Continuous vs. Discrete Height Scan Method in Normalized Site Attenuation Measurement for EMC Test Site Evaluation

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Abstract. *Normalized Site Attenuation is a standardized procedure for anechoic chamber validation in a frequency range from 30MHz to 1GHz. As an antenna positioning is a part of the measurement procedure, discrete or continuous scanning method can be used. The continuous height scan method has a significant speed advantage over the discrete approach, but the measurement accuracy comes to a question if antenna movement speed is not set properly. This paper deals with the theoretical analysis of the measurement error caused by antenna movement speed as well as the real measurement comparison of both methods. The final conclusions can be applied on various radiofrequency measurements.*

Keywords: RF measurement, site validation, frequency & height scan method

1. Introduction

The radiofrequency department of the Austrian Research Centres GmbH – ARC [1] deals with various site validation and calibration measurement tasks. As accredited test laboratory it performs on demand measurements all around the world. One of such measurements is the Normalized Site Attenuation (NSA), which is used for semi anechoic chambers validations. This type of measurement is designed for frequency range from 30MHz to 1GHz and is further defined by various standards [2]. The goal is to find out how much reflections occur from obstacles existing in measuring space and imperfections of the tested chamber [3]. In the ideal case if the signal is transmitted by transmit antenna the receive antenna should receive only interfered combination of the direct wave and wave reflected from the ground plane. To come near to the ideal behaviour, walls of the chamber are covered with absorber material (usually ferrite or graphite pyramids) to eliminated reflections as much as possible. Of course this intention is never fully achieved, and thus some reflections always occur. The purpose of the validation procedure is to find out if the chamber meets the standard specification of 4dB deviation from the theory.

2. Subject and Methods

The measurement procedure itself involves frequency scans at various receiving antenna heights from 1 to 4 meters to measure the maximum intensity of the wave interference (see Fig. 1). For antenna positioning a specialized mast device is used. In principle there are two ways how the receive antenna movement can be realized, using the discrete or the continuous method.

The discrete height scan is a classical method. It works the way the receiving antenna is positioned in specific height, then a frequency sweep is performed and afterwards the antenna is moved to the next height determined by a height step. This procedure is repeated until 4 meters height is reached. Then for each frequency the maximum received signal (= minimum attenuation) is calculated among all sweeps.

The continuous height scan performs frequency sweep at the bottom 1m height then the mast starts its movement until reaches the top 4m height. During the mast movement frequency sweeps are continuously executed and when mast stops one more sweep is done at the top height. Finally the results are computed in the same way as mentioned above.

As complete chamber validation process requires performing described procedure for up to 10 positions and 2 polarisations of the transmitting antenna, the time duration of the measurement is critical. Comparing both described height scan options, the continuous method is approximately 3 times faster than its discrete alternative. It is mainly because there is no needed to wait until the scan is finished and no need to start/stop mast movement many times. When a real NSA site validation is performed using the continuous height scan several days of work can be saved in this manner. The only think one should have in mind is that the sweep speed must be fast enough in relation to the mast movement to ensure finding the maximum signal. Accordingly the continuous height scan procedure accuracy is examined and optimal antenna movement speed is determined in the following.

A reason why the size of the height step has an impact to the NSA measurement results has its origin in the physical phenomena of the interference of direct and reflected signals. Due to this the signal attenuation depends on constructive or destructive interference occurrence as the receive antenna position (height) changes. This way attenuation minimums and maximums alternate over the height range. Additionally the higher the signal frequency is the more such alternations occur as shown in Fig. 1. The height step size is more critical for higher frequencies than for lower ones, because if the attenuation extremes alter more frequently it is probable to miss it if the height step is too big.

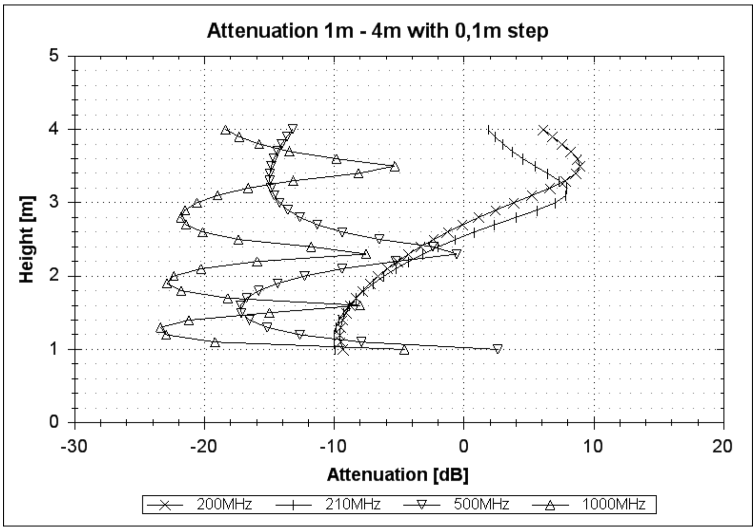

Fig. 1. Attenuation value for various signal frequencies when receive antenna changes its height from 1 to 4 meters with 10cm height step.

In the continuous height scan simulation the duration of a sweep is assumed to be equal to a certain mast movement. This means the movement speed can be defined as distance per sweep. We get 30 frequency sweeps if mast moves from 1m to 4m with a distance per sweep of 0.1m. In addition sweeps at top and bottom height positions with antenna not moving are taken.

The reference simulation was in fact the discrete height scan with 0.01m step, what resulted in 301 sweeps. In Fig. 2 results are displayed for both reference and continuous height scan using various height steps. Obviously by increasing height step size the error grows.

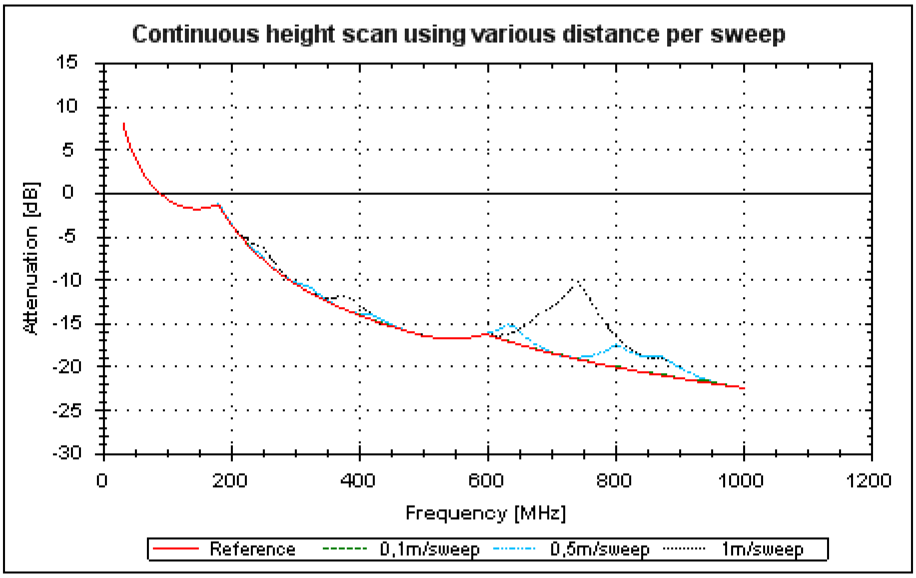

Fig. 2. Results of the continuous height scan using various mast speed (antenna setup: vertical polarization, 1m transmit antenna height, 3m transmit/receive antenna distance).

By computing maximal error from reference for various antenna positions (as defined in [2]) and movement speeds, it can be shown (see Fig. 3) that with distance per sweep of 0.2m the error keeps below 1.4dB. Using distance per sweep of 0.1m the error resides below 0.4dB.

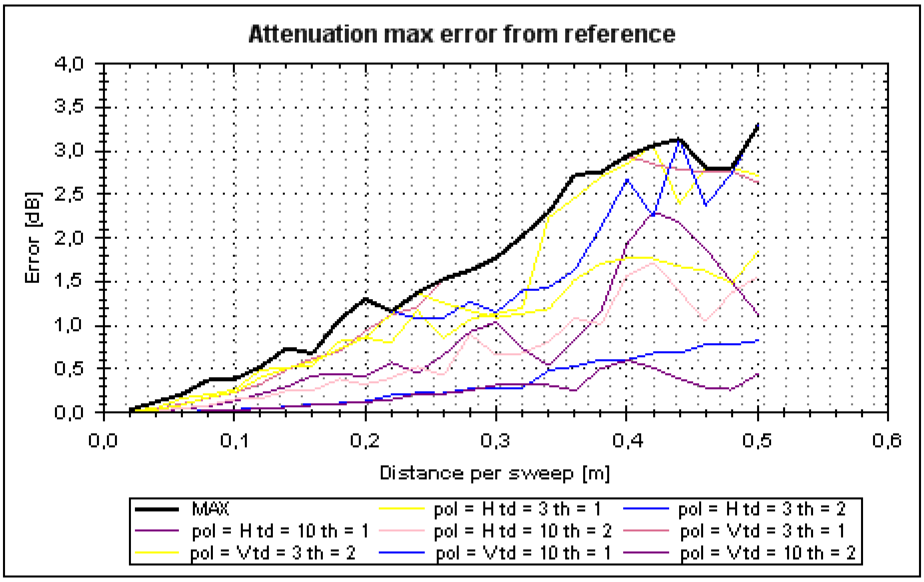

Fig. 3. Maximum deviation of the continuous height scans from the reference for various antenna positions using various movement speeds in the frequency range 30MHz - 1GHz. In the legend pol = polarization (horizontal/vertical), td = transmit antenna distance [m], th = transmit antenna height [m]

3. Results

The signal attenuation depends on the frequency range in which the measurement is performed. As seen in Fig. 2 in a range of 30MHz to 200MHz the receive antenna movement speed has negligible influence on the measurement results. On the other hand for frequencies above 200MHz the influence is much more significant. Performed simulations implied that continuous height scan method is close to the discrete method precision if appropriate mast speed is used. To support our theoretical findings we present real on site measurements using both discrete and continuous height scan methods (see Fig. 4).

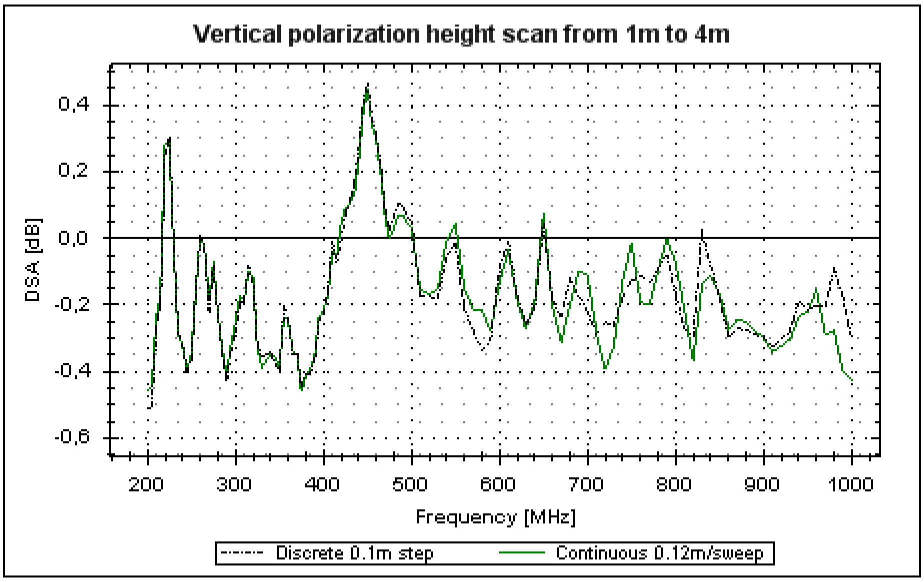

Fig. 4. Continuous vs. discrete height scan in the frequency range 200MHz - 1GHz.

4. Discussion

Performed simulations as well as real measurements have proven that the discrete height scan method can be substituted by significantly faster continuous height scan method if appropriate mast speed is used. The determined error/speed functionality is important for the measurement technicians to identify NSA measurement results validity. The continuous height scan method was implemented in automated measurement software Calstan [3] and is used in various measurement procedures.

References

[1] Austrian Research Centers GmbH – ARC, RF-Engineering, A-2444 Seibersdorf Austria, “www.seibersdorf-rf.com”

[2] CISPR 16-1-4 Ed.2, IEC, www.iec.ch ; ANSI C63.4, IEEE, www.ieee.org

[3] Bittera M., Hallon J., Smieško V. Measurement and Simulation of Field Homogenity Inside Semi-Anechoic Chamber.In: Measurement Science Review. Vol. 3, sect. 3 (2003). - pp. 143-146

[4] Kollar M. Calstan – A software for Automation of Radio Frequency Measurements and Calibrations. Measurement 2007, Proceedings of the 6th International Conference, Smolenice, Slovakia