Estimation of Variabilities due to Stochastic Variation in Geometric Parameters in Microwave Applications

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INTRODUCTION: Predicting the stochastic behaviour of electromagnetic systems is important in microwave circuit in applications [1].

- Terahertz circuits
- Millimetre wave circuits
- Resonating structures
- Substrate integrated waveguides

Intrusive methods do not work well due to the re-meshing requirements for geometrical alterations [2]. The stochastic collocation method is a good candidate for geometrical variation to predict the system stochastic behaviour.

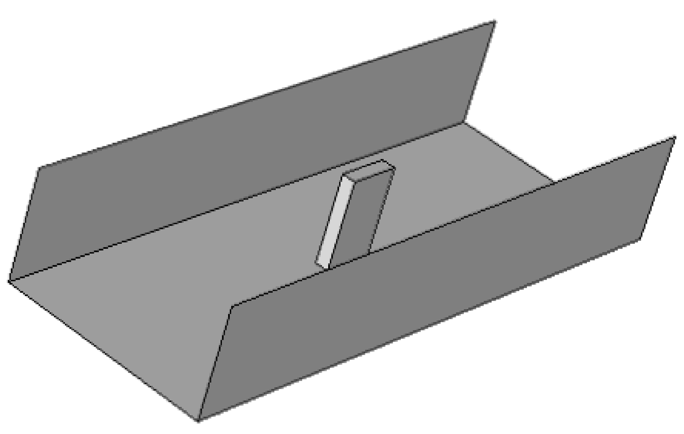

Figure 1. Model with Top-plane Removed

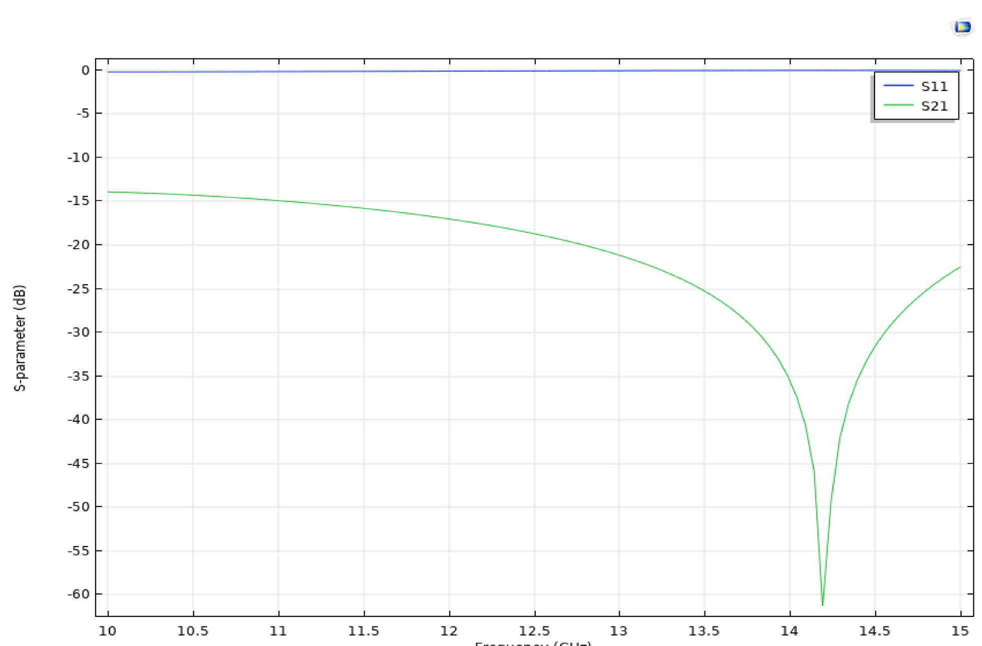

Figure 3. S-parameters

STOCHASTIC COLLOCATION: Stochastic collocation involves evaluating the problem at a few selected sample points and uses a polynomial interpolation or least square approach [3].

$$P(\xi) = \sum_{j=1}^{n} P_j(\xi) \qquad P_j(\xi) = y_j \prod_{k=1,k\neq j}^{n} \frac{\xi - \xi_k}{\xi_j - \xi_k}$$

where $\xi_1, \xi_2 \dots\dots \xi_k$ are the interpolation points, $p(\xi)$ is the polynomial approximation of the dependence of the system on the random variable and y_i is the system response at ith collocation point. The points are chosen based on quadrature rules by Wiener-Askey scheme.

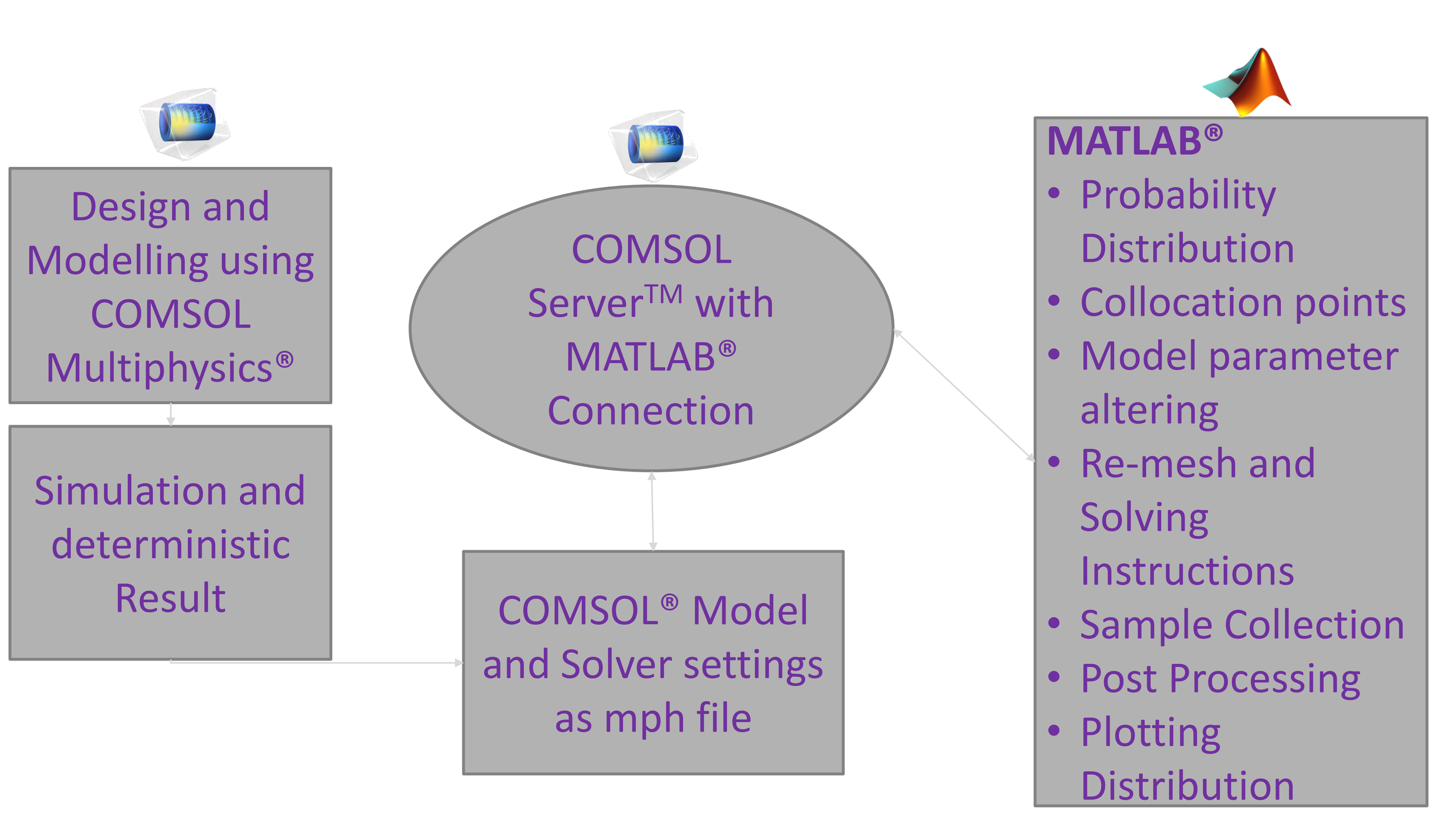

Figure 2. Flow of stochastic analysis

SIMULATION: Deterministic modeling is done using COMSOL Multiphysics®. The solution setup is configured and the '.mph' model is saved in a file. This can be accessed using LiveLink™ for MATLAB®.

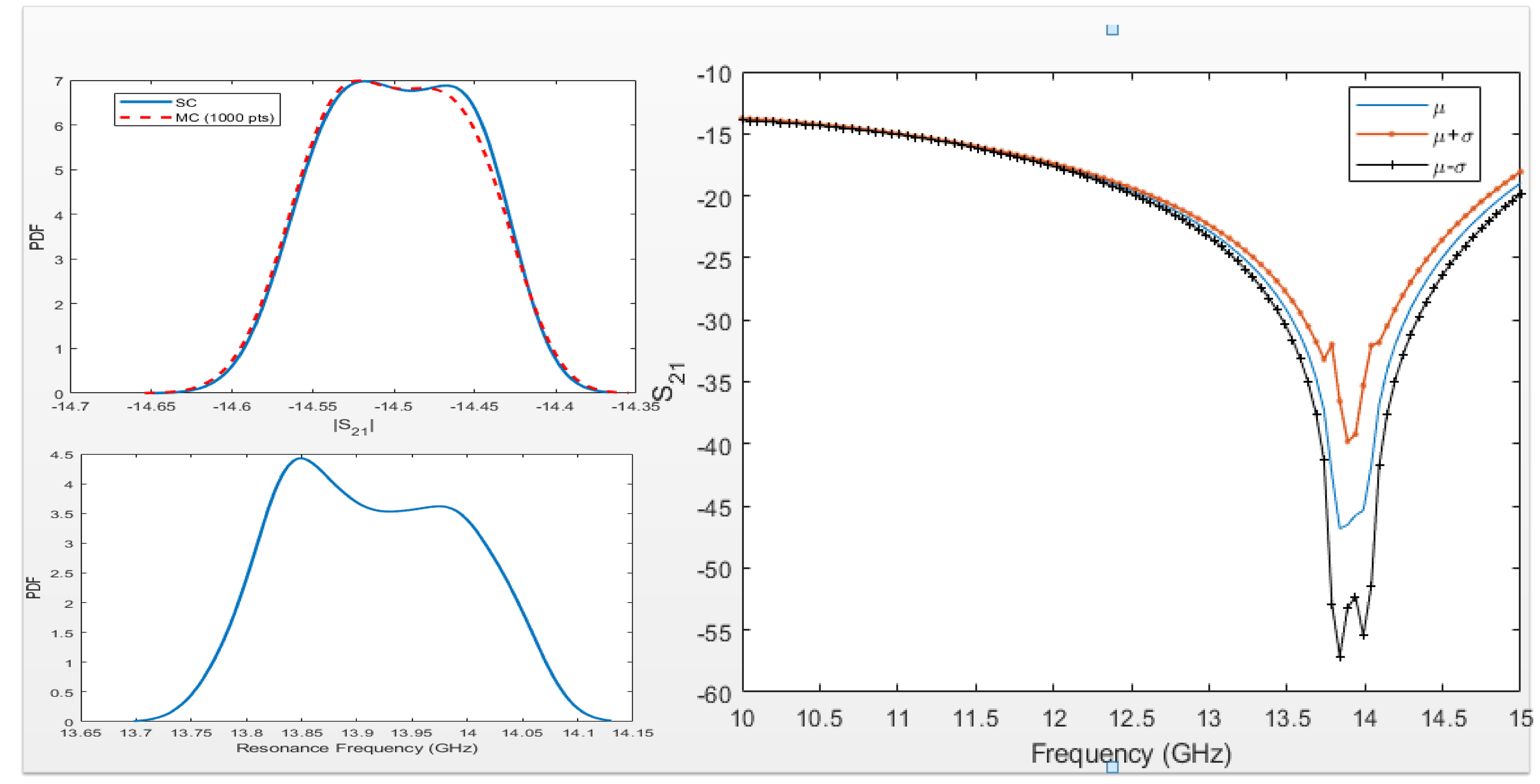

Fig 4: **Uniform variation in geometry**. (a) |S21| probability distribution (pdf) at 10.5 GHz. (b) Frequency sweep standard deviation (c) Resonance frequency pdf.

The height and width of the center post is varied stochastically. Two cases are considered. One for uniform distribution and the other for Gaussian distribution. The input distributions are as given in Table 1.

Variable	Mean	Uniform distribution	Gaussian Distribution
Width	1.016	U[0.816,1.216]	$\sigma = 0.05$
Height	7.619	U[7.319,7.919]	$\sigma = 0.07$

Table 1. Distribution of Different Parameters

Analysis is done as in the flow chart in Fig. 2. Single frequency result is compared with Monte Carlo for verification.

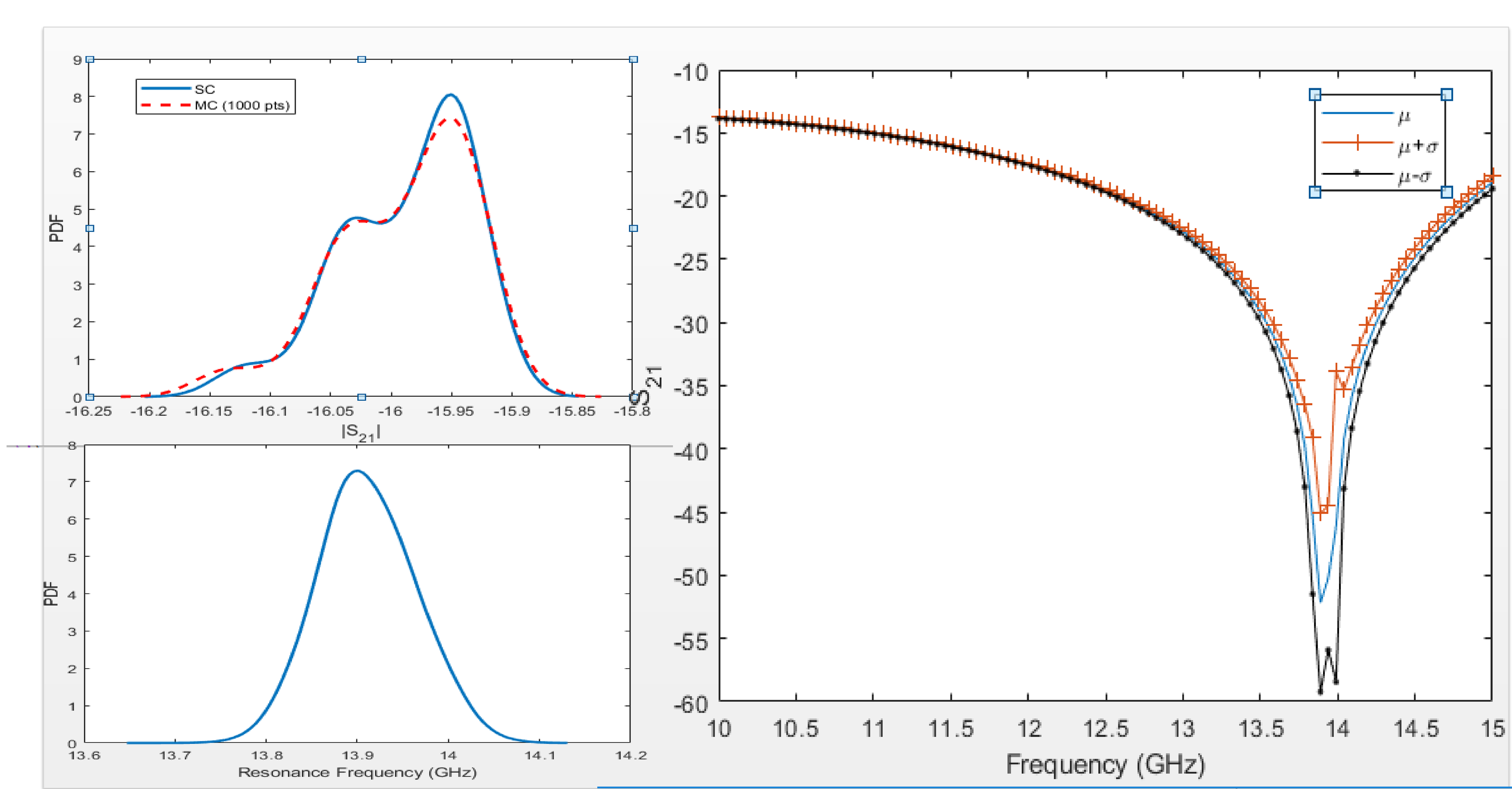

Fig 5: Gaussian Variation in geometry: a) |S21| probability distribution (pdf) at 10.5 GHz. (b) Frequency sweep standard deviation (b) Resonance frequency pdf.

CONCLUSIONS: COMSOL Multiphysics® with LiveLink™ for MATLAB® is used to perform stochastic analysis on electromagnetic model.

- Non-intrusive analysis can be done using the COMSOL® model as base solver and the intermediate.
- The post processing is handled using MATLAB®.
- Sensitivity analysis is done over a broadband to obtain the distribution and sensitivity of transmission parameters.

REFERENCES:

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Excerpt from the Proceedings of the 2019 COMSOL Conference in Bangalore