Research of Signal Integrity at High Speed Interconnects

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1. Introduction & Background

WHAT IS SIGNAL INTEGRITY (SI)?
WHY DOES IT MATTER?

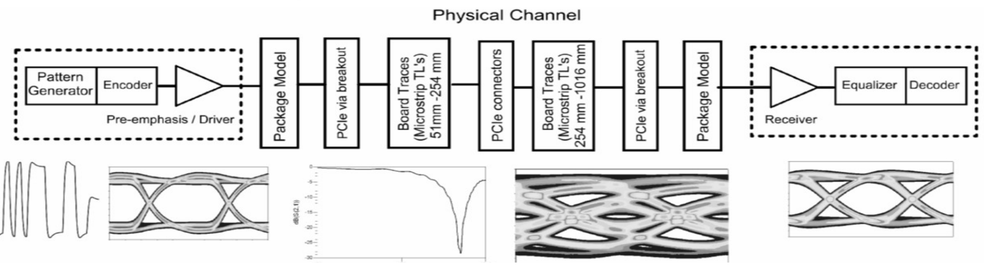
- SI is a set of measures of the quality of an electrical signal

PRESENT PROBLEM:

- High speed digital systems with sufficiently high clock frequencies create SI problems & cause device malfunctions

GOAL:

- to ensure reliable high-speed data transmission



TIMING:

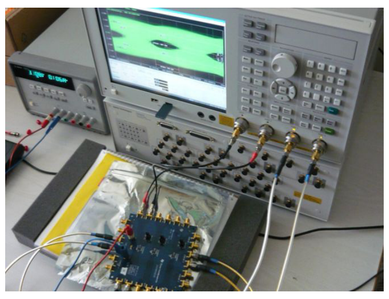
- interconnections affects timing budget that divides out and allocates one cycle of a clock to all the various operations

NOISE:

- electrical properties of interconnects effect the waveform of digital signals.

2. Ongoing Research

- Signal integrity problems in the design of high-speed serial communication devices
- SDE-based variance simulation in transmission line models with random excitations.
- Approaches to derive and generalize aprroximate formulas of NILT methods for solving defferential equations and nonlinear circuits.
- Analysis of interconnects and high frequency circuits up to 20 GHZ
- Analysis and optimization of high-speed serial links up to 16 Gb/s
- The project connects to research activities of the Analog and Digital Systems of the SIX research center, FEEC BUT in Brno.



3. Research Plan

- The aims of the research are divided into the following work packages

- WP1
- Research of mathematical models of interconnects based on RLCG lumped elements and their solution
- Laplace transform techniques will be improved including numerical inversion of the Laplace transform(NILT)
- Innovative techniques including SDE approach for delay estimation, sensitivity and worst-case analyses.

- WP2
- Research of mathematical models for distributed-parameter-defined interconnects and their solution
- Innovative approaches to the solution of PDE's describing lossy coupled multiconductor transmission lines (MTL)
- A new approach for interconnect parameters variability analysis based on partial SDE's will be elaborated.

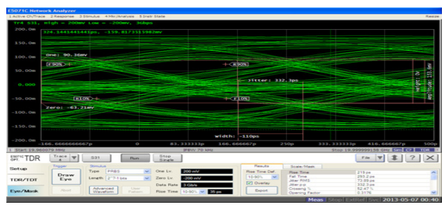
- WP3
- Research of mathematical models of nonlinear interconnects, structures and techniques of their solution
- New posibilities of the application of the Volterra theory will be elaborated
- Further investigation on the multivariable Laplace transform inversions to process images from the expansion of nonlinear system responses.

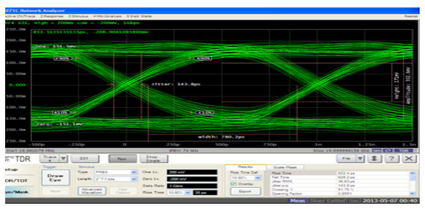
- WP4
- Experimental measurments on custom-made PCB traces to verify our developed analysis and techniques
- Characterization of the signal at the end of the stressed TL line in order to put requirements on CDR circuitries
- time-domain pre-emphasis techniques beyond the light of develoments in CMOS scaling
- Computer simulation, optimization and experiments.

4. Expected Findings

1. **YEAR 1**

- Improved novel techniques of lumped-parameter interconnect models solution
- Parameters variability assessment based on ordinary SDAEs
- Improved pre-emphasis, equalization techniques and orientation measurments.





2. **YEAR 2**

- Improved or novel techniques of distributed-parameter interconnect models solution
- NILT and FDTD improved and/or novel techniques
- Initial results from the field of partial SDEs and fractional-order DEs and nonlinear interconnects analysis
- Improved CDR techniques for high-speed transmissions and its VHDL implementations

3. **YEAR 3**

- Improved multivariable NILTs
- Nonlinear interconnects analysis based on Volterra series and n-dimensional LT approaches and evaluation of approaches based on partial SDEs and fractional order DEs
- Compare the theory with the real results of the measurements on interconnects and experimental verifications.

5. Research Objectives

1. OBJECTIVE -MATHEMATICAL MODELS

- research on RLCG lumped element models
- using transmission-line theory for interconnects solution
- research of MTL systems variability analysis based on stochastic ordinary and partial differential equations
- further research on NTL using NILT with the use of Voltera series expansion

2. OBJECTIVE - PRACTICAL MEASUREMENTS

- simulation credibility by comparing the theoretical with the real results of the measurements on interconnects.
- development of CDR algorithms that feature some unique parameters and are a perspective for the use in high speed communication protocols
- reduce the negative effects of dielectric losses or skin effect of interconnects