Background information to the proposals in CISPR/A/WG2(TF CT/Ryser)01-03

1. Introduction

This document presents the background information which led to the formulation of the draft CD for the validation procedure of ferrite clamps in the frequency range 30MHz to 1000MHz, as presented in CISPR/A/WG2(TF CT/Ryser)01-03

Measuring the insertion loss is a pragmatic approach for the verification of the ferrite clamps.

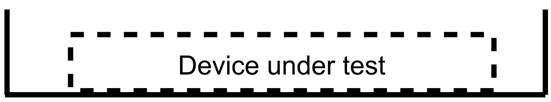
From the theoretical point of view the insertion loss is a combination of "mismatch loss" at the ends of the device and "dissipative loss" inside the device. Other measurements might be more appropriate, but from the practical point of view, the insertion loss measurement is a simple measurement which is possible in most labs, and which gives a raw indication of the quality of the ferrite clamps.

2. Discussion of different possible constructions

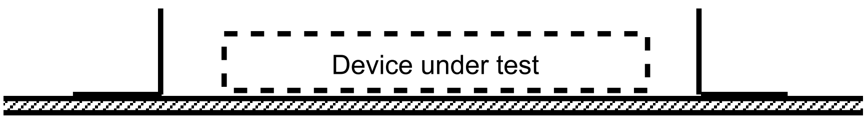
The test jig can be constructed in different ways and CISPR should not restrict to use different constructions as long as the influence to the measurement result is negligible.

Possible basic construction variants of the jig:

a. Using a single U shaped metal sheet



b. Using two metal angles in combination with a metallic groundplane.



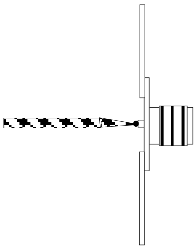
Such a construction can be adaptable to different sizes of the device under test. The contact of the metal angles to the ground plane can be provided by placing metal blocks of appropriate weight or by providing other means insuring the contact to the groundplane.

An experiment comparing the result of the measurement with two different sizes of the U shaped metal sheet and a measurement on a 75cm x 150cm metal groundplane is shown in Annex 1. From this experiment we see no significant difference between the three cases.

The draft CD specifies a width of minimum 100mm

Possible construction solutions of the wire connection:

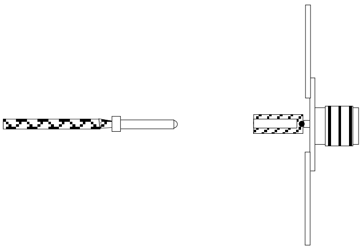
a. Directly soldering the test wire to the pin of the N connector fixed to the test jig.



Advantage:
- simple realisation.

Disadvantage:
- less flexible for different sizes of the device under test.
- less flexible for the insertion of the device under test into the test jig.

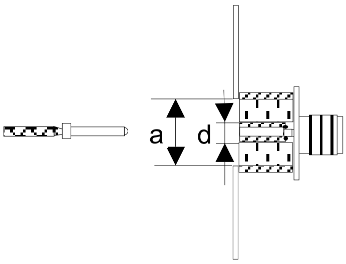
b. Using a banana plug soldered to the test wire and a banana jack soldered to the N connector



Advantage:
- relative simple realisation.
- flexible for different sizes of the device under test.
- flexible for the insrtion of the device under test into the test jig.

Disadvantage:
- mechanically not very robust.

c. Using a banana plug soldered to the test wire and a banana jack integrated into the test jig



Advantage:
- flexible for different sizes of the device under test.
- flexible for the insertion of the device under test into the test jig.
- mechanically robust.

Disadvantage:
- relative complicated realisation.

If the test wire is defined to be 6mm +/- 0.5mm, the 4mm banana plug / jack system does not form a severe mismatch. The insulation material around the banana jack can be adapted in the dimension to represent a 50Ω impedance.

Starting with the formula for the impedance: $$z = \frac{60}{\sqrt{\varepsilon_r}} * \ln\frac{a}{d}$$

With z = 50Ω and d = 6mm,
we can calculate the diameter a as: $$a = 6 * e^{\sqrt{\varepsilon_r} * 0.833}$$

Regarding the measurement results, all the different construction solutions are equivalent.

Therefore all possibilities are included in the draft CD.

3. Discussion of the test wire diameter and the distance to the ground plane

The test wire diameter (d) and the distance to the ground plane (h) has a influence to the measurement result which is different for different ferrite clamp types. Some ferrite clamp types are more sensitive to these variables than others. (See experimental results in Annex 2 and 3)

It is necessary to fix these two variables in the standard.

One first idea could be to realize a a defined impedance with the selection of the two values h and d. However there are two points against this idea:

a. If a fixed impedance (for example 150Ω) in the empty jig should be realized, the relation between h and d is specified (d/h= 0.323 for 150Ω and air dielectric). This would result into unrealistically high values of d.

b. The impedance of the jig including the device under test is completely different from the impedance of the jig with the device under test and depends very much on the device under test. It is therefore not possible to create a defined impedance with the device under test introduced into the jig.

Conclusion: it is not possible to select the values of d and h by defining the impedance.
The selection of d and h has to be guided by other considerations.

The heigth h an the diameter d of the test wire should be close to the real application of the device.

In the real application, the heigth h is given by the height h_1 of the wire as guided in the ferrite clamp itself plus an unknown height h_2 of unknown material between the clamp and the ground plane where the ferrite clamp is used. If the ferrite clamp is positionned directly on the ground plane, h_2 is zero.
If we consider the application of the ferrite clamps directly on the ground plane as typical, we can specify the height of the testwire h to be the height of the center of the possible positions of the test wire in the ferrite clamp.

Possible heights are:
25mm: Typical height of commercially available ferrite clamps
30mm: Height defined for the verification of CDN in IEC61000-4-6
65mm: Typical height of absorbing clamps used for interference power measurement
85mm: Height proposed in a draft for the absorbing clamp calibration
(Reason for 85mm: Possibility to insert the clamp into a jig with fixed test wire. This requires to rise the device under test by 20 mm during the test in the jig.)

The draft CD proposes to use the height given by the construction of the device under test.

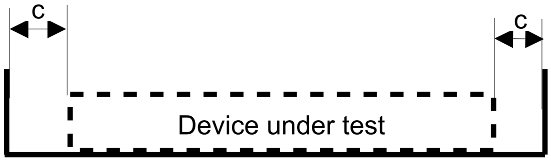
Reason for this selection:
- This is closest to the most likely mode of application of the ferrite clamps.
- Using the proposed constructions, it is possible to have the jigs adapted to each ferrite clamp type.

The diameter d in the real application is the diameter of the ensemble of the metallic parts in the cable (e.g. the outside diameter of the shieldeded cables or coaxial cables, or the average diameter of the cross section of multiwire cables) in general, this diameter is higher than the diameter of a single wire.
Annex 2 shows test results with three wire diameters:
- 1.4mm diameter (simple wire of 1.5mm^2)
- 2.3mm diameter (wire of 4mm^2 as defined for absorbing clamp calibration)
- 6.0mm diameter (outside surface of a typical RG58 coaxial cable)

The draft CD proposes to use 6mm +/-0.5mm diameter

Reasons for this selection:
- 6mm diameter is the typical representation of a small coaxoal cable, a small shielded cable or a small multiwire cable. Smaller diameters as a cable will be rare.
- 6mm diameter fits well to the proposed constructions using 4mm banana plug and jack

4. Discussion of the distance c between device under test and test jig reference surface



Experimental results with different values of c for one type of ferrite clamps are shown in Annex 4.

It can be seen that the distance c between the device under test and the jig reference surface has an influence to the measurement result at higher frequencies. (Direct coupling between the two exposed lengths of wire.) The value at 30MHz however, which is the most important to meet the specification, is practically unchanged for the values of c and the clamp type tested in Annex 3.

Theoretically, c should be as small as possible. For practical reasons c should not be too small.

The draft CD proposes to use a c of 30mm

An additional detail has not been considered here:
The construction of the device under test is not known in the general case. Therefore it is not known at which distance to the end of the device the ferrites are placed inside the device. The function of the ferrite clamps however is related to the distance to the ferrites and not to the distance to the external parts of the device. Therefore, in case of the absorbing clamp, a clamp reference point CRP has been defined in the newest draft on the calibration of the absorbing clamp.

In the case of the ferrite clamps used as cable termination, it can be accepted that the position of the ferrites inside the device under test is not exactly known, and c is referenced to the outside surface of the device under test.

5. Discussion of proposed specification

The specification proposed in the draft CD is taken from CISPR 22 Amendment 1 where an insertion loss of >15dB is required.

Looking at the measured data in the Annexes to this document, it can be seen, that some types of ferrite clamps will fulfill >20dB without problems. If the specification would be increased to this value, this would exclude some types of ferrite clamps (including the standard absorbing clamp which has typically 17dB at 30MHz) but would guide the laboratories to use available types with higher insertion loss.

It is also possible to define a insertion loss requirement which is frequency dependent and fits more or less to the typical measured data. Also with such a limit, it would be necessary to decide wether the range of used ferrite clamps should be more or less restrictive.

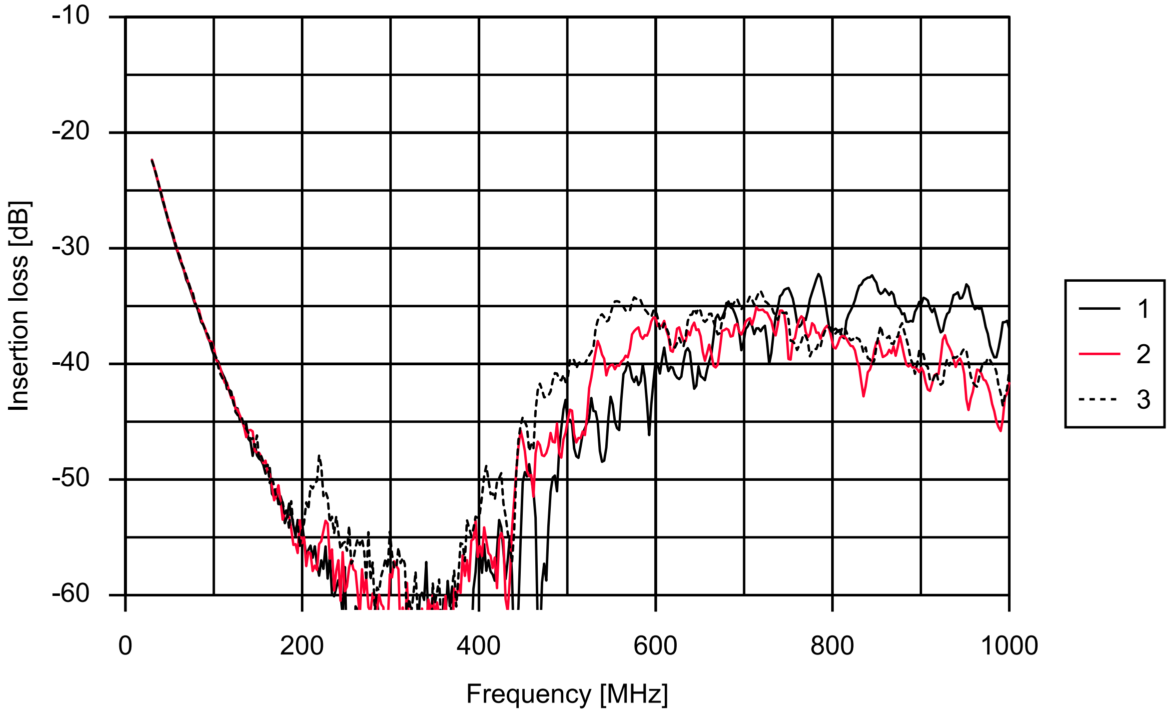
For the time being, the draft CD uses a limit of >15dB independent of the frequency.

Annex 1

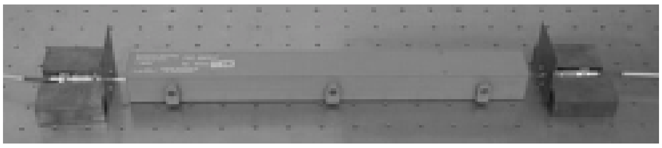
Comparison of different ground plane dimensions

1: 1m X 2m metal table as ground plane
2: ground plane strip of 12cm width
3: ground plane strip of 7cm width

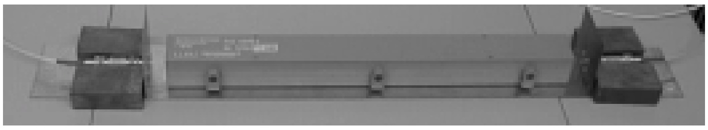
Device under test: FGZ 15X40 E
Distance of the wire above ground: 30mm
Wire size 6mm diameter (RG58 outside surface)



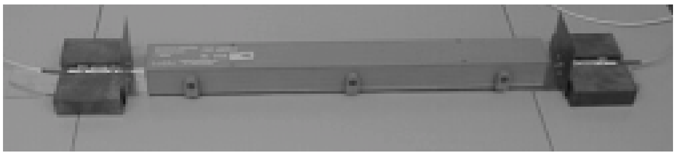
1m X 2m metal table as ground plane



ground plane strip of 12cm width



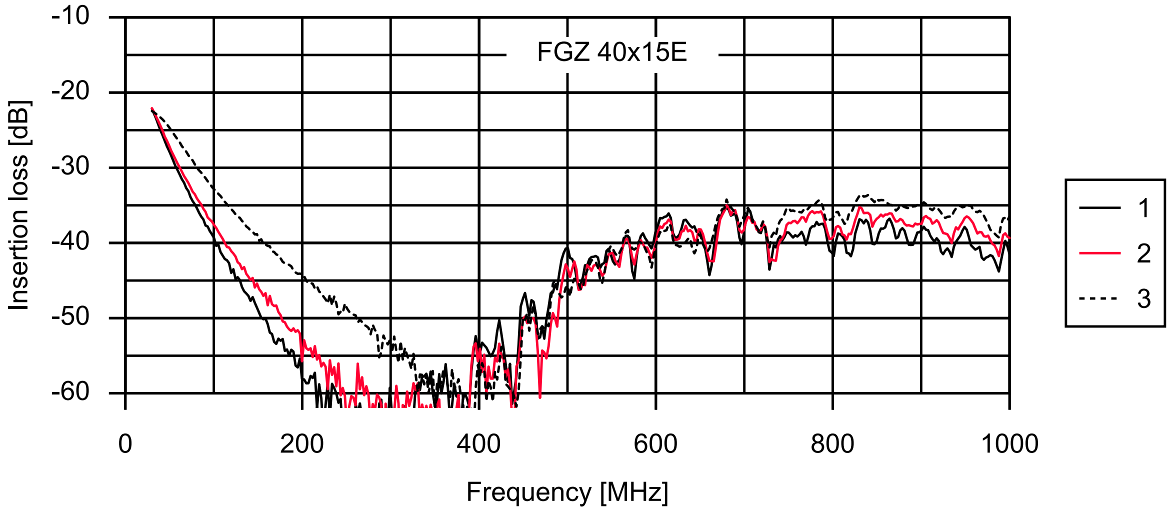
ground plane strip of 7cm width

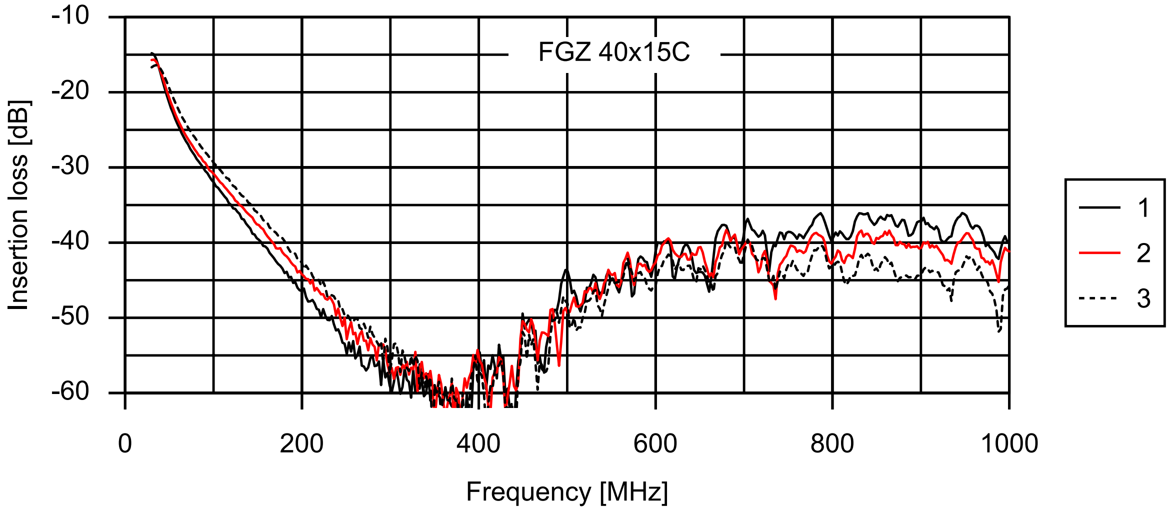


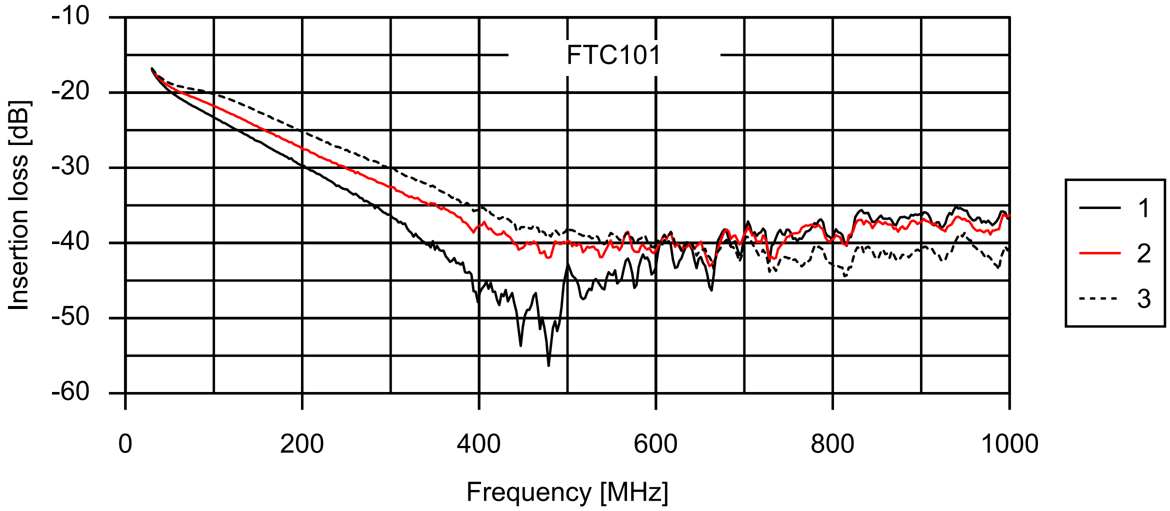
Annex 2

Comparison of different diameters of the test wire

1: 6mm diameter
2: 4mm square
3: 1.5mm square



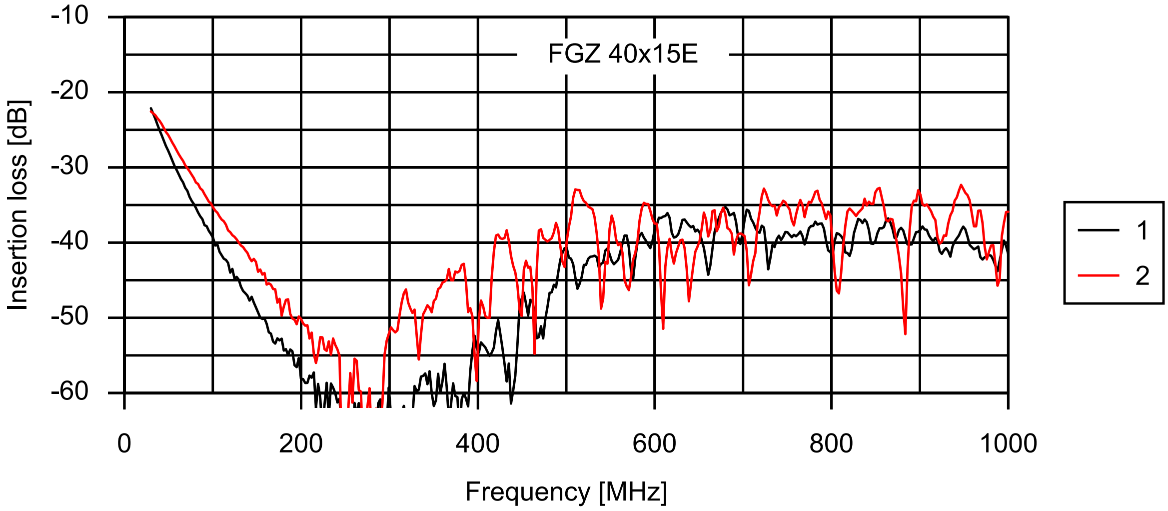


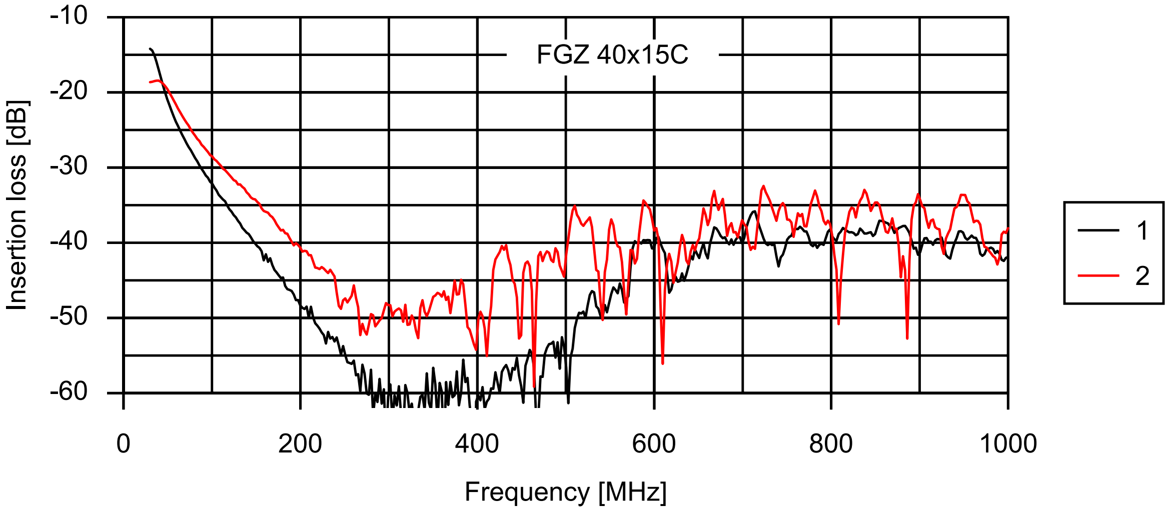


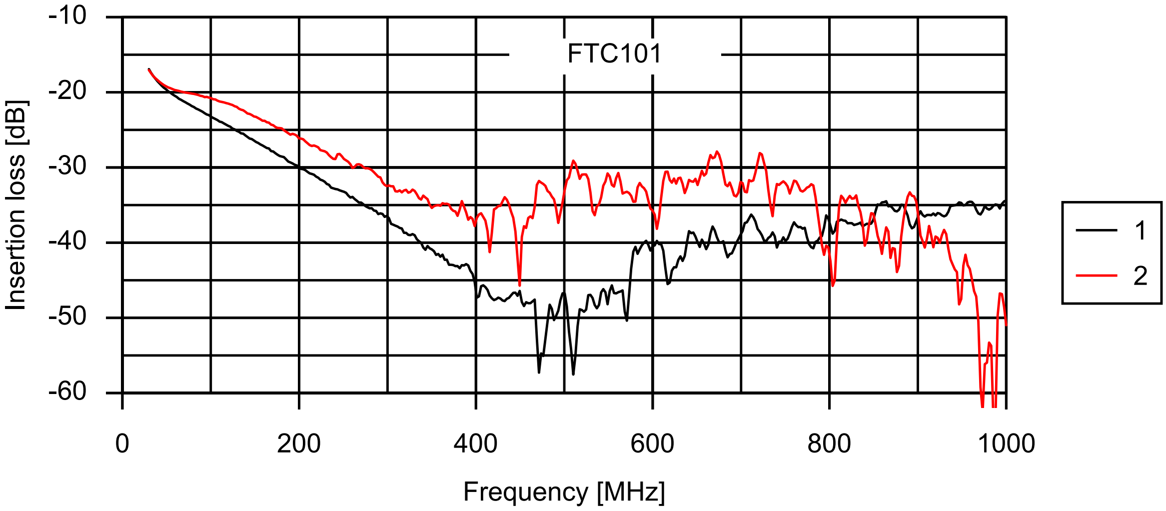
Annex 3

Comparison of different distances to the ground plane

1: 30mm distance to the ground plane
2: 66mm distance to the ground plane







Annex 4

Comparison of different distances c to the device under test