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Recommendations on filters for shielded enclosures

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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1 Scope

This document was prepared to give users general advices on filtering solutions adopted in shielded enclosures. It is mainly a collection of hints derived from practical experience. This document is coordinated with the others of the EN 50147 series.
The document covers the frequency range DC to 40 GHz. The range above 40 GHz and up to 400 GHz is under consideration.

2 Normative reference

This European Standard incorporates dated or undated references, provision from other publications. These normative references are cited at the appropriate place in the text and the publications listed hereafter. Dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in by amendment or revision. For undated references the latest edition of the publication referenced to applies.

- IEC 50 (161) 19 International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic Compatibility
- CISPR 17 Methods of measurement of the suppression characteristics of passive radio interference filters and suppression components, first edition, 1981.

3 Definitions

For any definition see CISPR 17.

4 General recommendations on filters

To prevent interference or over-voltages from being fed into, or out of the shielded enclosure via lines, all lines passing through the shielding must be filtered. In many cases it is not only necessary to protect equipment from broadband interfering signals, but also to limit pulsed type interference (effects of lighting and any man made pulse type phemonena e. g. industrial process). The filter shall not degrade the shielding attenuation of the shielded enclosure. Filters that meet the requirements of the refered specification below should not be retested after installation because the testing of filters is done in 50 Ω-System and shielding is a measure of transmission loss performed with antennas. If cables that penetrate a shielded enclosure, cannot be filtered, they shall have adequate shielding effectiveness and termination on both sides so as to avoid degradation of the shielding effectiveness of the whole installation.

Filters are required at each point where an unshielded wire or cable passes through the shielding material of a shielded enclosure. This is to prevent uncontrolled transfer of electromagnetic energy into, or out of, shielded enclosure.

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5 Insertion loss

5.1 Insertion loss of filters

Practical experience has shown that the insertion loss value of the filters shall be at least as great as the required shield attenuation values of the enclosure. The insertion loss of the filters shall be carefully selected keeping in mind that in the low frequency range (say < 100kHz), the interference is mainly propagated over lines (conducted interference). The shielding effectiveness of the filter housing shall not reduce that of the shielded enclosure.

5.2 Insertion loss values

The insertion loss of the filter is characterised by the lowest attenuation value recorded by three measuring circuits (balanced, unbalanced, asymmetrical) described in CISPR 17. The specified insertion loss value shall be met with the full current load over the entire specified frequency range. During approval measurement of the shielded room, all the cabling of the filters should be noticed and taken into account during the measurement of the shielding attenuation of the enclosure. The filter is expected to attenuate all current lines and neutral by frequency dependent factor while the power frequency attenuation should approach zero. Signal filters shall behave in the same manner as above and particular attention is to be paid to the low band, pass band and high band (e. g. of shielded cables).

Measurement configuration see figure B3 and B4 of CISPR 17.

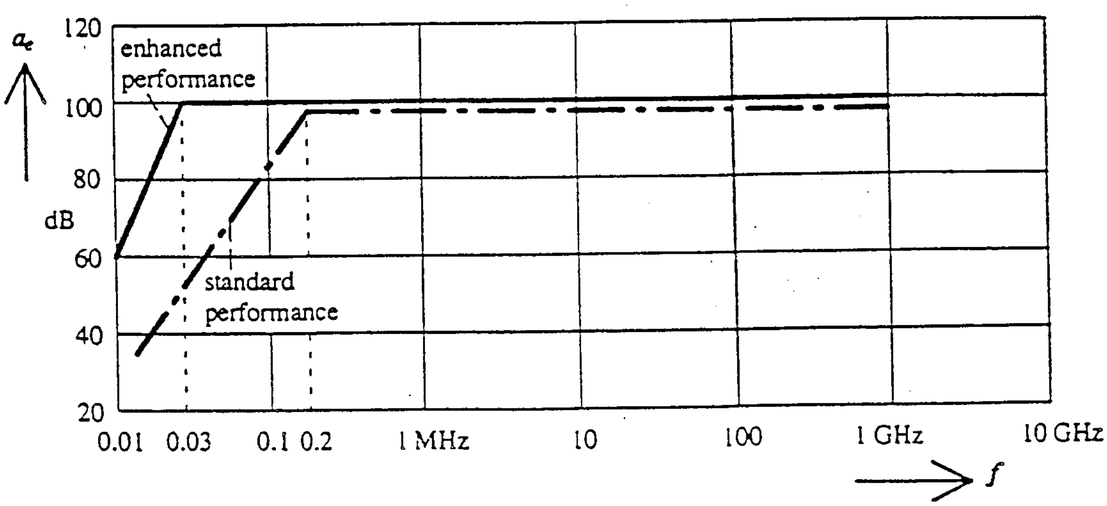

Figure 1: Filter insertion loss value a_e
(typical performance for shielded enclosures)

6 Filter selection

In the case of filters with current compensated chokes, steps should be taken to ensure that the outgoing and return lines are routed through the same filter. If artificial mains networks (according to CISPR 16) or coupling/decoupling networks for immunity tests are installed in shielded rooms, the use of filters with current compensated chokes is not recommended, because of saturation of the core. A considerable reactive current flows in that artificial network and does not ensure compensation of the current in the chokes. In these cases filters with non-saturable coils shall be used. Balanced telecommunications lines shall be routed via a special filter.

6.1 Choice of filters

Basic designs are available for power-, control- and telecommunications filters:

— **Filter to suppress interference**
Interference suppression filters are configured as reflective low pass filters, i.e. they always reach their maximum stop band attenuation if they are mismatched to the impedance of the interfering source or interfering sink, as well as the line impedance.

— **Filter to suppress overvoltage**
Overvoltage protection filters are configured using non linear devices, e.g. gas arrestors SVP (surge voltage protector), varistors and suppression diodes TAZ (= Transient Absorption Zener), for which the switching characteristics (speed, threshold level) are fundamental to the function of the filter.

— **Both filters may be combined**

6.2 Power Line Filters

The user of the enclosure determines his filter requirements in terms of power frequency and current rating, any power line filter for DC, 50 Hz-, 60 Hz- and 400 Hz- (or any other required frequency) supply shall be used within its specification.

Line filters at higher frequencies (max 400 Hz) may also be used for lower frequency applications. The current rating of the filter should always be higher than the maximum operating current.

6.3 Signal Line Filters (including telecom-lines)

A signal line filter shall be adequate for the application (e. g. correct passband example: Fire protection system).

7. Electrical Safety

For safety reasons all metallic parts of the shield must be connected to protective earth. The following specifications should be observed:

— IEC 364-6-61 (CENELEC HD 384.6.61 S1: 1992)
Regulation for grounding in AC systems for rated voltages up to 1 kV.
— IEC 364-Serie
Incorporation of gas- and water-pipes in the main equipotential bonding system of electrical installations.

All RF suppressor filters contain a continous line for the protective earth (PE) conductor. The PE conductor is in contact with the housing. Although the filter housing will be fixed on the shielded wall and in good electrical contact with it. Safety reasons require, that it will be connected to the ground bolt of the shielded wall via a conductor from the ground terminal of the RF suppressor filter. The protective ground is connected to the ground bolt.

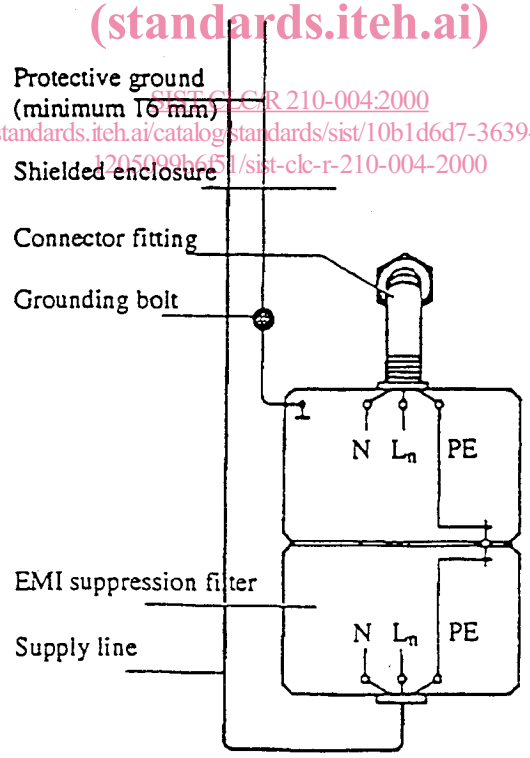

Figure 2: Filter installation schematic

Power line filter may have high leakage current adequate protection may be ensured using a combination of ELCB (Earth leakage circuit breaker) and transformer.

In certain cases insolation of the shield from the host building is necessary. To meet this requirement care must be taken that no electrical connection exists between the shield and conductors like metal reinforcing bars in concrete walls, gas and water supply tubes, ground conductors of fluorscent lamps outside the shielded room , and other metallic materials. In

this case it is essential that the ground connection of the entire shielding structure is made at one, carefully selected point (single point grounding). Moreover for EMC-reasons it is also essential, that this ground connection has an impedance as low as possible and is frequently checked.

8 Installation of filters

Whenever possible, the filters shall be bonded directly to the shield and shall be located in close proximity to each other.

The bond impedance shall be as low as practicable. If the bonding is established by conduit between the shielded enclosure and the filters, then the conduit shall be metal with welded seam or equivalent and the connection of the conduit to the filter and the shielding shall be welded, soldered or bolted to achieve the lowest practicable bond impedance.

In the case of filters with current compensated chokes, the appropriate steps should be taken to ensure that the outgoing and return lines are routed through the same filter.

Literature

CISPR 16-1 (1993) Part 1: Radio disturbance and immunity measuring apparatus.

CISPR 17 (1981) Methods of measurement of the suppression characteristics of passive radio interference filters and suppression components.

IEC 364 Serie Electrical installation of buildings.