28º SIMPÓSIO SUL DE MICROELETRÔNICA

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MULTI-LEVEL STOCHASTIC PROCESSING CIRCUITS

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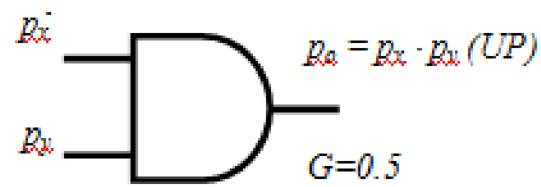
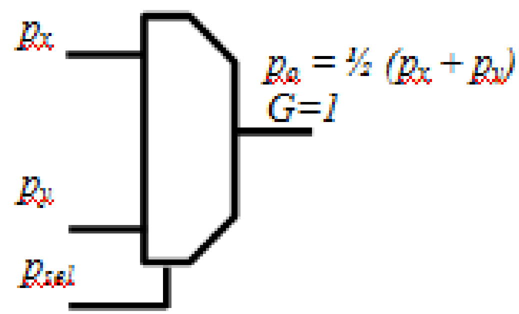
Introduction

- Stochastic arithmetic-
  - E{px}=XN
- Advantages :
  - Low area
  - Fault Tolerance
- Disadvantages-
  - Length pulse streams (K)

Stochastic Operators





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Resolution and Convergence

- Resolution X Convergence

$$K > 2^{2r-2}$$

-K quadruples with the resolution r

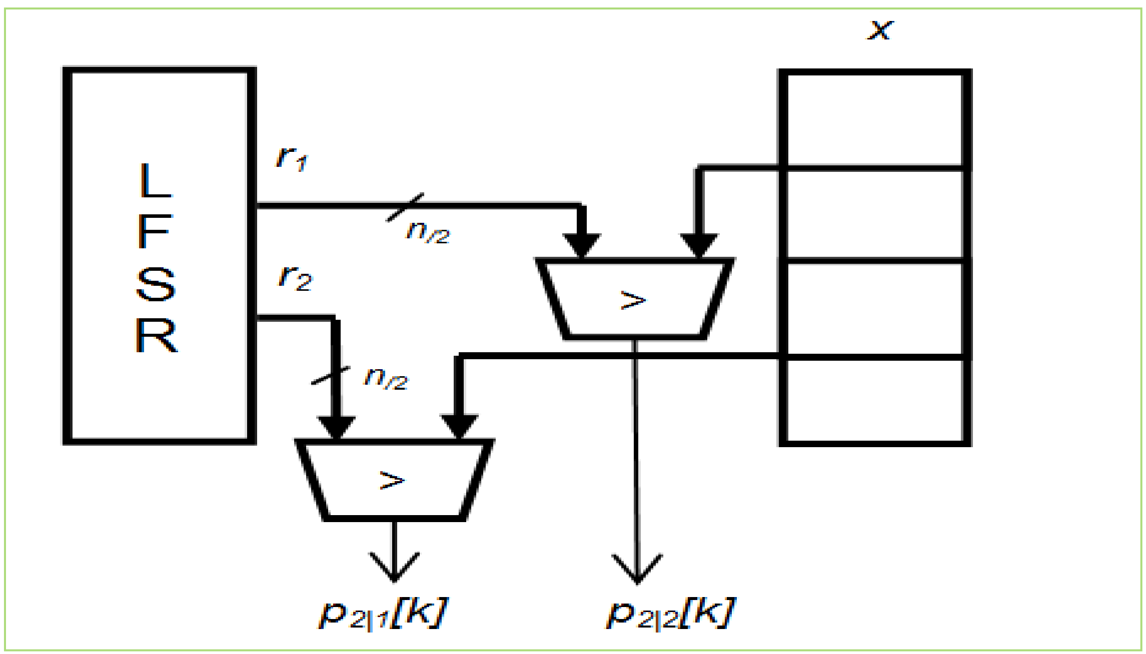
Resolution and variance

- Importance of the variance in the length of the pulse stream

- New technique to decrease the resulting variance of stochastic codification

Multi-level Stochastic Codification (MSC)

- Basic principle - the dynamic range of the values in the stochastic number generator is split in L parts and each part is separately encoded in a pulse stream.



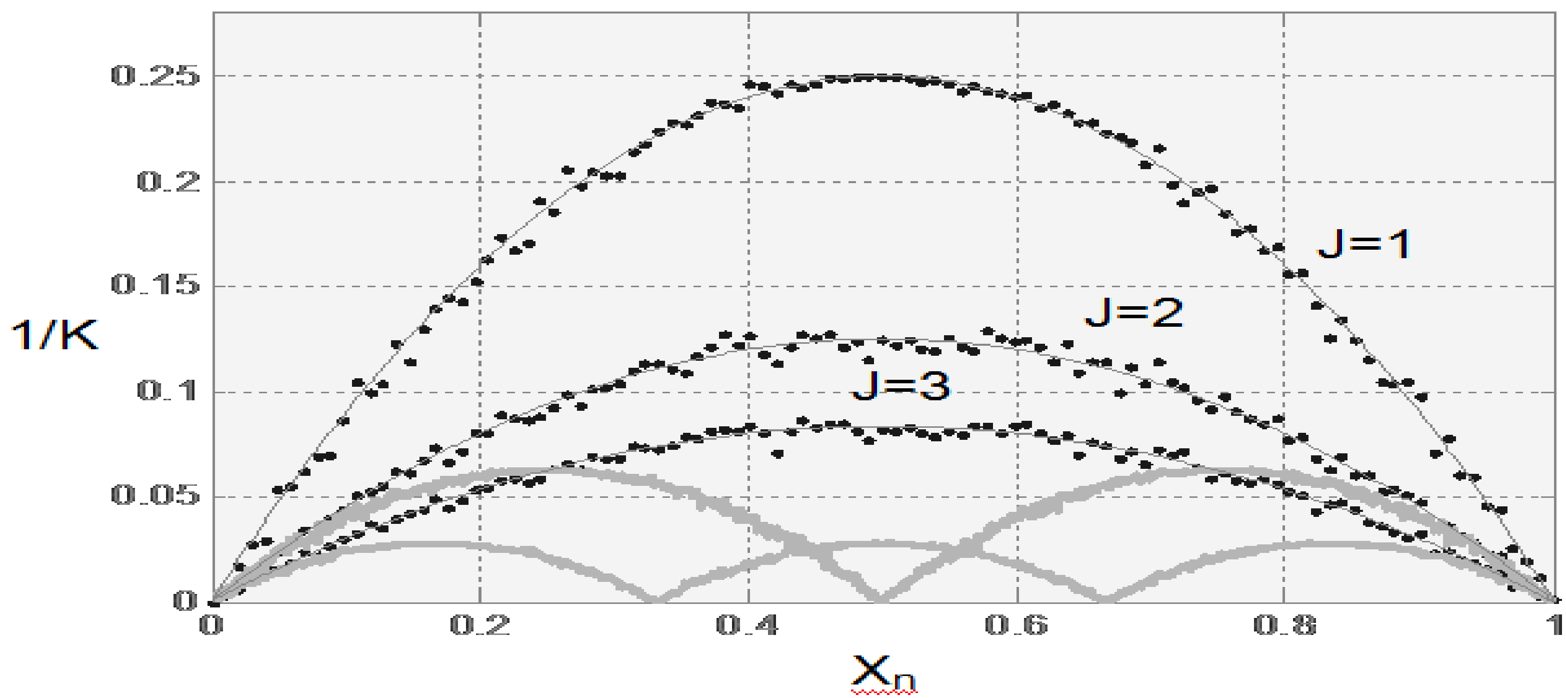
Parallel Stochastic Codification (PSC)

- Basic principle - each value is represented by J stochastic numbers generated with uncorrelated random sequence.

Behavior of the variance

$$\sigma_M^2 = Var(\,M(p_x, K)|_{x(t0)=X}) = \frac{x_N \cdot (1 - x_N)}{K}$$

-Maximum value for variance will occur in the center of the dynamic range
-Figure shows theoretical and simulated variance for a fixed value of K.
-Variance is normalized by 1/K, where K is the average estimator depth.



Length K in the techniques MSC and PSC

The number of K samples needed for the representation of a given value with a resolution r is defined by the following equation:

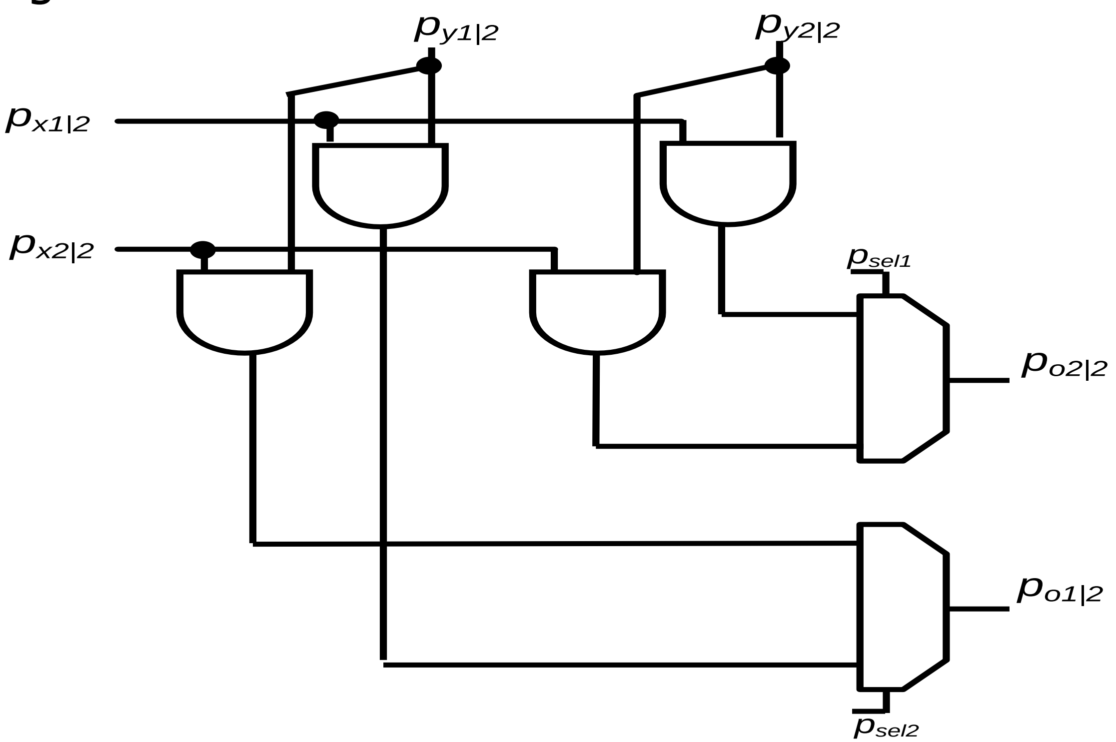
$$K > \frac{2^{2r-2}}{J.L^2}$$

J->linear relationship
L->quadratic relationship

Observations

- Length K decreases quadratically with increasing L

- The area consumed by the multiplier increases quadratically with increasing of L



Multilevel stochastic multiplier for a data representation with two subsections (L=2).

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Conclusions

- MSC is a viable alternative to implement stochastic arithmetic systems

- Despite being a good alternative in stochastic circuit design, still do not know how this technique affects the system fault tolerance

Future works

- Main lines:
  - -fault tolerance
  - -automated synthesis.
  - -Behavior of variance

- Main focus: compare multilevel and stochastic parallel circuits for various failure scenarios and assess its robustness

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