3G SHIELDING SPECIALTIES

EMI SHIELDING FOR HIGH FREQUENCY APPLICATIONS

Abstract

- While board level shielding is the most common and cost effective method of mitigating RF/EMI interference it often becomes ineffective in high-frequency applications.
- As a result, engineers must rely on relatively expensive solutions such as machined housings which also have the disadvantages of increased weight and board footprint.
- As an alternative hybrid shielding offers the same performance as machined housings with a significant cost savings using the footprint of a traditional metal shield.

Index Terms—Board level shield, machined housing, shielding performance. Die cast shield, EMI shielding, 5G shielding.

Board Level Shielding

- Board level shields are manufactured in a number of configurations and are typically available as single-piece shields or shields with removable covers.
- Cost-effective solution and can be readily scaled from prototypes to high-volume production.
- Board level shields can be designed in virtually any shape or size allowing for extreme flexibility in board layout.
- Board level shields provide 60 dB isolation for frequencies up to 10 GHz.
- At higher frequencies board level shields are susceptible to a loss of isolation between cavities and leakage between the cover and fence.

QUBE

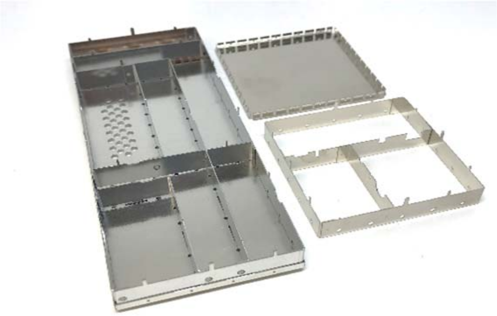
QUBE is a one-piece board level shield designed for surface mount, clip mount, or through hole applications. These shields are ideal for price sensitive applications where accessibility to components is not required.

SWIPE

SWIPE is a two-piece frame and cover board level shield design for surface mount applications. The perimeter flange design provides structural support, and is available with a PIC-Spot for pick & place automation.

FLEX

FLEX is a two-piece board level shield consisting of a frame with a removable cover for the greatest component accessibility. The welded construction frame offers superior shielding performance.



MULTIZONE

MULTIZONE is a two-piece welded construction frame, combining many single shields into one multi-cavity shield with a single cover. Advantages include unparalleled design flexibility and excellent inter-cavity isolation.

- As seen in Fig. 1. shield covers are typically retained to the shield frame using formed dimples. These dimples offer both mechanical retention and electrical grounding. The distance between individual dimples create electrical apertures.

Fig. 1. Shield frame with cover using retention dimples.

- As frequencies increase in shields designed with discrete cavities the likelihood of inter-cavity cross-talk increases.

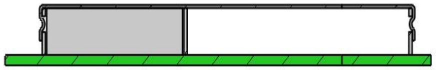
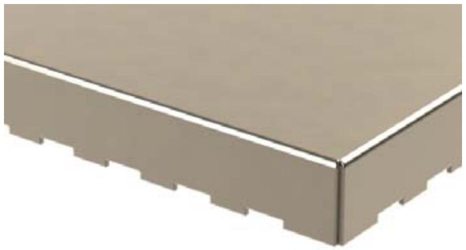


Fig. 2. Shield frame with internal wall.

- As seen in Fig. 2., regardless of the number of cavities, the only retention point continues to be the shield's perimeter.
- While positive grounding exists at the perimeter there is no positive grounding between the cavity wall and cover which creates apertures between shield cavities.

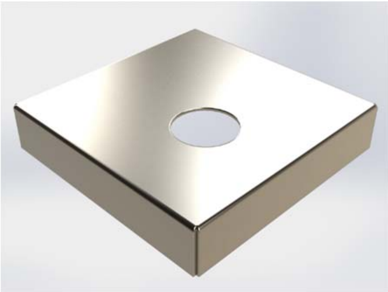


CASTELLATIONS

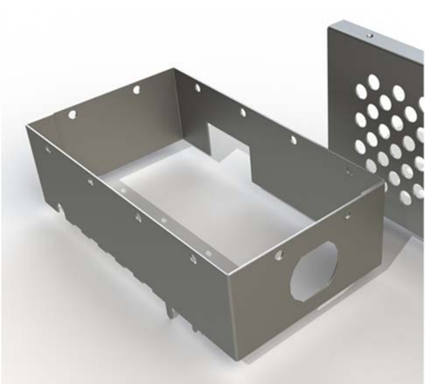
KNIFE EDGE

PIN W/ STANDOFF

ALIGNMENT PINS

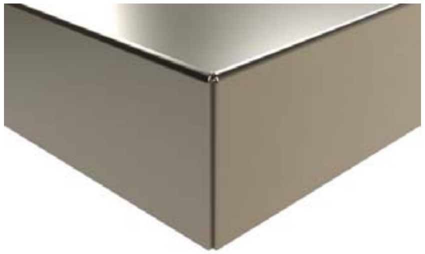


TUNING HOLE



CONNECTORS

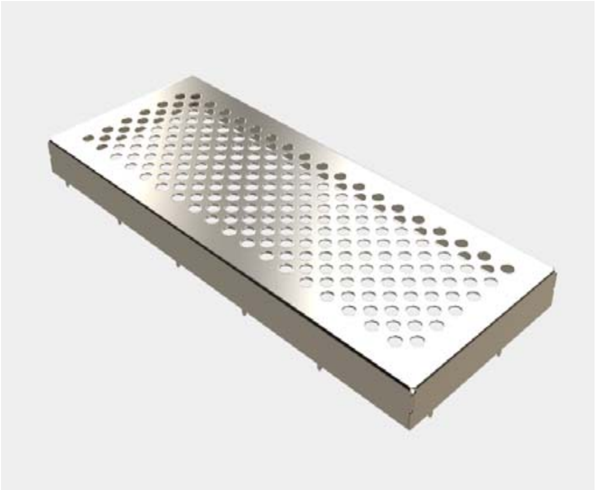
TRACE RELIEF

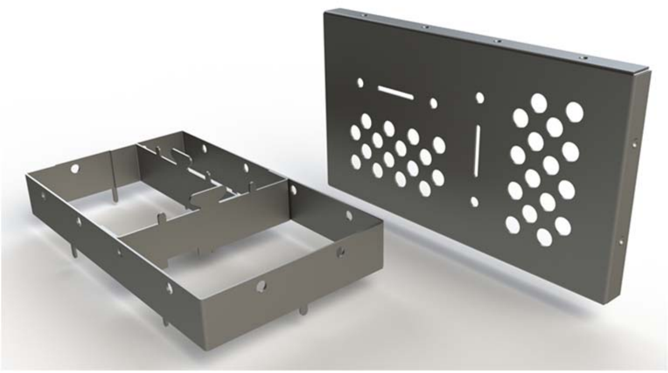


TIGHT CORNER

WELDED CORNER

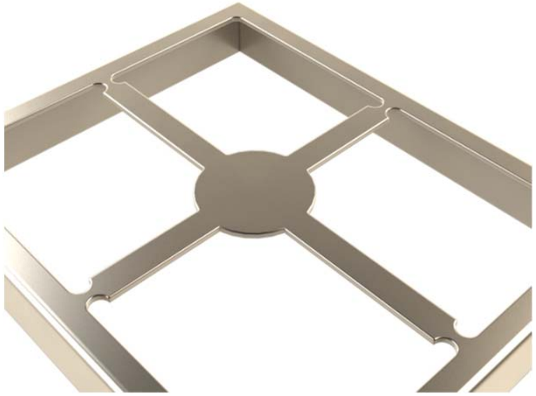
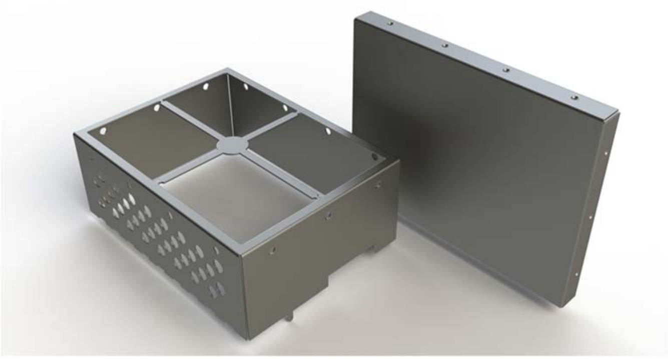
SPLIT CORNER



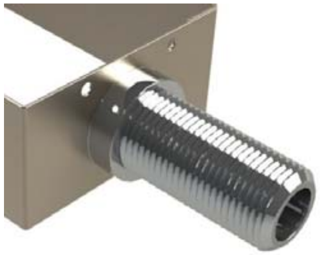


DIMPLE RETENTION

SEGMENTED FLANGES

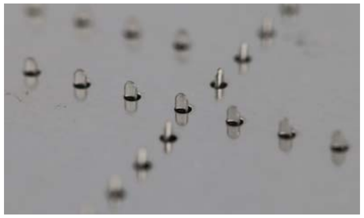
EMBOSSING



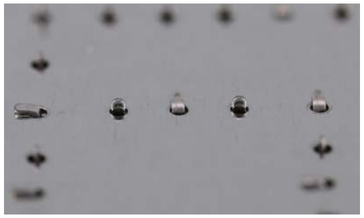
CONNECTOR STAKING

COUNTERSINKS

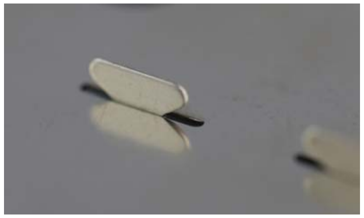
- Inter-cavity isolation is a critical aspect of most multi-cavity shielding.
- Usually referred to as reducing/eliminating ‘cross-talk’ between circuits.
- A variety of techniques exist to improve inter-cavity isolation:
  - Aperture segmentation (metal-only).



PASS-THROUGH



FOLD-OVER

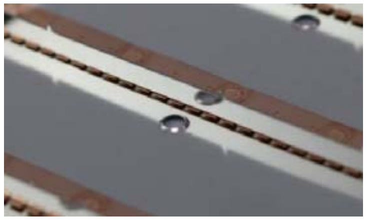


TWIST-LOCK

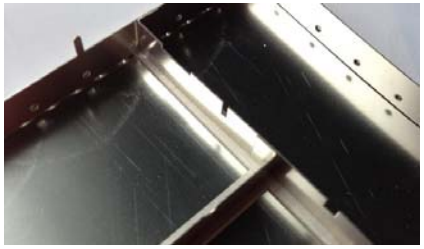
  - Short tabs that pass through the cover but remain standing.
  - Longer tabs which are folded over on final assembly.
  - Twist tabs which are rotated on final assembly.

- Use of compliant elements or gasketing materials.

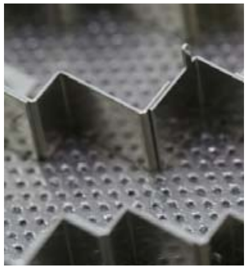
STANDARD FINGERSTOCK



CUSTOM FINGERSTOCK



FABRIC OVER FOAM



CONDUCTIVE FOAM

- Use of microwave absorbers to quiet noise-emitting cavities.

Machined Housing

- At higher frequencies or where high intercavity isolation is required the most widely used solution has been machined housings.
- Rather than being soldered to the PCB, machined housings must be secured through the use of screws through the PCB.
- In the absence of solder, conductive gasket materials are used to provide grounding between the machined housing and the PCB.
- An additional benefit of machined housings is that they may be designed with heat dissipation features acting as both a EMI shield and heatsink.
- In low volumes, the cost of producing machined housings is significantly higher than board level shields. At higher production volumes costs can be reduced by migrating to a die-cast solution with secondary machining
- As seen in Fig. 3. board layout may be less efficient when using machined housings as they require more PCB space and reduce the ability to route via internal layers in certain areas.

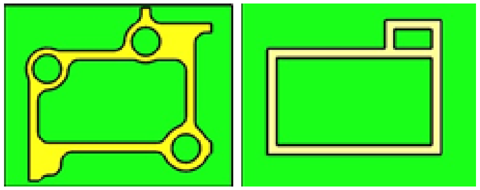
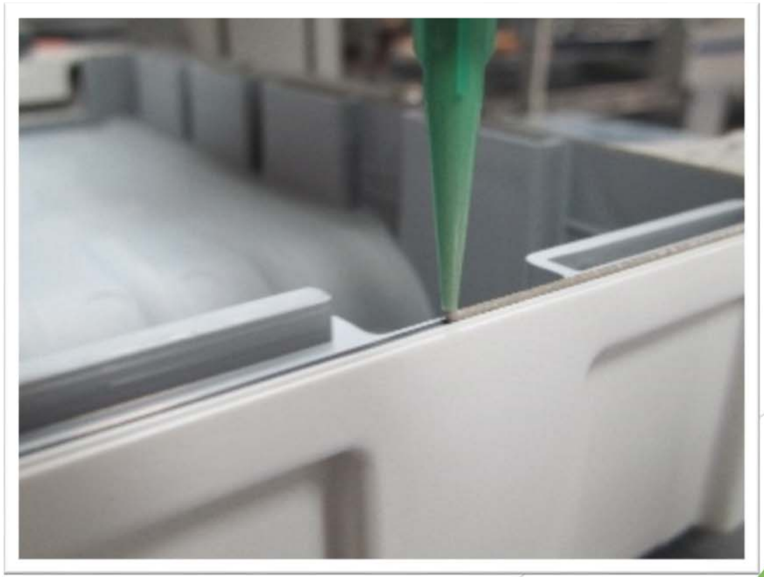
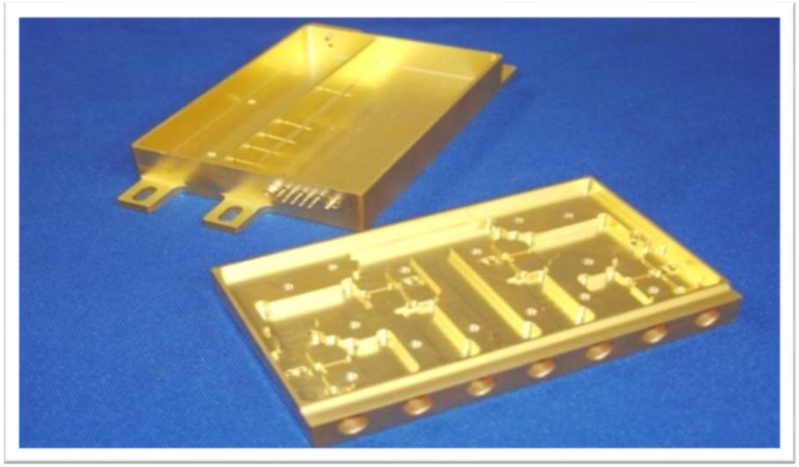


Fig. 3. Board level layout of a machined housing (Left) vs board level shield (Right).

- Any shape, size, height is possible with machined housings, ~1/8” corner radius
- PCB ground plane must be ~0.100” in width due to min wall thickness.
- Assembly requires through holes for screws in PCB. Typically > 0.100”.
- Screw number and placement depends on:
  - Size, Shape, Number of Cavities, Shielding Performance, Gasket Choice
- Gaskets can be die-cut or installed via (FIP) formed-in-place process.
- For high volumes, die castings are a cost-effective alternative to machined housings but:
  - Require a custom tool.
  - Require secondary machining.
  - Gaskets are still required.



PROS	CONS
▶ Best isolation.	▶ Very high cost.
▶ Also acts as a heat sink.	▶ Die cast tooling requires long lead times. (> 16 weeks to first unit).
▶ Can be used as final package for device.	▶ Significantly increases weight.
▶ Available in any shape/size.	▶ Increases per unit assembly time.
▶ Very robust/rugged solution	▶ Occupies significant board space.



Designed considerations for development of a combined approach

- Both board level shields and machined housings have discrete advantages and disadvantages. Developing a solution that takes the advantages of both solutions into account results in a shielding solution that provides significant inter-cavity isolation at high frequencies.
- The design layout flexibility of board level shielding. In addition, perimeter leakage must be minimized or eliminated. The ability to mount to the PCB without the use of screw holes in order to minimize shield real estate is beneficial.
- The elimination of expensive dispensed conductive gasket materials used on machined housings. Reduced mass and cost as compared to machined housings. Allow for heat dissipation.

Hybrid Shields

- Hybrid shields were developed as a direct replacement to costly machined housings and are available as are a two-piece multi-zoned customizable shield.
- Providing similar shielding performance to a traditional machined enclosure, they can be produced in a more cost-effective manner in both low- and high-volume.
- The innovative cover design and conductive foam gasket provide excellent inter-cavity isolation while still allowing access to the underlying board.

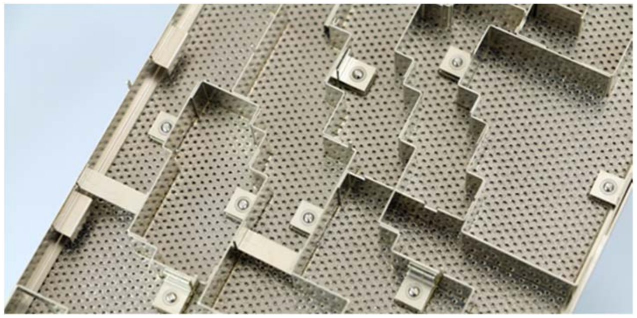


Fig. 4. Hybrid shield with cover, PCB side.

- As seen in Fig. 4. Hybrid shield frames are manufactured using the same thin gage materials common to board level shields and have a removable cover.

- Hybrid shield covers utilize a conductive PE foam gasket in place of dispensed gaskets typically found on the PCB-facing surface of machined housings or dimples on a board level shield.
- Conductive PE gaskets require lower compression force compared to dispensed conductive materials which results in a decreased need for mechanical attach points and offer significant increase in isolation as compared to a board level shield using dimples.

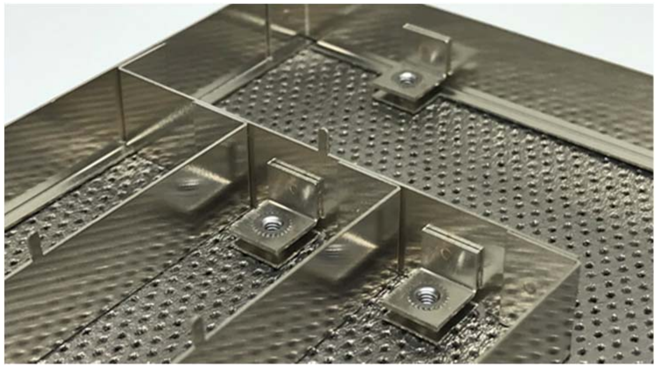


Fig. 5. Hybrid shield with cover, showing attachment lugs.

- As seen in Fig. 5. Hybrid shields utilize a formed perimeter flange to ensure adequate gasket compression and provide shielding effectiveness. To secure the cover and provide effective intercavity isolation Hybrid shields utilize a formed lug with threaded insert to allow mechanical attachment of the cover with screws.

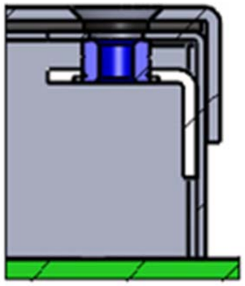


Fig. 6. Hybrid shield cross-section view.

- Hybrid covers are typically lined with 40 mil conductive gaskets affixed with a conductive PSA and designed for 50% compression.
- As seen in Fig. 6. spot welded lugs are aligned with cover openings for mechanical attachment.
- Lugs are typically manufactured of 25 mil material similar to the Hybrid cover.
- Frame walls are constructed of 16 mil thick materials and require a 50 mil wide solder pad on the PCB plane for proper reflow.

- In cases where thermal dissipation is required from hot components heatsink features can be easily included in the Hybrid cover.
- As seen in Fig. 7. aluminum blocks can be affixed to the cover. Thermal interface materials can be attached to the aluminum block to ensure adequate thermal transfer takes place between the PCB level component and the cover.

Fig. 7. Hybrid shield cover with thermal feature.

- In addition to heatsink features additional shielding components such as microwave absorbers may also be affixed to the hybrid cover.
- Typically, Hybrid shields provide a 30% cost reduction against comparable machined housings.

Deployed Hybrid Shield Solutions

- Hybrid shields were initially introduced in 2015 and have been deployed in a number of applications since their introduction. In telecom, Hybrid shields are the shielding choice for 5G base stations and provide 90+ dB of isolation at frequencies up to 28 GHz.
- Hybrid shields have been successfully deployed in Test & Instrumentation applications providing 80+ dB of isolation at frequencies up to 65 GHz.
- In military applications, Hybrid shields have replaced machined housings in a number of existing applications and have provided significant weight savings with comparable performance results.

Conclusion

- As frequencies increase the difficulty in providing adequate isolation also increases. The divergent needs of providing significant shielding performance while also development a low-weight and flexible solution has resulted in the development of the Hybrid shield.
- Comprised of the flexible design elements of a board level shield and utilizing the grounding elements of a machined housing, Hybrid shields provide the best of both worlds.

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