Improvement of Radiated Emission Measurement Reproducibility by VHF-LISN

- Interim Results of International Inter-Laboratory Comparison -

Shinichi Okuyama
EMC Center
NEC AccessTechnica, Ltd.
800 Shimomata, Kakegawa, Shizuoka, 436-8501 Japan

Katsuyuki Tanakajima
Calibration/Engineering
Intertek Japan K.K.
3-2 Sunayama, Kamisu, Ibaraki, 314-0255 Japan

Kunihiro Osabe
Accreditation Operations Department
Voluntary EMC Laboratory Accreditation Center Inc.
7F NOA Bldg, 2-3-5 Azabudai, Minato-ku, Tokyo, 106-0041 Japan

Hidenori Muramatsu
Coordinator
VCCI Council
7F NOA Bldg, 2-3-5 Azabudai, Minato-ku, Tokyo, 106-0041 Japan

***Abstract*—At present, radiated emission measurement standards do not specify the common mode impedance for the outlet terminal of mains network to equipment under test (EUT) in the test site. Because of the difference in the terminating condition of EUT power cable which dominantly causes radiated emission in the frequency range between 30 MHz and 300 MHz, radiated emission measurements of a tabletop EUT are poor in reproducibility. In an effort to resolve this issue, we developed a device called very high frequency line impedance stabilization network (VHF-LISN) and investigated its effectiveness. After performing the domestic inter-laboratory comparison, we proposed an international inter-laboratory comparison program to CISPR Subcommittee I, and the proposal was accepted. For the comparison purpose, we have investigated the reproducibility also by using a common mode absorbing device (CMAD) and a versatile coupling/decoupling network of AC mains for emission testing (CDNE-M). This investigation is just in progress as a future work of CISPR SC-I WG2 until February, 2014. As a glance from an interim result, we could find that all devices are effective to improve the reproducibility of radiated emission measurement in comparison with the case of no such device. But also we were able to presume that the effectiveness of devices to the measurement reproducibility differs with the type of EUT.**

Keywords—Very High Frequency Line Impedance Stabilization Network (VHF-LISN); power cable; radiated emission; comparability among sites; measurement reproducibility

I. INTRODUCTION

At present, measurement standards and technical standards for radiated emission measurement do not specify impedance for the power source of a measurement site that supplies power to the equipment under test (EUT). Consequently, in radiated emission measurements for tabletop EUTs, radiated disturbances from the EUT power cable vary with the impedance between the power line and the ground in the power source of each site. This has been the cause of significantly poor reproducibility.

In an effort to resolve this issue, a device called very high frequency line impedance stabilization network (VHF-LISN) was developed by us. [1][2][3][4] And its effectiveness to the reproducibility of radiated emission measurements was investigated by the domestic inter-laboratory comparison. [5] Thereafter, an international inter-laboratory comparison test has been proposed and accepted to WG2 of CISPR Subcommittee-I. The comparison test is now under progress. In order to investigate the effectiveness of the VHF-LISN, a commercial tower PC and a fabricated comb generator have been used as the EUTs. For the comparison purpose, a common mode absorbing device (CMAD) which has been proposed to the radiated emission measurement setup by CISPR Subcommittee-A, and a versatile coupling/decoupling network of AC mains (CDNE-M) proposed by U.K expert member has been also investigated to the reproducibility of radiated emission test. This investigation is just in progress as a future work of CISPR SC-I WG2 until February, 2014. We had described that intermediate result in this paper.

II. DESCRIPTION OF DEVICES UNDER TEST

A. *Very High Frequency Line Impedance Stabilization Network (VHF-LISN)*

The VHF-LISN is intended to insert between the EUT power cable and the power supply outlet on the ground plane, as illustrated in Fig. 1. The practical performance specifications were determined based on CISPR 16-1-2 and verified the compliance with these specifications as shown in Table I. Fig. 2 shows the external and internal views of the VHF-LISN. Fig. 3 is the circuit diagram of the VHF-LISN. The constants of components are adjusted to the specifications of Table I.

Fig. 4 shows the impedance characteristics, while Fig. 5 shows the phase characteristics.

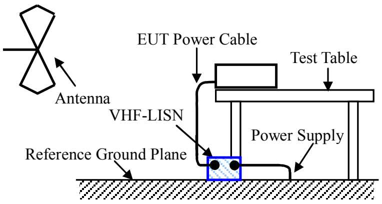

Fig. 1. Intended Use of VHF-LISN

TABLE I. SPECIFICATIONS OF VHF-LISN

Topic	Practical Performance Specifications	Verified Specifications
Frequency range	30 MHz to 300 MHz	30 MHz to 300 MHz
Impedance	50 Ω ± 20 % (i.e., 50 Ω ± 10 Ω)	50 Ω ± 2 Ω or less
Phase	0 deg ± 20 deg	15 deg or less
Isolation	Over 30 dB	40 dB or more

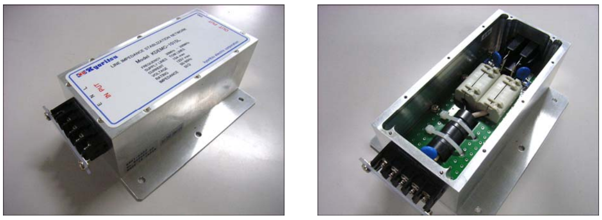

Fig. 2. External and Internal Views of VHF-LISN

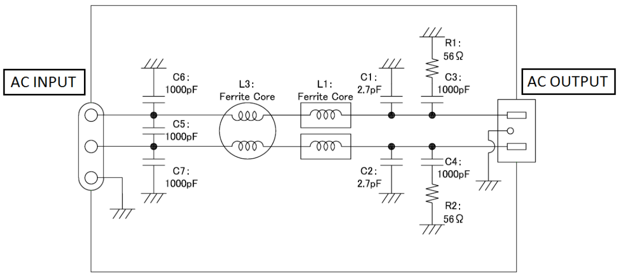

Fig. 3. Circuit Diagram of VHF LISN

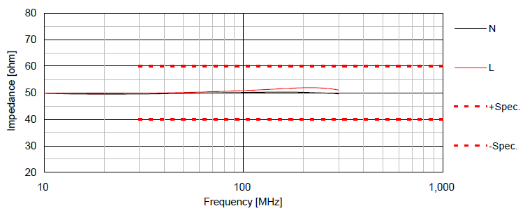

Fig. 4. Impedance Characteristics

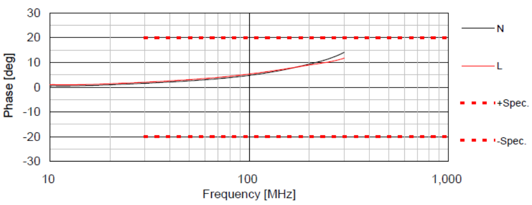

Fig. 5. Phase Characteristics

B. Common Mode Absorbing Device (CMAD)

The CMAD has been considered for a device used to suppress common mode disturbance radiated from the EUT power cable as illustrated in Fig. 6. Fig. 7 shows an external view of the CMAD.

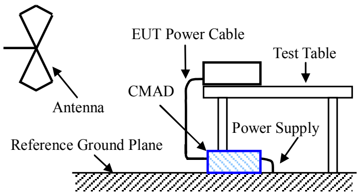

Fig. 6. Intended Use of CMAD

Fig. 7. External View of CMAD

C. Versatile Coupling/Decoupling Network of AC Mains for Emission Testing (CDNE-M)

This device can be provided both types (Balanced and Unbalanced) of impedance configurations by the use of adaptors. We investigated the reproducibility with both configurations. Fig. 8 shows the external views of the CDNE-M. Fig. 9 is the circuit diagram of the CDNE-M and adapters. These photo and circuit diagrams were quoted from Type 16XM2 Versatile ISN/CDNE-M User's Manual. [6]

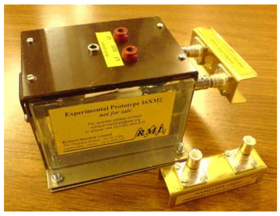

Fig. 8. External View of CDNE-M

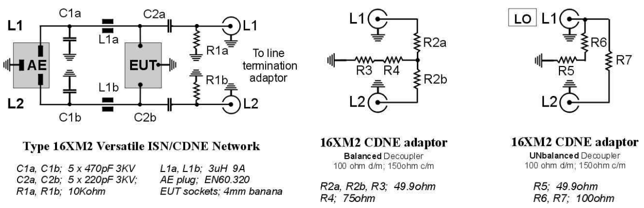

Fig. 9. Circuit Diagram of CDNE-M and adapters

III. INVESTIGATION DETAILS AND RESULTS

A. Investigation Details

1) Dates and Test Sites: For the purpose of correlation among test sites, the international inter-laboratory comparison measurements were started from May, 2013 at 20 sites by using their own semi-anechoic chambers (SACs) in 11 countries nominated by WG members as shown in Fig.10.

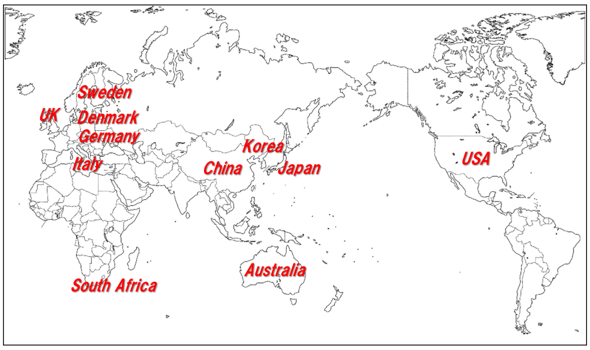

Fig. 10. Participants of International Inter-laboratory Comparison Program

2) EUTs: The inter-laboratory comparison measurements were performed with two EUTs; a comb generator and a tower PC. Fig.11 shows their external views. The EUTs were circulated from one site to another site within one economy in the manner of round-robin.

a) Comb generator: The comb generator under test is driven by AC mains power. The common-mode signal from this EUT is simultaneously injected to both L and N wires of the EUT power cable.

b) Tower PC: To investigate the emission from the mains cable of EUT and to eliminate other potential noises, the tower PC under test was modified to activating only the power supply module during measurement.

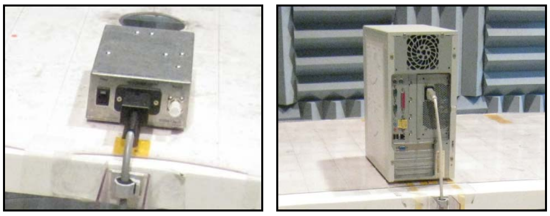

Fig. 11. External View of Comb Generator (Left) and Tower PC (Right)

3) Measuring Instruments: Participants' receiving antenna, attenuator, preamplifier, spectrum analyzer, coaxial cable and table were used to perform the round robin test.

4) Measurement Process: Fig. 12 shows the measurement system and Fig. 13 shows the measurement setup for the tests. Each measurement process consists of the steps below.

a) To place the EUT with its reference point positioned to the center of the turntable.

b) To secure the EUT power cable using the fixing pillar of PVC (polyvinyl chloride) for the vertical direction and the wiring platform of polystyrene foam on the ground plane. And to eliminate routing differences among sites and among devices under test as much as possible.

c) To maximize the receiving level of the radiated emission from the EUT power cable. And to set the receiving antenna for the vertical polarization measurement.

d) To rotate the turntable by one turn along with moving the antenna height between 1 m and 2.5 m. And to perform the radiated emission measurement for the frequency range of 30 MHz to 300 MHz and to obtain the Max Hold value.

5) Measurement Conditions: The measurement process mentioned above was repeated under the following conditions differentiated by the device under test.

- Condition 1, "Without Device": This is the "as is" condition for the radiated emission measurement serving as the reference standard for the comparison among sites.
- Condition 2, "VHF-LISN": The EUT power cable is connected to the receptacle of the VHF-LISN and the power cable of the VHF-LISN is connected to the power source outlet of the test site.
- Condition 3, "CMAD": An extension power cable is connected to the EUT power cable and clamped at the position leaving the test volume. The setup is adjusted so that the extension power cable is clamped at the same position as the VHF-LISN connects to the EUT power cable under Condition 2.
- Condition 4, "CDNE-M with Balanced Adapter": The EUT power cable is connected to the power connecter of the CDNE-M and the power cable of the CDNE-M is connected to the power source outlet of the test site. This condition is used with balanced adapter.
- Condition 5, "CDNE-M with Unbalanced Adapter": The measurement setup is same except to use unbalanced adapter.

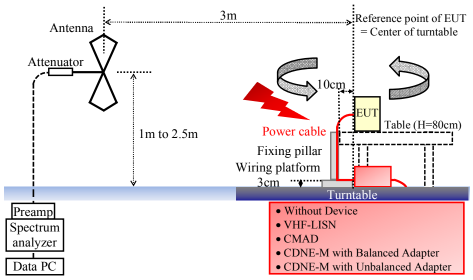

Fig. 12. Measurement System for Inter-laboratory Comparison Measurements

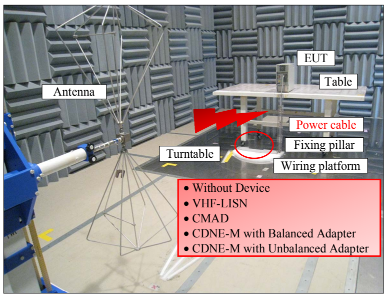

Fig. 13. Measurement Setup for Inter-laboratory Comparison Measurements

B. Results

1) Scrutinizing of the measurement result

We have received the final data from 7 test sites. But we removed two test results for the following reasons.

a) A test site used the movable turntable, so the routing of AC mains cable of EUT became the different from the specified conditions.

b) One test site performed the measurement by using a extended wide band type biconical antenna, so called shortened type biconical antenna. It was different from the specified antenna for the round robbin test.

2) Results with Comb Generator

Fig. 14 shows the standard deviations by devices, which are calculated to a total of all measurement results with the comb generator. The standard deviation having the maximum 6 dB under the condition 1 (without device) was decreased approximately to 2 dB by adding the terminating control devices to the power cable of the comb generator.

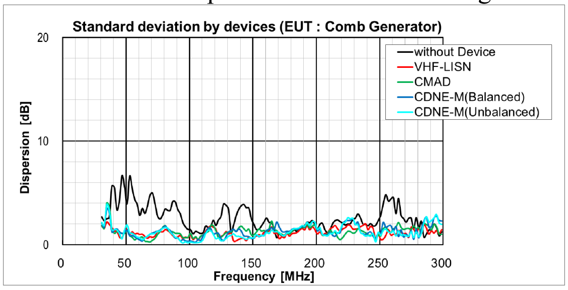

Fig. 14. Standard Deviation by devices (EUT: Comb Generator)

3) Results with Tower PC

Fig. 15 shows the standard deviations of tower PC measurement by devices, which are calculated to a total of all measurement results with the tower PC. The standard deviation having the maximum more than 9 dB under Condition 1 (Without Device) was decreased approximately to 3 dB by adding the VHF-LISN and the CDNE-Ms. On the contrary, the case of CMAD the maximum standard deviation were still kept higher values of more than 6 dB.

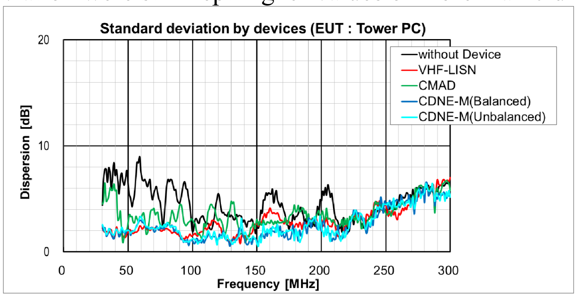

Fig. 15. Standard Deviation by devices (EUT: Tower PC)

IV. SUMMARY

The effect of termination devices was investigated at 5 sites with comb generator and Tower PC. The interim results of the investigation indicate that the addition of the each device to the outlet terminal of the mains network for supplying power to the EUT is effective and viable for improving the measurement reproducibility in comparison to the case without such a device.

However, from the investigation we found that the effectiveness of devices differs with the type of EUT.

V. CONCLUSION

As an interim result by the 5 test sites, we could see the similar tendency of the result which we carried out at 9 test sites in Japan last year. In addition, because no impedance is defined by any standard at present, we cannot discuss which value is correct but the average value of the VHF-LISN was shown the almost same characteristics with the average without device as shown in Fig.16 and Fig.17. From the above interim results, we assume the VHF-LISN is the best device to improve the measurement reproducibility of the radiated emission measurement.

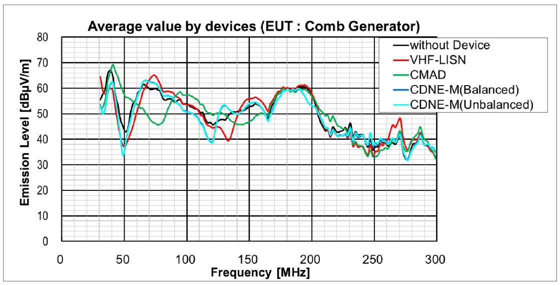

Fig. 16. Average Values by devices (EUT: Comb Generator)

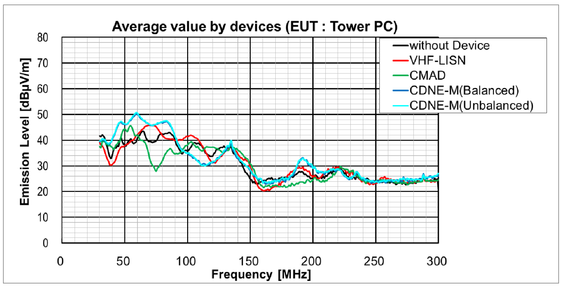

Fig. 17. Average Values by devices (EUT: Tower PC)

VI. FURTURE WORKS

The end of the international inter-laboratory comparison measurements is a schedule in February, 2014. We are going to make a final report if this program is completed on time.

ACKNOWLEDGMENT

This investigation was performed by VCCI Technical Subcommittee. We would like to express thanks for their effort.

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