STANDARDS AND INFORMATION DOCUMENTS

Call for comment on DRAFT REVISED AES standard on interconnections — Grounding and EMC practices — Shields of connectors in audio equipment containing active circuitry

This document was developed by a writing group of the Audio Engineering Society Standards Committee (AESSC) and has been prepared for comment according to AES policies and procedures. It has been brought to the attention of International Electrotechnical Commission Technical Committee 100. Existing international standards relating to the subject of this document were used and referenced throughout its development.

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DRAFT REVISED AES standard on interconnections — Grounding and EMC practices — Shields of connectors in audio equipment containing active circuitry

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Abstract

This standard specifies requirements for the termination, within audio equipment, of the shields of cables supporting interconnections with other equipment, taking into account measures commonly necessary for the preservation of EMC (electromagnetic compatibility) at both audio and radio frequencies.

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Contents

Foreword

This foreword is not part of the AES48-2005 *AES standard on interconnections — Grounding and EMC practices — Shields of connectors in audio equipment containing active circuitry*.

This document was developed under project AES-X13 by task group SC-05-05-A headed by J. Brown, and with the following members: J. Dow, S. Macatee, N. Muncy, B. Olson, D. Queen, R. Rayburn, J. Schmidt, B. Whitlock, J. Woodgate, and M. Yonge.

Bruce C. Olson, chair
Jim Brown, vice-chair
SC-05-05 Working Group on Grounding and EMC Practices
2004-09-24

Corrigendum 2005-05-12
Minor editorial corrections

Foreword to second edition, xxxx

This revision includes changes to clarify the grounding of circuitry inside a device when EMI filters are employed.

This document was developed under project AES-X245 by task group SC-05-05-A headed by Richard Cabot

Bruce C. Olson, chair
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xxxx- xx- xx

NOTE In AES standards documents, sentences containing the verb "shall" are requirements for compliance with the standard. Sentences containing the verb "should" are strong suggestions (recommendations). Sentences giving permission use the verb "may." Sentences expressing a possibility use the verb "can".

AES standard on interconnections — Grounding and EMC practices — Shields of connectors in audio equipment containing active circuitry

0 Introduction

The shielding of audio equipment, cables, and microphones can be critical for electromagnetic compatibility (EMC). The improper connection of these shields can cause common-impedance coupling in equipment. From XL connector usage, where Pin 1 is standardized as the designated shield contact, this has been identified as the “Pin 1 problem” (see Whitlock 1995 and AES14-1992).

1 Scope

This standard specifies requirements for the connections of the designated shield contact of connectors built into audio equipment using active circuitry. These requirements are necessary for the preservation of electromagnetic compatibility (EMC) at both audio and radio frequencies.

2 Normative references

There are no normative references

3 Definitions and abbreviations

3.1 Active (adjective, as applied to electronic circuitry)
Contains one or more circuit elements that are capable of detecting or demodulating an electrical signal. Vacuum tubes (valves) and semiconductor devices are examples of active circuit elements.

3.2 Enclosure
All the walls which surround the live parts of electrical apparatus including doors, covers, cable entries, rods, spindles, and shafts.

3.3 Shielding enclosure
Continuously conductive frame or enclosure housing electronic equipment, and whose potential is taken as a reference.

3.4 Screen
Term sometimes used to mean the same as “shield”.

3.5 Equipment Ground
Also referred to as the Safety Ground.

3.6 “Star” Point
Also referred to as the Single Point reference.

4 Connection of shields

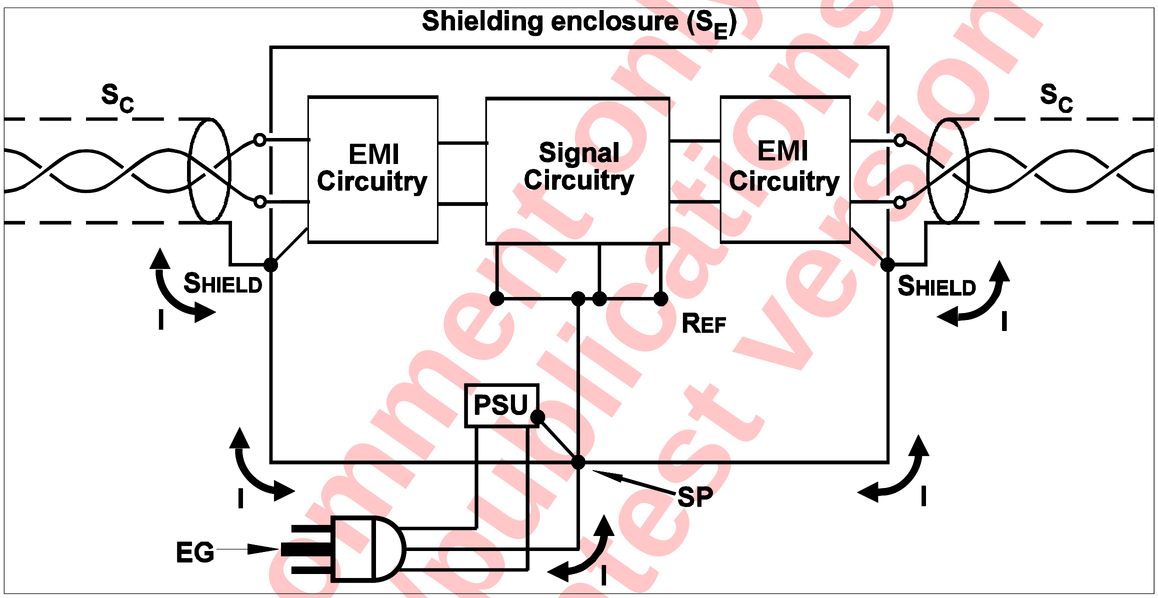
4.1 Connections to shielding enclosure

The designated shield contact and the shell of the equipment connector(s) shall have a direct-current connection to the shielding enclosure via the lowest impedance path possible. It is strongly recommended that this connection be to the outside of the chassis or shielding enclosure. See Figure 1.

When a shielded connector is used, it should be of a type that provides a connection having the lowest practical impedance at radio frequencies between its shell and the shell of a mating connector.

When EMI rejection circuitry is present it shall return EMI currents to the interface shield connection point with the lowest practical impedance.

NOTE: Over the widest possible frequency range, the lowest impedance path is generally achieved with a short, wide conductor.



KEY

REF	Signal reference	I	Shield currents
EG	Equipment ground	S_E	Shielding enclosure
PSU	Power supply unit (typical)	S_C	Cable shield
SP	Star point	SHIELD	Designated shield contact

NOTE 1: Good engineering practice encourages implementers to locate the ‘Star Point’, the connectors, and the signal circuitry as close as possible to each other in order to gain the greatest benefit from the cable shielding.

NOTE 2: EMI filtering circuitry shown is optional and application dependent.

Figure 1 - Connections with a Shielding Enclosure

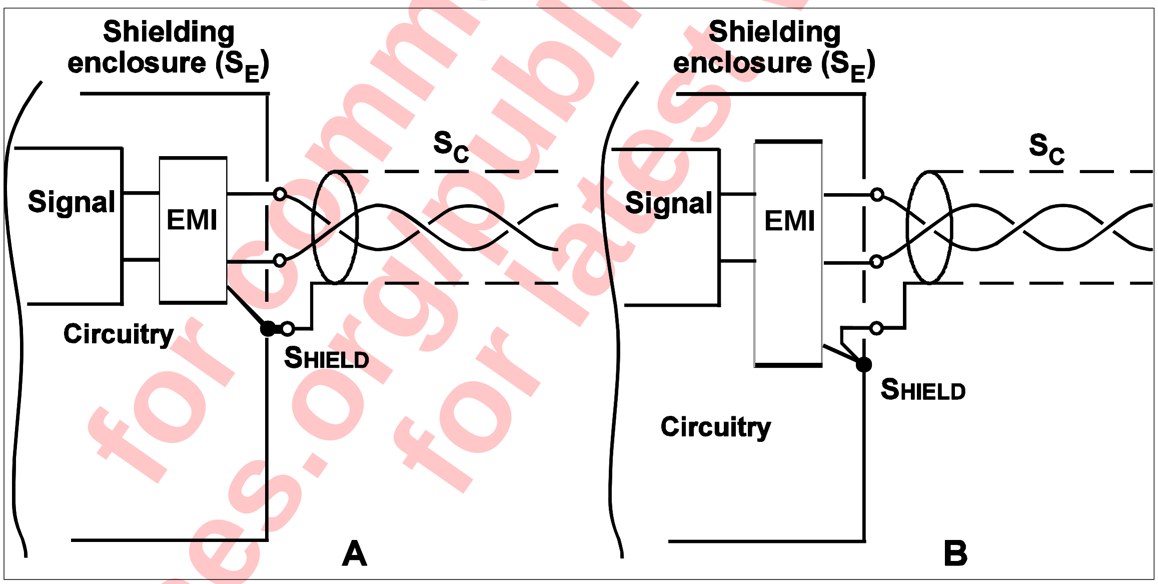
4.2 Unshielded connectors

Unshielded connectors include, but are not restricted to, terminal-strip and pluggable terminal-strip connectors. Cable-mounted connectors shall be located outside the shielding enclosure, and the smallest practical openings shall be provided in order for them to mate to the equipment connector. The openings shall be as widely separated as possible, so that the path for interfering signals into or out of the equipment is minimized. When possible, each connector should have its own opening.

Terminals directly connected to the outside of the shielding enclosure shall be provided for termination of each cable shield. The location of each shield terminal shall be such that both the shield connection and the length of the unshielded signal leads can be made very short. Each shield connection should be made to a shield terminal. Figure 2A shows this preferred connection. In cases where this is impractical, connection may be made via a connector contact wired directly to the shielding enclosure via the lowest impedance path possible, shown in 2B.

When EMI rejection circuitry is present it shall return EMI currents to the interface shield connection point with the lowest practical impedance.

NOTE: Connectors of this type require particularly careful attention to their shielding and shield wiring. Three common problems can arise. First, because the connectors are inherently unshielded, the signal conductors can both receive and radiate electromagnetic interference. Second, it is common for the shield connection to the shielding enclosure inside equipment to be relatively long, and for the shields for several lines to be bussed together before being connected to the shielding enclosure. This allows noise on the shield lead to radiate inside the equipment, with this lead acting as an antenna. Third, a common method of construction is for an opening to be created in the shielding enclosure so that a mating connector can pass through it. This opening provides a path for interfering fields into and out of the equipment.



KEY

S_C	Cable shield	SHIELD	Shield terminal
S_E	Shielding enclosure	EMI	Optional EMI circuitry

NOTE 1: The shield terminal has commonly been identified as "G" in older equipment designs

NOTE 2: EMI filtering circuitry shown is optional and application dependent.

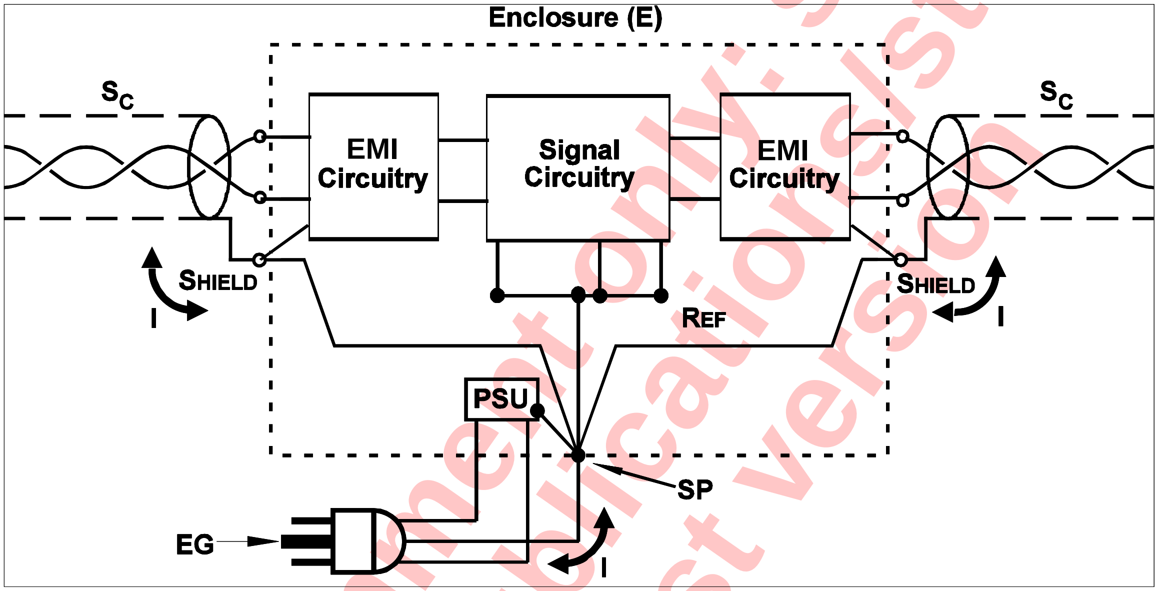
Figure 2 – Unshielded Connectors with a shielding enclosure

4.3 Connections where no shielding enclosure exists

Unshielded enclosures can be a problem where EMC performance is important. An unshielded enclosure is far more likely to radiate and receive electromagnetic interference than a properly shielded enclosure. This standard shall not be interpreted to condone or encourage the use of unshielded enclosures.

Where there is no shielding enclosure, each designated shield contact and each connector shell shall have a direct-current connection to the star point (labeled SP in Figure 3) via the lowest impedance path possible. See Figure 3.

When EMI rejection circuitry is present it shall return EMI currents to the interface shield connection point with the lowest practical impedance.



KEY

E	Enclosure (non-shielding)	I	Shield currents
EG	Equipment ground	REF	Signal reference
PSU	Power supply unit (typical)	S_C	Cable shield
SP	Star point	SHIELD	Designated shield contact

NOTE 1: Good engineering practice encourages implementers to locate the ‘Star Point’, the connectors, and the signal circuitry as close as possible to each other in order to gain the greatest benefit from the cable shielding.

NOTE 2: EMI filtering circuitry shown is optional and application dependent.

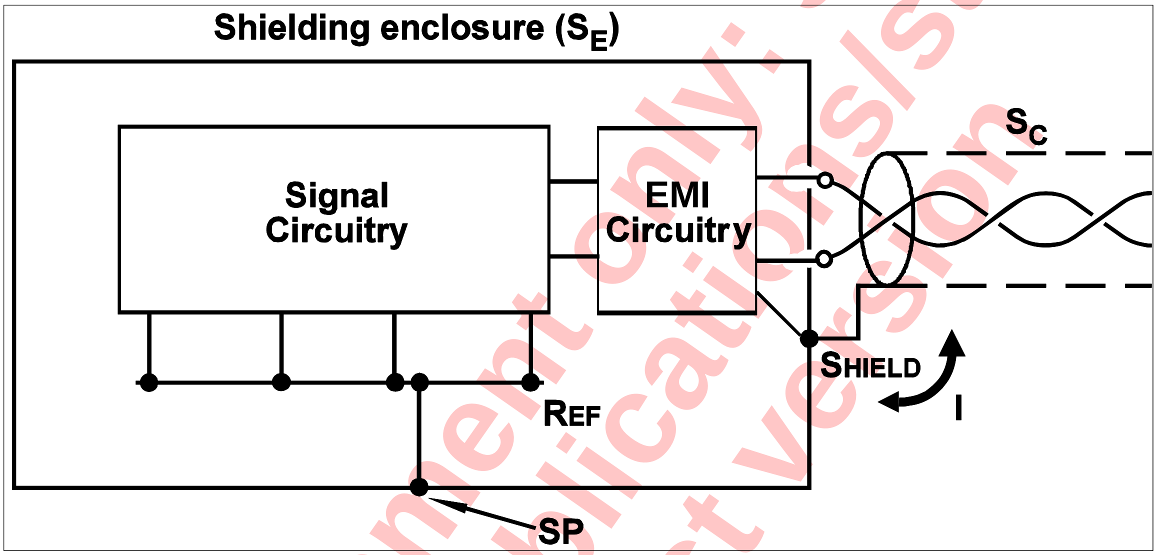
Figure 3 - Connections where no shielding enclosure exists

4.4 Connectors built into microphone cases

The designated shield contact and the shell of the microphone connector shall have a direct-current connection to the shielding of the microphone via the lowest impedance path possible. See Figure 4.

When EMI rejection circuitry is present it shall return EMI currents to the interface shield connection point with the lowest practical impedance.

NOTE: Connections that utilize the retention screw of XL connector shells are typically unreliable electrically and mechanically. It has also been shown that the inductive reactance of such a connection will result in common impedance coupling (the "pin 1 problem") at very high radio frequencies. See Brown and Josephson 2003, and Annex A.



KEY

I	Shield currents	S_C	Cable shield
REF	Signal reference	S_E	Shielding enclosure
SP	Star point	SHIELD	Designated shield contact

NOTE 1: Good engineering practice encourages implementers to locate the 'Star Point', the connector, and the signal circuitry as close as possible to each other in order to gain the greatest benefit from the cable shielding.

NOTE 2: EMI filtering circuitry shown is optional and application dependent.

Figure 4 - Microphone cases

4.5 Shield interruptions

If for any reason the shield connection of wiring that interconnects audio equipment is interrupted to prevent the flow of current on the shield, the interruption shall be external to the equipment. It has been shown that, in the general case, the interruption should be at the receiving end only (see Whitlock 1995).

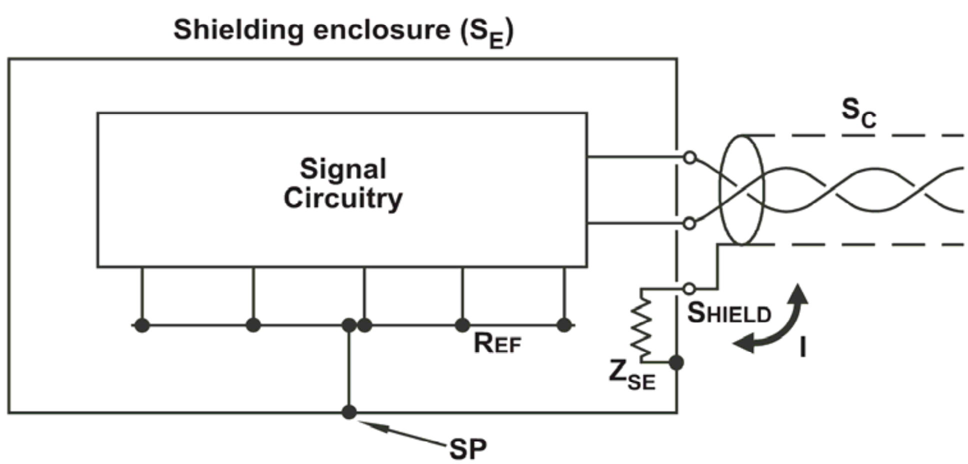
Annex A (Informative) - Examples of terminations that do not meet this standard

The examples below illustrate designs that can create problems. While these use the balanced output circuitry typical of a capacitor microphone, the same mechanisms exist with all wired interfaces, whether balanced or unbalanced. Such interfaces include, but are not limited to, inputs and outputs for audio, video, RF, data, and control, as well as power connections.

A.1 Problem Example 1

Common mode voltage increases linearly with increasing impedance (Z_{SE}) between the cable shield and the enclosure (Figure A1). To minimize the common-mode voltage, the impedance of the connection within the enclosure should also be minimized.

When the allowed connection is inside the shielding enclosure, it will behave as an antenna, coupling RF energy into the enclosure. This is also minimized by making the connection as short as possible.



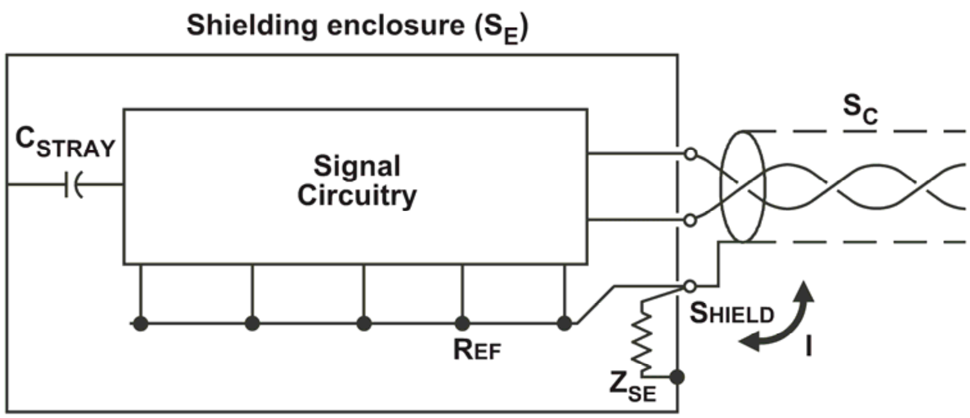
KEY

I	Shield currents	S_C	Cable shield
REF	Signal reference	S_E	Shielding enclosure
SP	Star point	SHIELD	Designated shield contact
Z_{SE}	Impedance (cable shield to enclosure)		

Figure A1 – Effects of the impedance of the connection between the cable shield and the enclosure

A.2 Problem Example 2

The connection of the signal reference to the designated shield contact (pin 1 in the case of an XL connector; see AES14-1992) causes the impedance of the loop (Z_{SE}) to be a common-coupling impedance between shield current and the signal circuitry (Figure A2). Stray capacitance between signal circuitry and the enclosure completes the path.



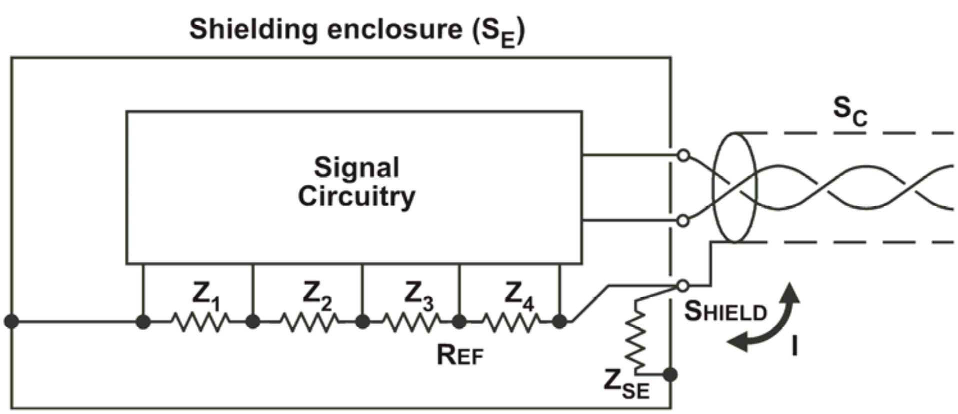
KEY

C_{STRAY}	Capacitance (circuit to enclosure)	S_C	Cable shield
I	Shield currents	S_E	Shielding enclosure
REF	Signal reference	SHIELD	Designated shield contact
Z_{SE}	Impedance (cable shield to enclosure)		

Figure A2 – Common-impedance coupling (i) (Pin 1 problem)

A.3 Problem Example 3

Current from the cable shield divides into two parallel paths to the enclosure. Path 1 is the shield to enclosure connection at pin 1 (labeled Z_{SE} in Figure A3). Path 2 is along the signal reference and its bond to the enclosure. Common-impedance coupling occurs both in the first path as previously noted, as well as within the second path along the signal reference. The resulting potential differences will be impressed at various points in the signal circuitry based upon its geometry. The impedances of each segment of these paths vary in a complex fashion with frequency as a function of its geometry.



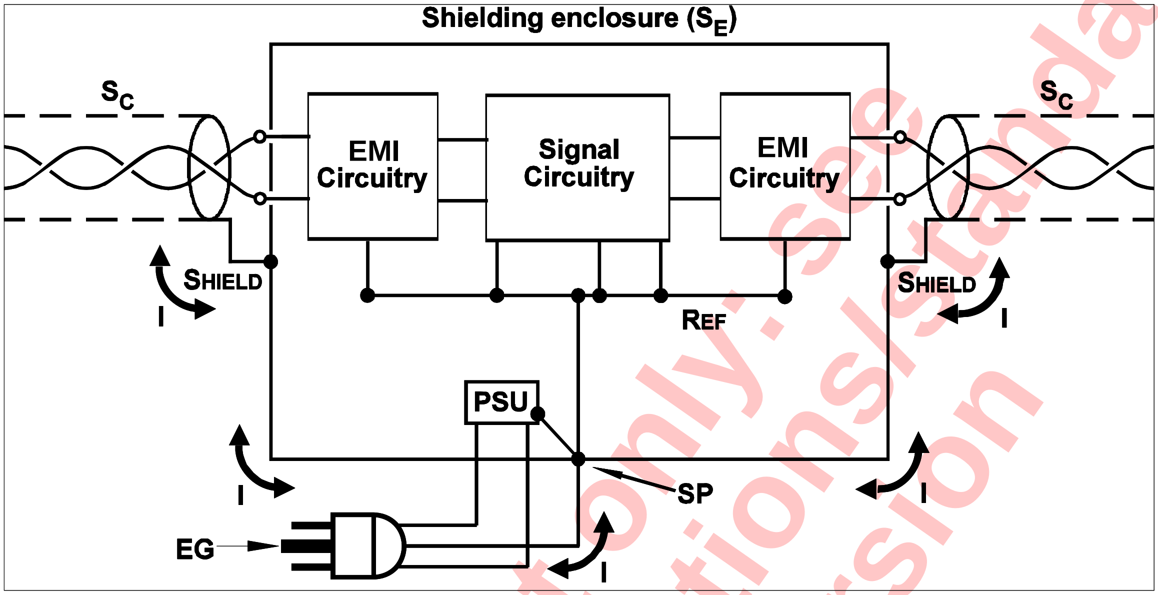
KEY

I	Shield currents	S_C	Cable shield
REF	Signal reference	S_E	Shielding enclosure
Z1 etc.	Distributed impedances	SHIELD	Designated shield contact
Z_{SE}	Impedance (cable shield to enclosure)		

Figure A3 – Common-impedance coupling (ii)

A.4 Problem Example 4

Current from the EMI filter circuitry is routed to the enclosure at the star point. Common-impedance coupling occurs at EMI frequencies. The resulting potential difference will render the filter ineffective.



KEY

REF	Signal reference	I	Shield currents
EG	Equipment ground	S_E	Shielding enclosure
PSU	Power supply unit (typical)	S_C	Cable shield
SP	Star point	SHIELD	Designated shield contact

Figure A4 – Misconnection of EMI circuitry

Annex B - Bibliography

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