Fault Detection and Diagnosis Using Wavelet Based Transient Current Analysis

Swarup Bhunia and Kaushik Roy
School of Electrical and Computer Engineering, Purdue University
W. Lafayette, IN 47907-1285, USA
(swarup, kaushik)@ecn.purdue.edu

Abstract

We present a novel integrated method for fault detection and localization using wavelet transform of transient current (IDD) waveform. The time-frequency resolution property of wavelet helps us detect as well as localize faults in digital CMOS circuits. Experiments performed on an 8-bit ALU show promising results for both detection and localization.

1 Introduction

Wavelet transform has the potential to resolve a signal in both time and frequency domain simultaneously [1] unlike Fourier. We propose using wavelet transform of IDD signal for fault detection and localization. Time-domain information from the wavelet coefficients is used to efficiently localize a fault.

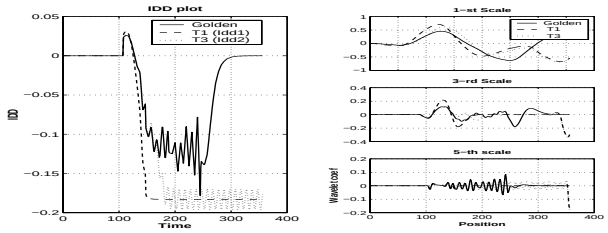

Figure 1. Plot of IDD waveform and wavelet coefficients at different scales

2 Detection and Localization using Wavelet Transform

Detection is performed comparing wavelet coefficient based current signature. Since, we consider both the time and frequency components, we get better sensitivity in detection than methods based on pure spectral [3] or pure time-domain components [3, 2]. Localization is based on delay-measurement technique [3]. We compute the delay T_d as time difference between application of a stimulus and activation of fault. Wavelet allows us to compute T_d efficiently at different scales (frequencies). We use a partitioning algorithm to distinguish potential faulty cells for a given vector and T_d. In successive runs of the algorithm with different vectors, intersection between the faulty cells generates a narrower faulty region. Figure 1 shows the plot of IDD waveform with corresponding wavelet coefficients at three different scales for a 4-inverter chain. Three cases considered are fault-free (golden) and faults after 1-st (T1) and 3-rd (T3) inverter.

3 Experimental Results

An 8-bit integer ALU ($\sim$1000 cells) was used to test our method. We simulated the circuit using *HSpice* for 0.25 μ TSMC technology with random input stimuli. Table 1 shows results for different types of faults injected at various locations. The *mother wavelet* used is *db2* [1]. Sampling frequency is 1 ps. Only few low frequency components are used for both detection and localization.

Table 1. Fault Detection and Localization result for an 8-bit ALU

Fault	Detect/ Locate	# vectors	# faulty cells	% of tot cells
VDD bridge	Yes/Yes	13	71	7.00
Gate short	Yes/Yes	16	52	5.13
Open	Yes/Yes	3	72	7.10

4 Conclusions

Wavelet based delay computation method has been observed to withstand IDD waveform changes due to process variation and measurement noise. Generation of optimal set of test vectors for localization is important to make the testing process more efficient. Wavelet based method can also be very effective for pure analog and mixed-signal circuits. Currently we are working on these aspects.

References

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