Consideration of the Number of Test Bench Ground Straps in CISPR 25 Radiated Emission Test

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***Abstract*—This paper presents consideration of the number of test bench ground straps in CISPR 25 radiated emission test. Through the actual tests in which the number and locations of test bench ground straps were varied and interpretation of numerical simulation, we confirmed that the measurement value of field strength changed regularly in a particular frequency range (80 MHz ~ 200 MHz). The problem of bad repeatability that occurs frequently at numerous test sites is expected to be solved, if the standards on ground setup conditions become clearer through re-examination of ground conditions for CISPR 25.**

Key words: CISPR 25, Radiated emission test setup, test bench ground strap

I. INTRODUCTION

The schematic test setup in CISPR 25 for radiated emission testing is shown in Figure 1.

The electric field of test harness is measured with a monopole antenna in the frequency range from 150 kHz to 30 MHz, with a biconical antenna in the frequency range from 30 MHz to 200 MHz, and with a log periodic antenna in the frequency range from 200 MHz to 1000 MHz.[1]

As the radiated emission measurement results depend on the wave propagation characteristic of a test site, it is required to define the characteristic of test site to ensure a good reproducibility / repeatability and to obtain similar results from different test facilities.

For automotive component testing according to CISPR 25, the measured results depends on the absorber lined shielded enclosure (ALSE), the test bench (metallic table), and the artificial network (AN).

In particular, our focus is put on the changes in the characteristics according to the difference in ground (GND) conditions. Detailed conditions on the test bench GND and GND strap are as follows:

- The minimum dimensions of the test bench (GND plane) are defined in CISPR 25 (2200 mm wide, 1000 mm long).
- The height of the GND plane shall be (900±50) mm above floor.
- The plane should be bonded to the wall or floor of the shielded enclosure such that d.c. resistance would not exceed 2.5 mΩ.
- The distance from the edge of a GND strap to the edge of the next strap shall not be greater than 300 mm.
- The maximum length to width ratio for the GND straps should be 7:1.

As shown above, the standards of GND conditions for CISPR 25 are not clearly specified, and GND conditions are supposed to be set based on the situation at each test site. If the disparity of GND conditions influence measurement, the problem of bad repeatability would occur among different test sites.

To examine this issue, the paper analyzed the influence of GND strap connecting test bench and ALSE chamber GND on the noise source (NS) field strength through two tests. An analysis of each test was carried out based on the results of actual test and the results of numerical simulation.

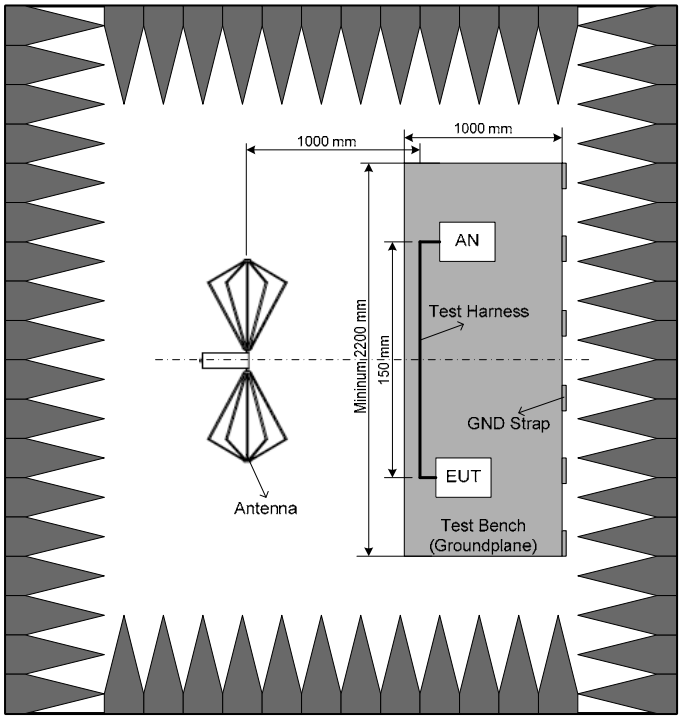


Figure 1. Example of RE test setup – biconical antenna

II. Analysis of Validation Test

A. Validation Procedure

We tested for the frequency range from 1 MHz to 1000 MHz. Instead of the NS, the wire and the artificial network, a small antenna should be used to generate a well defined electronic field. Our new validation procedure uses a 'comb generator' (small monopole antenna) instead of the test harness which improves the repeatability and avoids impedance problems of the artificial network and the NS.[4] Comb generator radiates regular signals at 1 MHz in the frequency range from 1 MHz to 1000 MHz. Also, the field strength detected by antenna is measured using EMI receiver.

The height of the antenna above the GND plane of bench is 50 mm. The dimension of our test bench is 2,400 mm wide, 1000 mm long, and 900 mm high. The distance from the edge of a GND strap to the edge of the next strap is less than 300 mm, and they are rather evenly spaced from P1 to P6. as shown in Figure 2.

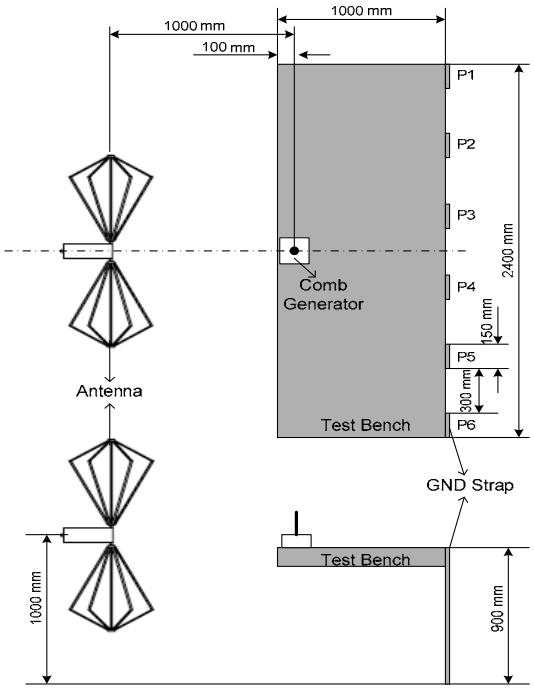


Figure 2. Setup of validation test

The setup of the numerical simulation are as follows.

The condition of the test bench GND and GND strap is the same as the real validation test. The boundary condition is 'Open' for not being reverberated. In the test, 'Ideal monopole antenna' was used instead of comb generator, 'E-fiend probe' instead of measurement antenna.

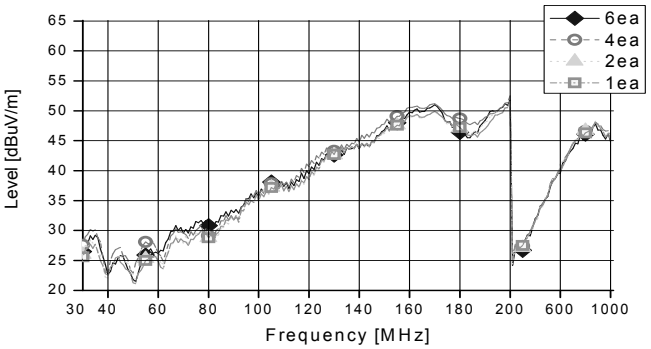
B. Test on the Changes in the Number of Test Bench GND Straps

We varied the mumber of straps connecting the test bench and ALSE floor GND. After starting with six straps, we reduced the number to four, two, and one.

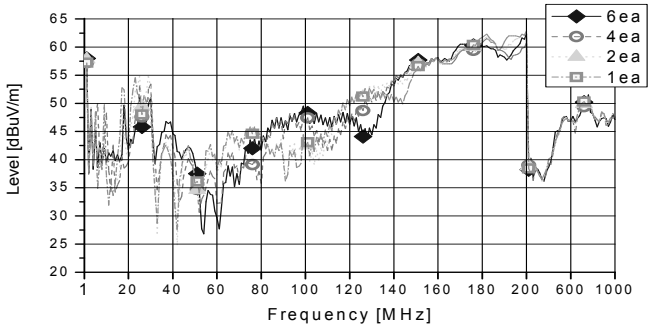
The GND straps were placed:

- Six GND straps at P1 ~ P6
- Four GND straps are at P2 ~ P5
- Two GND straps are at P3, P4
- One GND strap are at P3

Polarity of antenna was measured in horizontal and vertical modes, and the peak level during one-second time limit was detected at 1 MHz step in the frequency range from 1 MHz to 200 MHz, and at 20 MHz step in the frequency range from 200 MHz to 1000 MHz.



(a) In horizontal mode



(b) In vertical mode

Figure 3. Measured electric field strength vs. frequency by changing the number of straps

Field strength did not show much variance according to the changes in the number of GND straps in the horizontal mode (Figure 3.(a)), but showed considerable variance in the vertical mode (Figure 3.(b)). Thus, we only analyzed the results of the measurement in the vertical mode. Also, we focused on the frequency range from 30 MHz to 200 MHz in which the design of the GND plane is most critical.

The discontinuity that appears at 200 MHz is generated because of the length of output antenna of the comb generator is changed at 200 MHz (300 mm / 70 mm).

Figure 4 shows the results that appeared in the frequency range from 30 MHz to 200 MHz in the vertical mode.

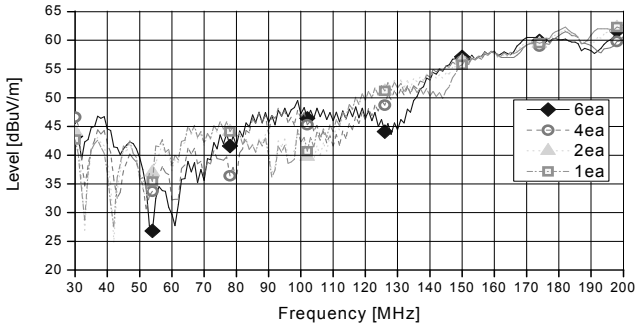


Figure 4. Measured electric field strength vs. frequency by changing the number of straps (from 30 MHz to 200 MHz in vertical mode)

As seen from the results shown in Figure 4, reduction of the number of GND straps from the side led to decreased field strength in the frequency range from 80 MHz to 120 MHz, and to increased field strength in the frequency range from 120 MHz to 140 MHz.

The results of numerical simulation shown in Figure 5 also show the pattern of decrease and increase in field strength in the same frequency ranges. (The output level is different from the actual test because the characteristics of NS used in the simulation and those of the comb generator used in the actual test are different from each other and the simulation is intended for relative comparison rather than confirmation of the absolute value of field strength.)

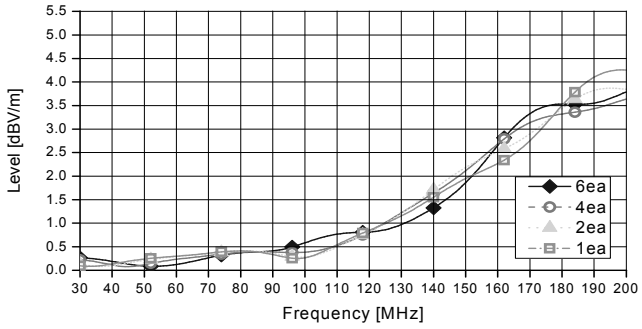


Figure 5. Simulated electric field strength vs. frequency by changing the number of straps

With this test, we confirmed that the field strength changes regularly according to changing the number of GND straps within specific frequency range.

C. Test on the Changes in the Locations of Test bench GND straps

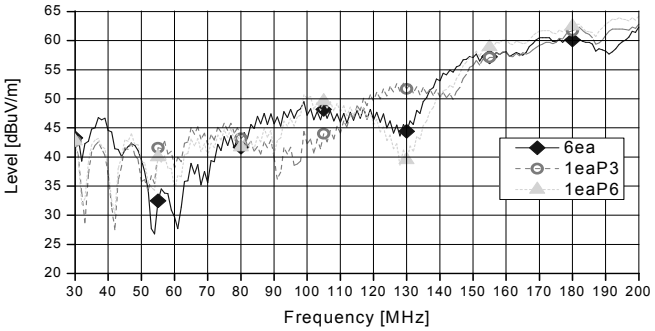
We carried out the test on the influence of the locations of the GND straps.

We tested on three cases, with one GND strap, two GND straps, and four GND straps, respectively. For each case, we compared the results of when the GND strap location was in the middle of the test bench and when the location was at the side(s).

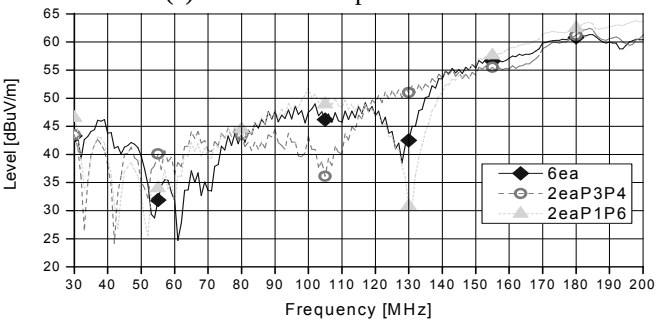
The GND straps were placed:

- One GND strap at P3 versus P6
- Two GND straps at P3,P4 versus P1,P6
- Four GND straps at P2, P3, P4, P5 versus P1, P2, P5, P6

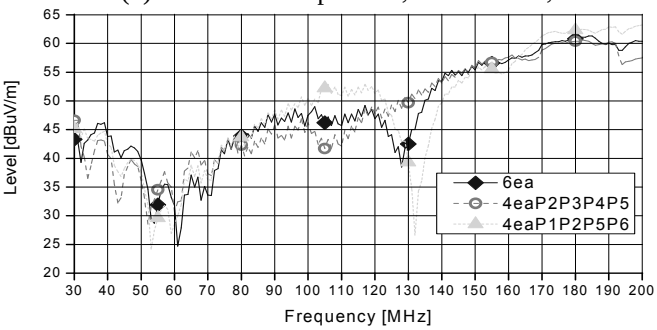
As in the previous test, we tested in the frequency range from 30 MHz to 200 MHz in the vertical mode, which showed the greatest influence.



(a) One GND strap at P3 versus P6



(b) Two GND straps at P3,P4 versus P1,P6



(c) Four GND straps at P2, P3, P4, P5 versus P1, P2, P5, P6

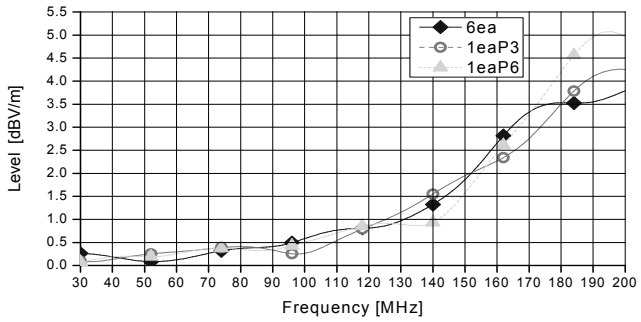
Figure 6. Measured electric field strength vs. frequency by changing the locations of straps

As seen from the results shown in Figure 6, GND straps located at the side(s) increases the field strength in the frequency range from 80 MHz to 120 MHz and decreases the field strength in the frequency range from 120 MHz to 140 MHz. On the other hand, GND straps located in the center has an opposite influence compared to the GND straps at the side(s). We can see that the gap of field strengths in the frequency range with the largest difference is above 10 dB.

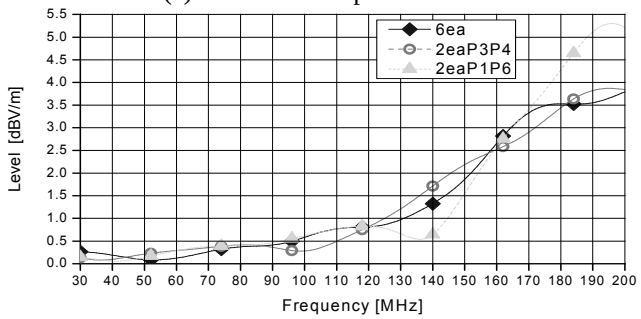
Figure 7 shows the results of numerical simulation. The frequency range, in which the change occurs, and the patterns of the results, are the same with those of the actual test.

The reason that the field strengths of NS measured in the above two tests show large variance according to the number of GND straps in the frequency range from 80 MHz to 200 MHz is because, the GND setup conditions (dimension of test bench - 1 m * 2.4 m, length of GND strap - 0.9 m) are similar to the wave length (λ) in the relevant frequency range.

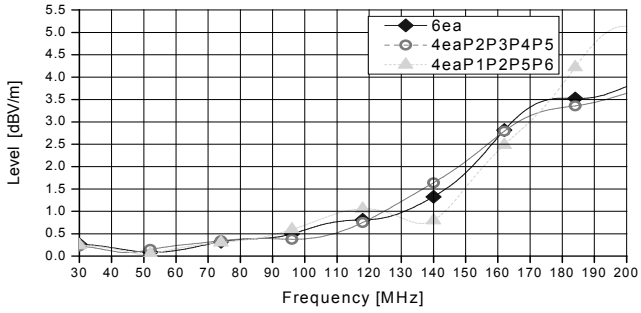
Changes in the field strength occur according to the number and locations of GND straps because the narrow GND area of comb generator leads to the formation of the field as the GND plane of the test bench, and the surface current flow moving out to the ground changes according to the locations of straps connected to ALSE floor. This is based on the same principle as the changes in radiation characteristics according to the locations and widths of GND at designing PIFA (Planar Inverted-F Antenna).[3]



(a) One GND strap at P3 versus P6



(b) Two GND straps at P3,P4 versus P1,P6



(c) Four GND straps at P2, P3, P4, P5 versus P1, P2, P5, P6

Figure 7. Simulated electric field strength vs. frequency by changing the locations of straps

III. CONCLUSION

This paper analyzed the correlation between the number and of locations of GND straps in the CISPR 25 RE test setup and NS field strength through actual tests and numerical simulation, and verified that the GND conditions have a major influence on the measurement of field strength in a particular frequency range (80 MHz ~ 200 MHz).

In this relation, we would like to propose that the number and locations of GND straps be clearly stated in the CISPR 25 RE tests to deal with the problem of bad repeatability occurring based on different GND conditions in various test sites.

Future tests that examine the influence of coupling characteristics of measurement antenna are required for more accurate analysis. Also, we will conduct further tests and analyses with various conditions of GND strap (amount increase, interval coordination etc.) to find the exact location that influences the radiation of side GND and center GND.

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