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An efficient prediction framework for multi-parametric yield analysis under parameter variations

Key words: Yield prediction, Parameter variations, Multi-parametric yield, Performance modeling, Sparse representation

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Motivation

- process, voltage, and temperature (PVT) parameter variations have become one of the most problematic issues in circuit design. The resulting correlations among performance metrics lead to a significant parametric yield loss.
- Most of the existing work in yield prediction has been limited to considering one single performance metric, and therefore has neglected the correlations among performance metrics under PVT parameter variations.
- To address the above-mentioned issue, Recent research has been fully aware of the importance of the correlations among performance metrics. However, the proposed methodologies provide only trade-off information among multiple parametric yields.

Main idea

- We aim to predict parametric yield considering multiple performance metrics in a simultaneous manner. The prediction framework regards multiple performance metrics as the constraint conditions and provides a multi-parametric yield estimate.

- As a result, designers can conveniently and efficiently obtain an accurate value for multi-parametric yield considering arbitrary performance metrics.

Method

1. The proposed framework maintains the correlations among performance metrics by modeling them in terms of PVT parameter variations sparsely with the AEN method.
2. Based on the multiplication theorem and the MCMC method, a single-parametric yield prediction methodology has been developed to estimate the parametric yield for one single performance metric.
3. A copula-based multi-parametric yield prediction procedure is suggested to predict the parametric yield considering multiple performance metrics simultaneously.

Major results

- Our method can make the model of a performance metric sparse.

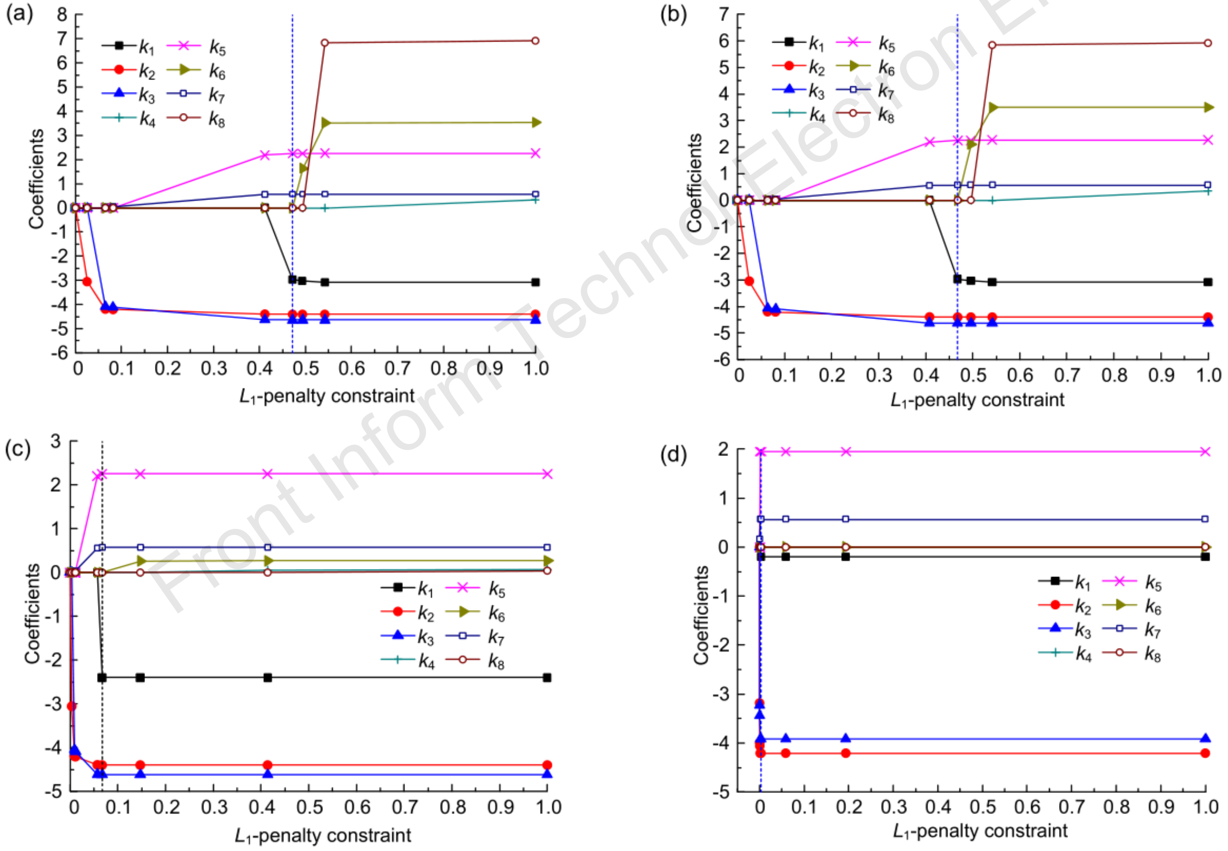

Fig. 3 The coefficient selection paths of the subthreshold current under different conditions: (a) λ_1=1e-13, min(AIC)=63.0989; (b) λ_1=1e-5, min(AIC)=63.0994; (c) λ_1=1e-2, min(AIC)=63.6353; (d) λ_1=0.5, min(AIC)=84.1606

Major results

- The results obtained by our single-parametric yield prediction method are effective.

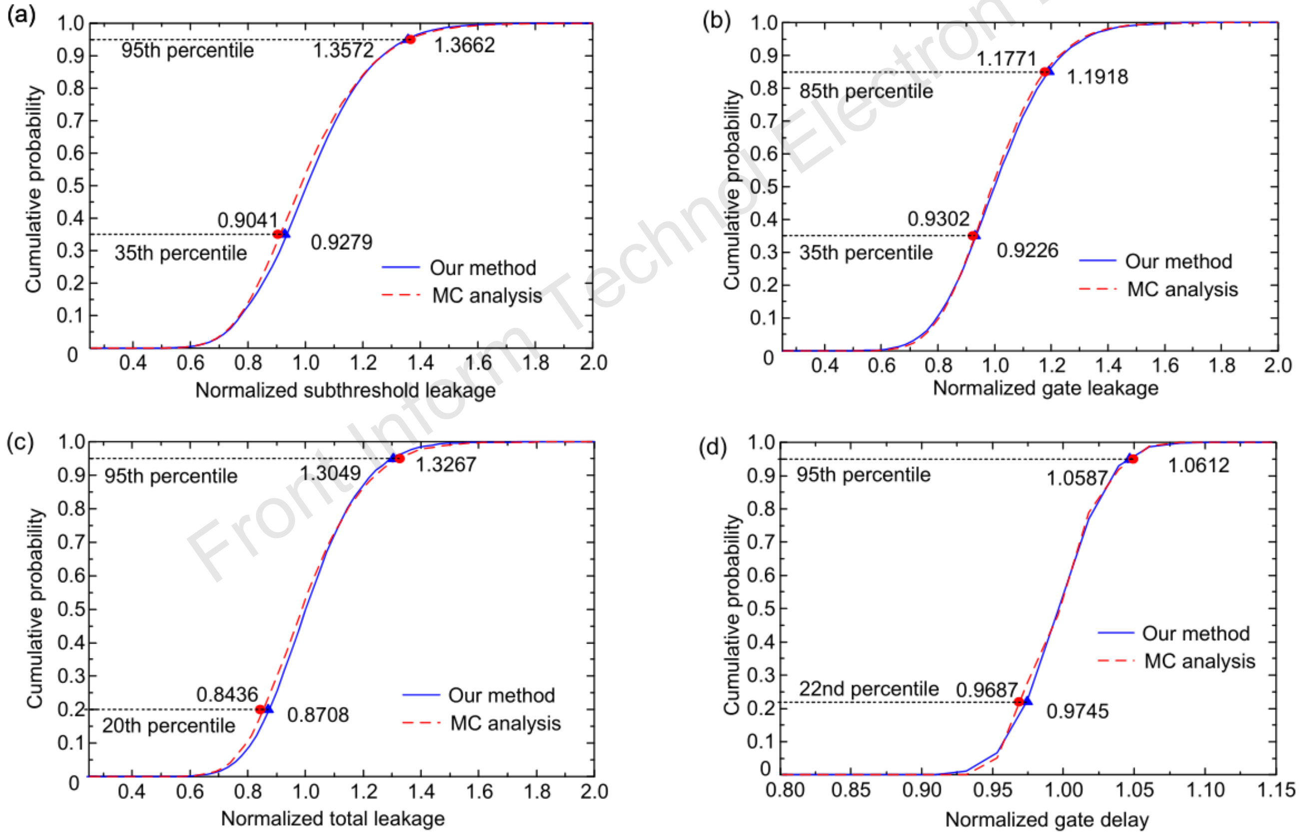

Fig. 4 The CDF obtained by our method and MC analysis: (a) subthreshold current; (b) gate leakage current; (c) total leakage current; (d) gate delay

Major results

- Our framework could effectively predict the multi-parametric yield and provide the multi-parametric yield surface.

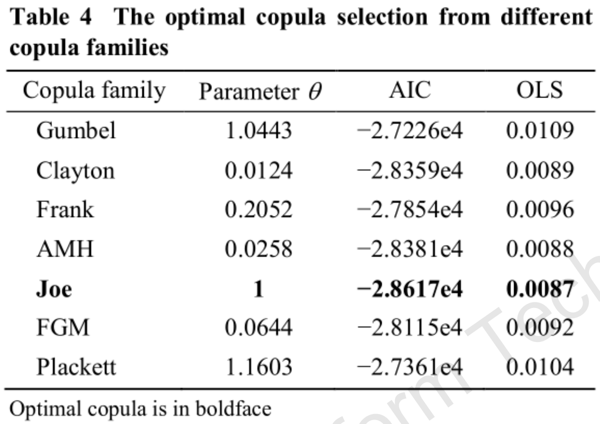

Table 4 The optimal copula selection from different copula families

Copula family	Parameter θ	AIC	OLS
Gumbel	1.0443	−2.7226e4	0.0109
Clayton	0.0124	−2.8359e4	0.0089
Frank	0.2052	−2.7854e4	0.0096
AMH	0.0258	−2.8381e4	0.0088
Joe	**1**	**−2.8617e4**	**0.0087**
FGM	0.0644	−2.8115e4	0.0092
Plackett	1.1603	−2.7361e4	0.0104

Optimal copula is in boldface

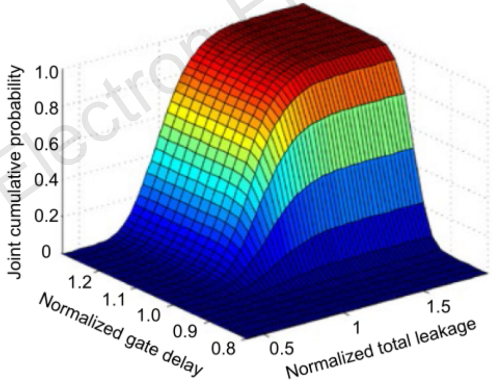

Fig. 6 The multi-parametric yield surface for the C432 circuit obtained by our framework

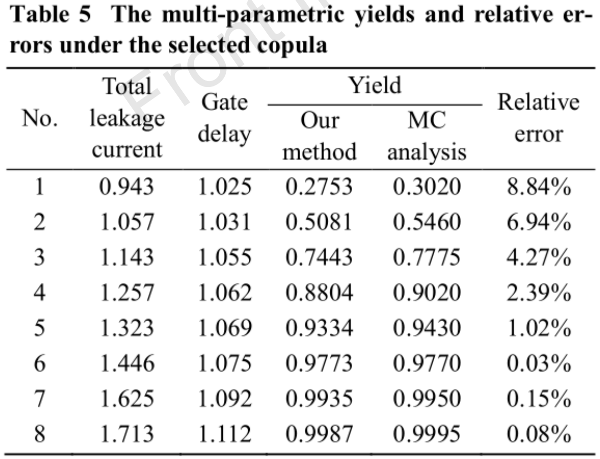

Table 5 The multi-parametric yields and relative errors under the selected copula

No.	Total leakage current	Gate delay	Yield		Relative error
			Our method	MC analysis	
1	0.943	1.025	0.2753	0.3020	8.84%
2	1.057	1.031	0.5081	0.5460	6.94%
3	1.143	1.055	0.7443	0.7775	4.27%
4	1.257	1.062	0.8804	0.9020	2.39%
5	1.323	1.069	0.9334	0.9430	1.02%
6	1.446	1.075	0.9773	0.9770	0.03%
7	1.625	1.092	0.9935	0.9950	0.15%
8	1.713	1.112	0.9987	0.9995	0.08%

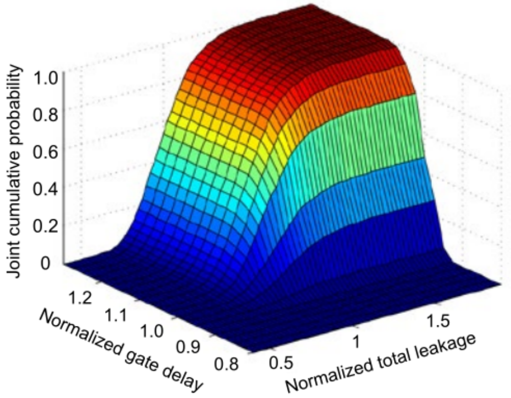

Fig. 7 The multi-parametric yield surface for the C432 circuit obtained by MC analysis

Conclusions

- We have proposed an effective multi-parametric yield prediction framework that integrates the AEN method, multiplication theorem, MCMC method, and copula theory.
- the proposed strategy can be used to predict the multi-parameter yield by estimating the joint CDF of the performance fluctuations propagated from parameter.
- The efficiency of this new method has been verified with various ISCAS benchmark circuits.