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RF bonding techniques

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RF bonding techniques

Keith Armstrong expands on the six rules for cabinet shielding
that he introduced in the July edition of PSB

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The last edition of PSB discussed some reasons why a shielded cabinet might be required. It introduced the six basic design and assembly rules for cabinet shielding:

i) The cabinet must be made entirely of metal. (Glass-fibre or other non-conductive cabinets might be acceptable if they are entirely plated with metal on one surface, usually the inside).

ii) All conductors and any metal items (e.g. pipes) that can be earthed should be RF-bonded directly to the cabinet's metal surface at their point of penetrating the cabinet wall (or other surface).

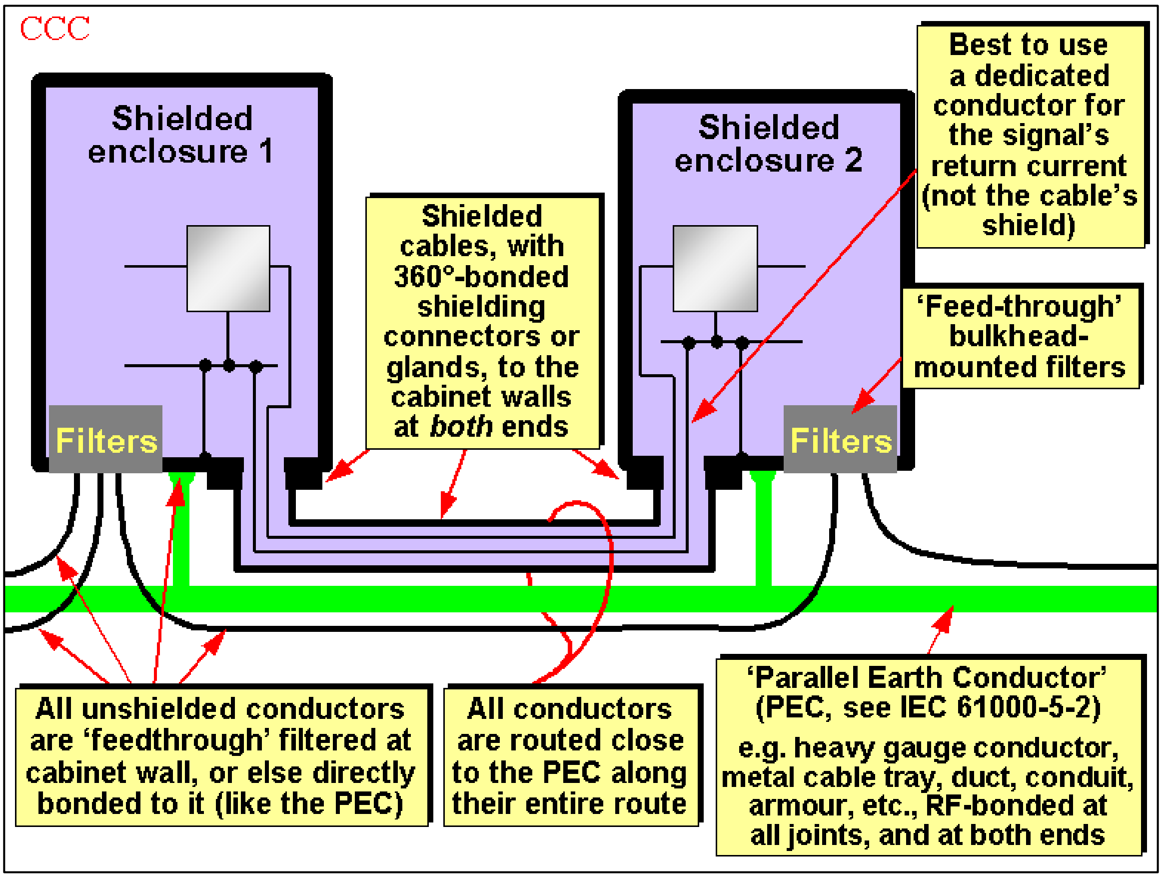
iii) All unshielded conductors that cannot be earthed should be fitted with RF filters that are RF-bonded to the cabinet's metal surface at their point of penetrating the cabinet wall (or other surface).

iv) All shielded cables entering/exiting the cabinet should have their shields RF-bonded to the cabinet's metal surface at their point of penetrating the cabinet wall (or other surface). Cable armour should be treated the same way.

v) The sizes of all apertures in the external metal surfaces of the cabinet (i.e. where there is not a seamless high-conductivity surface, for whatever reason) should be minimised, for example by replacing a large ventilation aperture with a metal mesh. This includes apertures associated with ventilation, seams and joints, displays, around doors and removable panels, etc.

vi) All cables, printed-circuit boards and electronic devices should be kept well away from any apertures in the metal cabinet.

The figure sketches an overview of two shielded cabinets, showing the application of rules ii), iii) and iv) to their interconnections.



It is easy to pay more money to buy a well-shielded cabinet from most enclosure suppliers, and it is then very easy to ruin its shielding performance, and waste its extra cost, by not rigorously applying items ii) to vi) in the above list.

I am often asked to fix emissions or immunity problems with equipment housed in expensive well-shielded cabinets, but which will not pass their EMC tests. Usually I very quickly find that the problem is caused by a cable, typically for a mouse or keyboard, that penetrates the wall of the cabinet without having had rules iii) or iv) applied. Other typical problems are caused by metal hydraulic or pneumatic pipes, fibre-optic cables with metal draw-strings, etc., that have not followed rule ii). The designers think that because these conductors are not carrying high-speed data the above rules do not apply – but they do, they apply to all wires, cables and *any other types* of conductors (such as metal pipes).

Even when using an ordinary industrial metal cabinet, it is still a good idea to follow the above rules. They all provide some degree of shielding over some frequency ranges, and rigorously applying the rules helps achieve their maximum shielding performance.

We normally use unscreened twisted-pair (UTP) or shielded (screened) twisted-pair (STP) cables for differential signals (such as serial data). But the sketch shows an STP cable being used to interconnect an earth/ground referenced signal, using one of the conductors in the pair for the signal's 'earthy' return current. An earlier column in this series discussed cable routing, and said how important it was to keep a signal's send and return current paths in close proximity all along their route.

The shield of the STP cable carries the common-mode (CM) leakage current from the twisted-pair on its *inside* surface, to reduce emissions. The STP's shield also carries the CM currents caused by external electromagnetic fields on its *outside* surface, plus the common-mode currents caused by differences between the earth/ground potentials of the two cabinets.

The shields of all flexible cables are never perfect, so even in very high-quality types there is always some leakage between the RF currents that are supposed to remain on their inner and outer surfaces, and as a result they can never achieve perfect emissions and immunity. Cables with solid shields are very much better, although of course they are not flexible so are only used in special installations. Some types of 'superscreened' cables can be as good as solid-screened cables, and they are also flexible, but they are very expensive so once again are generally only used in special installations (e.g. nuclear submarines).

For good EMC we prefer to use STP instead of UTP (unscreened twisted-pair). Ethernet responds to interference by retransmitting data packets, reducing its data rate. Using STP instead of UTP means we are much more likely to achieve the full data rate at all times.

We also prefer to use STP to coaxial cable types. This is because in a coaxial cable the signal's DM return current travels on the inside surface of the cable shield, and these are generally between 10 and 1,000 times larger than the CM leakage current from a twisted-pair. So the emissions from a coaxial cable can be between 10 and 1,000 times higher than from STP.

As regards immunity, the inevitable leakage through the shield of a coaxial cable results in a noise voltage being introduced into the signal's DM return path – which is exactly the same as adding the noise voltage into its send path, so immunity can be much worse than STP too.

Future columns will discuss more of the details associated with the rules in the above list in more detail – but if you can't wait, download "*Good EMC Engineering Practices in the Design and Construction of Industrial Cabinets*" from http://www.reo.co.uk/knowledgebase. These techniques are described with more technical background in: "*EMC for Systems and Installations*" (Newnes, 2000, ISBN 0-7506-4167-3, www.bh.com/newnes, RS Components P/No. 377-6463).

The upcoming REO Guide "*Good EMC Engineering Practices in the Design and Construction of Fixed Installations*" will describe how to use RF shielding in systems and installations using (for example) existing metal structures, and will be available from http://www.reo.co.uk/knowledgebase soon.

For those who wish to investigate further, the Directives and Regulations, and their official guides, plus a great deal of useful and practical information, are available as described in the document: '*Some Useful References on EMI and EMC*' posted on this site.