Low Impedance Shield Termination Methods

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Abstract
Experience has shown that building cables with low impedance shield terminations is a very efficient way of reducing emissions from equipment. The material presented defines a fabrication technique that provides a low impedance bond between a cable shield and connector backshell. Historically, a cable shield termination used a ferrule and drain wire (pigtail) combination, bonding the shield to the connector backshell. The method defined in this paper uses shielding wrap to extend the outer shield of the cable onto the backshell of the connector, providing a low impedance shield termination (without pigtails). Shield terminations involving EMI backshells will also be explored, along with cable preparation details.

Introduction
The material presented is a direct result of hardships overcome while attempting to meet the stringent EMC requirements of the aerospace industry. Published data and EMC testing experience revealed that our cable fabrication methods were a large contributor to our EMC woes. In order to reduce the radiated emissions from a cable, it is vital that the cable shield be terminated with a low impedance connection (1). For as long as anyone could remember, our cable shields were terminated using a ferrule and drain wire (better known as a pigtail). A pigtail does not provide the low impedance required, because of the inductance of the drain wire. There lies the problem: How do we terminate the cable shields without using pigtails? This paper defines several cable fabrication techniques that will reduce emissions, improve data quality, and standardize cable design.

A common I/O connection for data acquisition is several individual cables terminating into one backshell. The cables are twisted pairs enclosed in copper braid, and a protective outer coating. To provide low impedance shield termination's on this type of cable bundle, Scotch® No. 24 shielding tape is used to extend the outer shield of the cable onto the backshell of the connector.

Another common problem with cable shield termination involves EMI backshells. These backshells are designed to provide a low impedance termination by circumferential contact with the outer shield of the incoming cable. This poses a problem when several separate cables feed into a single EMI backshell. The outer shield of the cables will not fit into the backshell properly. To overcome this problem, copper overbraid is used to encompass all the cables and then insert into the backshell. This provides the protective circumferential shield to reduce EMI. A similar problem occurs when the incoming cable diameter is much smaller than the backshell. Overbraid will prevent the outer shield from being "fanned-out". Both scenarios involve the use of a braided copper shield.
Cable Preparation Methods

There are many different types of shielded cable available to industry, and each pose unique problems when attempting to terminate the shields. This paper will discuss cable preparation methods for several common types: braided copper shield, foil wrap with a drain wire and multiple shields on the same cable.

Cable preparation for standard twisted pair cable with braided copper shield, is shown below in Fig. 3. Strip the outer jacket back approximately 5 inches on all the cables coming into the connector being assembled. This length is a judgment call, according to the size of the wire being used. Trim the shield back several inches to provide sufficient length to install the wires into the connector. Terminate the outer shield by folding the frayed end back over itself (approx. ¼") and cover with heat shrink tubing.

An equivalent method for preparing cables with braided shields involves folding the shield back over the protective sleeve on the cable (Fig. 4). Begin by stripping the outer jacket back approximately 3 inches. Fold the braided shielding back along the cable and terminate with heat shrink tubing. Finally, trim the inner conductors for installation into the connector.

Terminating cables with foil shielding is difficult because the foil material is so fragile. Fortunately, foil shields usually include a drain wire which is used to terminate the shield. To prevent the wire from becoming a 'pigtail', it is folded back along the cable and covered with a piece of overbraid (Fig. 5). Strip the outer jacket and foil shielding back approximately 3 inches on all the cables coming into the connector being assembled. Fold the shield drain wire back along the outside of the cable. Slide a piece of copper overbraid on the cable and over the drain wire. Terminate the overbraid on both ends with the fold-back method described earlier and cover with heat shrink tubing.

Cables with multiple shields create a unique set of problems, specially when the shields must remain isolated from each other. Figure six shows a single twisted pair for simplicity. The normal configuration is 3 or 4 twisted pairs, each with their own internal foil shield and drain wire. Strip the outer jacket back approximately 6 inches. Trim the outer shield back several inches to provide sufficient length to install the wires into the connector. Terminate the outer shield by folding the frayed end back over itself (approx. ¼").

Take extra precautions in keeping the inner and outer shields isolated from each other. For example: the drain wires will require insulation along the length of bare wire when terminating into a pin of the connector. If the drain wire is dead ended, don't forget to insulate the location where the inner jacket starts with heat shrink tubing. The purpose here is to prevent the foil shields from making contact with each other. Dead-end outer shield with heat shrink to prevent fraying.
Shield Termination into a Standard Backshell

This process requires that the connector and backshell are made of a conductive metal to provide a low impedance termination to chassis ground. Watch out for nonconductive finishes that may prevent continuity.

At this point, all the individual cables should be prepared using the techniques described in the previous section. Install all the cable peripherals over the cable bundle (cable ID’s, backshell parts). Strip the signal wires, and install the pins/sockets onto the signal wires. Insert the wires into their proper location on the connector.

Screw on the backshell and install the foam tape and cable clamp. The foam tape will prevent the wires from chaffing or being crushed. It may also be beneficial to shorten the cable clamp screws. To install Scotch® 24 shielding tape, locate the section of exposed shield farthest away from the connector. Anchor the shielding tape within the cable bundle by wrapping several of the individual cables and then the entire bundle, as shown. Continue to wrap the bundle tightly up over the backshell and anchor the wrap with a metal band or panduit. Use lock-stitch to secure the wrap to the exposed shield on the cables.

Fig. 7 Shield Termination into a Standard Backshell
Shield Termination into an EMI Backshell

This process is demonstrated using a Glenair Type 380 backshell, but it can be applied to any EMI backshell with subtle modifications.

All the individual cables should be prepared using the techniques described in the previous section. Install all the cable peripherals over the cable bundle (cable ID's, heat shrink tubing, copper overbraid, EMI backshell, ferrule, and retainer). Strip the signal wires, and install the pins/sockets.

Insert the wires into their proper location on the connector, and then install the EMI backshell. Insert the metal overbraid through the ferrule, fold the overbraid back, and trim off the excess. Install the braid and ferrule into the end of the EMI backshell, securing the assembly with the ferrule retainer. Screw the strain-relief brackets onto the retainer, further anchoring the overbraid. At the end away from the connector, terminate the metal overbraid, using heat shrink. Use lock-stitch to secure the overbraid to the exposed shield on the cables.

Fig. 8 Shield Termination into an EMI Backshell
As stated before, the methods presented can be applied to all types of backshells including the Sunbank Type SB51 shown below.

Install the metal overbraid onto the end of the EMI backshell, while keeping the braid tightly bound. Anchor the overbraid to the backshell using a metal band with the appropriate installation tool. At the end away from the connector, terminate the metal overbraid, using heat shrink. Use lock-stitch to secure the overbraid to the exposed shield on the cables.

Wire Diagrams

One problem often overlooked is how to represent the shield termination on a schematic or wire diagram. Because the wire fabrication shop associated the standard shield termination symbols with pigtails, we developed a symbol that would better represent the wrapping and overbraid methods, and signal to the technician that a different method was required. The figure below displays the new schematic symbol as a solid line encompassing the cable bundle and terminating at the backshell. Flag notes were also developed to identify the correct termination method used during fabrication.

Fig. 11 Schematic Diagram

As a finishing touch, a protective cover can be added to any of the assemblies presented. Install the plastic overbraid on top of the shielding tape. Fold each end of the overbraid inward to prevent fraying and secure the overbraid with lock-stitch.

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References