Design Methodology for an Embedded System for High-Performance Computing

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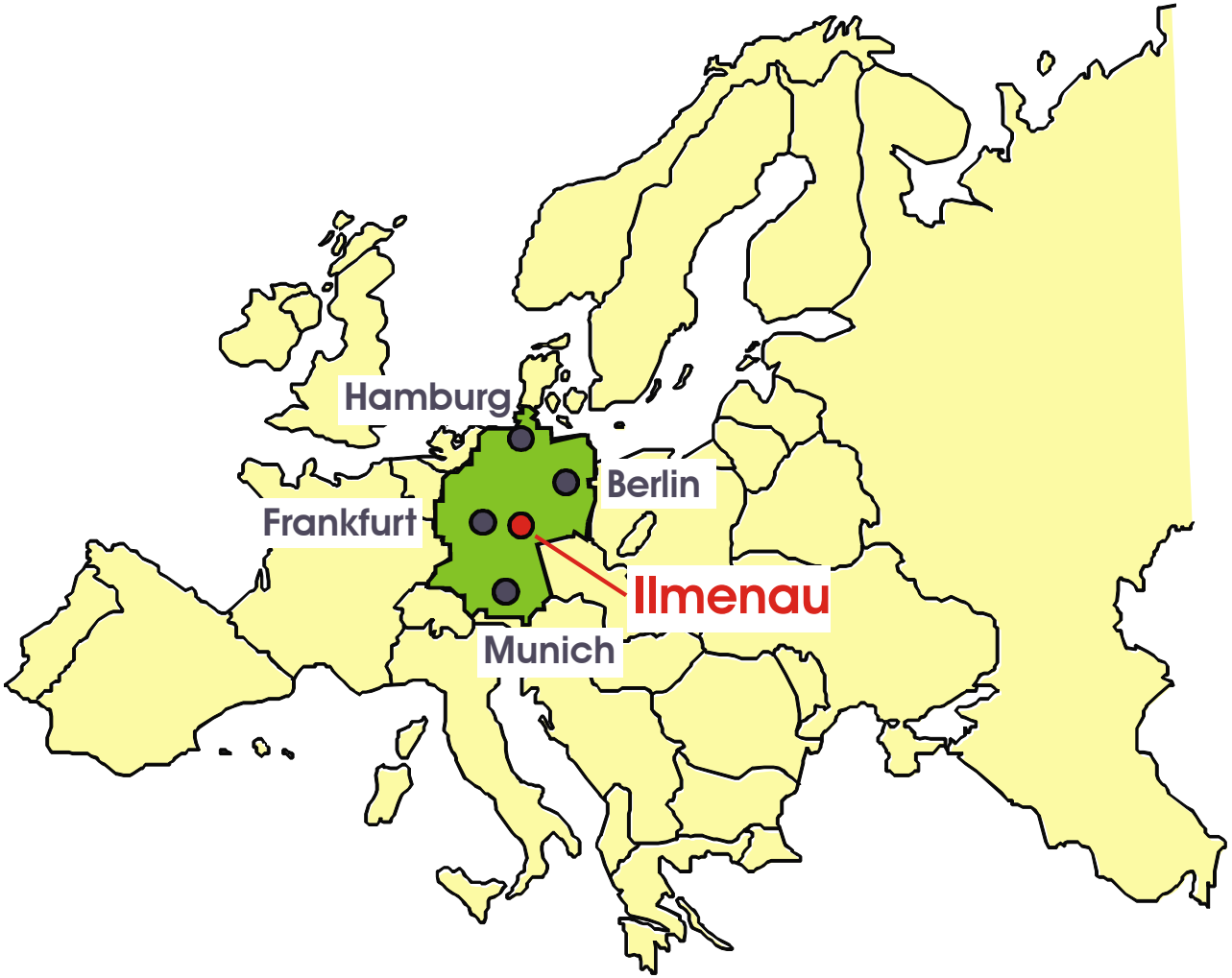
Where is Ilmenau?



Topics

1. Introduction and Overview
2. Design of the Computer System
3. Example Model
4. Simulation Results
5. Summary

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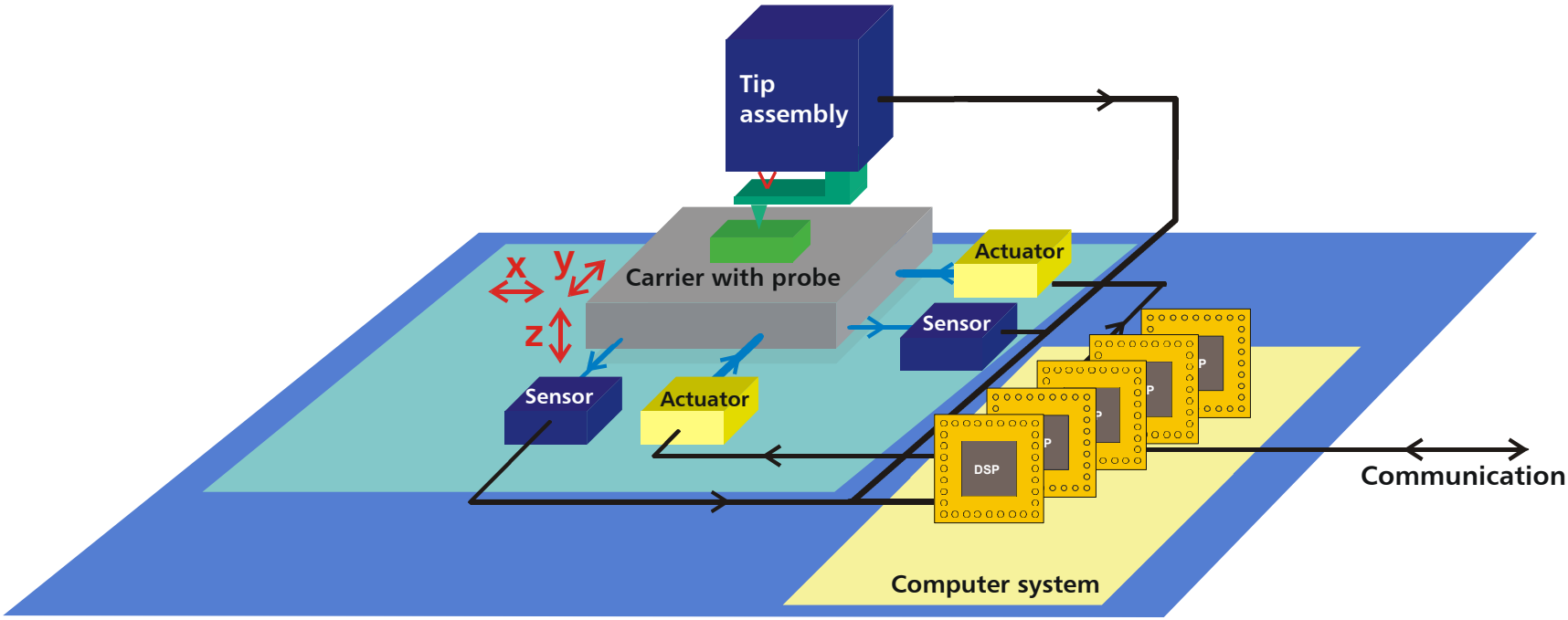
1. Introduction and Overview

- Nano positioning and measuring machines:
  - Machines for fast positioning and position determination with nanometer and subnanometer resolutions
- Examples of application:
  - Manufacturing and assembly of very small parts
  - Measurement on semiconductor wafers
  - Atomic Force Microscopes (AFM)

Principle of an Atomic Force Microscope

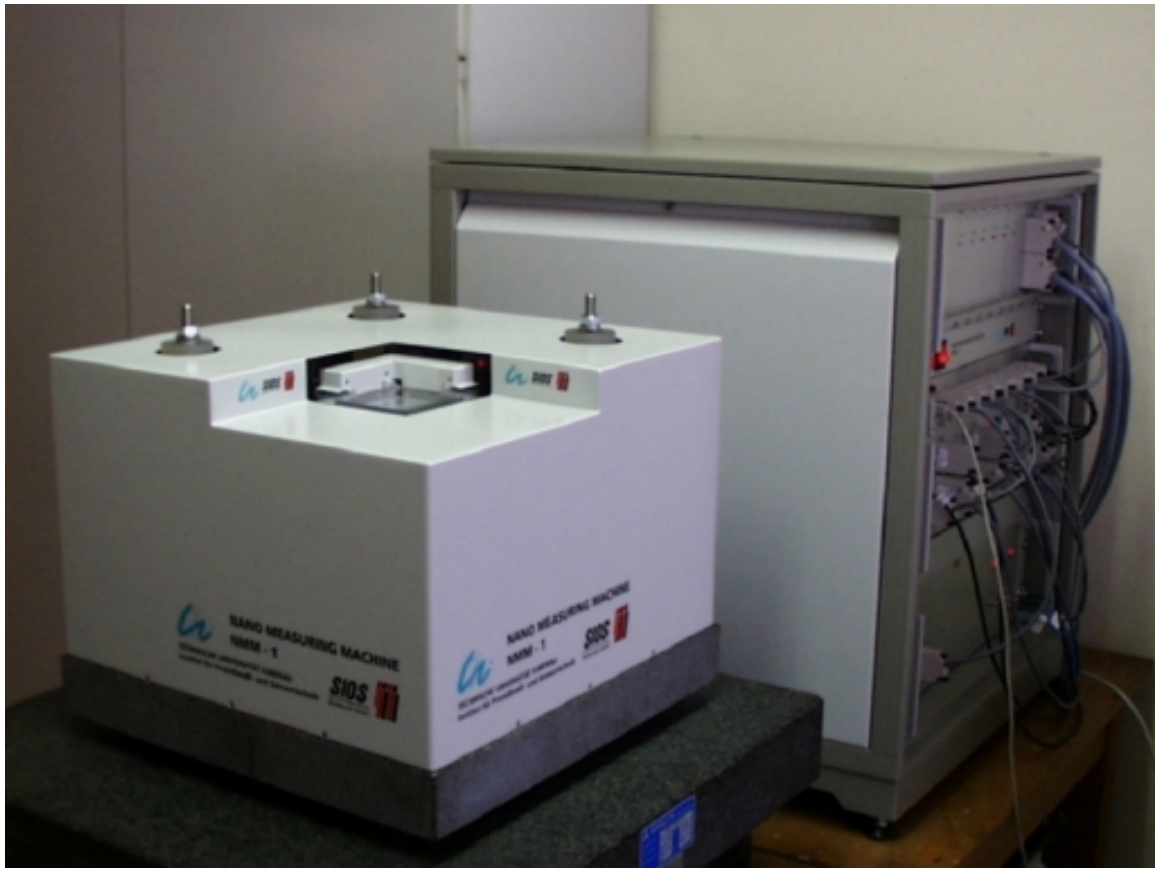
(From a project team at Ilmenau Technical University)



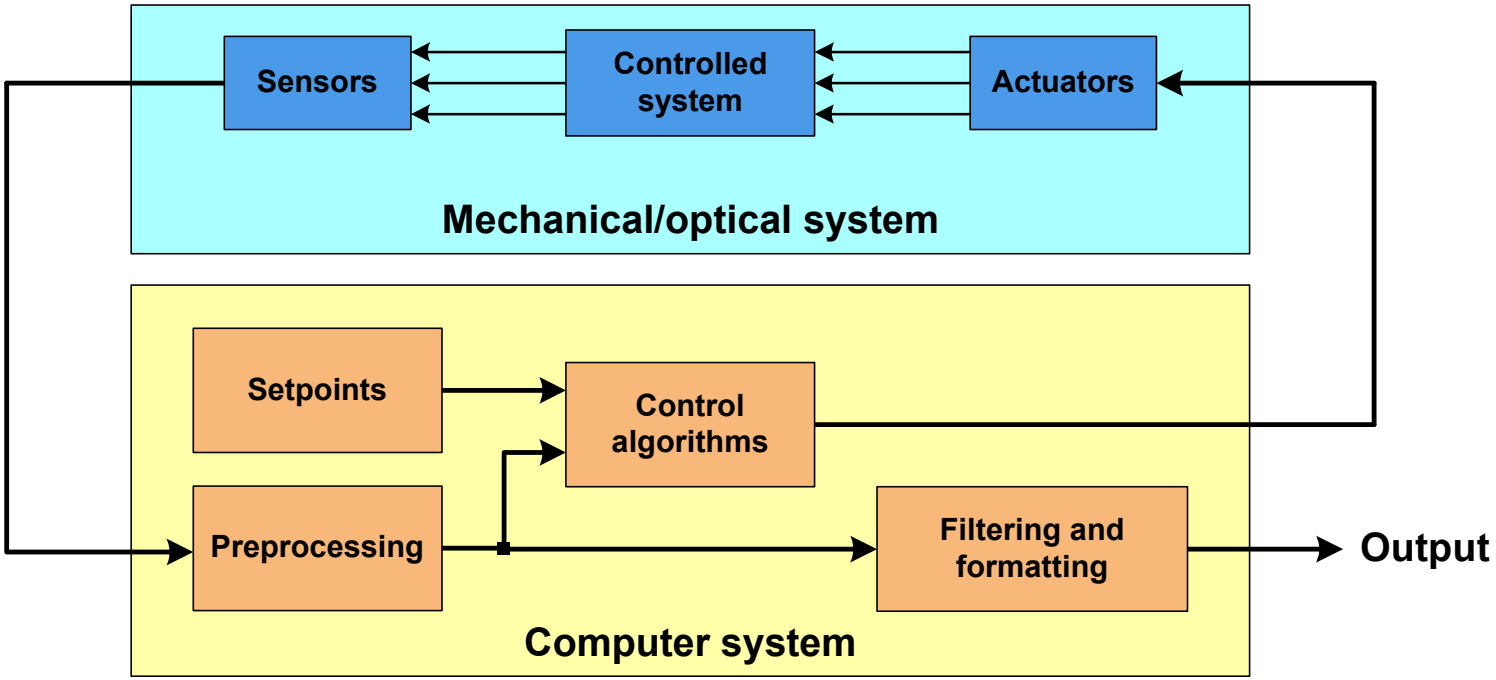
Operation Details

- Position measurement by laser beam interference (multiple axis)
- Closed loop control of position
- Very fast calculation of filter and control algorithms by embedded DSP system

Picture of the Machine



Simplified Flow of Signals



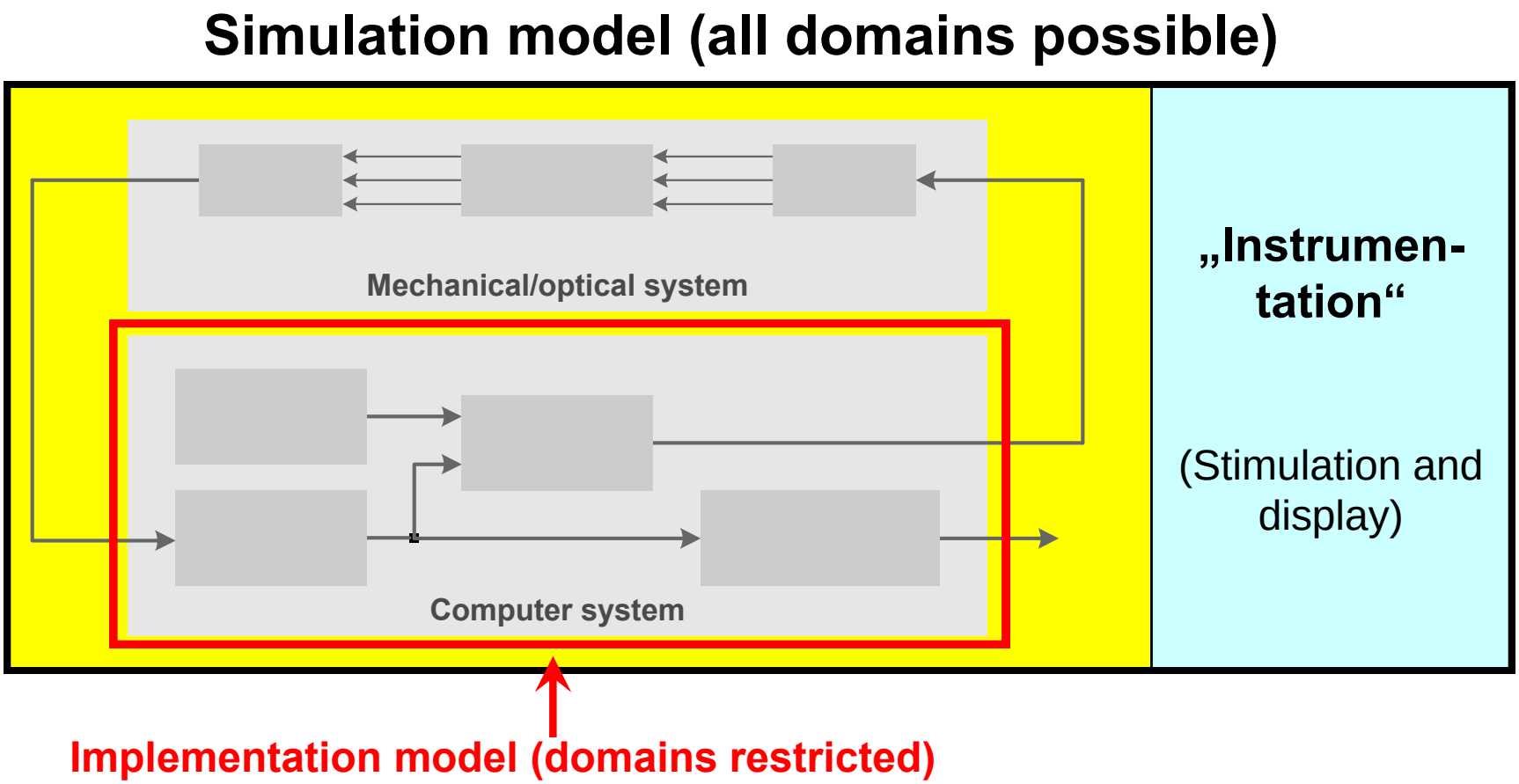
2. Design of the Computer System

- Multi processor system with very fast DSPs
  (Texas Instruments TMS320**C67xx**)
- Proprietary real time operating system
  (with multiple scheduling strategies)
- Management of high sample rates
- **Model based design methodology**

Model based design methodology

- Includes embedding environment
- Multi domain modelling
- Combination of different models
- Continous design flow towards implementation
- Modular design
- Integration into design tool suite

Model Structure



Steps in the Design Process

- Signal flow model of whole system
- Behavioral model of operating system
- Generating software from the model
- Verification and validation

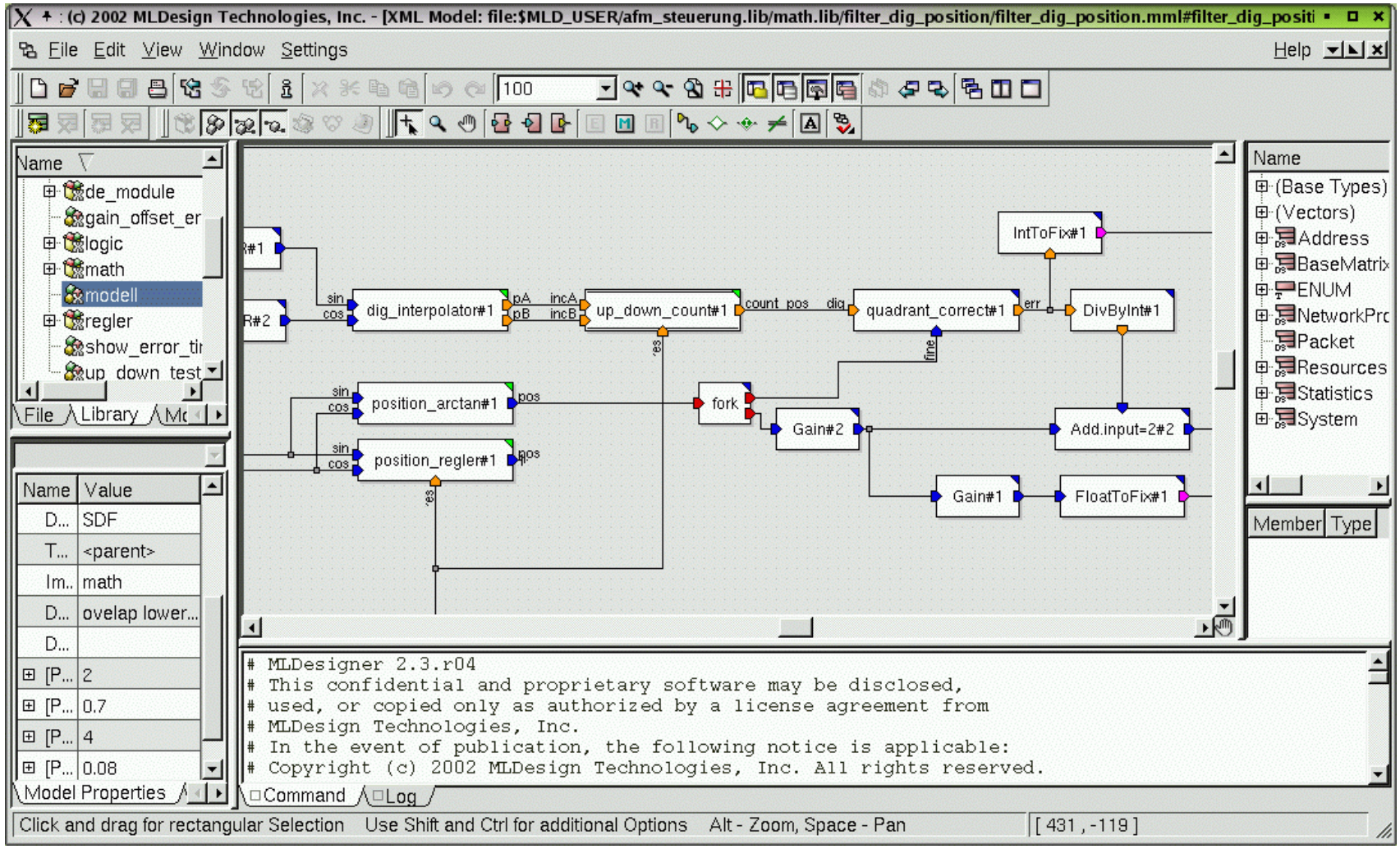
Modelling tool under consideration:

MLDesigner® from MLDesign Technologies, Inc.

MLDesigner Basics

- Hierarchical multi domain modeling framework
- Covers module, system and strategy („mission“) levels
- Combines numerous modeling domains (discrete and continous paradigms)
- Capabilities for simulation, design check, code generation, export
- Derived from well-known Ptolemy tool (University of Berkeley)

MLDesigner Sample Workspace

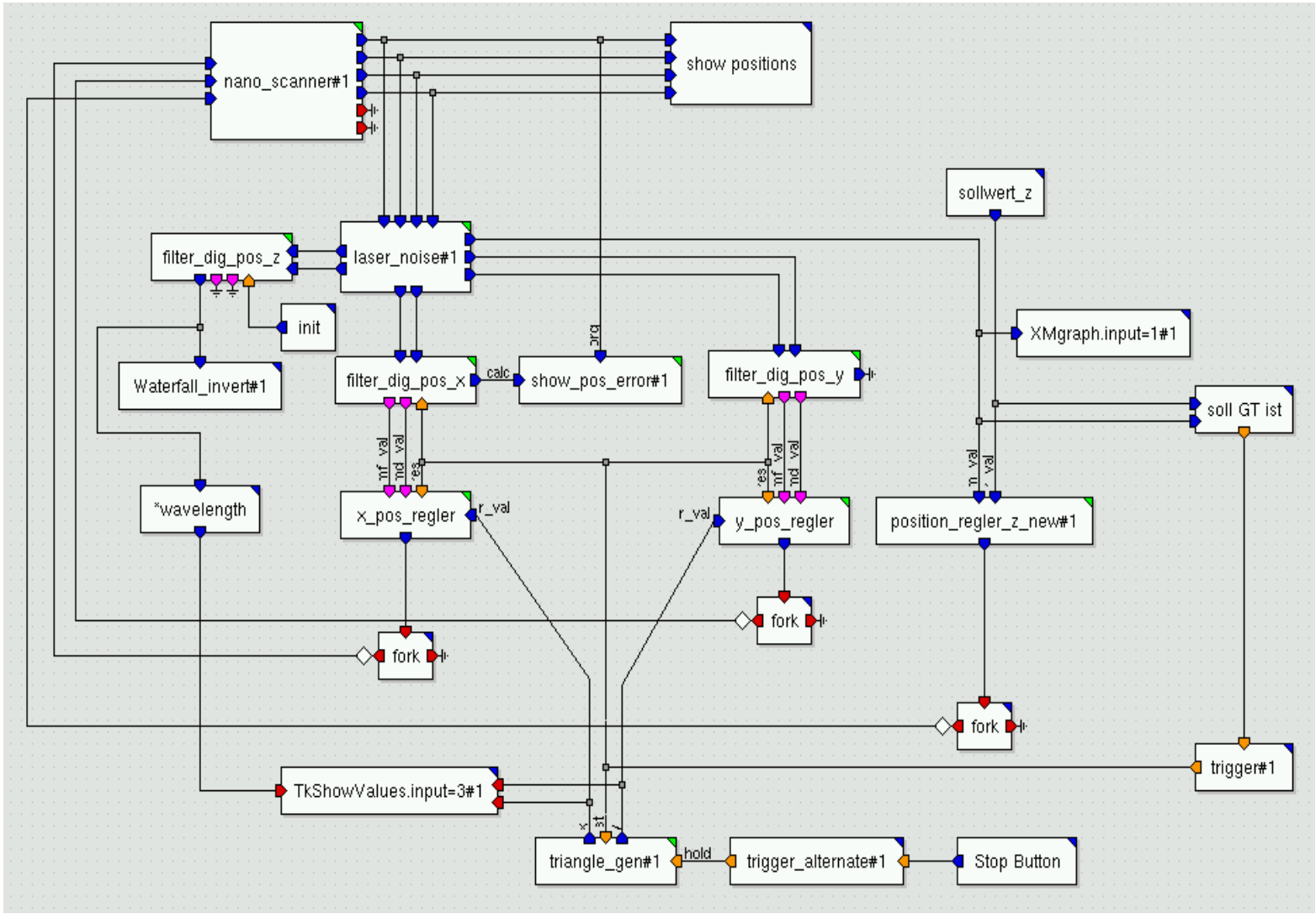


3. Example Model

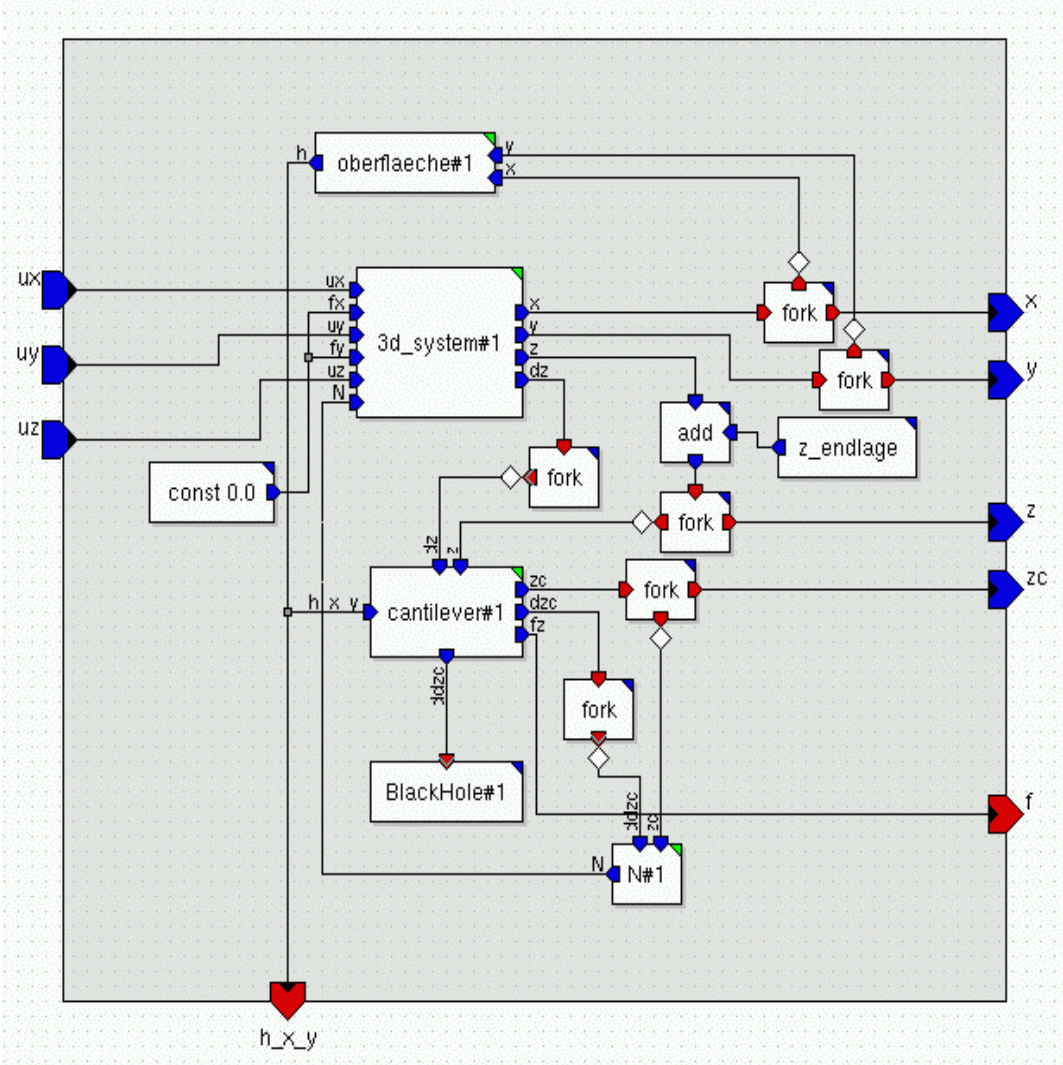
First result: Example model for an Atomic Force Microscope

- Modelled with MLDesigner
- Combines discrete and continous parts
- Detailed dynamical simulation
- Equipped with elements for stimulation and display

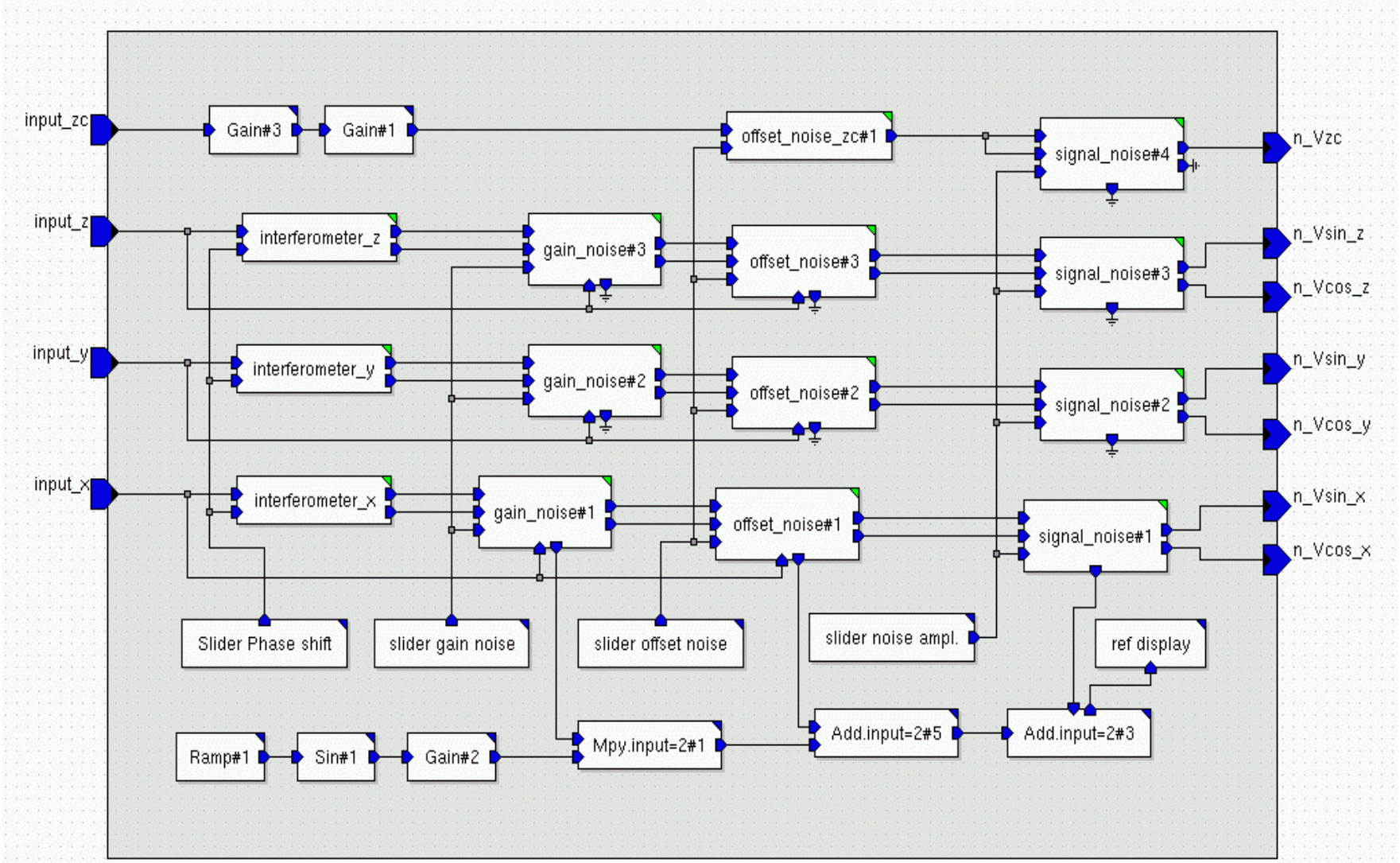
Top Level of Model



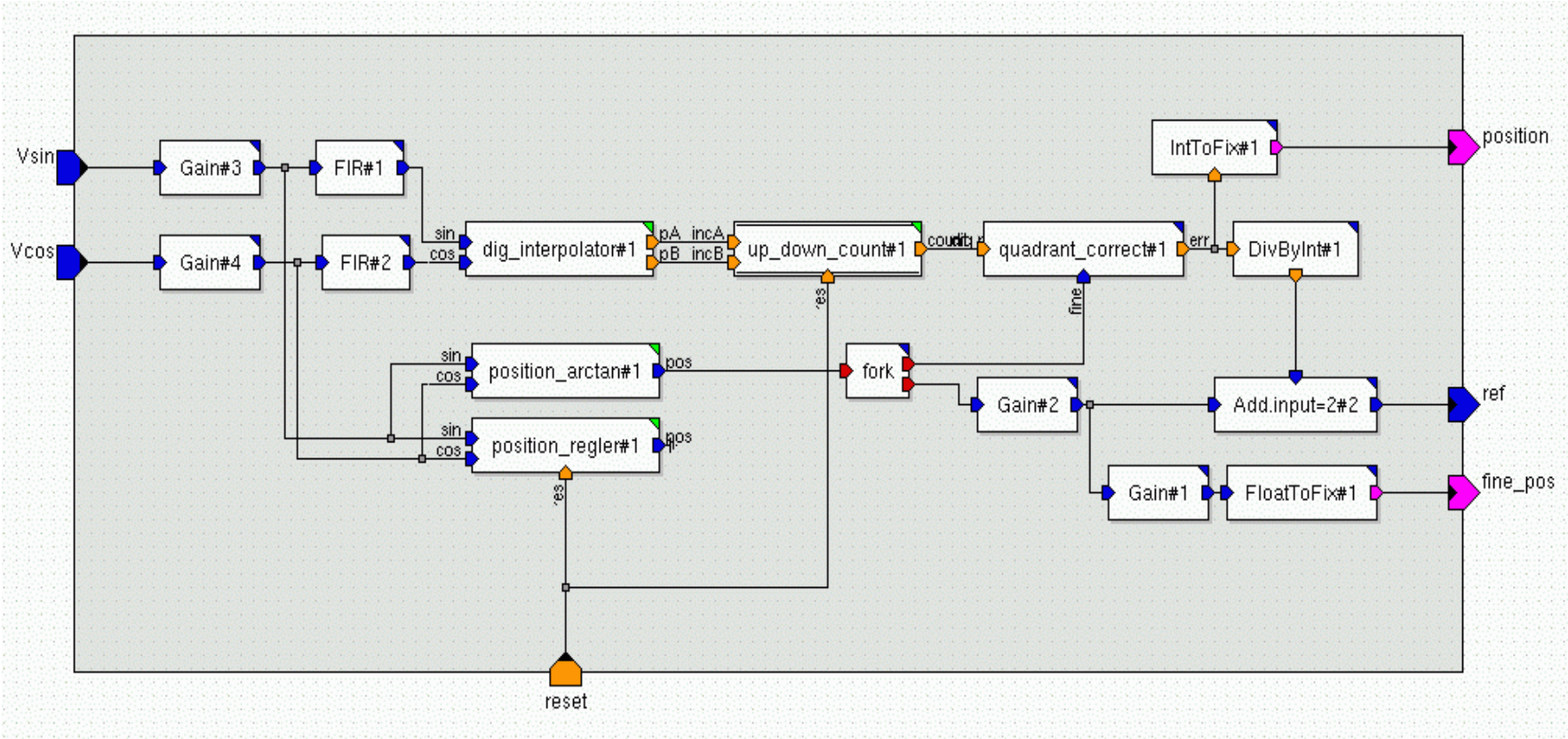
Module ‚nano_scanner‘



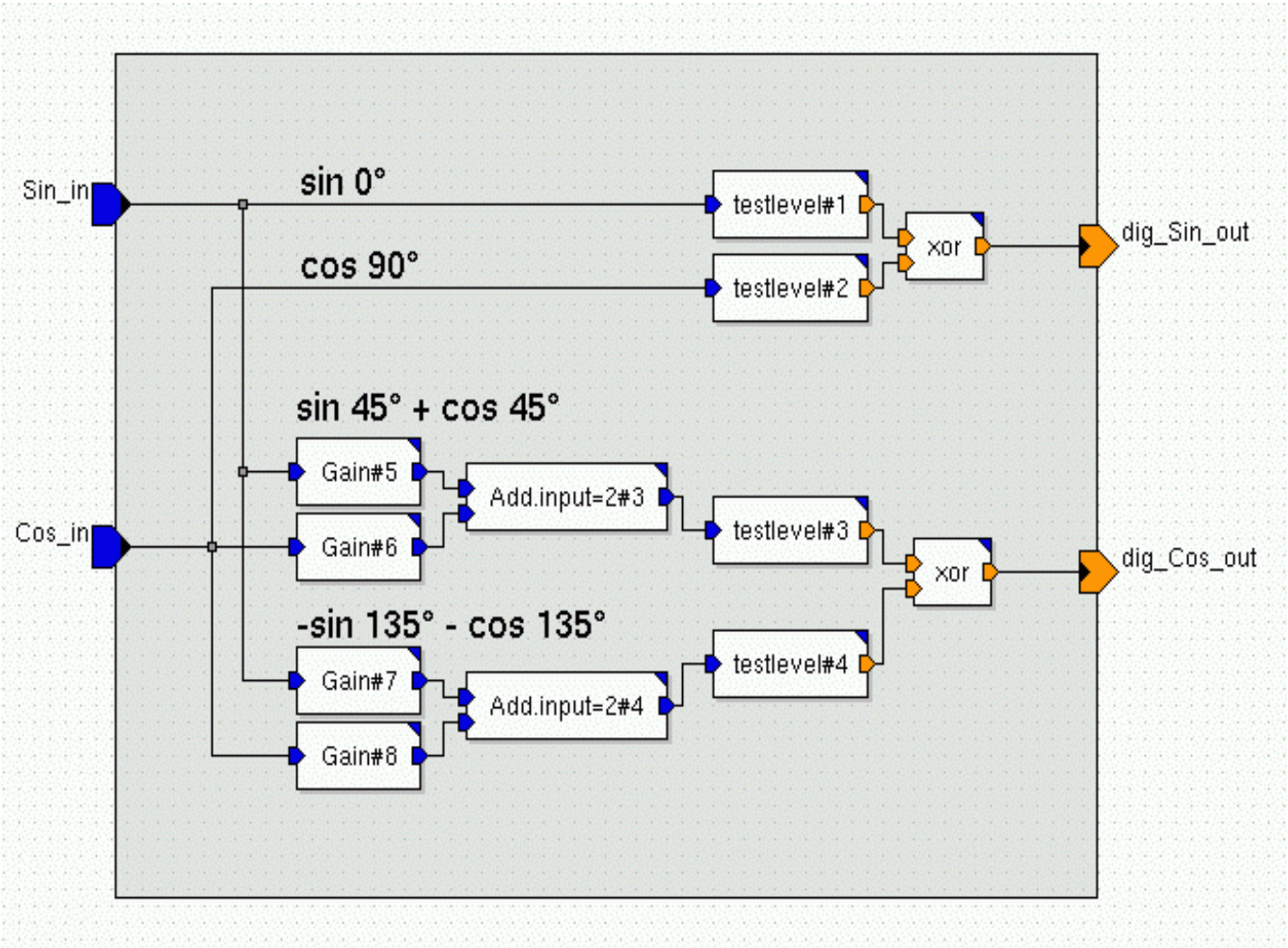
Module ‚laser_noise‘



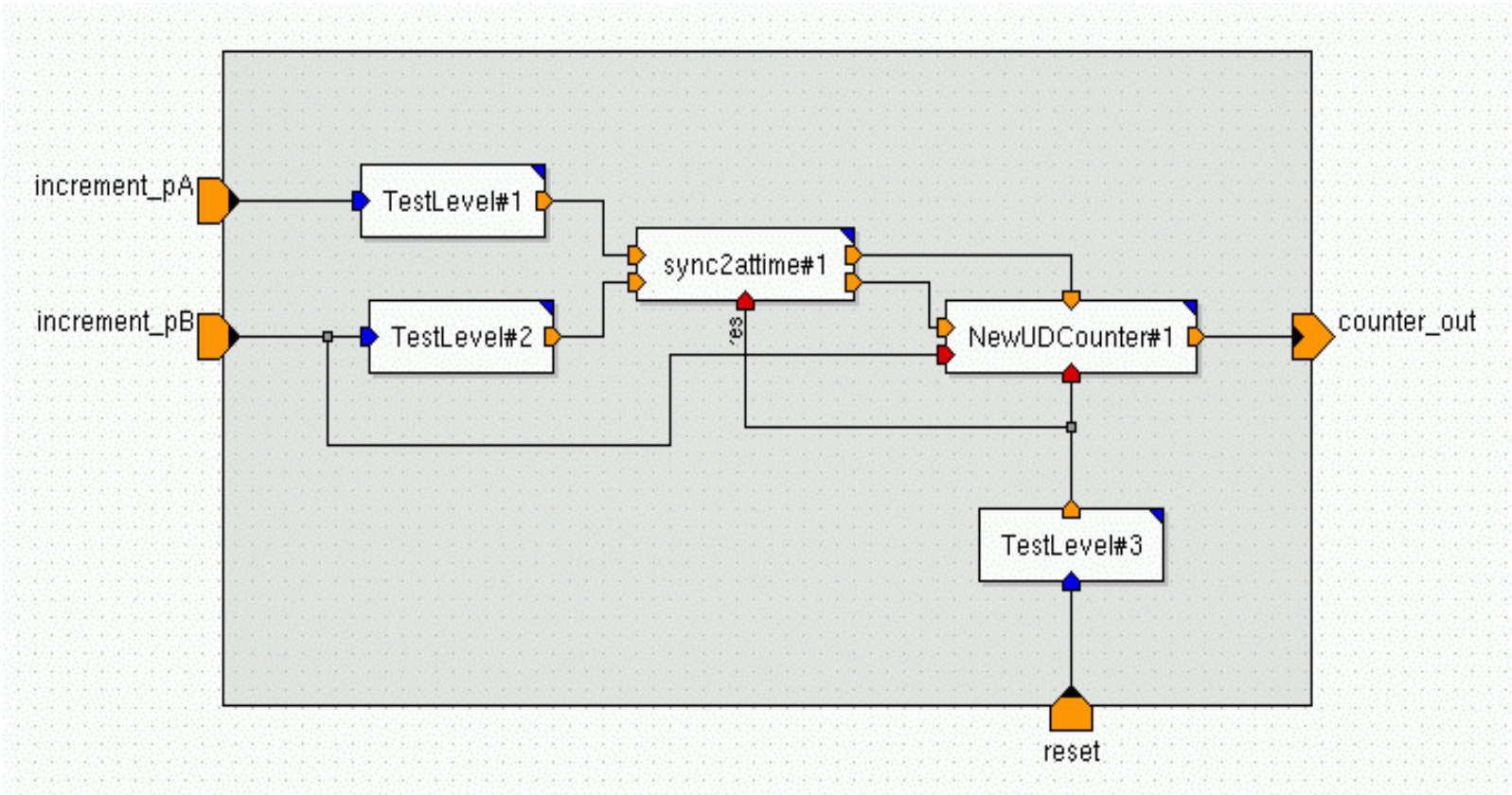
Module ‚filter_dig_pos‘



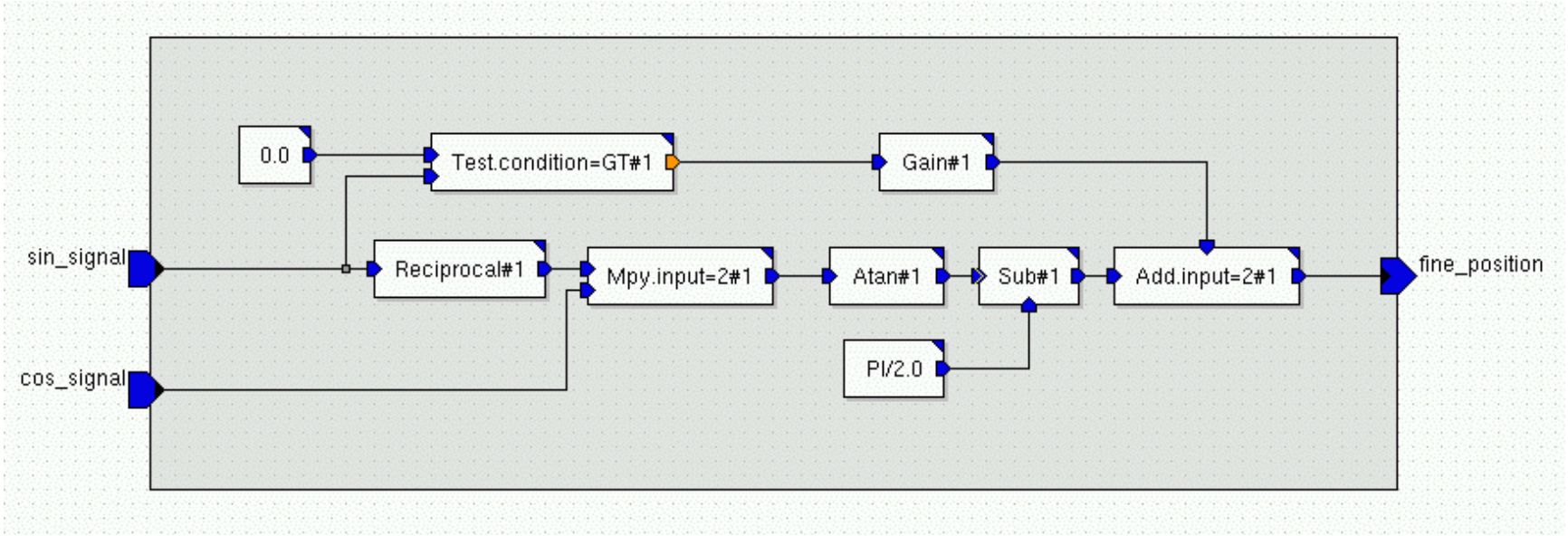
Module ‚dig_interpolator‘



Module ‚up_down_count‘



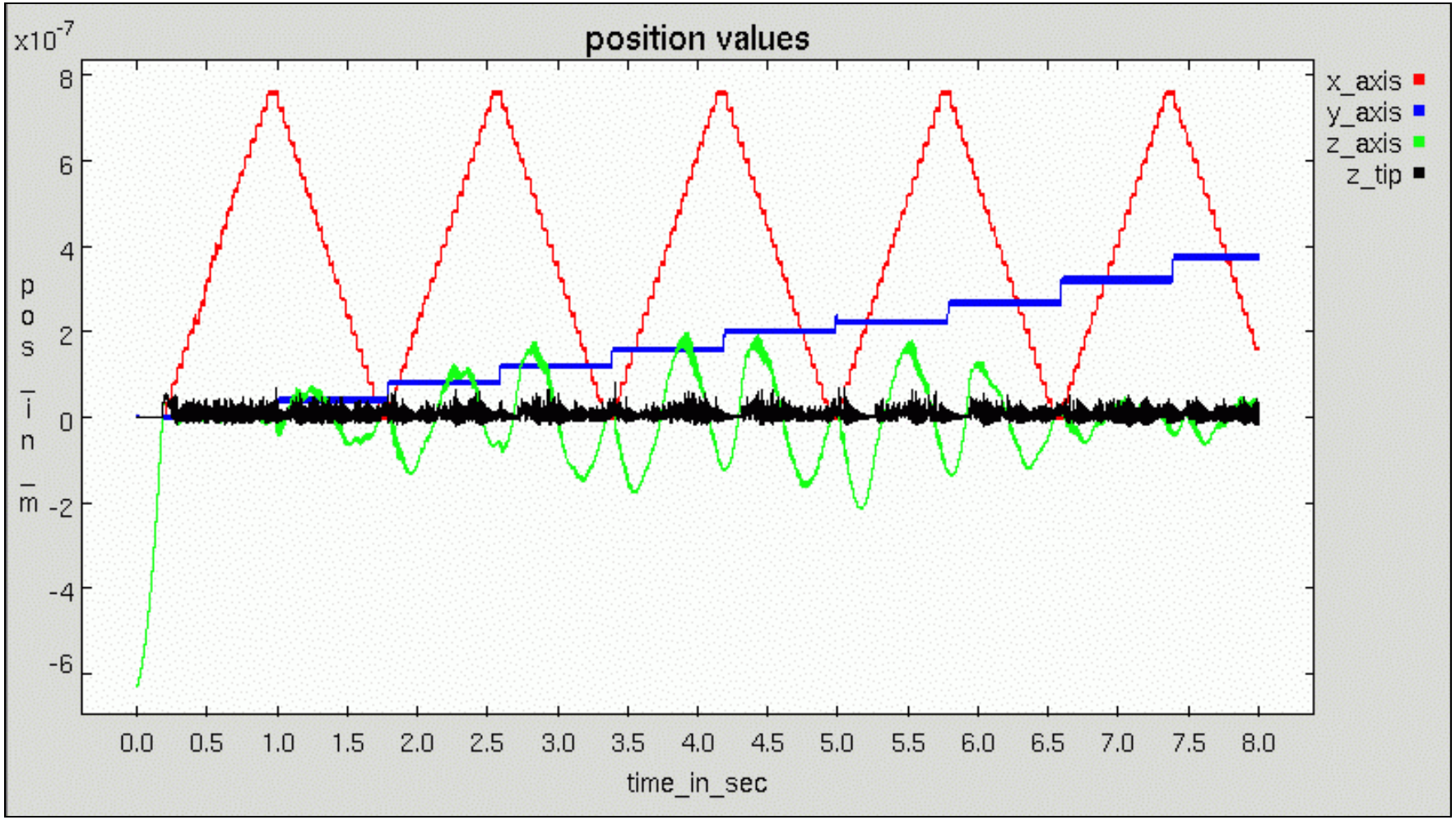
Module ‚position_arctan‘



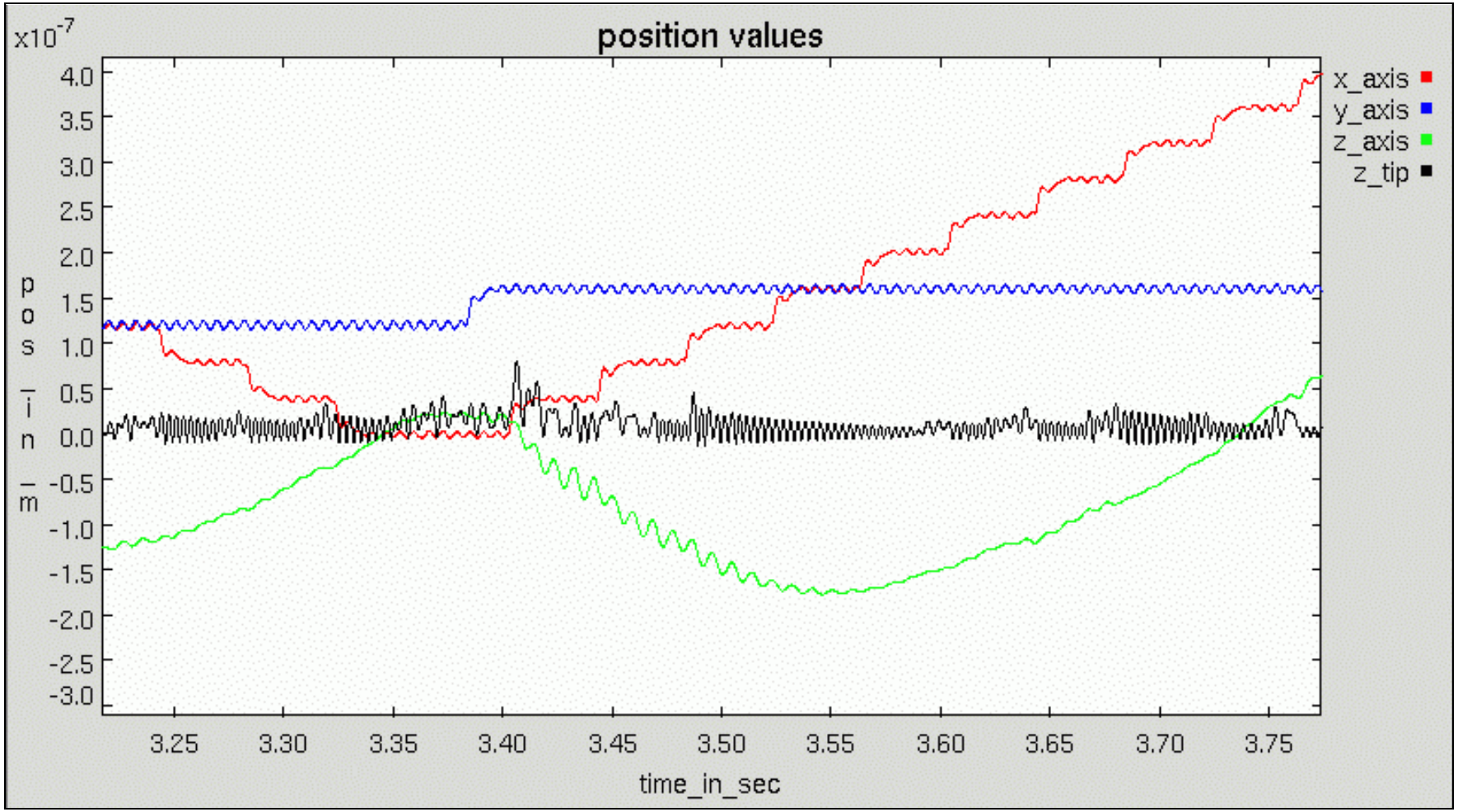
4. Simulation Results

- Validation of overall function
- Visualization of the behavior of control loops
- Examination of the influence of different error sources
- Simple variability

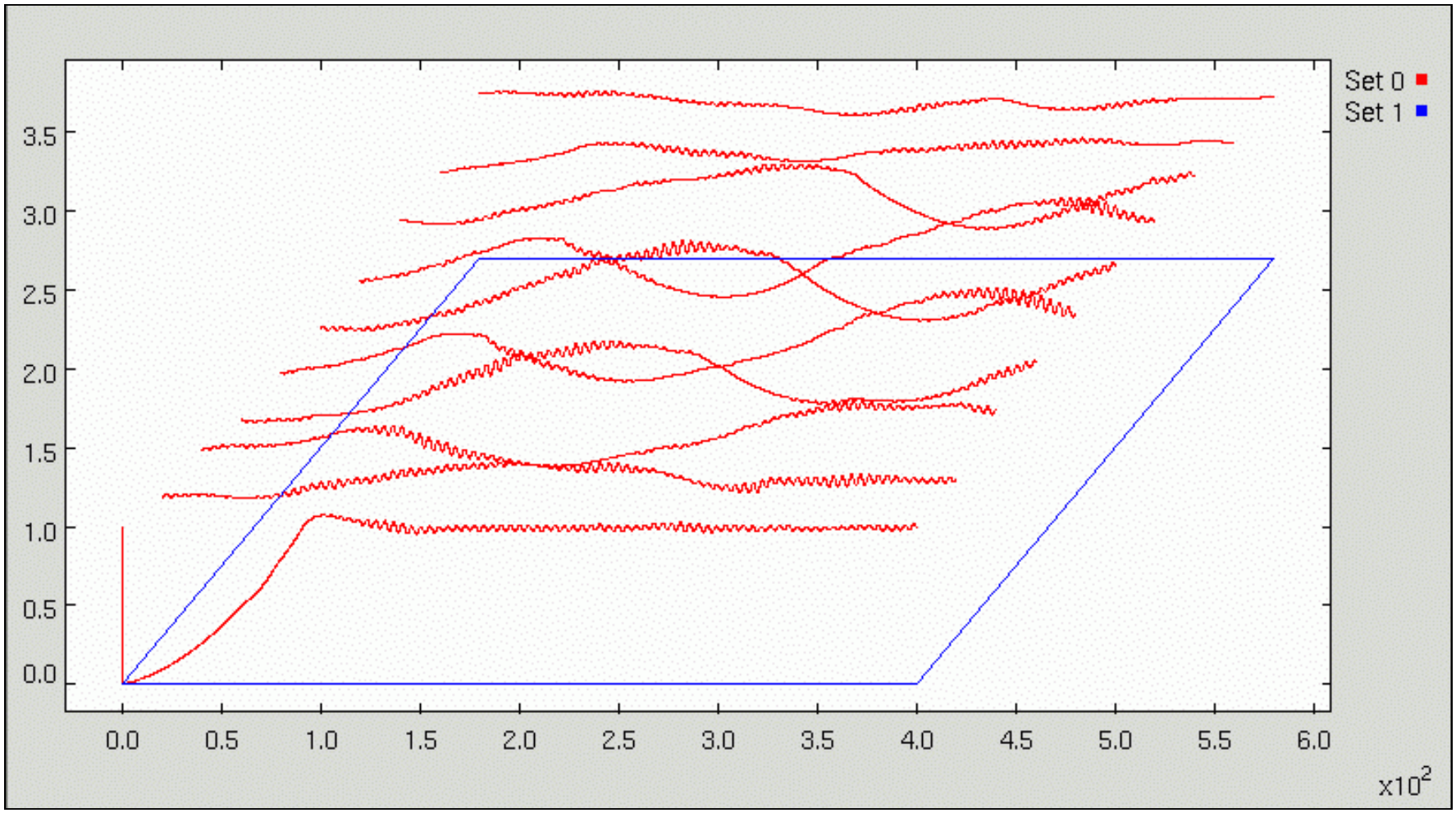
Position Values vs. Time



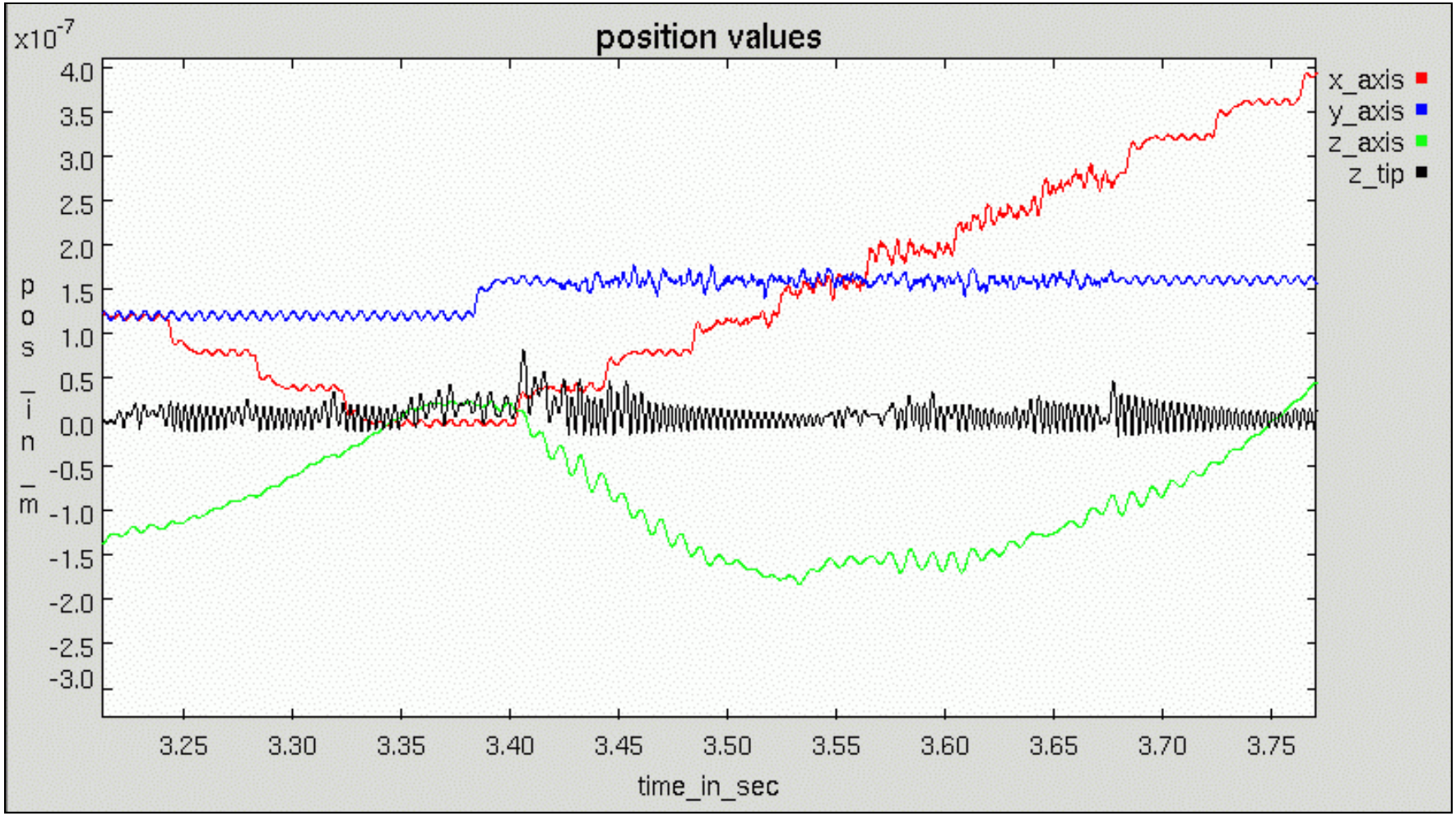
Enlarged Detail



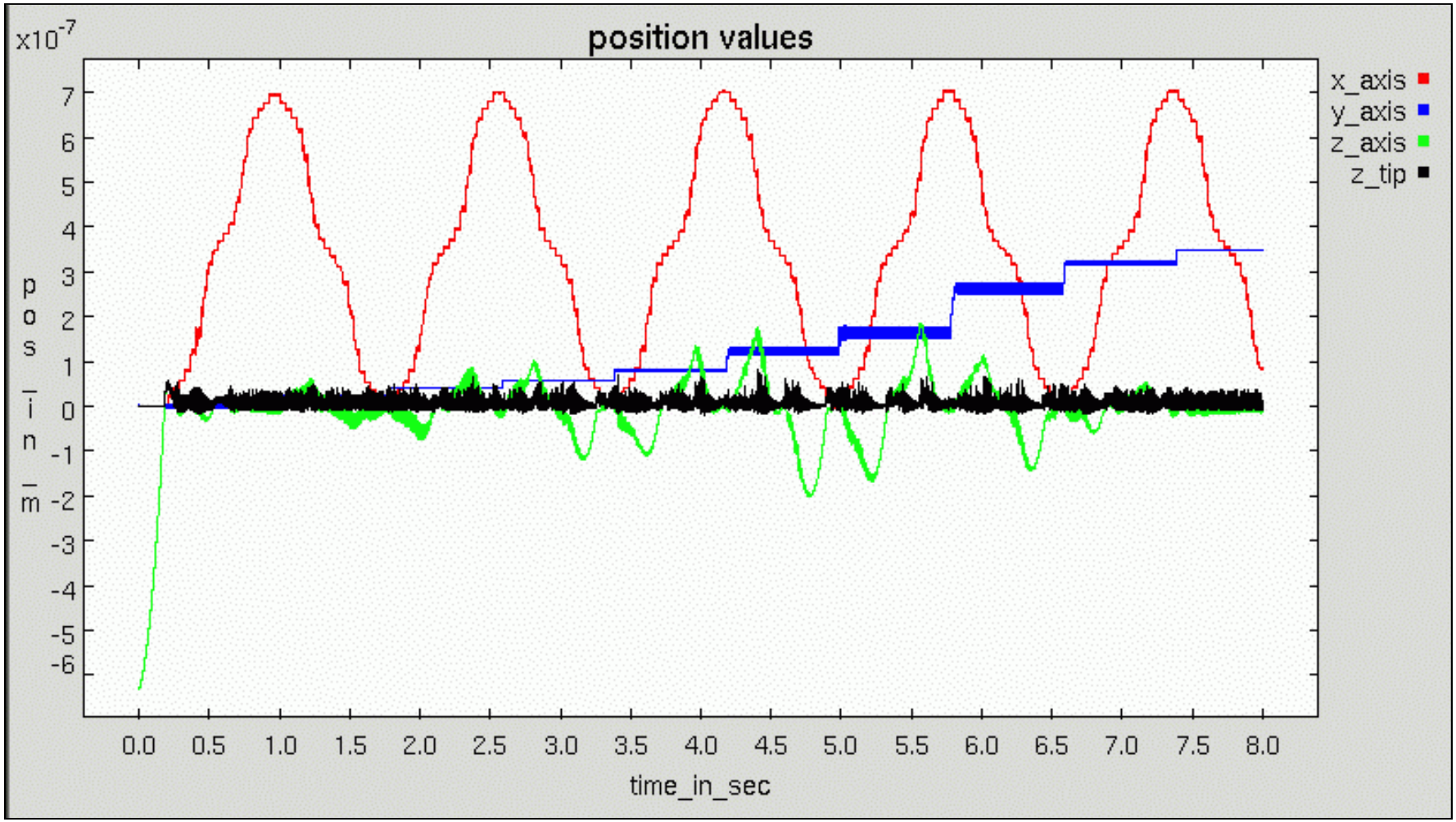
Reconstructed Surface Topology



Detail Including Noise Error



Position Values With Phase Error



5. Summary

Modelling of the whole system has been demonstrated.

Next steps:

- Methodology for software implementation
- Support for multiprocessor systems
- Consideration of limited resource such as computing power
- Inclusion of models for the operating system
- Inclusion of models from external sources
- Validation and verification methods

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