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Verification method for quasi-test site used in measuring radiated electromagnetic disturbance from EUT unable for conventional test site

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Abstract

Abstract—In this paper, regarding the measurement of radiated emissions from 30 MHz to 1 GHz, it has been studied that the method to verify whether it can be applied as a quasi-test site in the place that is not conventionally used as a test site, assuming the inside of the factory of electronic and electrical equipment manufacturers. We proposed a method for evaluating the site insertion loss (SIL) of a quasi-test site using the site attenuation (SA) evaluation method of a test site specified in CISPR 16-1-4. As the results of the evaluation using an ideal semi-anechoic chamber (SAC) with no reflection of surrounding obstacles, for the ΔSIL at the limited height scanning of the receiving antenna between 1 m - 2 m, it was found that the deviation from SA_{SAC} was within 2.2 dB. In addition, it was found that at least more than five measuring points between 1 m - 2 m would be needed for the deviation within 2.4 dB. It is shown that the measurement of ΔSIL can verify the characteristics of the quasi-test site where the measurement environment is limited such as FIS (factory inspection site) with a simple procedure.

1 Introduction

In recent years, as the number of devices that use radio waves has increased rapidly and the frequencies used have become wider, the regulations under the Radio Law and the regulations for unnecessary radiation radio waves have also changed. Furthermore, as the frequencies used have expanded, the usage scenes have expanded beyond those intended for communication, and have become diversified. For example, there are wireless power transmission systems that use an intermediate frequency band of 30 MHz or less to send power to electric vehicles and large buses, and large-scale medical diagnostic equipment in hospitals that use the ISM band.

These devices are sometimes high power or large, exceeding the maximum size that can be measured in conventional open sites (OATS) and anechoic chambers (SAC and FAR), and the weight exceeds the load capacity of the test site turntable, so they are unable to be tested in conventional test sites. The example of this kind of large equipment (medical equipment) in the CISPR 11 field is shown in figure 1.

Regarding this problem, CISPR SCB (International Special Committee on Radio Interference, Subcommittee B) is currently studying large-scale & high-power devices measurement method and in-situ measurement method. A new working group (CISPR/B/WG7) specializing in this issue has also been officially approved at the 2019 CISPR Shanghai Conference. In the WG7, 'the factory inspection site (FIS)' is being discussed to be define as the quasi-test site for new CISPR 37, which means not to comply with CISPR 16-1-4 but defined in product & product family standards as shown in Figure 2 [1, 2].

In this paper, for electronic and electrical equipment that cannot be measured in conventional test sites the characteristics of test sites where are not defined as test sites such as the inside of factories are studied from 30 MHz to 1 GHz by evaluating the site insertion loss (SIL) and the site attenuation (SA) of test sites and quasi-test sites. In addition, assuming radiated interference wave measurement, we evaluated SA in which the scanning of the receiving antenna in the height direction was limited to

Figure 1. Example of large equipment (medical equipment).

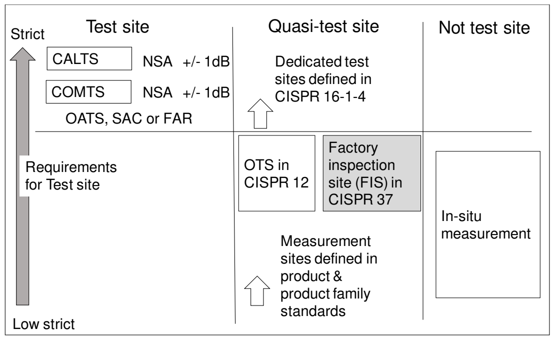


Figure 2. Positioning of Factory inspection site (FIS) in CISPR 37.

several fixed heights, and confirmed the validity of this study.

2 Measurement method using SIL for Quasi-test site evaluation

As the quasi-test sites that are not open sites or anechoic chambers under consideration by CISPR SCB, the inside factories or outdoors are being studied. There are various surrounding objects such as ceilings, production lines and pillars in the factory, which affect the EMI measurement results. In order to investigate how much the ground surface materials and the surrounding environment actually affects, the evaluation using the site attenuation (SA) can be applied to find out them.

For the formal test site defined by CISPR 16-1-4 such as open sites (OATS) and semi-anechoic chambers (SAC), SA is measured using the setup in Figure 3 and calculated by following formula,

$$\begin{aligned} SA &= [V_{direct} - V_{site}]_{min\ during\ 1\text{–}4\ m\ height\ scan} \\ &= AN + (F_{aT} + F_{aR} + \Delta A_{TOT}), \end{aligned} \quad (1)$$

where

V_{direct} is the voltage level in dB with the two coaxial cables directly connected to each other via an adaptor,

V_{site} is the voltage level in dB with each cable connected to transmitting and receiving antennas respectively,

F_{aT} is the transmitting antenna factor in dB,

F_{aR} is the receiving antenna factor in dB,

AN is the NSA (Normalised site attenuation) in dB,

ΔA_{TOT} is the mutual impedance correction factor in dB.

In addition, SA is measured with height scanning of receiving antenna between 1 m and 4 m and it is minimum site insertion loss between two polarization-matched antennas
located at a test site. When the receiving antenna is fixed at a certain height without scanning, it is called site insertion loss (SIL) as shown in following expression.

$$SIL = [V_{direct} - V_{site}]_{at\ fixed\ height}, \quad (2)$$

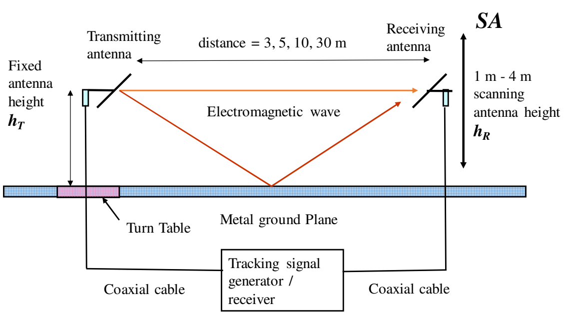


Figure 3. Measurement setup for site attenuation (*SA*) of test site complying with CISPR 16-1-4.

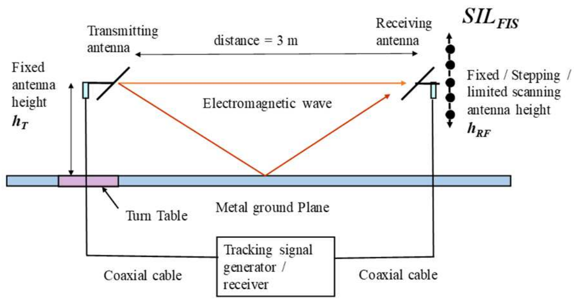


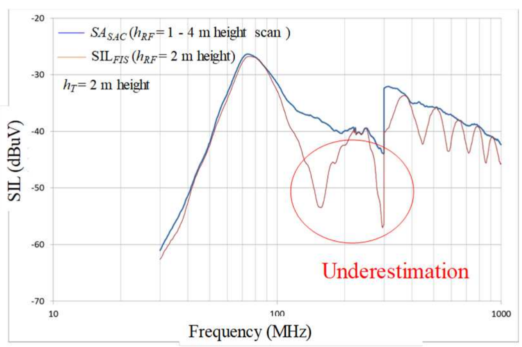
Figure 4. Measurement setup for SIL of FIS.

In case of the FIS, it is considered that the measuring SIL is suitable for evaluation method as the quasi-test sites. One of the reason is that it is difficult to move vertically receiving antenna over a specified height range at the place such as inside factories.

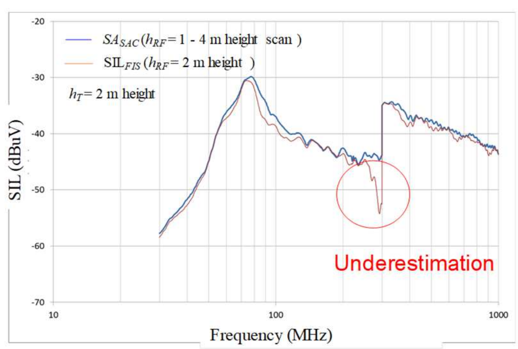
The measurement setup for evaluating FIS by SIL is shown in Figure 4. The receiving antenna is set the fixed height h_R, the several stepping height or the limited range height scanning h_{RF} in order to avoid the complex procedure of height scanning in the factory. The ΔSIL is defined as follows,

$$\begin{aligned} \Delta SIL &= SIL_{REF} - SIL_{FIS} \\ &= SA_{SAC} - SIL_{FIS} \\ &= AN + (F_{aT} + F_{aR} + \Delta A_{TOT}) - SIL_{FIS}, \end{aligned} \quad (3)$$

where



(a) Horizontal polarization

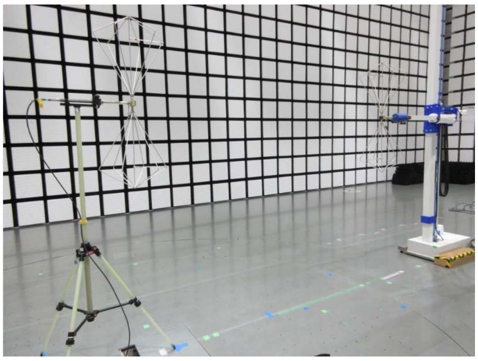


(b) Vertical polarization

Figure 5. Measurement results of SIL in SAC.

SIL_{REF} is the site insertion loss in ideal test site, and now we consider SIL_{REF} as SA_{SAC} which is the reference value of SAC complying with CISPR16-1-4. Therefore, ΔSIL means the deviation of FIS characteristics from the reference test site.

Figure 5 shows the example measurement results of SA_{SAC} and SIL_{FIS} which is assumed to be measured in FIS. The transmitting and receiving antenna height, h_T and h_{RF}, were fixed at 2 m. It is found that the underestimations of receiving electromagnetics strength for SIL_{FIS} at several frequencies occur. Now the SIL measurements were conducted for the three different kinds of surface as shown in Figure 6. The transmitting and receiving antenna height, h_T and h_{RF}, were also fixed at 2 m. The measurement results of ΔSIL are compared in Figure 7. It is considered that the deviation is maximum in case of the metallic surface, which is the worst case as the quasi-test site. The maximum deviation was less than about 15 dB.



(a) Metallic surface (SAC)

(b) Asphalt surface

(c) Soil surface

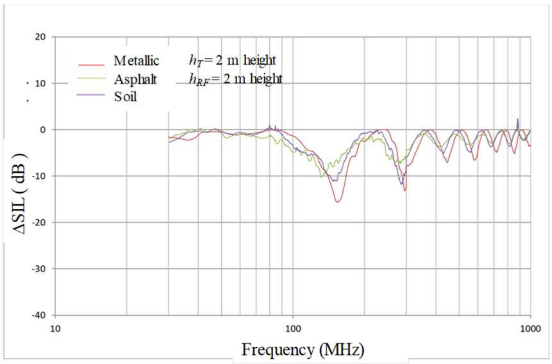
Figure 6. Measurement setup for site attenuation (*SA*) of test site.

3 Analysis of verification method for quasi-test site using ΔSIL

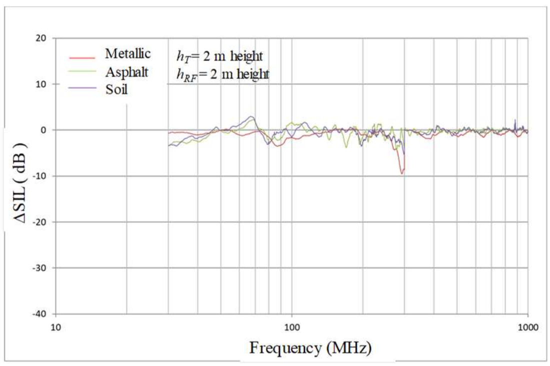
In order to analyze the simplified procedure for FIS verification where the receiving antenna scanning would be limited, the ΔSILs were studied for the several cases of the receiving antenna height in SAC. Regarding the study of the previous Chapter II, it is considered that the measurement of ΔSILs in SAC would be the worst-case made by reflections of electromagnetic waves from metallic surface. Therefore, the assessments of ΔSIL in SAC were conducted as the verification method of FIS.

Figure 8 shows the measurement results of ΔSIL for the four cases of the limited range height scanning h_{RF}, from 1 m to 2 m, from 1 m to 2.5 m, from 1 m to 3 m and from 1 m to 3.5 m. It is found that the maximum deviation of ΔSIL from SA_{SAC} is within 2.2 dB in case of 1 m – 2 m height scanning with vertical polarization. Here, the transmitting antenna height h_T was fixed at 2 m.

As a simpler procedure for the FIS verification, the several stepping height of receiving antenna was investigated between 1 m and 2 m, at the two steps of 1 m and 1.5 m, 1 m and 2 m, the three steps of 1 m, 1.5 m and 2 m, the five steps of 1 m, 1.25 m, 1.5 m, 1.75 m and 2 m.

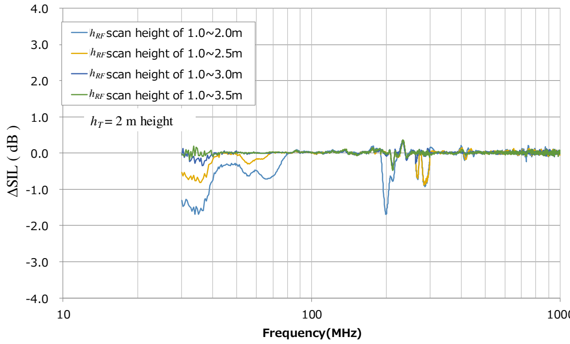


(a) Horizontal polarization

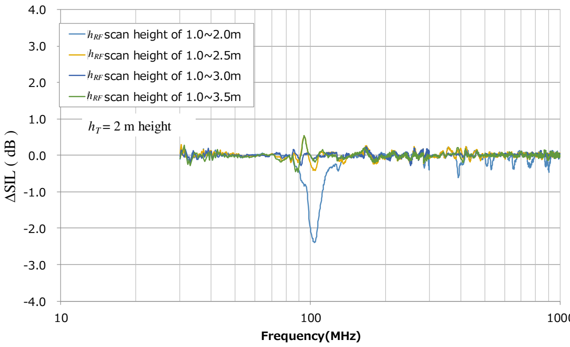


(b) Vertical polarization

Figure 7. Measurement results of ΔSIL for different surfaces.



(a) Horizontal polarization



(b) Vertical polarization

Figure 8. Measurement results of ΔSIL for the different limited range height scanning of the receiving antenna.

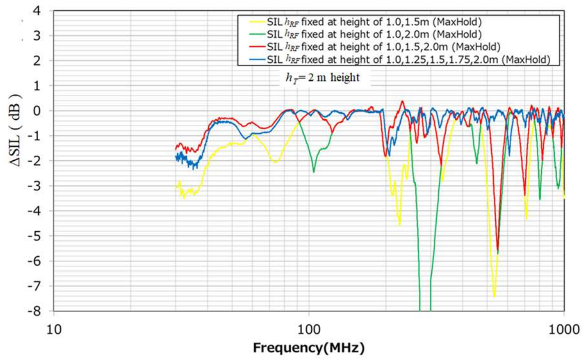
It is easy to understand that the more many steps are better for FIS verification. As shown in Figure 9, it is found that the maximum deviation of ΔSIL from SA_{SAC} is within 2.4 dB in case of the five steps of 1 m, 1.25 m, 1.5 m, 1.75 m and 2 m with horizontal polarization.

From the both of the measurement results, for the FIS verification considering the worst-case of influence by surface reflections the limited range height scanning is 1 m – 2 m height scanning should be selected. One of the reason is that this range is the smallest one on the investigation in this time. At the same time, the five stepping height of receiving antenna in 1 m – 2 m is also effective to get precise verification for FIS within 2.4 dB.

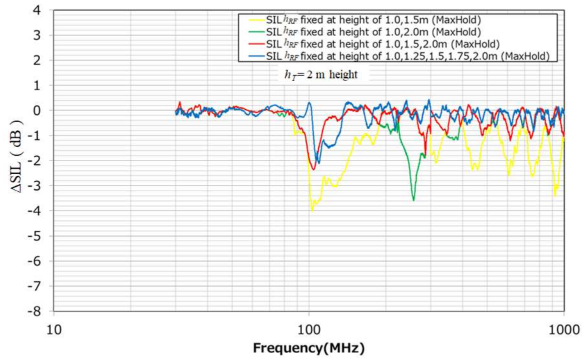
4 Conclusions

In this paper, regarding the measurement of radiated emissions from 30 MHz to 1 GHz, it has been studied that the method to verify whether it can be applied as a quasi-test site in the place that was not conventionally used as a test site, assuming the inside of the factory of electronic and electrical equipment manufacturers.

We proposed a method for evaluating the site insertion loss (SIL) of a quasi-test site on basing the site attenuation (SA) method of the reference test site specified in CISPR 16-1-4. As the results of the evaluation using an ideal semi-anechoic chamber (SAC) with no reflection of surrounding obstacles, for the ΔSIL at the limited height scanning of the receiving antenna between 1 m - 2 m, it was found that the deviation from SA_{SAC} was within 2.2 dB. In addition, it was found that at least more than five measuring points between 1 m - 2 m would be needed for the deviation within 2.4 dB. It has been shown that the measurement of ΔSIL can verify the characteristics of the quasi-test site where the measurement environment is limited such as FIS (factory inspection site) with a simple procedure.



(a) Horizontal polarization



(b) Vertical polarization

Figure 9. Measurement results of ΔSIL for different stepping height of the receiving antenna.

The ΔSIL at fixed height receiving antenna become as large as 15 dB, it can be decreased by the limited range height scanning to 2.2 dB as long as only ground plane exists. More investigations would be needed for FIS having reflected surrounding structures such as ceiling and walls, etc.

5 References

1. N. Mitsuzuka and K. Tajima, "Proposal of SIL estimation for Defined Site in CISPR 37," CISPR/SCB/WG7 Task Force document, 14th, 15th Jan. 2020.

2. CISPR 16-1-4 Ed. 4.1, "Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements," Jun 2020.