# Multi Architecture Modeling Design Method for Mixed Signal and Multi Domain System Simulation – First Solutions

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## Abstract

During the design process of MEMS digital, analog electrical and non-electrical models at different abstraction levels may appear. The abstraction levels of the interfaces depend on the abstraction levels of the models. If models are developed within the scope of a system design it might be necessary to modify the interfaces of the system and component models as design advances to lower level of abstraction. The aim of this work is to present a new methodical approach for defining multi abstraction level interfaces that can be used without modifications at all abstraction levels of the model belonging to the interface.

## Motivation

The hardware description language VHDL allows to describe more than one architecture for one interface (entity) when designing digital systems. So it is possible to handle architectures with different abstraction levels for one component. Now this feature is also available for the design of heterogeneous systems by means of the extension of VHDL to VHDL-AMS (VHDL Analog and Mixed Signal). But when this feature of VHDL is used to describe components at different abstraction levels then the problem could arise that the models at different abstraction levels may use different interfaces. As a result, the model of the entire system has to be modified when the interface of one component changes, which is a time-consuming and error-prone process.

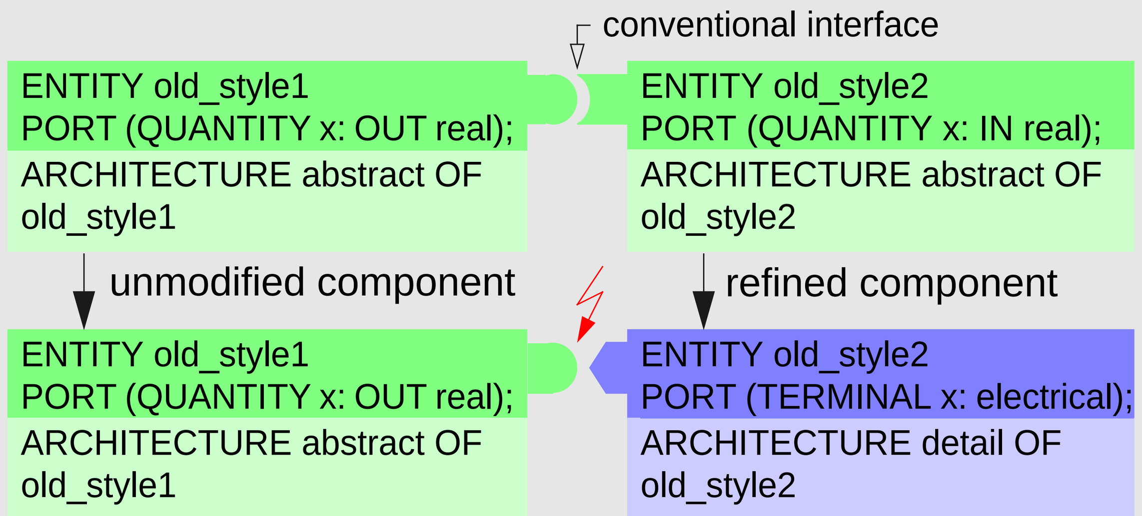



*Figure 1. Possible problem during conventionally top down design process due to different interface objects*

## Method

This poster presents a new methodical approach called Multi Architecture Modeling (MAM). When this new approach is used during the design of the first abstract models in a top down design process then these models can be replaced later by refined models without any modification of their interfaces or the interfaces of the system model. As a constraint to this new methodical approach, the modeling overhead should be as small as possible in comparison to conventional techniques.

### Analog Interface

To solve the problem shown in figure 1, common interface objects for abstract and detailed models have to be identified. There are two possible solutions. Either the interface of the abstract or that of the detailed model may be applied. During the development of this approach it could be shown that the usage of the interface of the abstract model will not work. The usage of the interface of the detailed model also in the abstract model is the better solution (for details refer to the paper). Therefore e. g. in analog models a TERMINAL port has to be applied at every abstraction level instead of a QUANTITY port.

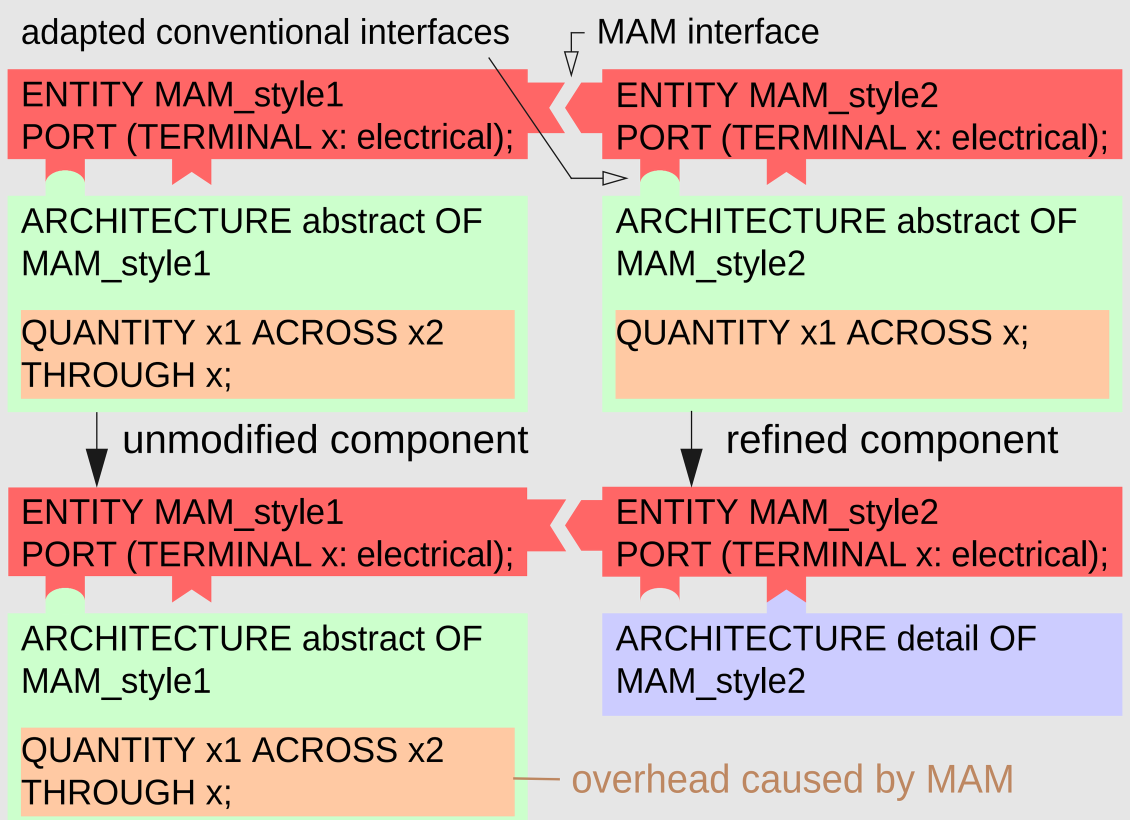



*Figure 2. Unified interface for analog models using MAM*

### Analog/Digital mixed Interface

An exchange of a digital modeled component against an analog modeled component normally is impossible. In the context of the MAM even this can be done by using a TERMINAL instead of a SIGNAL. Therefore special A/D and D/A converters are necessary.

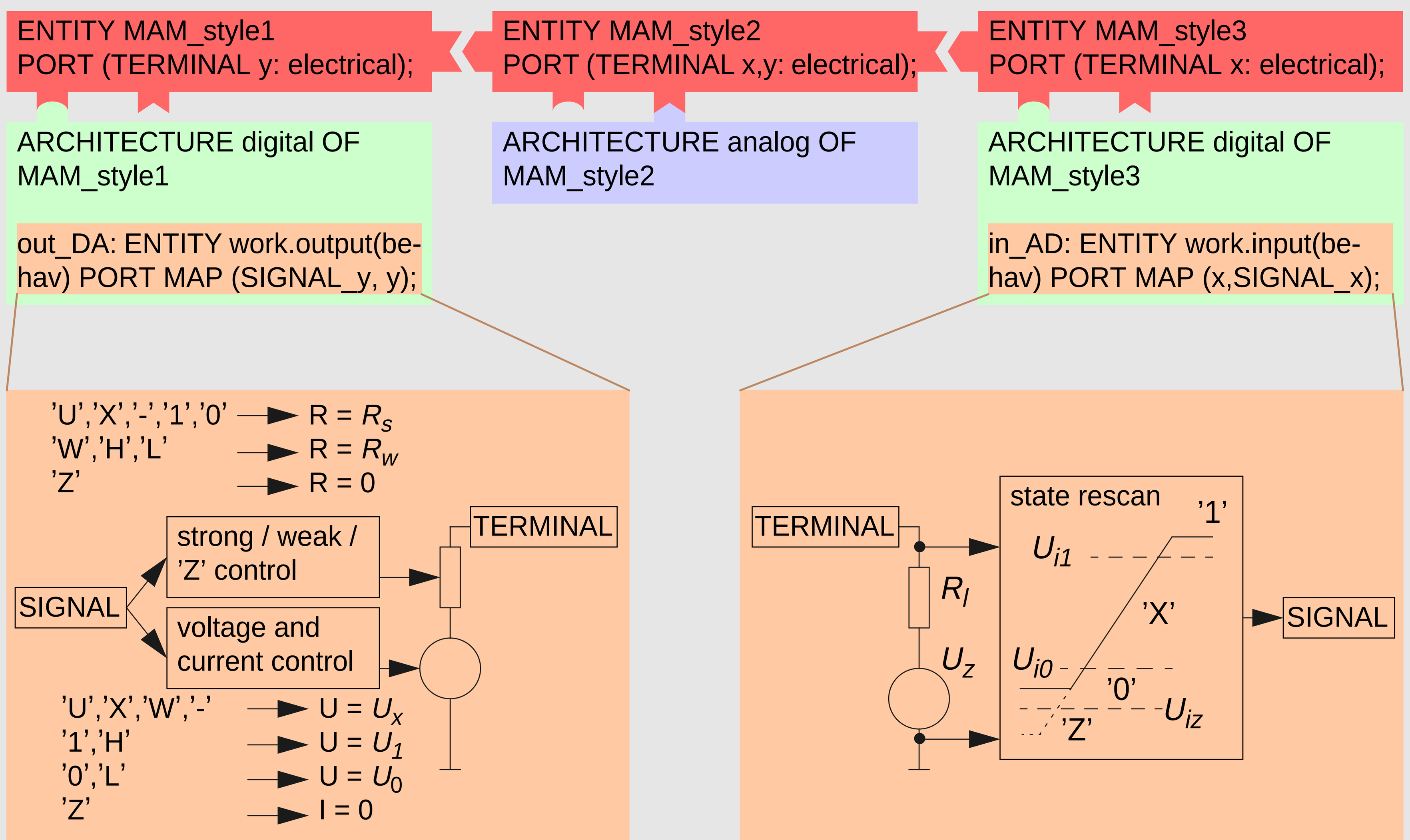


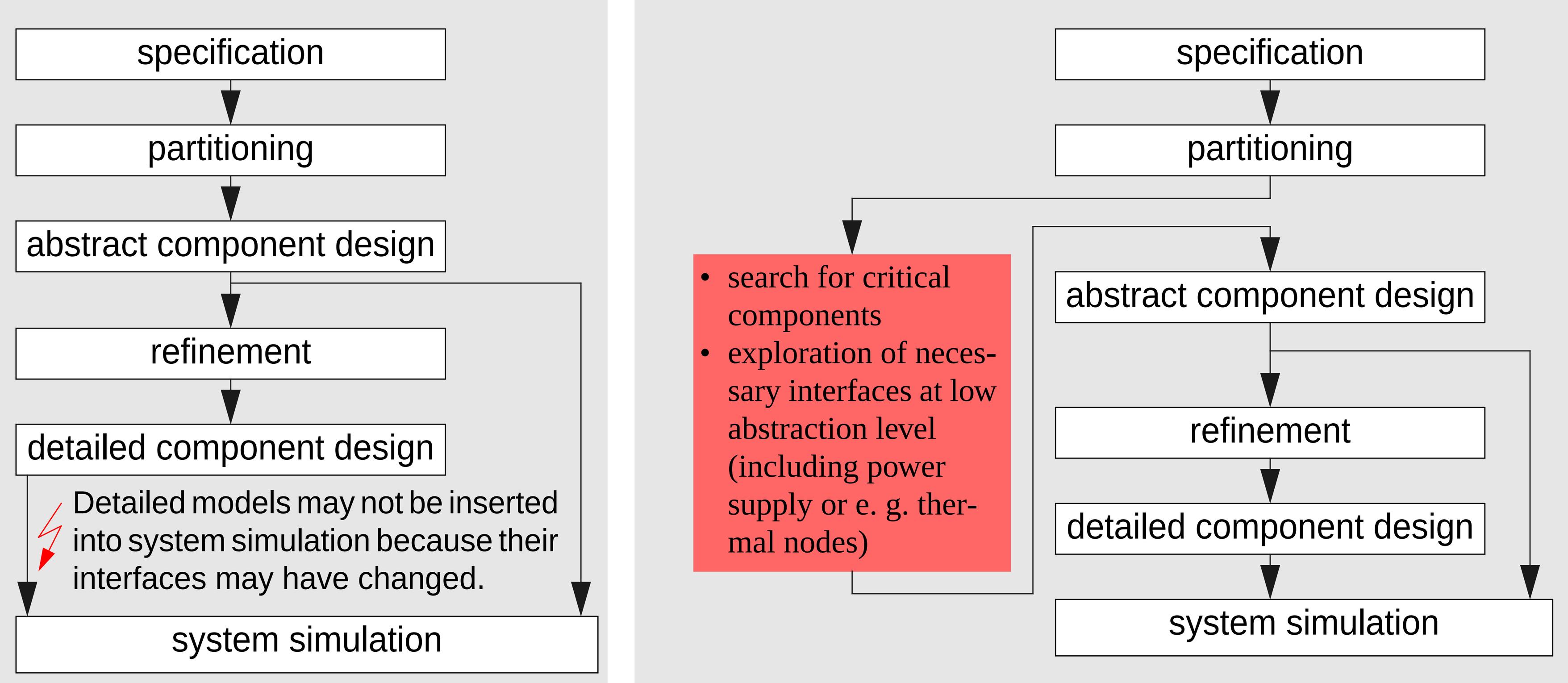

*Figure 3. Connecting analog and digital models using MAM method*

If the MAM method is applied to SIGNALS of datatype `std_ulogic` then the outputs and inputs have to provide a resolution of multiple driven SIGNALS according to the resolution function. To meet the requirements of the resolution function of the datatype `std_ulogic` the following conditions must be met:

*n*: maximum number of drivers to recognize the state 'X' if one driver has the state 'X' and *n*-1 drivers have the state '1' or '0'

| parameter | technology dependent | technology independent |
|---|---|---|
| $U_{i1}$: minimum input voltage to detect the state '1' if no driver has the value 'X' or '0'<br>$U_{i0}$: maximum input voltage to detect the state '0' if no driver has the value 'X' or '1' | $U_{i1}$ and $U_{i0}$ are determined by technological parameters | $\frac{U_x + U_1 \cdot (n-1)}{n} < U_{i1} < U_1$<br>$\frac{U_x + U_0 \cdot (n-1)}{n} > U_{i0} > U_0$ |
| $R_s$: output resistance for strong drivers,<br>$R_w$: output resistance for weak drivers,<br>$R_l$: input resistance | $R_s$, $R_w$ and $R_l$ are determined by technological parameters | $0 < R_s < R_w \ll R_l$<br>$R_w \geq max\left[(n-1) \cdot R_s \cdot \frac{U_0 - U_{i1}}{U_{i1} - U_1}, (n-1) \cdot R_s \cdot \frac{U_1 - U_{i0}}{U_{i0} - U_0}\right]$ |
| maximum ratio of drivers with states 'W', 'L' or 'H' to drivers with states '1' or '0' which allows a correct recognition of the states '1' and '0' at the input | $\frac{N_{w,l,h}}{N_{1,0}} = \frac{R_w}{R_s} \cdot \frac{U_{i1,0} - U_{1,0}}{U_{x,0,1} - U_{i1,0}}$ | according to resolution function |

## Top down design process with MAM in the focus of the system simulation




## Examples

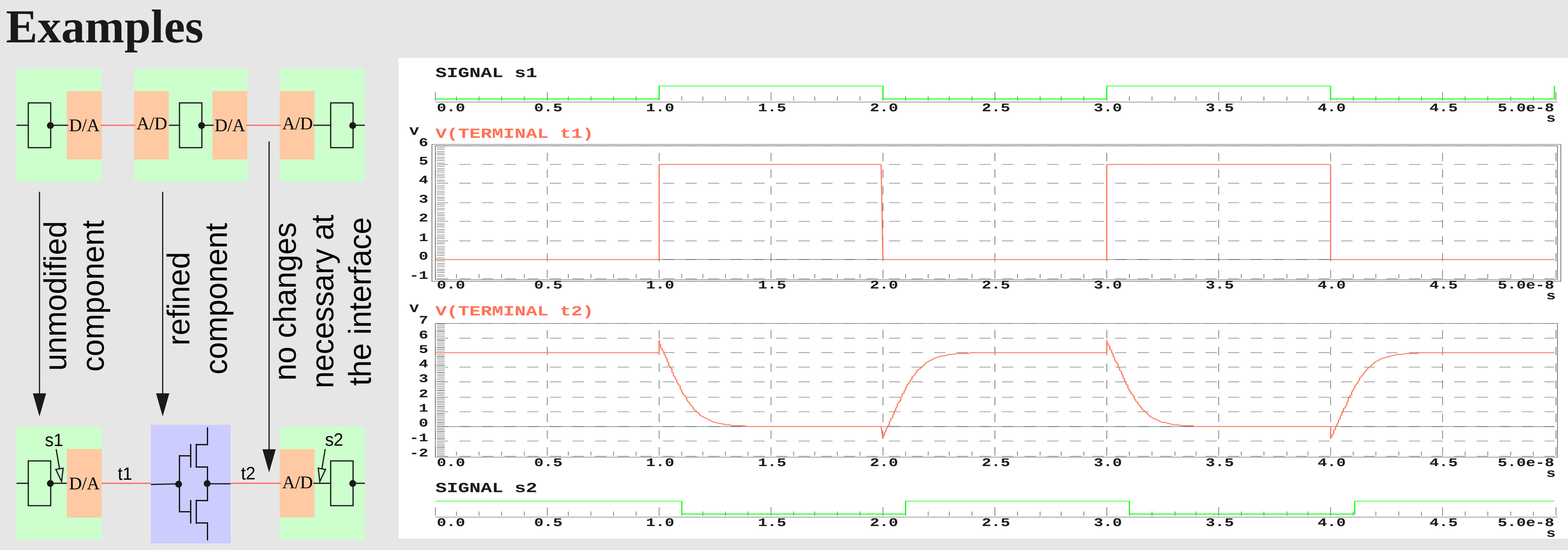



*Figure 4. Simulation plot of a digital/analog mixed example*

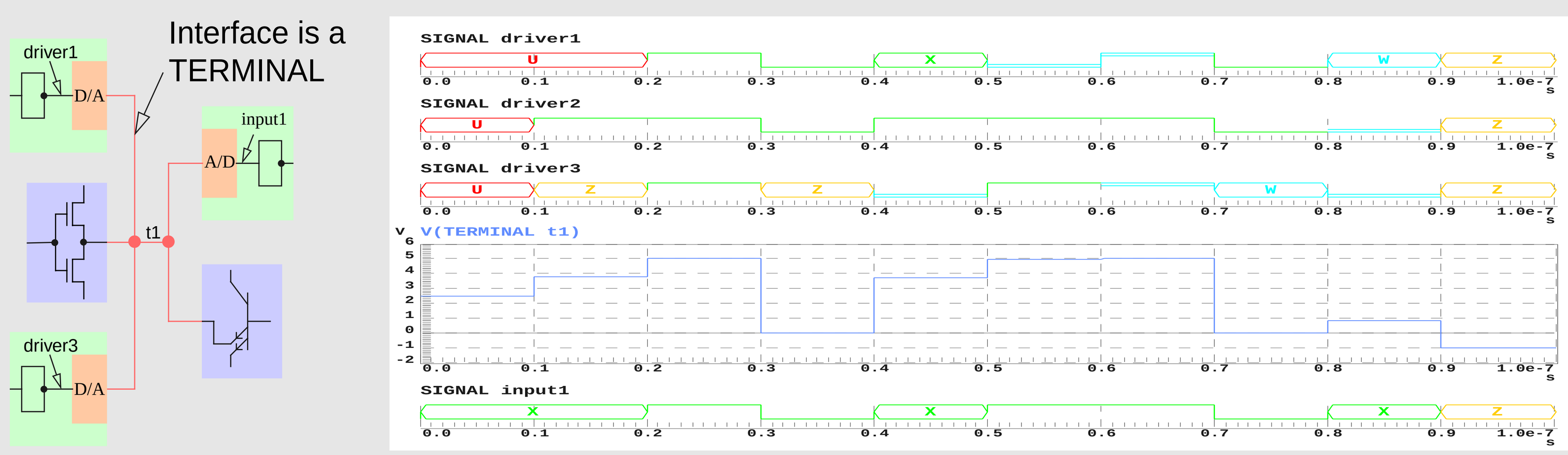



*Figure 5. Simulation plot of resolved ports of datatype std_ulogic*

## Conclusion and Outlook

If a component uses the interface which is necessary on low abstraction level already at the highest level then the exchange of this component at different abstraction levels during system simulation can be done easily. The MAM approach may help to reduce errors in system design and it seems to be a powerful approach for improving the cooperation between component and system designers when developing MEMS. The overhead at component modeling is limited to a conversion of the interfaces inside the abstract models. The methodical approach of the MAM is in conformity with the Language Reference Manual of VHDL-AMS which could be proved by first simple examples.

The disadvantage of this new approach is that the interfaces of all components have to be known in every detail even at the beginning of the design process when doing a design by a „top down" method. For highly automated designs e. g. pure digital designs this method cannot be recommended. Possibilities to remove this problem will be explored in the next steps of evaluation of this approach.

This new methodical approach to design components of heterogeneous systems on different abstraction levels with uniform interfaces has to be evaluated by future designs. Therefore the design of a vibration sensor system using a sensor array – in the scope of the SFB 379 (collaborative research center) – will be done using the MAM method. Here the focus will be set on the evaluation of the feasibility of this method.

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