A Phase-matching Based Phase Center Determination Method for OATS Antenna Calibration

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Antenna phase center (PC) is defined as a location from which radiation is considered to emanate. Active elements of a log-periodic dipole array (LPDA) antenna shift during a frequency sweep, which causes PCs to change with frequencies. This results in an undefined actual distance between the radiation and reception points, and thus forms a dominant error for LPDA antenna calibration. This paper concentrates on the phase center determination for broadband EMC antenna (such as LPDA, bi-log antennas).

A lot of previous work has been focused on the phase center determination. Some are based on numerical simulations or classical phase measurements, which are quite time-consuming and not practical for regular calibrations. The analytical formula in the CISPR draft document (CISPR/A/990/CD) assumes that a phase center locates exactly at the resonant elements and moves linearly with frequencies. Such linear interpolation is an approximation within about 50 mm around 200 MHz, and 30 mm around 1 GHz. Chen of ETS-Lindgren proposed a CFNSA model, but the representation of LPDA pattern with cosine and higher order polynomial functions may not sufficient at high frequencies.

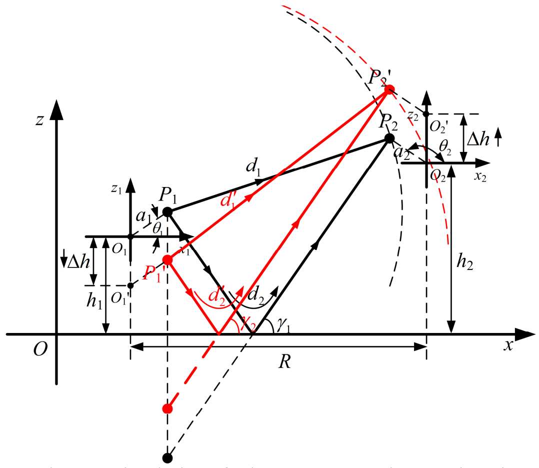

Fig.1 Principle of phase center determination

The proposed phase center determination method is based on site attenuation (SA) measurements. Fig.1 illustrates the measurement setup, where O_1 and O_2 denote terminations for measuring antenna separation, i.e., pseudo phase centers. The actual phase center P_1 and P_2 can be described by (a_1, θ_1) and (a_2, θ_2). Heights of two antennas are adjusted in opposite directions, of same values. The specific procedure is intended to keep ground-reflected waves (ray-lengths) constant ($d_2' = d_2$), and to keep reflection coefficients $^{-}{}_h = | \ {}_h| e^{j\phi_h}$ unchanged. In this case, (1) can be deduced from the theoretical site attenuation model, where K is a constant. With measured SA of different height configurations, independent equations can be formed from (1) by matching phases of two sides. The unknowns d_1 and d_1' are functions of phase center parameters, a_1, a_2, θ_1, and θ_2. Optimization algorithms can be utilized to get best solutions.

$$\frac{1}{SA} \quad \frac{1}{SA} = K\left[\frac{e^{\ j \ \ d_1}}{d_1} \quad \frac{e^{\ j \ \ d_1}}{d_1}\right]. \qquad (1)$$

A serial of calculable dipole antennas are firstly used for simulation and measurement validation since their PCs are foreknown. In addition, measurements of a pair of LPDAs (VUSLP 9111) are carried out in our new OATS (60 m by 40 m, central flatness within 4 mm).