# Positioning Uncertainty of Near-Field Probes


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***Abstract*— This work stochastically analyzes the positioning uncertainty of electric near-field probes. For this purpose, a virtual test bench is built and simulated in a full-wave solver using a Monte Carlo method, showing its impact on the probe factor.**



***Keywords*— Microstrip; Near-field probe; Uncertainty**


## I. Introduction

Near-field (NF) probes can be used as either sensors for radiated emission analysis [1], or injection tools for immunity analysis [2]. Before NF measurement, the relationship between the measured voltages at the probe terminal ($V_{probe}$) and the electromagnetic field strength ($E$, $H$) should be obtained. In the standard [3], this relationship is defined as the probe factor (PF), which is usually calibrated by using microstrip lines. Since the measured NFs are quite sensitive to probe positions, as shown in [2], it is also interesting to understand the impact of probe positioning uncertainty on the PF. For this purpose, this work provides a Monte Carlo (MC) based analysis using a virtual NF measurement setup built in Ansys HFSS.

## II. Setup and Stochastic Analysis

The principal diagram of the setup is shown in Fig. 1. The model of the probe is the coaxial-cable-based electric-field (E-field) probe RG405 used in [2]. The microstrip is set based on [3] (Table A.3 in [3]) to have a characteristic impedance close to 50 Ω.

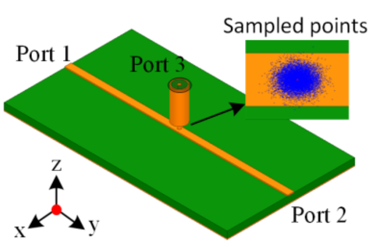
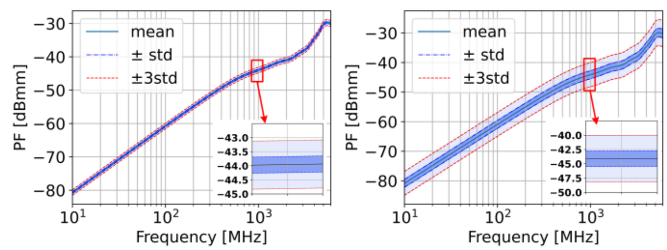



Fig. 1. Principal diagram of the setup (trace width is 1mm, Probe tip radius is 0.255 mm). All geometrical information can be found in [2] and [3].

Since an E-field probe is considered, the PF is defined based on the E-field [3], [4], .as

$$PF = \frac{V_{probe}}{E} = \frac{S_{31}V_f}{E} \quad (1)$$

where $S_{31}$ is the transmission S-parameter from port 1 to port 3, and $V_f$ is the forward voltage wave at port 1, which is set equal to 1 V in this work. The probe height is set as 1.0 mm [3]. During measurement, the actual probe position ($p_x$, $p_y$,) can differ from the nominal values set by the operator due to the uncertainty of the probe positioner. Gaussian distributions are perfect for evaluating this kind of uncertainty. For this reason, $p_x$ *and* $p_y$ are treated as random variables distributed around the nominal values ($p_{xn}$, $p_{yn}$) = (0, 0) mm with standard deviation of 0.15 mm. This value was chosen by inspection such that the sample points fall reasonably over the trace (see Fig. 1). It is worth mentioning that this uncertainty can be placed on either $S_{31}$ or the E-field $E$ in the definition of (1). Here, we consider the uncertainty on the E-field because of much smaller computational demand. In other words, $E$ is a random variable calculated at the real position ($p_x$, $p_y$) while $S_{31}$ is fixed and simulated when the probe is at the nominal position ($p_{xn}$, $p_{yn}$). 10,000 points are sampled with a binormal distribution centered at the origin. The computed PF is presented in Fig. 2(a).




(a) (b)

Fig. 2. Simulation results of the uncertainty in (a) x, y and (b) z direction.

Fig. 2(a) shows that even the maximum three standard deviations on the PF estimation is ~ 0.95 dB. Note that if this same uncertainty were placed on the probe height (with no uncertainty in x and y directions), a Monte Carlo simulation would reveal a maximum uncertainty of 5.2dB on the PF (see Fig. 2(b)). This shows that possible uncertainty on the xy plane has negligible effect on the calibration procedure if compared to vertical probe positioning. This is due to smaller changes of the field above the trace in the xy plane with respect to the vertical direction.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