Southern Region Compliance Group

E MAC services

On-board shielding: principles and practice

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Consultancy and training in electromagnetic compatibility

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Outline

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- Options for on-board shields
- Electric or magnetic shield?
  - Choice of shielding material
- Connection of the shield
  - Interfaces
  - Apertures
- Application examples
  - On-board wireless
  - Heatsinks

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Options for on-board shields

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- Formed metal can
  - Typically tin-plated cold rolled steel, but also: plated copper, beryllium copper, brass, nickel-silver, tin plated aluminium
  - Photo-chemically machined or die-cut and pressed
- Conductively coated injection moulded plastic
  - Typically conductive paint or electroless plated nickel/copper
- Multi-compartment construction
  - Labyrinths or conductive elastomer internal walls
- Foil laminates
- Microwave absorber/shield combination

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Formed metal PCB shields

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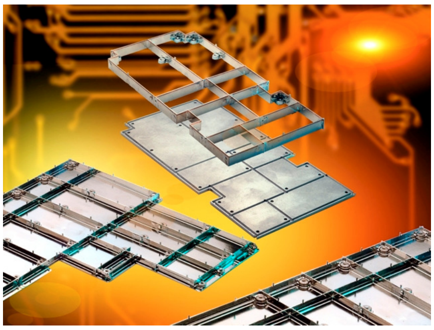
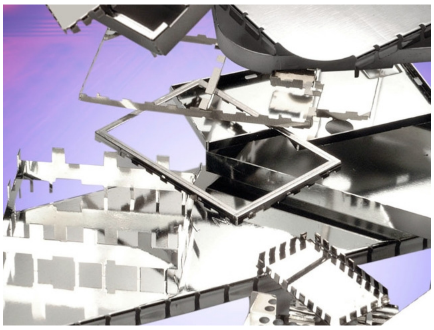


- custom parts
- standard parts
- kits

- separate wall and clip-on lid
- single-piece (beware re-work!)
- surface mount or through-hole



Pictures courtesy Tecan

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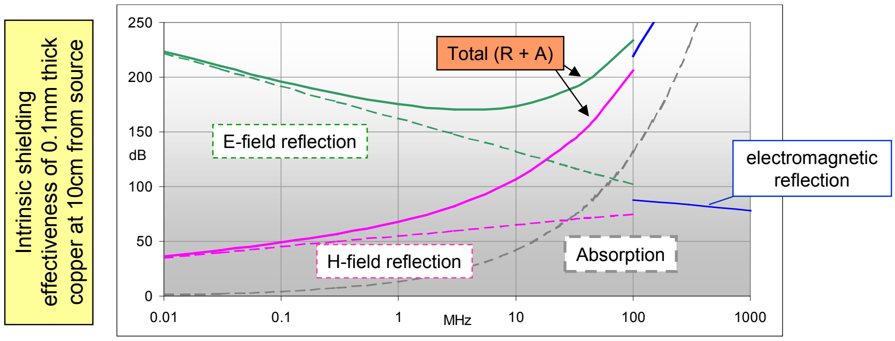
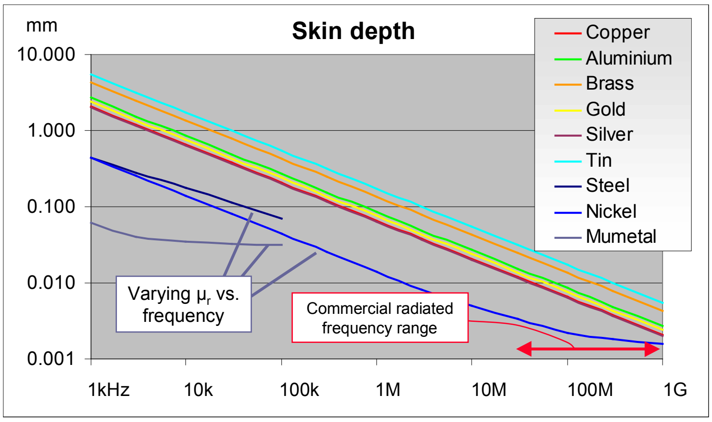
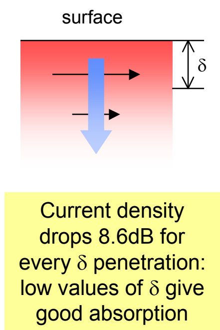
Electric versus magnetic field



- There are three field types: electric, magnetic and electromagnetic
- Reflection from a conductive surface of any thickness is good for electric (E-field) and electromagnetic but poor for magnetic
- Good magnetic (H-field) shielding needs either a permeable material (LF) or a thicker conductive material (HF) for absorption

The effect of skin depth





- Skin depth: $\delta = 66.1 \cdot 1/\sqrt{(\mu_r \cdot \sigma_r \cdot F)}$ mm (F in Hz)
- Above 30MHz, many materials have $\delta < 20\mu m$
- RF current falls 8.6dB for every δ penetration into material

Choice of material for the shield

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- For high frequency and low frequency E-field applications any metal will do, although higher conductivity is better
  - because of δ, thickness is hardly important
  - choice determined by mechanical, assembly and environmental considerations

Microprocessors and VLSI ICs, wireless on board, hi-Z circuits

- For low frequency H-field applications a permeable metal is needed
  - greater thickness and μ_r gives greater absorption
  - although, some magnetic field cancellation occurs through current flow in a "shorted turn" conductive shield

SMPS, audio and power transformers, magnetic sensors

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On-board E-field shielding

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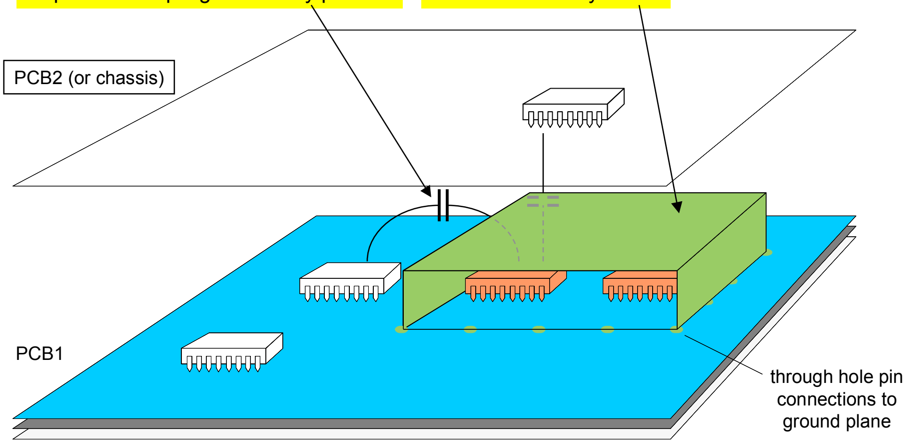
Capacitive coupling from noisy parts ...

…is eliminated by shield



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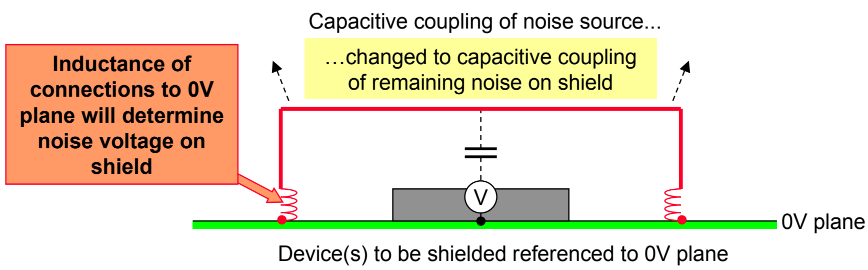
Where and how to connect?

- An on-board shield will normally be used in conjunction with a circuit 0V plane
  - an inadequate plane will limit the effectiveness of the shield
- The shield should be connected to this plane with the lowest possible inductance, to prevent it becoming "live"
  - implies multi-point or continuous connection all around the shield base



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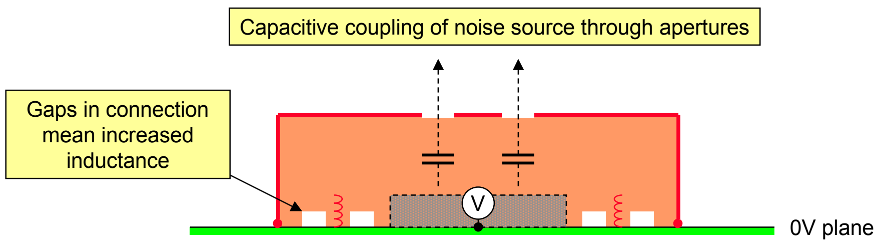
Apertures

- Apertures in the connection to the 0V plane will increase the inductance of this connection
  - keep spacing between connections to a minimum
- Apertures in the lid will cause capacitive leakage through the shield
  - don't put apertures near to devices with a high dv/dt noise voltage



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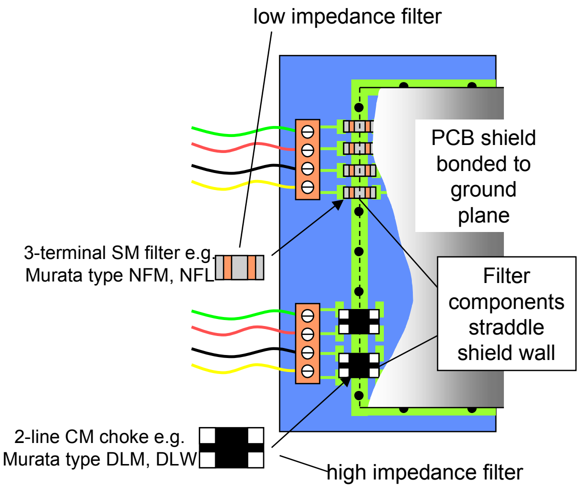
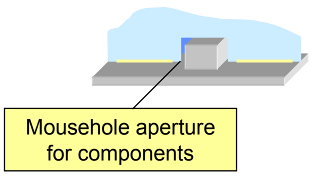
Filtering interfaces through the shield





- series chokes straddle the barrier
- parallel capacitors grounded with the lowest possible inductance

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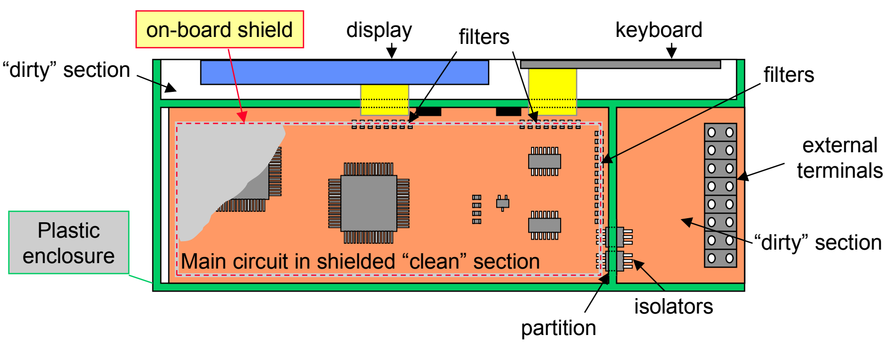
Partitioning the housing

- An outer enclosure doesn't always have to be shielded
  - partitioning sections into “clean box” and “dirty box” is effective and can be done with an on-board shield
  - but filter or isolation barriers between the sections are essential



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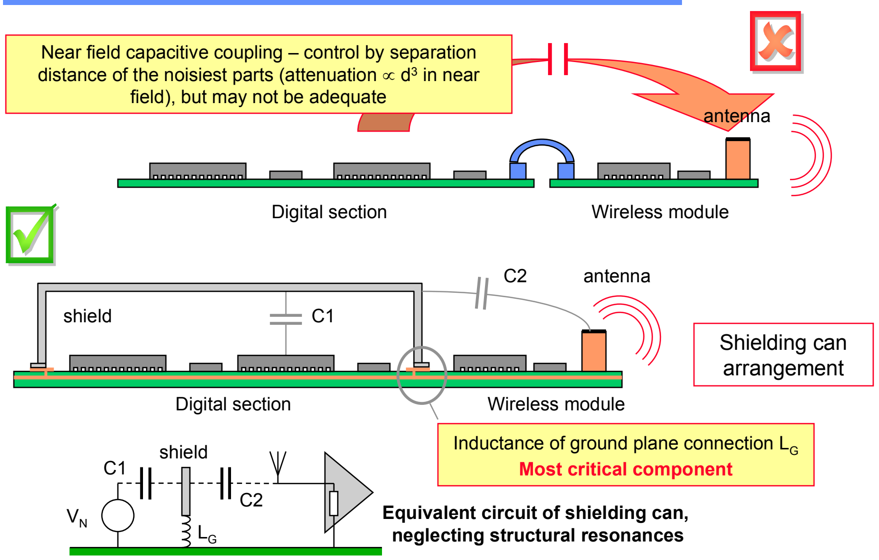
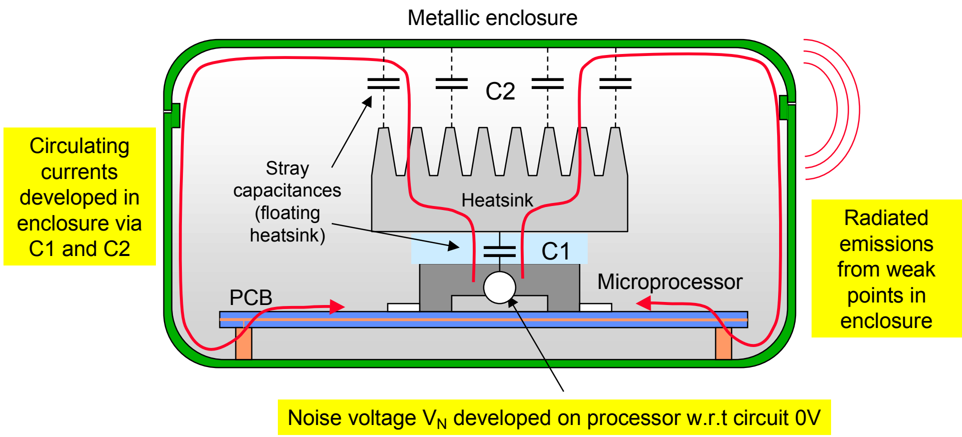
Wireless on-board

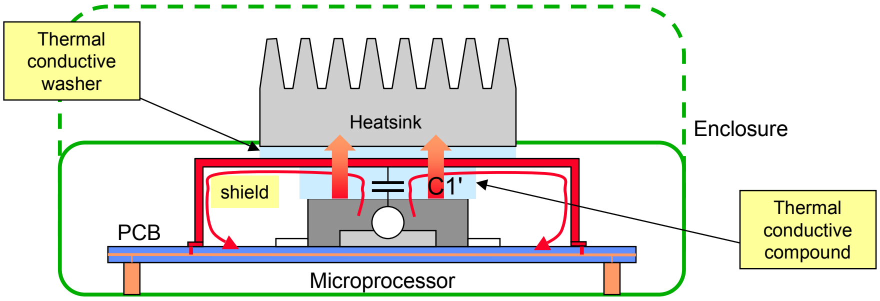


Heatsinks: the problem



Cure is to connect heatsink to circuit 0V (not to case) via multipoint links – but this might be difficult

Heatsinks: on-board shield solution



- C1' is referenced to shield, which returns noise currents to circuit 0V; minimum voltage appears on heatsink
- device dissipation is conducted to heatsink through shield, which may act as a heat spreader

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Summary

- Know what frequency range is to be shielded
  - calculate skin depth and choose shield type/material accordingly
- lay out PCBs *expecting* that noisy/sensitive circuits will benefit from on-board shields
  - apply strict segmentation rules
  - allow land areas on the surface of the PCB where a shield might fit
  - it's much easier to omit a shield that was designed in, than vice versa
- design the shield in conjunction with a circuit 0V plane
  - create as many connections through to the plane as possible - the higher the frequency range, the closer together must be the connection points
  - ensure that interfaces through the shield are adequately filtered
- keep the shield box design as simple as possible
  - less complexity makes for a cheaper unit cost
  - fewer apertures make for better shielding performance

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On-board shielding

The End

Thank you for your attention!

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