Alternatives in EMI Connectors

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There is no generic solution for all problems associated with I/O interfaces.

Sources of RF Interference

With clock frequencies of a few hundred megahertz, today's electronic systems are using pulse edges in the sub-nanosecond range. Networking interfaces deliver data rates of 100 Mbits/s (Fast Ethernet and FDDI - fiber distributed data interface) and 155 and 622 Mbits/s (ATM - Asynchronous Transfer Mode). High quality video circuits also use pixel rates at sub-nanosecond rates. These higher processing speeds present never-ending engineering challenges.

One such challenge is RF interference, which originates from a fast change of electromagnetic energy. The faster the slew rate (rise/fall times) and the higher the voltage/current amplitude, the more problematic a circuit becomes. As a result, electromagnetic compatibility (EMC) is harder to achieve today than ever before.

While fast changing pulses of current between two nodes of a circuit represent the so-called differential noise source, the field surrounding this circuit can couple into other components and etch connections. The noise induced via inductive or capacitive coupling represents common-mode interference. The RF interference currents are in phase with each other, and the system can be modeled as one which connects the source, "victim circuits" or "recipients" and the return path, which in many cases is represented by a chassis. Several factors are critical in defining the amount of the interference:

- Strength of the source
- Size of the area encircled by the culprit current
- Slew rate of the change

Thus, despite many possible causes of unwanted interference in a circuit, the noise is almost always the common-mode type. Once there is some RF voltage present between a cable plugged into an I/O (input/output) connector and the enclosure or the ground plane, the resulting RF current of a few mA can be enough to exceed the allowable emission levels.

Noise Coupling and Dissemination

Common-mode noise can be generated by less than an ideal layout. Some typical causes are an imbalance in the length of the individual conductors in differential pairs, or differences in distance to the power planes or the chassis. Other sources are imperfections of components - magnetic inductors and transformers, capacitors and active devices such as ASICs (Application Specific Integrated Circuit).

Magnetic components, especially the so-called "slug choke" type storage inductors used in power converters, always produce an electromagnetic field. An air gap in the magnetic circuit is equivalent to a large resistor in a series circuit, where most of the applied power is dissipated. Thus, the slug choke, which is built on a ferrite rod, is generating a strong field around the rod, with highest field density near the poles. In switching power supplies using flyback topology, the transformer must have an air gap, which is associated with the high density magnetic field. Components that are best suited for "keeping the field to themselves" are toroids, which distribute the field through the length of the core. This is one of the reasons the toroidal construction is preferred in high-frequency networking magnetics.

Circuits with inadequate decoupling often become the source of interference as well. If a circuit requires high pulses of current and the local decoupling is not able to support the need due to low capacitance or relatively high internal impedance, the voltage generated by the supply loop drops. This is equivalent to a ripple, or fast change of the voltage between terminals. Through the stray capacitance of the package, this event can couple into other circuits, causing common-mode problems.

When a circuit intended for I/O interface is contaminated with common-mode noise, the problem has to be resolved *before* it passes through the connector. Different applications suggest various ways of dealing with this problem. In video circuits, where I/O signals are single-ended and share the same common return, the solution is to filter out the noise with small LC filters. In lower frequency serial interface networking, some capacitive shunting to the chassis can be sufficient. Differentially driven interfaces, such as Ethernet and FDDI, are normally transformer-coupled to the I/O area, with center taps provided on one or both sides of the transformer. These center taps are connected via high voltage capacitors to the chassis, allowing shunting of the common-mode noise to the chassis without causing distortion of the signal.

Common-Mode Noise in I/O Area

There is no generic solution for all types of I/O interfaces. Designers, whose main goal is to get the circuit working, often overlook simple details. Some basic rules should be followed to minimize the amount of noise before it reaches the connector:

- Locate decoupling capacitors close to the load.
- Minimize the size of the loop of pulsed currents with fast edges.
- Keep high-current devices (i.e., drivers and ASICs) away from I/O ports.
- Evaluate signal integrity to assure minimum over- or undershoot, especially in high current critical signals (i.e., clock, bus).
- Use local filtering such as RF ferrites where necessary to absorb RF interference.
- Provide a low impedance bond or reference to the chassis in I/O area.

RF Noise and Connectors

Even if the designer takes most of the precautions listed above to reduce the amount of RF noise in an I/O area, there is no guarantee that the efforts will be successful enough to meet emission requirements. Some of the noise will be conducted, traveling from inside the circuit board as common-mode current. This source of the interference is between chassis and circuit etch. Thus, this RF current needs to close the path through the lowest impedance available between the chassis and the carrier signal lines. If the connector does not present low enough impedance (bond to the chassis), this RF current will travel via stray capacitance. While it is passing through the cable, the emissions are inevitably generated (Figure 1A).

Another mechanism for injecting common-mode currents in an I/O area is through coupling from nearby strong sources of interference. Even some of the "shielded" connectors with a metal cover over the top are not immune in such cases, since the culprit source can be located near the bottom side of the connector, as in a PC environment. If there is an opening between a connector and the reference chassis, the induced RF voltage between these two entities can substantially weaken the EMC performance (Figure 1B).

There are ways of packaging connectors with additional finger stock or gaskets. The connectors provide the bonding by filling the space between the face of the connector and the enclosure. This approach requires gaskets (Figure 2A). Metal gaskets work well if they are handled properly, that is, if the surface is free of residue from the installer's hands, if the fingers are not caught in any obstacle or otherwise damaged and if the pressure is enough to maintain good, low-impedance contact.

Other connectors are equipped with tabs or another means of making connections to the enclosure. The maximum area of contact in this arrangement is rather small, and it is restricted by the size of the tab and its flexibility. In the case of using the cutout in the enclosure for a shielded connector, the sides of the cutout must be properly prepared by removing the paint (Figure 2B). Any slack in tolerance may result in this connector being recessed too

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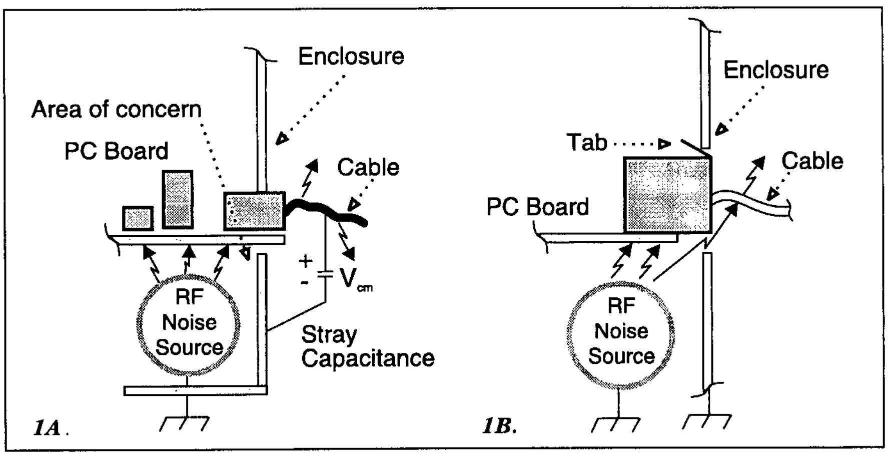

Figure 1. *How RF Noise Reaches Cables.*

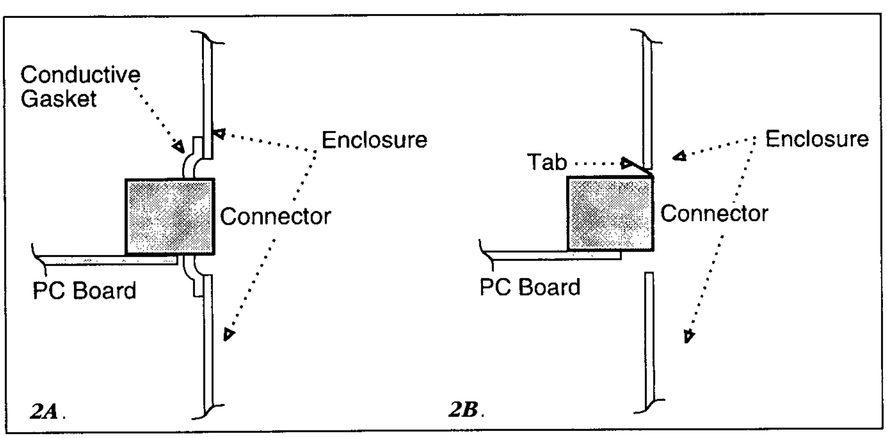

Figure 2. *Alternative Connector Designs.*

deeply inside the enclosure and the bond becomes intermittent. Every EMC engineer knows the difference between the "golden" system qualified to meet emission requirements and the one from the production line in audit. Loose or bent gaskets mounted over paint overspray in critical areas (such as connector cutouts) will cause frustration.

EMI connectors should be selected for the following reasons:

- The conductive foam is extremely flexible, and can be mounted around the whole connector. This eliminates problems associated with another item in stock, the gasket.
- The mechanical engineer can position the connector within an acceptable tolerance of the system package.
- The connector makes a low impedance bond to the chassis, eliminating concerns for the consistency of the contact. A gasket that slides on the inner side of the enclosure wall can be much more flexible with the masking requirements when the paint is applied.
- For designs with forced cooling, an optimum gasket provides an additional benefit: it seals the gap between the connector and the wall, reducing air leaks. In a dusty environment, a gasket helps to keep the inside of the system clean.

Conclusion

The variety of connectors available on the market today enables designers to select the optimum design for the specific interface.

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