ANRITSU EMC IEC 60601-1-2:2014 Test Site

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[Summary] Electromagnetic Compatibility (EMC) testing is becoming increasingly important as computers become faster, wireless equipment becomes more diversified, and the need for a compatible equipment becomes more urgent. As a consequence, both national and international organizations, such as the FCC and IEC, are updating EMC related standards as well as requiring compliance with these standards. To ensure compliance, we have upgraded the RF-energy absorbing materials in the anechoic chamber at our EMC test site as well as added new power amplifiers and antenna equipment. As a result of these upgrades, the NSA value used as one index for evaluating anechoic chambers at frequencies below 1 GHz has been improved to within ±3 dB while the durability and earthquake resistance of the EMC site have also being upgraded.

1 Introduction

The importance of Electromagnetic Compatibility (EMC) is increasing as electromagnetic interference problems increase due to faster computers, more commonplace wireless equipment, and expanding interconnectivity between equipment and devices. As a consequence, various regulations governing EMC testing have been updated, such as ANSI C63.4 (American National Standards Institute) C63.4, IEC61000-4-5 (related to EMC), and EC60601-1-2 (related to medical devices).

EMC tests are broadly divided into emissions tests (EMI) for evaluating the disturbance level of electromagnetic radiation produced by the device itself, and immunity tests (EMS) for evaluating ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance from other adjacent electrical equipment. EMI tests conducted in an anechoic chamber are measurement of radiated disturbance, measurement of conducted disturbance at mains terminals and telecommunication ports.

One of EMS tests is radiated electromagnetic immunity test. These tests must be run at an EMC test site designed so there is neither any effect from external electromagnetic waves nor leaks of electromagnetic waves to the exterior. Performing stable EMC tests supporting the upgraded standards requires upgrading the performance of the anechoic chamber and evaluation equipment. The Anritsu group uses its EMC test site for evaluating a wide variety of products ranging from large mobile telephone conformance test systems and metal detectors to small handheld devices. Additionally, more equipment is using internal LSIs with clock speeds operating at frequencies in excess of 1 GHz, increasing the need for verifying EMC quality at 1 GHz and above. As a result, we have upgraded the performance of our Anritsu EMC test site.

First, this article outlines the performance upgrades and then explains the Normalized Site Attenuation (NSA) evaluation methods and results used as evaluation indices for anechoic chambers at 1 GHz and below. Last, it describes Site Voltage Standing Wave Ratio (SVSWR) procedures and evaluation results used as evaluation indices for anechoic chambers at 1 GHz to 18 GHz.

2 EMC Anechoic Chamber Upgrade Concept

The EMC test site was constructed in 1999 to facilitate efficient development of products within the Anritsu group. This current upgrade was made to improve the performance of the EMC test site to comply with new international standards based on the following concepts.

(1) Obtain high-reliability stable test data (within ±3 dB for NSA standard ±4 dB).

(2) Update anechoic chamber with excellent durability and earthquake proofing (electromagnetic wave absorber).

(3) Be in full compliance with latest EMC test standards

[1] Use tilt antenna masts supporting ANSI C63.4-2014: FCC (Federal Communications Commission) requirements.

[2] Support IEC 61000-4-5:2014: Surge immunity test.

[3] Support IEC 60601-1-2:2014: General requirements related to medical equipment basic safety and performance-electromagnetic compatibility requirements and tests.
- Support intense field spot frequencies for radiated RF electromagnetic immunity (EMS) tests at 385 MHz to 5785 MHz.
  For example: Support 2.4-GHz band intense field 28 V/m test.
  However, also maintain support for legacy standard radiated RF electromagnetic immunity (EMS) tests at 26 MHz to 1 GHz.

[4] Support CISPR25 (standard related to automobile equipment interference measurement method, CISPR: Comite International Special des Perturbations Radioelectrique, International Special Committee on Radio Interference): onboard parts radiated emissions test and RF conducted emissions test.

[5] Support ISO11452-2: onboard parts level IV (100 V/m at 80 MHz to 2700 MHz.

3 Upgrading EMC Test Chamber

3.1 Electromagnetic Wave Absorber

TDK's RF-energy absorbing material IP-BL was used because TDK has a great deal of experience in designing large anechoic chambers. Figure 1 shows RF-energy absorbing materials. The IP-BL material is based on non-combustible expanded polystyrene with an IP material using carbon ohm loss to absorb electromagnetic waves combined with an IB material using ferrite magnetic loss to absorb electromagnetic waves, forming a composite type electromagnetic wave absorber. The IB material has good electromagnetic wave absorption properties in the lower frequency range of about 30 MHz to 500 MHz, whereas the IP material has good absorption properties in the high frequency bands above 500 MHz.

This radio-wave absorber has a typical absorption characteristics of 20 to 30 dB at a vertical incidence.

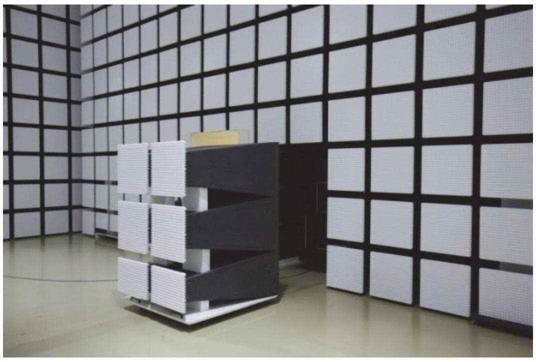

Figure 1 IP-BL RF-energy absorbing materials

3.2 Power Amplifiers

In addition to maintaining support for the old European Standard for medical electronic equipment (EN 60601-1-2:1993) in the frequency band from 26 MHz to 1 GHz (field strength of 3 V/m), the new anechoic chamber design also supports IEC60601-1-2:2014 radiated RF electromagnetic immunity tests. To satisfy this condition, we used a PRANA MT1400 as the power amplifier at 1 GHz and below with a special specification extending the low frequency range up to 26 MHz.

An AMETEK Group MILMEGA AS0860A-200/50 was used as the power amplifier for the high frequency range. This power amplifier incorporates two separate power amplifiers with different frequency bands of 0.8 GHz to 2.7 GHz, and 2.0 GHz to 6.0 GHz) to support a wide bandwidth from 1 GHz to 6 GHz. The output is in compliance with the IEC 60601-1-2:2014 standard for medical equipment supporting an intense field strength of 28 V/m in the 2.4-GHz band. Figures 2 and 3 show the external appearance of these amplifiers, and Figs 4 and 5 show the output characteristics (P1dB: 1 dB compression point).

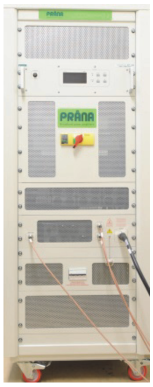

Figure 2 Power Amplifier 26 MHz to 1000 MHz
(PRANA MT1400)

Figure 3 Power Amplifier 1 GHz to 6 GHz
(MILMEGA 0860A-200/50)

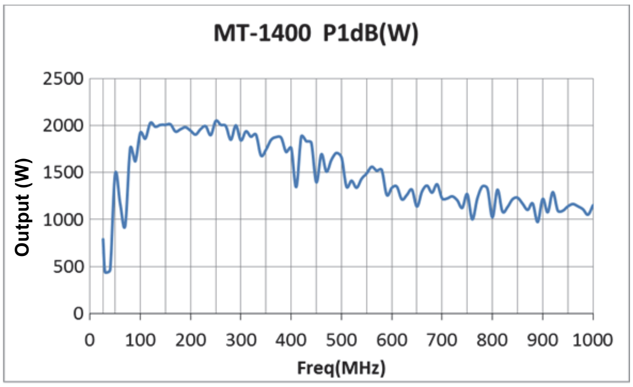

Figure 4 MT1400 Output Characteristics (Measured Value)

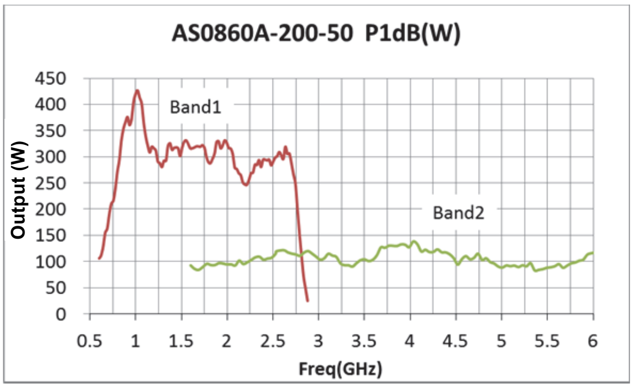

Figure 5 AS0860A-200/50 Output Characteristics (Measured Value)

3.3 Antennas

The previously described power amplifiers are combined with antennas, such as a Log Periodic Dipole Array antenna (LPDA) or High-Gain Horn Antenna to perform “radiated RF electromagnetic field immunity test”.

Figure 6 shows the LPDA STLP-9128Esp used in such tests. This antenna supports high output powers with a built in 7/16 size connector (inner conductor external form/external conductor internal diameter, mm units). Powers of up to 2 kW can be input at steady-state conditions depending on the test frequency up to 1 GHz. In addition, this combination of power amplifiers and antennas also supports non-medical applications, such as the automotive field (ISO 11452-2).

The left side of Figure 7 shows the High-Gain Horn Antenna ATH800M5GA and the right side shows the LPDA STLP-9149. The ATH800M5GA is used mainly for automobile applications. Using these antennas in combination supports “radiated RF electromagnetic field immunity test” for frequencies between 385 MHz and 5785 MHz for the IEC 60601-1-2:2014 (V4) standard governing medical equipment applications. Moreover, using a high-directionality antenna supports 200 V/m (CW) at a distance of 1 m for onboard equipment tests as well as strong field strength radiated immunity tests for 100 V/m of ISO 11452-2 Table C.1 Test Level IV.

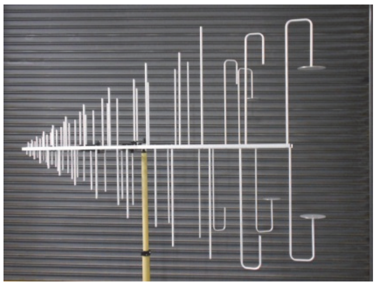

Figure 6 Immunity Test Antenna 80 MHz to 1000 MHz
(Schwarzbeck Double Stacked LPDA STLP-9128Esp)

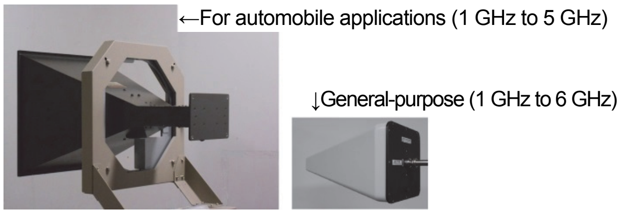

Figure 7 Immunity Test Antenna 1 GHz to 6 GHz
Right: Schwarzbeck Stacked LPDA STLP-9149
Left: AR High-Gain Horn Antenna ATH800M5GA

3.4 Test Table for Onboard Parts Evaluation

To perform CISPR25 evaluations of automotive parts, a 2.5-meter long test table has been installed in the anechoic chamber to perform radiated and conducted immunity tests of long automobile wiring harnesses. Figure 8 shows the grounding of the anechoic chamber turntable with grounding strap fixings from the copper plate on the top of the test table providing the 2.5 mΩ grounding resistance required by the standard. Additionally, the walls also have grounding bolts as shown in Figure 9 to facilitate easy support for the CISPR25 grounded walls requirements.

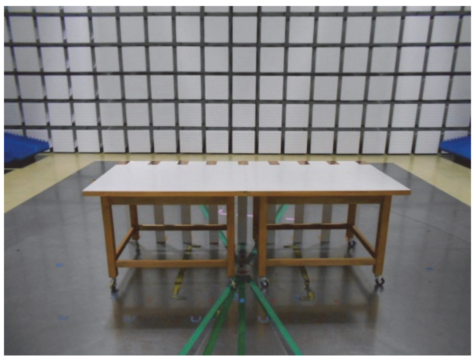

Figure 8 Measurement Table Setup: Floor Surface
(For Automobile Parts, Width: 2.5 m)

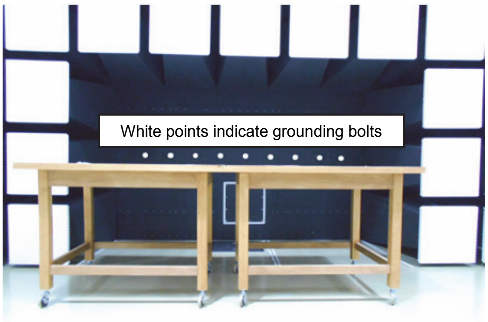

Figure 9 Measurement Table Setup: Wall Surface
(For Automobile Parts, Width: 2.5 m)

3.5 Tilt-Mounting Antenna Mast

To support the ANSI C63.4-2014 standard required by FCC Title 47 CFR part15, the new test site has an automatically controlled antenna tilt mechanism to ensure the antenna main lobe does not exceed the specified position of the equipment under test (EUT) when changing the antenna height. Figure 10 shows the antenna mast with tilting mechanism.

Figure 10 Antenna Mast (Tilt Mechanism)

3.6 Surge Tester

Surge testing is performed using a NOISE LABORATORY (Lightning) LSS-F03C1ED2 Surge Tester, which can impress surge voltages of 15 kV. A SURGE CDN (coupling/decoupling network) F-130814-1004-4 is installed externally to impress surge voltages onto a high-speed network connected via Ethernet cable (RJ-45 connector) in compliance with the IEC61000-4-5:2014 standard.

Figure 11 shows the surge tester and Figure 12 shows the SURGE CDN.

Figure 11 Surge Tester
(Noiseken LSS-F03C1ED2)

Figure 12 SURGE CDN
(FCC F-130814-1004-4)

4 Anechoic Chamber Evaluation by NSA

4.1 Outline of NSA Evaluation Method

EMC test results differ between an open site and an anechoic chamber with wave reflections from the RF-energy absorbing materials on the side walls and ceiling.

The anechoic chamber NSA evaluation method determines frequencies between 30 MHz and 1 GHz for the EMC international standard. The reference value in this standard uses the value of the attenuation (NSA) between Tx and Rx antennas in a chamber with metal walls and ceiling (completely non-reflective) with no reflective materials (virtual open site). Anechoic chamber measurements are only approved when the deviation from this reference value is within the standard (NSA theoretical value ±4 dB).

The NSA evaluation method is described below.

[1] Calculate NSA (theoretical value) for virtual open site and use as reference value

[2] Measure TRx characteristics of anechoic chamber

[3] Find difference between reference value and measured value

Figures 13 and 14 show the details of the evaluation.

In the measurement method described in CISPR16-1-4, Tx antennas are positioned in the horizontal plane as shown in Figure 14 (front/center/back/left/right) and the NSA is measured as shown in Figure 13 for two types of Tx antenna polarization (vertical and horizontal) and two heights (at measurement separation of 10 m with 1 and 2 m for horizontal polarization wave, and 1 and 1.5 m for vertical polarization wave).

At measurement, the Tx and Rx antennas are positioned as shown in Figure 14. Using this type of arrangement eliminates the need for distance correction and frequency dependent antenna-directivity correction, simplifying calculation of the TRx characteristics reference value (theoretical value).

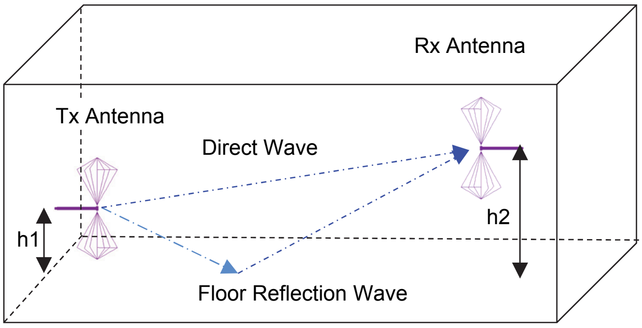

Figure 13 NSA Measurement Image
(Example: 10 m anechoic chamber, h1: vertical polarization wave 1 m/1.5 m, horizontal polarization wave 1 m/2 m fixed h2: 1 m to 4 m movement)

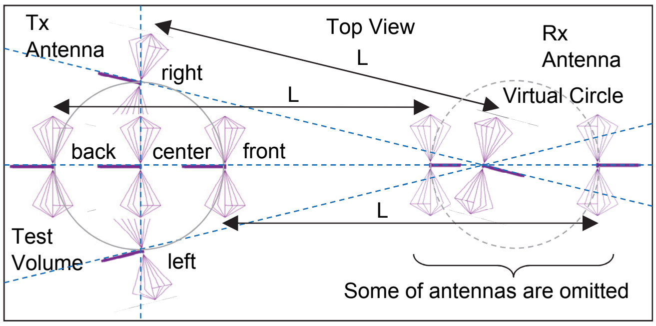

Figure 14 NSA Measurement Image
Top View (Ex. 10 m Anechoic Chamber L: 10 m)

4.2 NSA Reference Value

The equations for finding the Site Attenuation (SA) and NSA reference value are described in CISPR 16-1-4.

A correction coefficient is defined due to the interaction between antennas, and between antennas and the earth, as well as TRx antenna directivity and distance-dependent antenna characteristics.

When using a tuned dipole antenna, a near-field correction coefficient (mutual impedance correction coefficient) corresponding to the antenna height is applied at antenna correction described in the same standard (refer to Table E.1 and later in the standard). When using a biconical antenna with wideband characteristics to facilitate efficient measurement, the correction coefficient described in ANSI C63.5-2006 is applied following the NSA measurement procedure described in ANSI C63.4-2014.

4.3 NSA Measurement

There are two NSA measurement methods: 1. The discrete frequency method, and 2. The frequency sweep method.

The discrete frequency method uses a signal generator (SG) and spectrum analyzer (SPA) to find the maximum value of the received signal when moving the Rx antenna up and down at each measurement position at each specified frequency.

The frequency sweep method uses a wideband antenna and either a vector network analyzer (VNA) or SPA plus a Tracking Generator (TG). The entire frequency range is swept continuously at each antenna height and frequency and the Rx signal is measured using the Max. Hold function. In addition, the frequency sweep speed must be sufficiently faster than the speed of the change in the antenna height.

Accurate antenna factors of linearly polarized antennas are necessary in determining the measured NSA.

4.3.1 NSA Measurement using SPA and TG

This section describes frequency sweep measurement using a SPA and TG.

[1] Set the SPA SPAN frequency from 13 MHz to 1000 MHz.

[2] Set the data storage to Max Hold.

[3] Perform frequency sweeping while moving the Rx antenna vertically from 1 m to 4 m for each TRx antenna position to measure the maximum value of the received signal voltage. However, ensure that the frequency sweep speed is faster than the change in the speed of the antenna height.

[4] Change the Tx antenna position and change the Rx antenna position so the distance between the Tx and Rx antennas is 10 m.

[5] Ensure that the Tx and Rx antennas are facing each other.

Position the Tx antennas in the horizontal plane at five locations as shown in Figure 14 (front/center/back/left/right) and perform a total of twenty NSA measurements as described above using two types of Tx antenna polarization (vertical and horizontal) and two heights (when the measurement separation is 10 m, the antenna height are set 1 and 2 m for horizontal polarization wave, and 1 and 1.5 m for vertical polarization wave).

4.3.2 NSA Measurement Results

Figures 15 through 18 show the NSA evaluation results for the upgraded anechoic chamber.

The twenty SA measurement results provide relatively large amounts of data on the NSA values. At all areas at frequencies from 30 MHz to 1 GHz, the NSA value is within ±3 dB. Additionally, in the 200 MHz to 1 GHz area, the NSA value is within ±1.8 dB. Although the data is discontinuous at 200 MHz, this is due to switching antennas used for measurement at 200 MHz.

By constructing an anechoic chamber with excellent durability and earthquake resistance using superior electromagnetic wave absorption materials, we have successfully constructed an EMC test site maintaining stable long-term characteristics within the target NSA value ±3 dB.

Since many of the frequency points are within ±1.5 dB, the difference between the measured values and an open site has been kept small, which is useful when customers set margins for the EUT EMC standards.

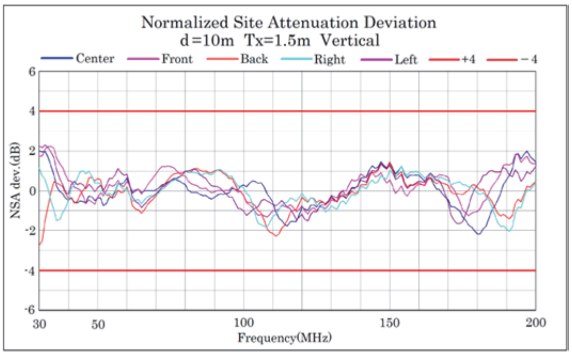

Figure 15 NSA Deviation
(d = 10 m Tx antenna height h = 1.5 m, vertical deviation biconical antenna)

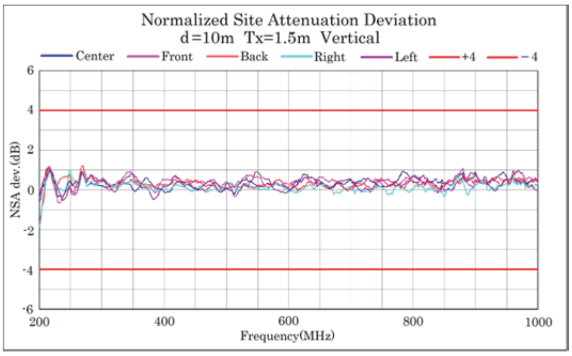

Figure 16 NSA Deviation
(d = 10 m Tx antenna height h = 1.5 m, vertical deviation Log periodic antenna)

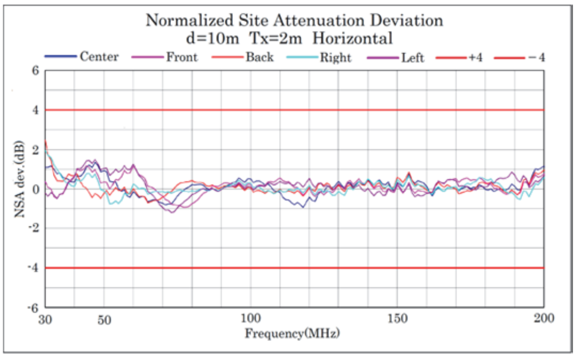

Figure 17 NSA Deviation
(d = 10 m Tx antenna height h = 2 m, horizontal deviation biconical antenna)

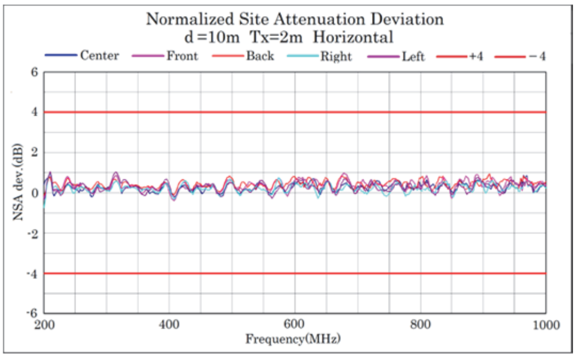

Figure 18 NSA Deviation
(d = 10 m Tx antenna height h = 2 m, horizontal deviation Log periodic antenna)

5 Anechoic Chamber Evaluation using SVSWR

5.1 Outline of SVSWR Evaluation Method

The Site Voltage Standing Wave Ratio (SVSWR) measurement method is specified by CISPR16-1-4 as the evaluation method for sites exceeding 1 GHz. This method simulates the real environment using a six-surface non-reflective space with electromagnetic wave absorbers installed on all surfaces including the floor; it performs evaluation by measuring standing waves due to interference from direct waves and from indirect waves caused by surrounding reflections. Direct waves radiated from the antenna and indirect waves from surrounding objects generate interference. Changes in the level of the field strength (standing wave) at the Rx antenna can be observed by moving the Tx antenna. The SVSWR value is the difference (dB) between the maximum and minimum value of this field strength level, or the difference between the maximum and minimum voltage (dB) measured by the receiver. If this SVSWR is less than 6 dB, the EMC is in compliance with the standard. The measured frequency range changes according to the EUT and the standard. This section introduces one part. The upper SVSWR frequency limit is 6 GHz in IEC 61000-6-3, 4 (general specifications) used by CISPR22, and in the Japanese VCCI standard. It is 18 GHz in the ANSI C63.4 specification of US FCC Title 47 CFR part 15. IEC 61326-1 of CISPR11 governing electrical equipment for measurement, control and test sites specifies Group 1 instruments, or in other words, instruments that do not measure above 1 GHz.

First, the SVSWR evaluation method is explained below in accordance with Figure 19.

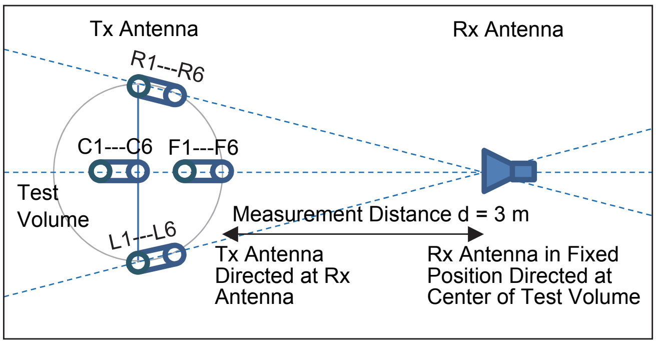

Figure 19 Illustration of SVSWR Measurement
Top View (Ex. 10 m Anechoic Chamber d: 3 m)

[1] Fix the Rx antenna at a position on the horizontal plane at the same height as the Tx antennas (h1, h2).

[2] Orientate the Tx and Rx antennas facing each other at height of h1.

[3] Arrange the Tx antennas as shown in Figure 19 at measurement positions front (F6), right (R6), left (L6), and center (C6).

* If the test volume has a diameter of greater than 1.5 m, measurement at the center is also necessary.

* When h2 – h1 > 0.5 m, it is also necessary to measure with the height h2 to added to h1 at the front.

Where,

h2: Test volume top surface height

h1: Either center of test volume or 1 m from bottom of test volume, whichever is lower

There may be up to 5 points: front (h1), right (h1), left (h1), center (h1), front (h2).

[4] Set the antenna polarization (horizontal or vertical).

[5] The left (L6) and right (R6) Tx antennas are close 40 cm to the Rx antenna.

[6] Perform measurement for up to 5 measurement positions with two polarization waves and 6 positions. For reference, either sweep the frequency range from 1 GHz to 6 GHz (18 GHz max.), or measure in steps of 50 MHz max. (101 frequency points when measuring up to 6 GHz in 50 MHz steps). (Maximum of 5 measurement positions × 2 polarizations × 6 positions × 101 frequency points = 6060 times)

[7] Using front (F6), right (R6), left (L6), and center (C6) as the 0 reference, move each Tx antenna to +2 cm, +10 cm, +18 cm, +30 cm, +40 cm from the Rx antenna and measure at these six positions.

[8] Find the difference (dB) between the max. and min. measured values.

5.2 SVSWR Measurement Results

This section presents some SVSWR measurement results for 1 GHz to 6 GHz for CISPR22 measurements mostly handled at this EMC test site. These SVSWR results were obtained using a high dynamic range VNA (+15 dBm typical output level) for antennas with high frequency characteristics attached to an antenna mast in an anechoic chamber using excellent polystyrene electromagnetic wave absorber materials. As shown in Figs. 20 to 24, good data of 6 dB less than the standard were obtained.

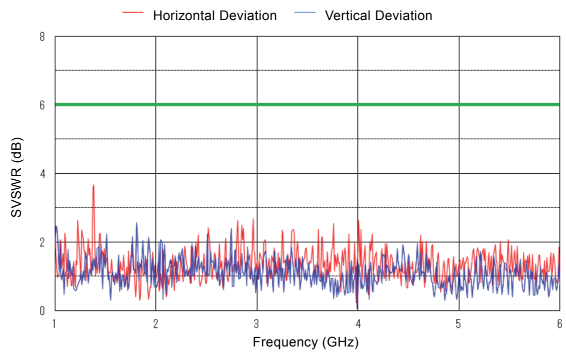

Figure 20 SVSWR Horizontal/Vertical Deviation
(d = 3 m Tx antenna height h1 = 1 m, Front)

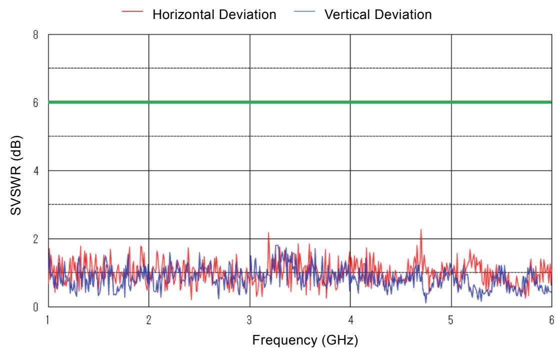

Figure 21 SVSWR Horizontal/Vertical Deviation
(d = 3 m Tx antenna height h1 = 2 m, Front)

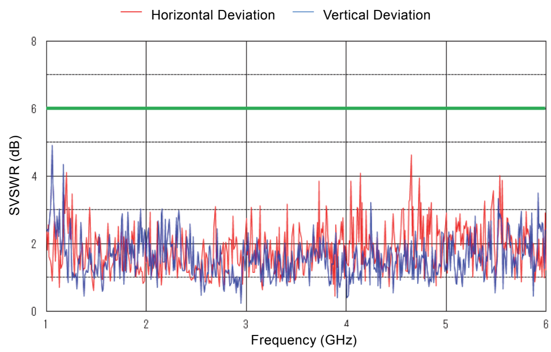

Figure 22 SVSWR Horizontal/Vertical Deviation
(d = 3 m Tx antenna height h1 = 1 m, Right)

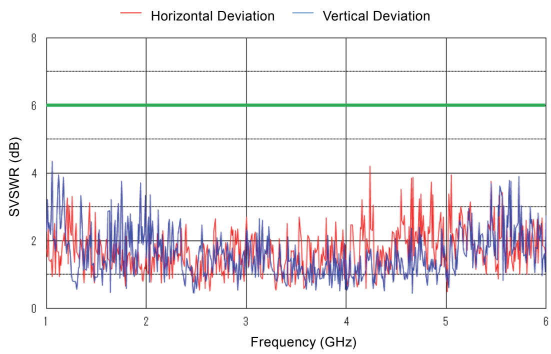

Figure 23 SVSWR Horizontal/Vertical Deviation
(d = 3 m Tx antenna height h1 = 1 m, Left)

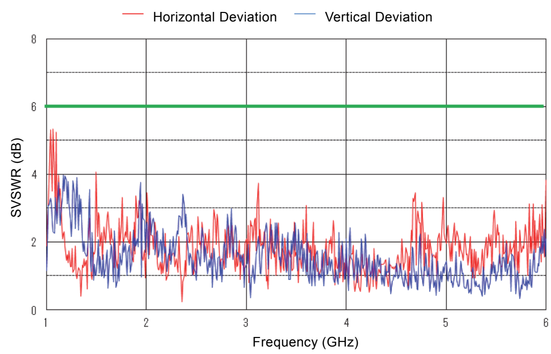

Figure 24 SVSWR Horizontal/Vertical Deviation
(d = 3 m Tx antenna height h1 = 1 m, Center)

5 Summary

We upgraded the anechoic chamber at the EMC test site with new electromagnetic wave absorbent materials, power amplifiers, antenna masts, etc., and evaluated the anechoic chamber performance using the NSA method. As a result of these improvements, the anechoic chamber NSA value was improved from within ±4 dB to within ±3 dB. Additionally, the durability and earthquake resistance of the EMC test site environment were also upgraded. Since most of the frequency points at NSA evaluation were within ±1.5 dB, the difference between the measured value and an open test site has been minimized, which is useful for customers setting margins for EUT EMC standards. In addition, the upgraded EMC test site supports the latest EC61000-4-5:2014 standard for test technologies and surge immunity as well as the IEC 60601-1-2:2014 standard governing the basic safety of medical electronic equipment and radiated RF electromagnetic immunity RS tests, etc.

We hope that the upgraded EMC test site will play a key role in improving EMC quality at every testing stage from research and development through to prototyping and mass production.

For more details of our EMC test services please visit the following website

- EMC test service: Search Web for ANRITSU EMC
  http://www.anritsu-customersupport.com/emc.aspx

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