Results of EMC round robin test on emission and immunity tests

(3) Conducted immunity round robin test

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Abstract - In the previous reports, we explained the round robin tests on the radiated and conducted emission test and Radiated immunity research report/result. In this report, we reveal methods and procedures of Round-Robin test (RRT) on conducted immunity test by KEC's EMC Special Committee Working Group, as well as we report and examine the results of the Round Robin testes from the participating originations.

Keywords – EMC; Round Robin Test; Comparison test; Conducted Immunity; IEC61000-4-6

1. Introduction

The Kansai Electronic Industry Development Center (KEC) established and operates a specialized organization on EMC as a public utility, and makes various efforts on EMC. The EMC Special Committee Round Robin Test Working Group has planned, prepared, and evaluated the methods for correlation testing between laboratories on various tests regarding EMC so far. We have already reported that experimental results of round robin tests on conducted and radiated emission and radiated immunity tests [1], [2], [3]. The round robin tests on emission tests has been planned by multiple accreditation bodies and many of the laboratories to be accredited have participated. On the other hand, no method has been established for immunity testing, so far there is no report on the round robin test. Consequently, individual laboratories could not compare and verify the results of their own tests with other laboratories and could not validate the results and the equipment. This time, following the radiated immunity testing described in the previous report, we conducted the round robin test on conducted immunity testing, and report the method and experiment results. We publicize them aiming to improve the reproducibility and problems of this test and to raise the quality of future immunity tests.

2. Outline of conducted immunity test

The conducted immunity test is specified in the IEC 61000-4-6[4], which is used as a harmonized standard in Europe. This proficiency test item must be performed by the bodies that acquire laboratory accreditation under ISO/IEC 17025.In this standard, high frequency voltage is applied to the EUT in the frequency range of 150 kHz to 80 MHz to check for malfunction. The applied high-frequency voltage is determined by the voltage between the conductive wire and the ground, and when the voltage higher than the specified voltage is applied, the test is stricter than the requirement. Also, it is not permitted to apply a voltage lower than the specified value. The accuracy of the test depends on how the tester applies a voltage with a small deviation from the specified voltage. Fig. 1 shows an example of the test equipment.

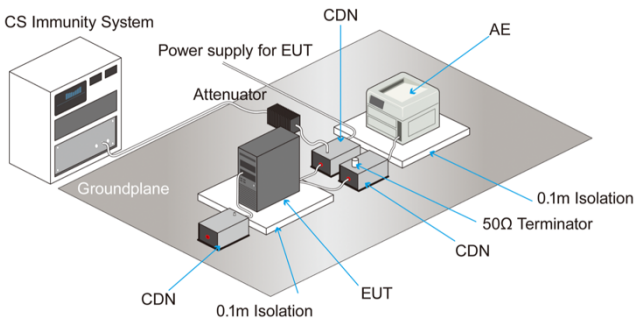

Fig. 1 An example of testing configuration in IEC 61000-4-6

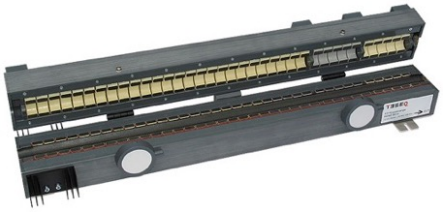

Fig. 2 EM clamp used in IEC 61000-4-6

Fig. 3 External view of CDN-S1

3. Content of implementation items

Before performing the round robin test on conducted immunity, some preliminary experiments were conducted by the participating members and the following items were agreed; 1) Methodology, 2) Testing procedure, 3) Artificial EUT for RRT and 4) Unified test conditions.

If an actual product was used as EUT during RRT, it might be impossible to make a stable comparison in monitoring situation and level of malfunction. Thus, artificial EUT was prepared to compare the test results at each testing laboratory. The artificial EUT was constructed referring to the circuit for evaluation of uncertainty proposed by ELMAC Service (UK). The round robin test was performed applying a specified voltage of 3 V to the artificial EUT and comparing the line-to-ground voltage at the monitor terminal. Fig. 4 shows the circuit configuration of the artificial EUT in use, Fig. 5 is the external view, and Fig. 6 is the internal view.

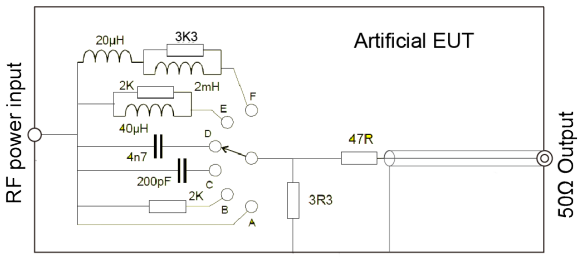

Fig. 4 Circuit diagram of artificial EUT

Fig. 5 External view of artificial EUT

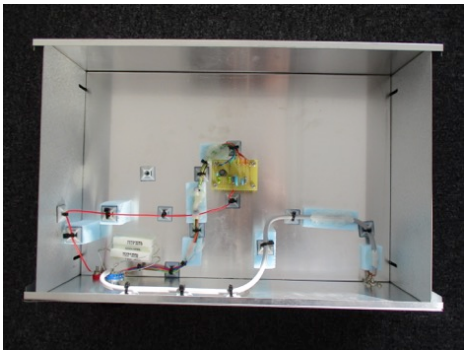

Fig. 6 Internal view of artificial EUT

4. Test conditions and procedures

The conditions determined by the preliminary experiments and the contents included in the procedures are shown below. For the matters that are not described in the procedures, we decided to follow each company's procedures and technical judgment.

4.1 Common procedures for test

The common procedures for the test are shown below:

1) Two modes selecting switch A and switch F were used out of the switches A through F (6 modes at the maximum) in the circuit configuration of the artificial EUT. (See Fig. 4)

2) Test conditions

- Applied frequencies; 0.15-80 MHz, 5% step
- Modulation: unmodulated
- Test level: 3 Vrms
- Dwell time: 3 s or more

3) Spectrum analyzer (SA) settings

Two band configurations (601 sampling points) consists of band-1 starting from 150 kHz and ending at 5 MHz and band-2 starting from 5 MHz and ending at 80 MHz with RBW and VBW setting to 10 kHz and 30 kHz, respectively. The sweep speed was set to "Automatic".

4) A high-power attenuator (2 W) of 20 dB or more was inserted in the front stage of the spectrum analyzer.

5) Test conditions: CDN method and EM clamp method according to IEC 61000-4-6.

4.2 Equipment used for testing

Table 1 lists the equipment commonly used by the laboratories participating in the round robin test.

Table 1 Test equipment commonly used in the round robin test

Test Equipment	Model #	Remarks
Artificial EUT	none	Made by WG
Artificial AE	none	Made by WG
CDN (S1)	KSI-8009	Kyoritsu Corporation
ATT (20dB:2W)	UFA-01NPJ-20	Tamagawa Electronics
EM clamp	KT30, others	Prepared by each laboratory
ATT (10 dB)		Prepared by each laboratory

4.3 Test details

The test results of two items 1) injection by CDN and 2) injection by EM clamp were intended to be compared among the participating laboratories. An outline of the experimental setup is shown in Fig. 7. The measured attenuation character of the manufactured artificial EUT are as shown in Fig. 8. The equivalent circuits of "switch A mode" and "switch F mode" are shown in Figs. 9 and 10, respectively. The output voltage of the artificial EUT was observed with the CDN. The measurement conditions are shown in Table 2.

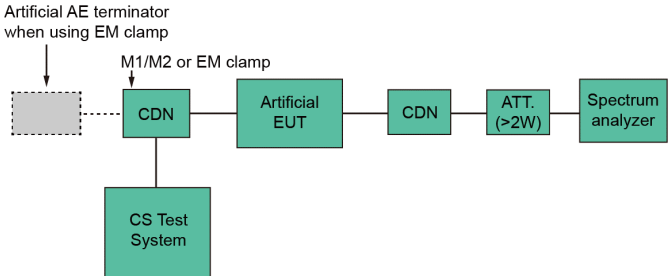

Fig. 7 Diagram of Conducted immunity RRT

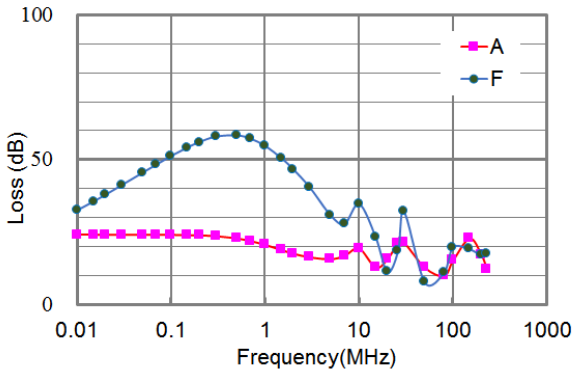

Fig. 8 Attenuation of artificial EUT

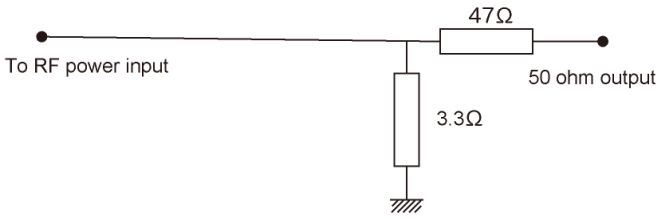

Fig. 9 Equivalent circuit of artificial EUT Switch A

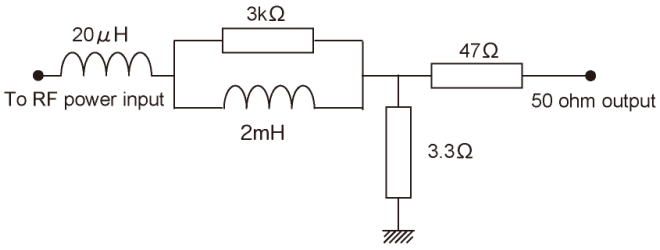

Fig. 10 Equivalent circuit of artificial EUT Switch F

Table 2 Round robin test comparison condition

Injection side		Monitor side	
	AE	Voltage monitor	Artificial EUT Switch
CDN	Open	CDN	A
			F
EM clamp	Artificial AE (150 Ω)	CDN	A
			F

5. Results of the experiment

16 laboratories participated in the round robin test and obtained the results from totally 22 equipment employed in these laboratories. Fig. 11 shows the RRT results from injection using CDN, and Fig.12 shows the results from injection using EM clump.

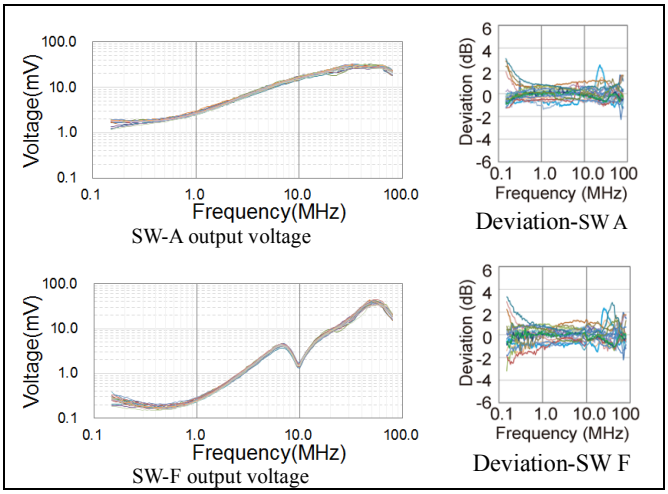

Fig. 11 Results of CDN injection

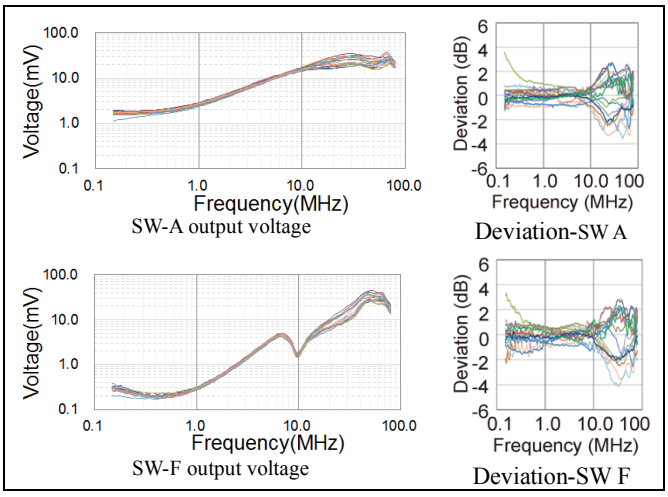

Fig. 12 Results EM clamp injection

Based on the obtained results from the experiment, the following facts are observed:

1) Output voltage values were significantly low below 5 MHz.
2) Deviations among testing laboratories were observed to some extent around 150 kHz and above 10 MHz.
No significant deviation is observed in other frequency range regardless of large output voltage range in dB.
3) Deviations of results from injection using EM clamp were relatively higher than CDN.

6. Discussion and Conclusion

The results of experiment show that deviation increases especially in case of injection using EM clamp. Fig. 13 shows the frequency distribution for representative injection frequency when EM clamp is used for injection with Switch A mode.

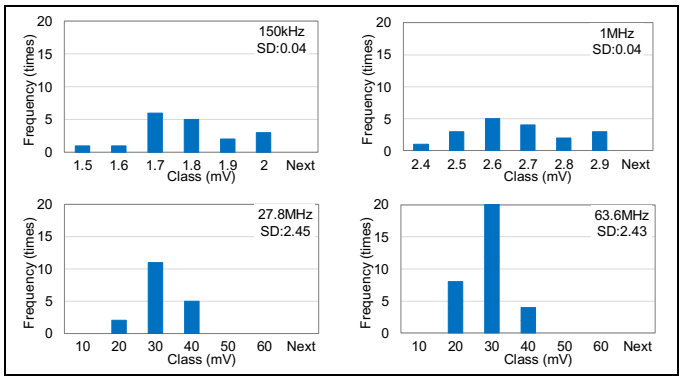

Fig. 13 Frequency distribution of classified voltage monitored with Switch A mode at representative frequency

It seems that the dispersion tendency differs at each frequency, suggesting that the cause of the dispersion is different at each frequency. We considered the cause of the dispersion as follows:
1) Output voltage is significantly low around 150 kHz and 1 MHz, therefore measurement sensitivity is insufficient. we reached to the conclusion that the injected voltage should be raised to 10 V in order to ensure the dynamic range at 150 kHz and 1 MHz.
2) Different condition is used above 10 MHz in reference value measurement of the testing system. In measuring the reference value at frequencies above 10 MHz, allowable range for the target value is set so that it might distribute equally within the range. We consider that it may be a cause of difference from normal distribution.

Although some extent of dispersions between laboratories at each frequency were observed by the round robin test, as a whole, stable results were obtained, and in case that an unusual value is found caused by misconfiguration, etc. it was clearly verified, therefore in our judgement the method of the round robin test on conducted immunity test developed by our WG is sufficiently effective. It is noteworthy that the method of comparing the output voltage using the artificial EUT is effective. On the other hand, as measurement sensitivity at around 150 kHz may not be enough, therefore a problem remains concerning the validity of injected voltage of 3 V accordingly.

During experiment we confirmed that monitoring voltage changes depending on the setting of passing frequency bandwidth when a spectrum analyzer is used as a voltage monitor, then recognized it is extremely important to set adequate allowable range and passing frequency bandwidth in reference measurement to improve measurement accuracy. In order to make it possible to continuously utilize this method, we would like to have comments and opinions from various aspects on this study.

Acknowledgment

This experimental study was conducted as a part of the working group activities of the Kansai Electronic Industry Development Center (KEC). EMC testing laboratories, certification bodies, and equipment manufacturers mainly take parts in the activities in the working group. Many people and related organizations cooperated with our joint experiments. We are thankful for everyone's guidance and encouragement to pursue this study.

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REFERENCES

[1] Y. Okuda, Y. Asaji, C. Asaba, M. Okumura, H. Shida, H. Ninomiya, K. Masaoka, Y. Mimura and O. Wada, Results of EMC round robin test on emission and immunity test (1) Radiated and conducted emission tests 115(217): August 28, 2015. p.25-30
[2] Y. Okuda, M. Inoue, H. Shida, H. Ninomiya, K. Masaoka, M. Yamanaka and O. Wada, *"Results of EMC round robin test on emission and immunity test (2) Radiated immunity round robin test "* IEICE technical report: 116(253): October 20-21, 2016. p.5-10
[3] Hiro Shida, Osami Wada, Y. Asaji, K. Otani, H. Shida, H. Ninomiya, Y. Okuda, and M. Inoue, "*Influence of test table materials on radiated immunity test: Report on investigation using a giant anechoic chamber"* 2018 IEEE International Symposium on Electromagnetic Compatibility and 2018 IEEE Asia-Pacific Symposium on Electromagnetic Compatibility (EMC/APEMC)
[4] IEC 61000-4-6:2013 Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields

