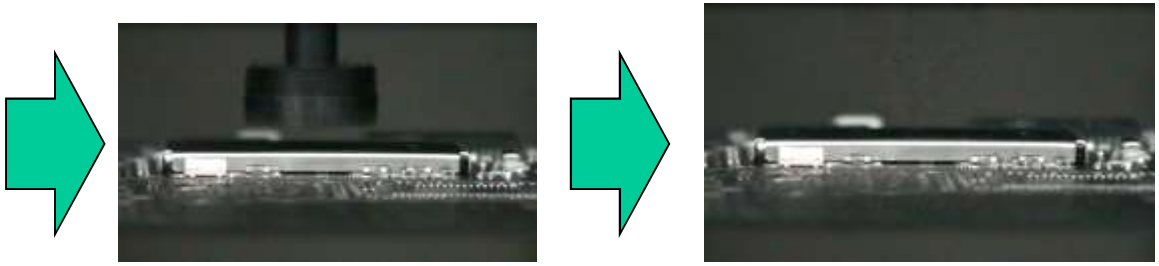
Installation complete

Designed with a wide opening on top to allow the shield cans to installed correctly without crushing or damaging the clip

Automated Shield Can Installation



*wide nozzle to accommodate the shield can's surface



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