Not for Reproduction CISPR/A/WG1 (Kriz) 16-01
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE (CISPR)

Sub-Committee A : Radio Interference Measurements and Statistical Methods

Working Group 1: EMC Instrument Specification

Subject : Influence of adaptor to AMN impedance calibration

References:

[1] CISPR/A/WG1 (Kriz) 15-04
[2] CISPR/A/WG1 (Kriz) 14-02
[3] CISPR/A/WG1 (Kriz) 15-05
[4] CISPR/A/WG1 (Ziadé)
[5] CISPR/A/WG1(Shinozuka, Fujii, Sugiura)15-01
[6] Takashi Shinozuka, Katsumi Fujii, Akira Sugiura, Osami Wada: "Calibration Methods for AC-Coaxial Adapter Used inAMN Impedance Measurements", IEEE TRANSACTIONS ON ELECTROMAGNETIC COMPATIBILITY

Proposal of changes to CISPR 16-1-2 regarding AMN calibration

During the last WG1 meetings in Stresa and Frankfurt several authors presented issues with the current standards [2][5] and proposals for maintenance [1][3][4].

With the help of these papers a list of items for discussion is created. This should find a common basis before drafting a text.
Proposals and action items are highlighted with the yellow marker.

1) Definition of “adapter”

In the paper several names for the “adapter” is used:

a. AMN adapter
b. AC-coaxial adapter
c. LISN adapter
d. Calibration Jig

It is proposed to use the term AMN adapter.

2) Method for adapter correction

It is undoubtful that the influence of the adapter needs to be corrected.
There are several methods for adapter correction.
From a RF-Engineering point of view the most comprehensive method is to use the S-parameter of the AMN adapter [4]:

$$\Gamma_{LISN} = \frac{\Gamma_{in} - S_{11}}{S_{22}(\Gamma_{in} - S_{11}) + S_{12}S_{21}}$$

With [4]

$$Z_{LISN} = Z_0 \frac{1 + \Gamma_{LISN}}{1 - \Gamma_{LISN}}$$

the reflection coefficient is converted into impedance.

To amply the method all four s-parameter must be known. Since the AMN adapter is a passive device S21=S12. So there are three complex unknowns.

It is proposed to use this method for AMN adapter correction.

3) Method for adapter characterization

In principle the S-parameter of the AMN adapter can be found via measurement or via simulation [4]. Both methods have their advantages and disadvantages.

Method	Pro	Con
Measurement	• Not time consuming	• Auxiliary adapter required
Simulation	• No auxiliary adapter required	• Expensive software • Experienced operator • Time consuming

Paper [6] presents a measurement method; However the assumption of S11=S22 is made.

To be discussed at ad-hoc level: Possibilities for improvement of the S-parameter method [6] to gain S11 and S22 separately or impact of current assumption.

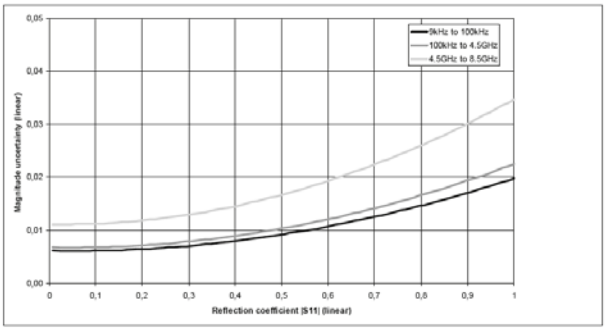
4) Uncertainty calculation method

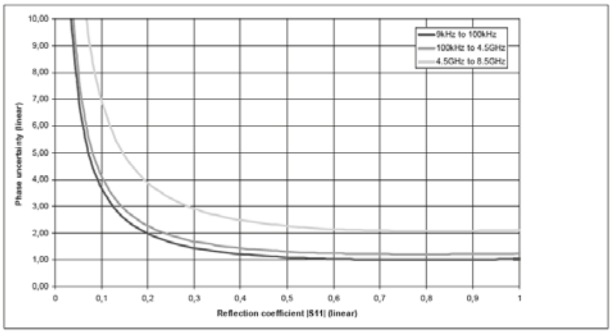
Dealing with a complex model function and measurand is a difficult task. This is very demanding even for people involved in research centers and calibration labs. The traditional method of error propagation (Gaussian error propagation; law of error propagation) becomes difficult since partial derivates in a complex domain are required [6]. A numerical methods (Monte Carlo method [4]) is quite new for many people, but much easier in implementation.

It is proposed to add an informative example code for the Monte Carlo method in MATLAB together with the traditional uncertainty budget table.

5) Uncertainty contribution VNA incl. calibration kit

Typically manufacturer of VNA deliver documentation of uncertainty via the following diagram.





These diagrams are based on the specification of the corrected error term:

- Directivity (eg. >46 dB)
- Source match (eg. >41 dB)
- Load match (eg. >44 dB)
- Reflection tracking (eg. < 0.02 dB)
- Transmission tracking (eg. < 0.028 dB)

Typically a worst case scenario is assumed where all effects superposition. Often it is unclear if the given data are worst case or statistical (uncertainty) and how to use them further on. Shall a Gaussian distribution (k=2) be assumed or a rectangular distribution?

WG1 members of VNA manufacturer are asked to deliver information how to deal with given specification.

6) Definition of measurand

To define impedance it is required to define a voltage. A voltage is defined by the difference in potential of two points.

In case of an AMN there are sometimes several possibilities. The impedance can be defined between live and:

- Reference Ground or
- GND pin/screw or
- PE pin

Following measurand is proposed:

AMN impedance (for V-type AMN)

The measurand is the complex impedance. In case of types for power plugs with PE the impedance shall be measured between live and PE. In case of other types the impedance shall be measured between live and reference ground. Specifications of the reference plane are part of this definition and are given in normative Annex XX.

NOTE The definition of PE as reference simplifies the AMN adaptor design for a large number of plugs. So effort and cost are saved.

This definition replaces following requirement:

> The impedance between each conductor (except PE) of the EUT terminal and the reference ground shall comply with the provisions of 4.3, 4.4, 4.5, 4.6 or 4.7, as appropriate, for any value of external impedance, including a short circuit connected between the corresponding mains terminal and reference ground. This requirement shall be met at all temperatures which the network may reach under normal conditions for continuous currents up to the specified maximum. The requirement shall also be met for peak currents up to the specified maximum.

To be discussed at ad-hoc level: Some plugs e.g. CEE 7/3 (German; Schuko) can be used with connectors with and without protective earth. What is the impact of the proposed measurand to the emission measurement method?

7) Current carrying capacity and series voltage drop

At the moment the standard specifies that voltage on the EUT side shall by not less than 95 % of the voltage of the main side. In other words the voltage drop on the main inductor shall be less than 5 % of the supply voltage. This is valid for the maximum peak current. There is no justification given for this number.

Following facts have to be considered

- For automotive application the voltage changes from approx. 12 V (empty) to 14.4 V (charging) depending on the test plan. This voltage has to be supplied by a power supply and checked during measurement.
- Austrian Standard (ÖVE/ÖNORM E 1100-2) specifies the mains stability by 10 % (of 230 V); other countries may be similar. If the EUT is supplied by the mains and not by a power supply this has to be taken into consideration.
- Typically AMNs are used inside a shielded enclosure, which means there is a filter between the mains and AMN mains input. The voltage drop of this filter is not specified within the CISPR 16 series.
- CISPR 16-2-3 states

  6.3.4 Supply

  The EUT shall be operated from a supply having the rated voltage of the EUT. If the level of disturbance varies considerably with the supply voltage, the measurements shall be repeated for supply voltages over the range of 0,9 to 1,1 times the rated voltage. EUTs with more than one rated voltage shall be tested at the rated voltage which causes maximum disturbance.

  This means provisions must be taken to control the supply voltage.

It is proposed to delete the 95 % requirement.

However it might be useful to test AMNs under various load conditions.

Ad-hoc members are requested to work on specification and test procedure

8) Frequency steps

Currently no frequency steps are defined for calibration. Following minimum steps are proposed:

20 frequencies/decade below 1 MHz
1 MHz steps above 1 MHz

Above 1 MHz resonances could occur, so the steps are narrowed there.

9) Reference plane

For measurements at higher frequencies (>1 MHz) a definition of a reference plane is required for precise calibration of the phase. The information is collected in a normative Annex XX.

Most popular power sockets are

- CEE 7/3 (German)
- CEE 7/5 (France)
- CEE 7/16 (Europlug)
- CPCS-CCC (China)
- NEMA 5-15, NEMA 1-15 (US, Japan)
- BS 1363 (UK)

Laboratory connectors are:

- Screw pin for snap spade (locking fork)
- AC binding post
- Banana jack
- Combined connectors (banana and snap spade)

Design drawings for the several plugs are required.

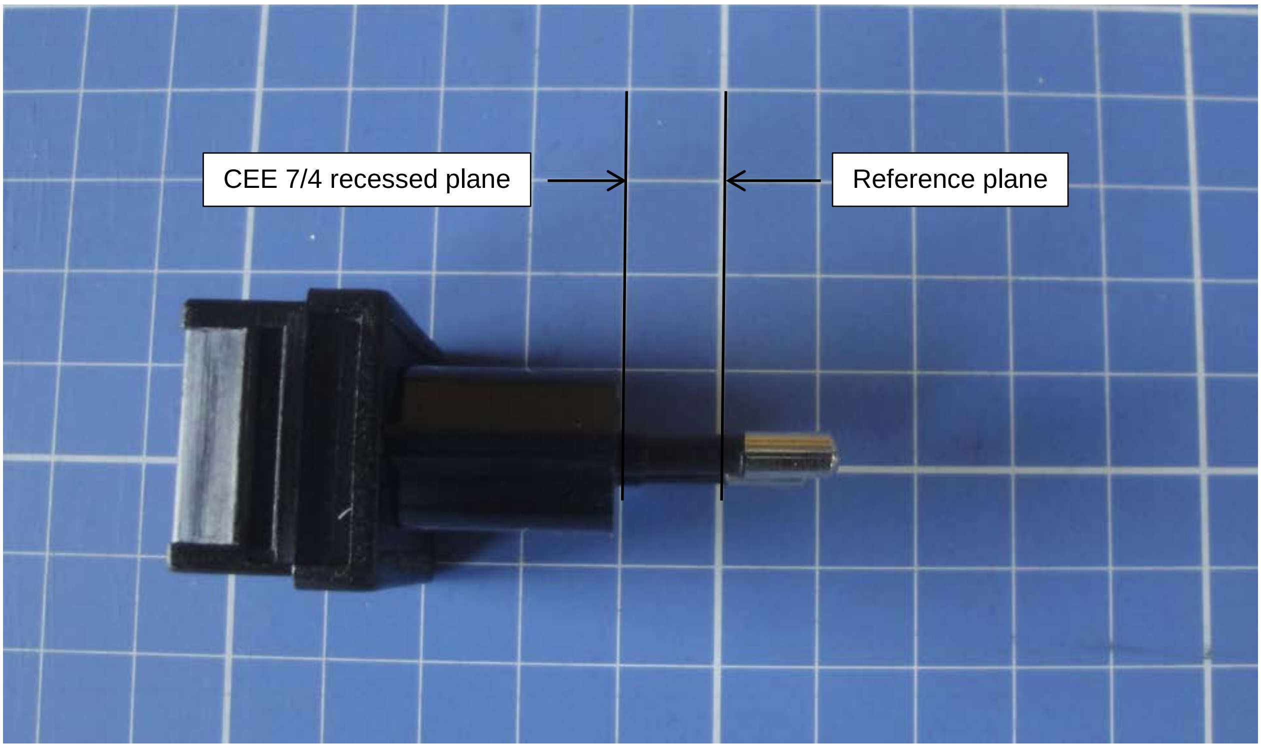
Following definition is proposed:

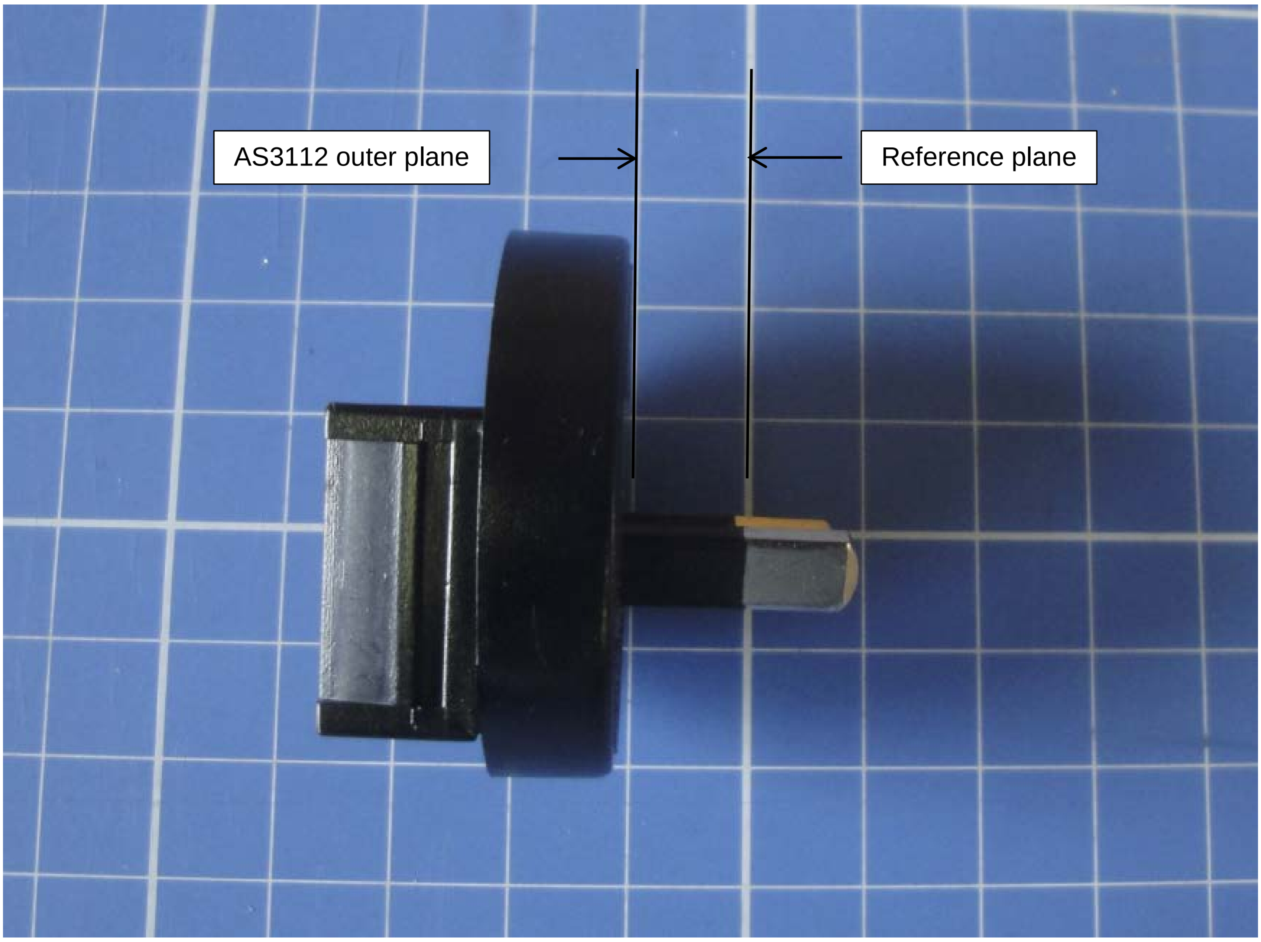
The reference plane is defined 10 mm behind (towards the AMN) following planes:

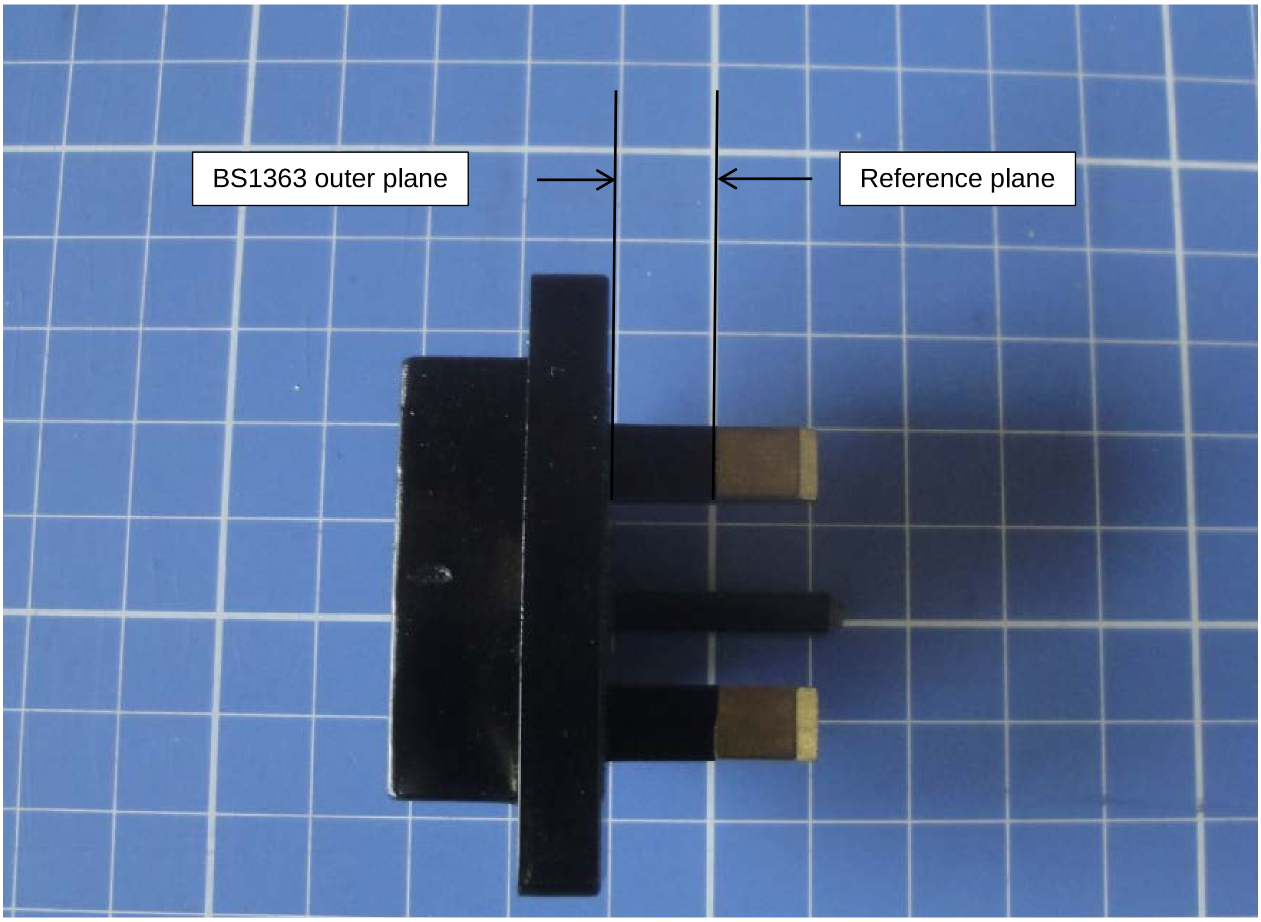
- Area of support for snap spade connectors; For combined connectors the snap spade part has to be taken
- For power plugs with recessed plane (e.g. CEE 7/4) the recessed plane
- For power plugs without recessed plane (e.g. NEMA 5-15) outer plane
- For laboratory connectors the most outward plane

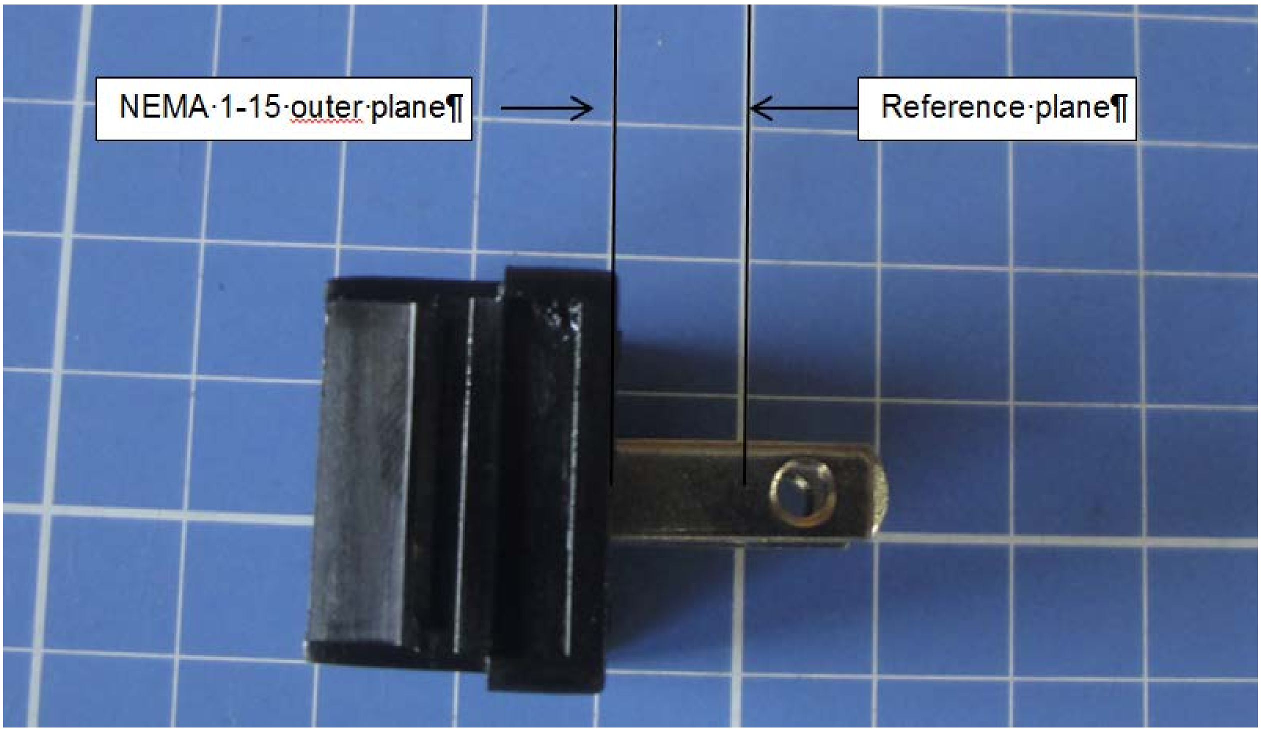
NOTE The reason for the recession of 10 mm is to simplify the calibration of the AMN adaptor. Some clearance is required to perform the back-to-back setup.

Examples:


CEE 7/4 recessed plane
Reference plane


AS3112 outer plane
Reference plane


BS1363 outer plane
Reference plane


NEMA·1-15·outer·plane¶
Reference·plane¶