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NONLINEAR MODELING AND OPTIMIZATION BY DESIGN OF EXPERIMENTS : A 2 GHZ RF OSCILLATOR CASE STUDY

Miss. Suman Kushwah

Manipal Institute of Technology, Manipal

ABSTRACT

This work presents nonlinear modeling of Analog/RF circuits on purpose of Experiments. Higher order modeling has been done by incomplete factorial experiments, that orthogonal arrays were used. RF circuit response is sculptural by restricted variety of experiments, that is developed more as a mathematical optimisation drawback for locating a minima/maxima. Particle Swarm optimisation is employed for finding the nonlinear programming drawback. A generic modeling and optimisation flow is conferred for Analog/RF circuits, with the case study of a two Gc RF generator. Key Words : style of Experiments, Analog/RF circuits, nonlinear Modeling, Particle Swarm optimisation, RF generator

I. INTRODUCTION

S TATISTICAL ways square measure wide accustomed model the response of varied circuits and systems. Response Surface Model (RSM) on purpose Of Experiments (DOE) square measure used considerably in circuit optimisation and modeling [1]. For higher order modeling, either Full Factorial Experiments or another ways like Central Composite styles (CCD) square measure used that need a major variety of experiments [2]. The automation of optimisation method for Analog/RF circuits by DOE has been done by earlier researchers conjointly [3][4][5]. a number of the researchers use DOE to style a specific circuit or system, for a specific output response [6][7], and a few of them use DOE for modeling and macromodeling of circuits and systems [8]-[11]. Linear models generation by DOE and Orthogonal Arrays (OAs) is conferred in our earlier papers [6][7]. For higher order nonlinear modeling of such circuits victimization DOE, some earlier literature is out there however in most of the literature, macromodeling by posynomial models generation is conferred [10][12]-[15]. STAR, ROAD and PRISM square measure a number of the examples [8][13][14]. Orthogonal experiments square measure used for fitting these posynomial models victimization RSM and orthogonal hypercubes [15] and once posynomial models generation, optimisation ways like geometric programming square measure used for optimisation of the circuits/systems [16][17]. One classic paper by Rob A. Rutenbar et al, explains concerning all the ways of class-conscious modeling, optimisation and synthesis for System-Level Analog and RF styles [18].

Posynomial model generation needs heap of experiments compared to the linear model generation. as an example, in [13], for posynomial model generation, 243 experiments square measure performed for thirteen style parameters whereas in [19], for linear OLS models, solely twenty seven experiments square measure in serious trouble thirteen style factors. however since planet circuit behavior is non linear, nonlinear models square measure found to be a lot of correct. nonlinear regression ways or nonlinear least sq. ways may also be used for generating nonlinear models however they're supported the iterations from linear models [18]. This work presents an easy approach of nonlinear modeling victimization incomplete Factorial Experiments. Orthogonal arrays square measure used for incomplete factorial DOE. RF circuit response is sculptural by restricted variety of experiments at intervals the suitable accuracy. The circuit will more be optimized as a mathematical optimisation drawback for a desired response, once it's sculptural accurately.This paper, presents a completely unique nonlinear model generation technique for Analog/RF circuits, that is less complicated and effective. The novelty lies within the proven fact that the amount of experiments square measure same as utilized in linear models. The issue effects on the specified outputs, square measure premeditated and supported these plots, the polynomials square measure fitted and nonlinear models square measure generated.

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II. PLANNING AND OPTIMISATION

Our earlier work presents a general methodology of planning and optimisation of RF circuits [6][7]. By DOE, circuit will be optimized, by finding the result of every issue on the output. once the experiments, these individual input style issue effects will be calculated by Analysis of Variance (ANOVA) or by standard Least sq. (OLS) ways. analysis of variance is conferred in [21][22], for optimisation of various styles of circuits with constraints, associated OLS methodology is conferred in [6][7] for an generator circuit that is shown in fig.1. during this paper, the upper order modeling is completed for constant generator circuit.

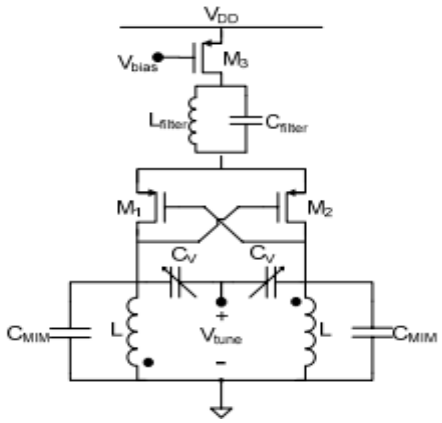

Fig. 1. RF CMOS Differential LC Oscillator Circuit

The outputs of interest were part noise and frequency. Taking into thought, the higher than nine style factors at 5 levels (as in table I), orthogonal array L50 was utilized in the analysis. The circuit was optimized by analysis of variance and also the exploit contribution of every style issue on output, was calculated. For a lot of details concerning experimental output table and analysis of L50 array, refer [21]. In DOE, supported the analysis of experimental outputs, the result of every issue on the output will be premeditated. this may be done by analysis of variance or by OLS methodology conjointly. For associate L level issue the variation of output from its mean, the least bit the amount of issue, square measure premeditated. The variations at every level is calculated from the experimental matrix supported the orthogonal array used for the experiments. once the DOE experimental outputs were subjected to OLS methodology, the individual style issue effects were premeditated as shown in fig. 2. this can be premeditated once victimization OLS ways, within which levels square measure in coded kind e.g will be coded as . this can be in serious trouble the convenience of implementation for calculations victimization matrix ways of OLS. The x-axes show levels of issue, whereas y-axes show the outputs. for every issue, there square measure 2 outputs premeditated, part noise and frequency. These issue plots were used for nonlinear modeling during this paper as shown in fig. 3.

III. MODELING

As mentioned within the previous section, supported the experimental knowledge, optimum levels for every style issue will be found and their result on output will be premeditated. once premeditated the result of varied style factors on output responses, the output therefore, will be sculptural as polynomials. If the amount of levels for a style issue is L, it will be sculptural victimization polynomial of L−1 degree by straightforward curve fitting algorithms as delineated in next section.

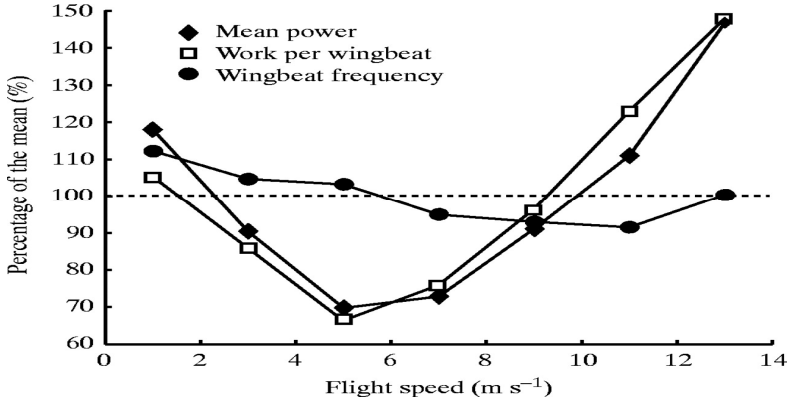

Fig. 2. Individual factor effects on outputs (all units are normalized)

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A. Novel Modeling Methodology

By DOE, besides finding the best style, circuits will be sculptural conjointly. In [6][7], RF circuits square measure sculptural and optimized victimization DOE by OLS models. Using OAs, circuits square measure sculptural linearly. A circuit response once premeditated against style factors, from orthogonal experiments, will be sculptural as polynomial. Thus, it's assumed that the interaction among the planning factors square measure negligible.This modeling will solely be done if the amount of levels L is quite two.

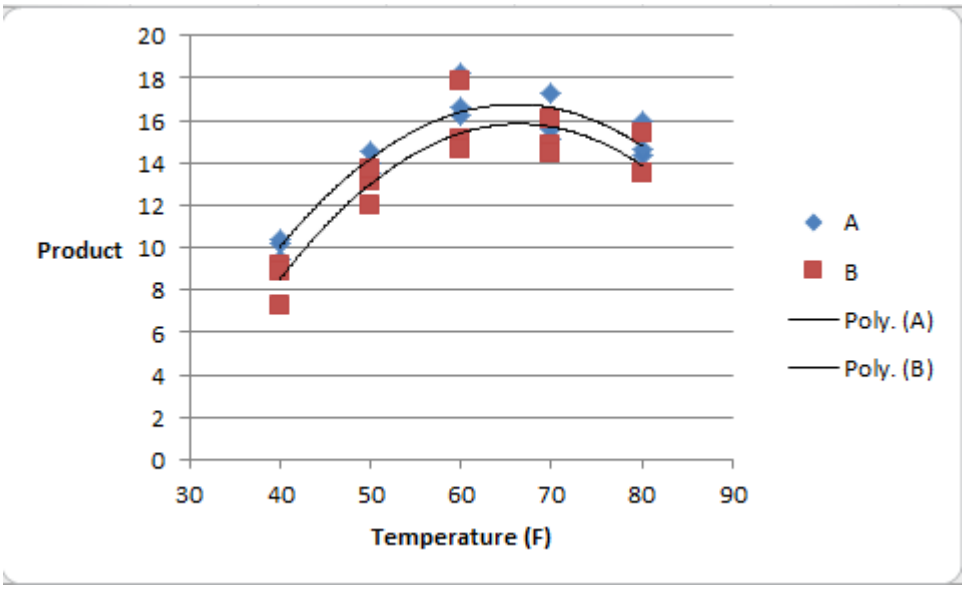

Fig. 3. Polynomial fitting of the factor effects

B. Accuracy

The accuracy of the nonlinear models obtained, will be calculated by cross checking from the orthogonal experiments. for every experiment sq. add of Errors (SSE) will be calculated by taking mean of sq. of errors for all the experiments. Table II shows the SSEs of varied higher order models, for this case study of two Gc RF generator. this may be seen that from the restricted variety of experiments, the circuit will be sculptural for higher degree polynomials, presumptuous that the interaction between the planning factors square measure negligible.

V. AUTOMATION

The search algorithms square measure utilized in Electronic style Automation (EDA) tools for locating any desired resolution. If a circuit is meant to supply a group of outputs and also the input style parameter combos square measure to be found for constant, associate EDA tool can apply search formula on every occasion such that|the required} output is specified by the user. this needs intense calculations on every occasion the circuit is simulated as a result of in every simulation calculations square measure done supported the model files of all the passive and active elements, provided by the foundries. If a styleer has to realize the input design factors for an outsized set of desired responses, these nonlinear models will be used. If the projected nonlinear modeling methodology is employed by EDA tools, the amount of calculations will be reduced up to an excellent extent, as on every occasion, to seek out the specified output and also the circuit needn't to be simulated by EDA tool. rather than it, mathematical calculations will be done by a separate computing tool. Once circuits square measure sculptural with high accuracy, they'll be accustomed predict circuit behavior. while not simulating it once more and once more, it's output will be foreseen. this can be appreciate behavior modeling of circuit. Further, such polynomial model will be used for mathematical optimisation drawback to style circuit with efficiency. the planning flow shown in fig. seven will be used for any circuit.

VI. CONCLUSION

In the planning and optimisation of RF Circuits, applied math ways, like style of Experiments (DOE) square measure established to be effective. The Orthogonal Arrays (OA) square measure used for the DOE. Results show that with the restricted variety of experiments, higher degree polynomial models will be obtained. The low worth of sq. add of Error (SSE) shows that the DOE methodology is ready to seek out correct nonlinear models for RF circuit.

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