A proposed setup to meet the new CISPR 25 Annex J Long-wire method

Adverse Effect Analysis of Antenna Cable Wiring in the Band below 30 MHz

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***Abstract*— This paper discusses CISPR25 edition 4 Annex J and reports the effects on the measurement results of the connection between a monopole antenna and a ground plane due to the connection symmetry of an antenna counterpoise and a ground plane, the placement symmetry of a jig for a long wire antenna, and the wiring placement of a coaxial cable connected to an antenna. From the experiment, it is shown that the placement symmetry and the resonance of a ground plane make a measurement value smaller than that of a reference setup. As for the wiring placement of a coaxial cable, the Backside Cabling is proposed to minimize the effects of itself on measurement results. The method is then verified based on experiment results. Finally, it will be shown that the measurement results least affected by the wiring placement correlate with the calculation results of an electromagnetic field simulator modelling an actual setup. The analysis results considering the size and connection method of a ground plane at each test site are the appropriate reference data for the long wire antenna method.**

Keywords*— *CISPR 25, Inter-Laboratory Comparison, Radiated Emission, Long-Wire Method, Round Robin Test

I. Introduction

Annex J was added to CISPR 25 edition 4 [1] as the standard for validation of an absorber-lined shielded enclosure (ALSE), including a ground plane, and an antenna used for emissions evaluation of in-vehicle equipment. By performing measurement in accordance with this standard, analysis of data correlation between multiple laboratories (ILC: Inter-Laboratory Comparison) as well as validation of measurement results obtained at test sites can be made. For this reason, there have recently been a large number of analyses regarding this standard [2]-[6].

In references [5]-[6], authors stated the following: the standardized validation reference setup of Annex J is different from the setup at actual test sites; the reference value does not consider the resonance between 10 MHz and 30 MHz caused by a ground plane on a measurement table behaving like a transmission line during actual measurement. The deviation between the reference value and the measured value due to the characteristic difference has a significant influence on ALSE validation. For some DUTs, the above mentioned resonance characteristics may cause measurement system saturation. Measurement system distortion characteristics can have an adverse effect on measurement results in other frequencies such as AM radio band. By increasing the number of connection points of the ground plane to the floor, the deviation between the reference setup and the actual site setup can be improved.

Firstly, this paper discusses factors affecting measurement results of the long wire antenna method except for the grounding of a ground plane as reported in the previous paper. This paper also analyzes the influence of those factors on measurement results. The included factors are: the connection symmetry of an antenna counterpoise to a ground plane, the arrangement symmetry of a jig for a long wire antenna, and the wiring arrangement of a coaxial cable connected to an antenna.

Secondly, as a method to minimize the influence of the wiring arrangement of a coaxial cable, the Backside Cabling method which we propose is explained, and the effect of this method is verified based on measurement results.

Thirdly, the comparison is made between the measurement result which minimizes the influence of the wiring arrangement, and the analysis result of the electromagnetic field simulator. Then, it is shown that the analysis result, when considering the size and the connection method of a ground plane, is appropriate for the reference data of the long wire antenna method.

II. Analysis of factors influencing measurement results of the long wire antenna method

A. Connection symmetry of antenna counter poise

CISPR 25 requires the connection between the antenna counterpoise and ground plane for monopole antenna measurements. However, a commercially available counterpoise for the monopole antenna is a square metal plate with 600 mm dimensions. Due to the size limitation, the counterpoise cannot be connected to the ground plane directly. Therefore, EMC test sites usually prepare a dedicated counterpoise conforming to CISPR 25 and the connection method of a counterpoise to a ground plane differs depending on the test site. An analysis will be made for a case in which a counterpoise is not connected to a ground plane along its entire rear length (600 mm), or if there is a gap in the bonding of a counterpoise and a ground plane. This analysis examines the influence of a gap on the measurement results. The following demonstrates an experimental method used for the analysis.

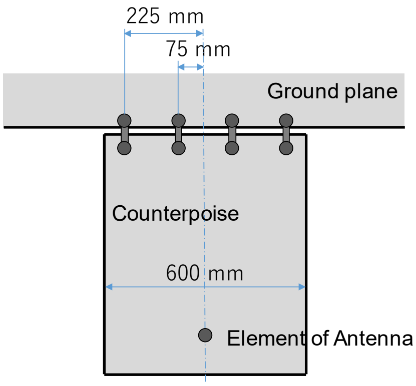

Fig. 1. *Connection between counterpoise and ground plane*

At the test site used for the experiment, the counterpoise and the ground plane are bonded with screws at four points where the ground plane extends over the counterpoise. The screw positions are 75 mm and 255 mm away from the center of the counterpoise to the both sides (Figure 1).

For this experiment, the above mentioned common setup is changed. A gap of 10 mm is made between the counterpoise and the ground plane. Braided straps 10 mm long by 5 mm wide are used for the connection using round terminals at the screw positions. Evaluation will be made if the number of connection points and the connection position(s) impact the measurement results of the long wire antenna method.

The number of connection points and connection position(s) are as follows: the common setup (Normal), two of four connection points at both ends (S, V) are connected, one point at feeding side (S) is connected, one point at inner feeding side (T) is connected, three points except for one at terminal side (S, T, U) are connected, and three points except for one at inner terminal side (S, T, V) are connected (Figure 2). Figure 3 shows the result of these experiments.

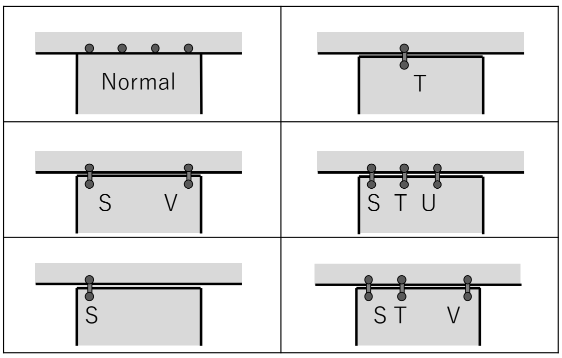

Fig. 2. *On the connection arrangements under the experiment*

These six experiments can be classified into three groups. First group consists of the data obtained from the common setup (Normal) and the setup with connections at both ends (S, V) (S, T, V). Second group consists of the data obtained from the setup with three connections other than one at terminal side (S, T, U) and the setup with one connection at inner feeding side (T). Third group consists of the data obtained from the setup with one connection at feeding side (S).

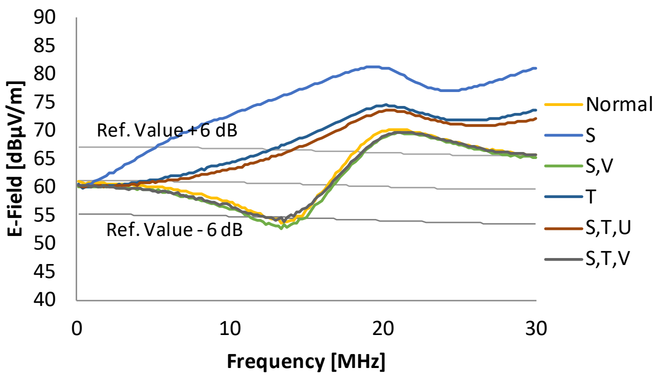

Fig. 3. *Influence of connection of counterpoise and ground plane on measurement results*

Regarding the first group, the data obtained from the setups with connections at both ends is similar to the common setup. This result is worthy of notice. Although the connection of the counterpoise is only made at points 225 mm away from the center and not along the entire rear length of the counterpoise, the result is similar to the common setup. As long as the connection between the ground plane and counterpoise is symmetrical, the influence of the connection on the measurement results is insignificant. By reviewing the experimental result from this perspective, the measurement data is classified into three groups depending on the difference in the length from both edges of the counterpoise to the first connection point, i.e. the difference in the length of the gap at both ends.

A test setup for the long wire antenna method is symmetrical except for the feeding coaxial cable. Regarding this method, the placement symmetry has a significant influence on the experiment results. This analysis demonstrates that the trend in measurement results corresponds to the degree of loss of symmetry.

B. *DUT arrangement symmetry*

The preceding section shows that the connection symmetry of a counterpoise and a ground plane has a significant influence on measurement results. On the other hand, a jig for a long wire antenna, treated as a DUT, is also symmetrically arranged with respect to a measurement antenna. Therefore, an analysis was made to know the characteristic variation when the symmetric property is lost.

For this analysis, the common setup (a counterpoise connected to a ground plane along its entire rear length) is used. A jig for a long wire antenna is placed at 0mm, 5mm, 10mm, 25mm, and 50mm away from the center of the antenna towards the terminal side. These positions are used as parameters. Measurement results are shown in Figure 4.

As the offset increases, the measurement value becomes greater. For an offset of 50 mm, there is no minimum value consistently observed at around 15 MHz at the test site used for this measurement.

The common setup has the minimum value at around 15 MHz due to the resonance, similar to the maximum value. The difference between the minimum value and the maximum value is that the depth of the minimum value, or a null point, becomes larger when the symmetric property of test setup is high. The long wire antenna method specified in Annex J is the measurement system having extremely high symmetry. Therefore, its measurement results could be greatly affected by the characteristic of a null point. A test setup with high symmetry causes a null point, but is often used for general measurement based on ALSE method. There is a possibility that values smaller than those expected in the reference setup are observed at a certain frequency.

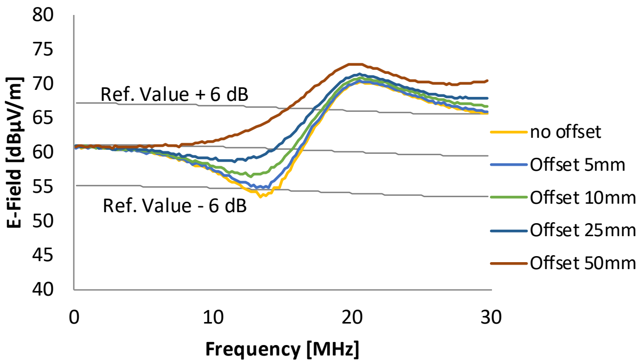

Fig. 4. *Influence of arrangement symmetry of DUT and measurement system (characteristic variation due to DUT position offset)*

C. *Wiring arrangement of coaxial cable for antenna connection*

In the previous report [5], the case in which a cable connector touches metal on the floor is reported as an influence on measurement results of the arrangement of a coaxial cable connected to an antenna. For consideration, a test setup specified in Annex J, or a setup with multiple ferrites on the cable, is used as a comparison reference. However, since one side of the coaxial cable is connected to the shielded surface of an ALSE, it cannot be said that there is no influence even though multiple ferrite cores are used. Therefore, an additional investigation was performed to confirm whether the wiring arrangement of a cable connected to an antenna has an influence on measurement results. (NOTE: As for some commercially available antennas, the cable jacket and a counterpoise float by the antenna function or the optional item.)

Measurement results obtained by using a FR-4003 made by NARDA Safety Test Solutions, which has a built-in EMI receiver and a fiber-optic cable connection, are used as the reference data not having influence of a measurement cable. Then a comparison between the results above and results taken conforming to Annex J with a 3301C made by ETS was performed. Figure 5 shows the result.

It was shown that the measurement results of 3301C having a coaxial cable connection and of FR-4003 resonate at a close frequency. However, the measurement results of FR4003 show a sharper resonance characteristic. This shows that the characteristics of ferrite cores used on the coaxial cable reduce the resonance.

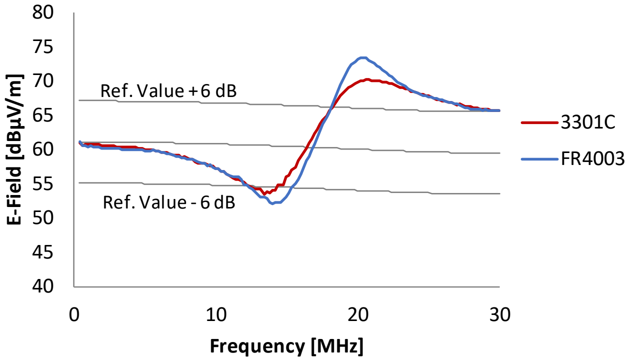

Fig. 5. *Influence of antenna connection cable on measurement results*

III. INVASIVENESS REDUCING METHOD BY MEANS OF CABLE ARRANGEMENT CONNECTED TO AN ANTENNA

The previous result is a comparison between different antennas, but there is a possibility that the differences arise from the antenna characteristics. Therefore, by using the same antenna the effect of cable wiring placement is investigated with the following method.

To minimize current inducted to a wire and to reduce the influence of the measurement system on measurement results, we would like to propose the Backside Cabling (B.C.). In this method, a cable used for measurement is routed (as much as possible) along the counterpoise, the ground plane, and the back of the ground strap.

In order to confirm the effect of this proposed method, a comparison to the common cable setup specified in Annex J was performed. In addition to 3301C used for the previous experiment, the HFH2-Z6E made by Rohde & Schwarz is used in order to confirm the influence of the antenna itself. Figure 6 shows the wiring arrangement of this experiment and Figure 7 shows the experiment result. (The test site related to Figure 7 is different from the test site related to Figure 1 through 5. Therefore, the sizes and frequency characteristics are not the same.)

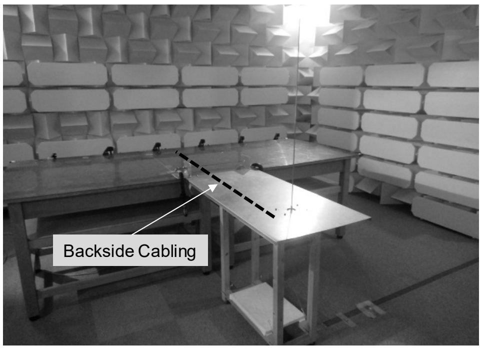

Fig. 6. *Low invasiveness cable arrangements using the B.C.*

Figure 7 shows that the experimental results using the B.C. have a sharper resonance for both antennas compared to those of the common setup. This feature is close to that of the antenna measurement result in Figure 5. Using an electromagnetic field simulator (MW-Studio2018, frequency domain solver, made by CST) Figure 8 shows the comparison to the analysis result of a model consisting of a ground plane, antenna, ground strap, and a jig for a long wire antenna (a coaxial cable is not included) (Figure 6)

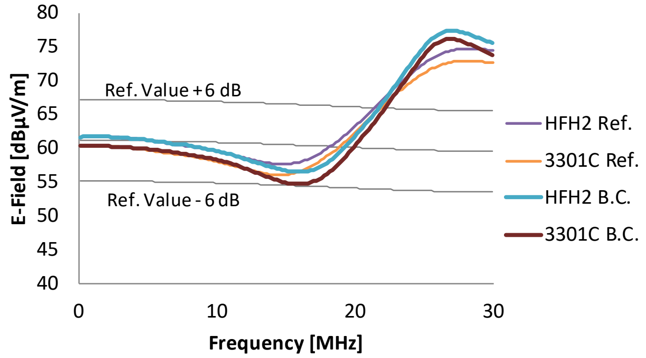

Fig. 7. *Influence of difference in cable arrangement on measurement results*

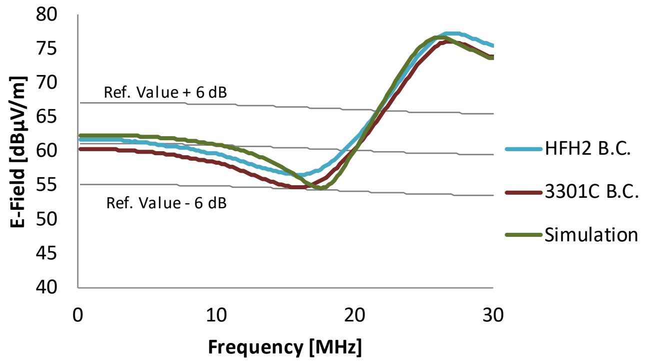

Fig. 8. *Comparison to analysis results*

Figure 8 shows that the experimental results and the analysis result have quite similar characteristics including a resonance frequency and sharpness of resonance. At all the frequency points in the measurement frequency range of a monopole antenna, the analysis result values and the experimental result values of the two antennas are within +/- 6 dB. The fact that the analysis result of the model without a measurement cable is in good agreement with the experimental result, shows that the measurement system in Figure 6 is a setup which is likely not influenced by cable arrangement.

In addition, it was shown that the analysis result values and the experimental result values are substantial reference data as well as test site characteristic data. It should be noted that since the analysis data and measurement results differ depending on specifications such as the ground plane of each test site, it is difficult to have different test sites bear the same characteristics. However, it can be said that by analyzing individual reference values and comparing the values to a measurement result, validity of an ALSE and measurement system can be evaluated for each ALSE.

IV. Conclusion

In this study, the effects of setup variables with respect to the long wire antenna method specified in CISPR 25 Annex J were evaluated. The result shows the following: the consideration of the connection of a counterpoise and the setup of a long wire antenna, measurement results had great variation when the arrangement symmetry was lost; the influence of a cable connected to an antenna cannot be disregarded even though multiple ferrite cores are used; Also, the B.C. can be used as a solution since this method effectively reduced the influence even when an antenna with a coaxial cable output was used.

Next, it was shown that the measurement result considering the above agrees with the electromagnetic field simulation result considering factors such as the size of a ground plane at a test site with the tolerance of +/- 6 dB. The issue was raised regarding the reference data used to confirm the validity of an ALSE.

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