# VHDL-AMS - based Hybrid Approach to ARGESIM Comparison 'C13 Crane and Embedded Control' with SystemVision

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**Simulator.** The VHDL-AMS model presented here implements the system model of a portal crane with embedded control as described in the Case Study by *Eduard Moser and Wolfgang Nebel, Proc. DATE'99, pp. 721-724*. This model incorporates both the continuous description of the crane dynamics and the embedded digital controller and the simulator used is SystemVision from Mentor Graphics. SystemVision is a state-of-the-art VHDL-AMS simulator which provides co-simulation capability for mixed signal designs as well as graphical design, waveform viewing etc.

**Model.** Figure 1 shows the system diagram of the model. The plant (i.e. car and load) is described by three differential algebraic equations (DAEs). In VHDL-AMS, DAEs are simply defined as simultaneous statements, no matter whether the equations are explicit or implicit. The sensor updates the car position and angle signals and sends them to the controller. The controller computes the values of drive voltage and brake signal according to the control signals from the crane operator and the monitoring signals from the sensor. The actuator is another DAE connecting the drive force and the drive voltage.

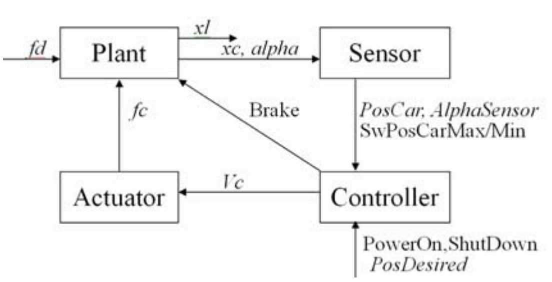


Figure 1: System diagram
(italics represent analogue quantities).

**Task a: Comparison of uncontrolled nonlinear and linear model.** The differences in the load position value $x_l$ between the linear and nonlinear models proposed by the Case Study in Task a) are shown in the following table:

| Disturbance(*Dest*) | -750 | -800 | -850 |
|---|---|---|---|
| $\Delta x_l$ (m) | 0.2428 | 0.0453 | -0.2336 |

**Task b: Simulation of the controlled system.** A VHDL-AMS testbench that describes the value and timing of each system stimulus (*$f_d$, PosDesired and PowerOn*) has been developed.

The linear crane model simulation results (Task b) are shown in Figure .2. The controller uses VHDL signals for event-driven objects, such as the Boolean signal '**Brake**' which stops the car immediately.

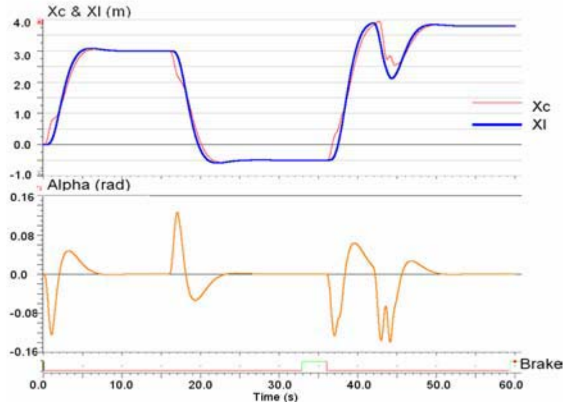


Figure 2: Simulation results for Task b.

The activation times of the brakes are: 32.88 sec and 59.36 sec. Unlike most previous published solutions, there is no brake applied around 13 sec, which means that in the SystemVision simulation the new desired position arrives before `abs(VC)<0.01 for 3 sec`.

**Task c: Simulation of controlled system with sensor diagnosis.** The diagnoses stipulated by Task c) are implemented by several processes in the controller architecture. Similarly to Task b), a suitable VHDL-AMS testbench was developed and simulation results are shown in Figure 3. The brakes are activated at 35.84 sec and 44.51 sec. The system enters the EmergencyMode at 18.09 sec and EmergencyStop is activated at 44.51 sec which is concurrent with the second brake.

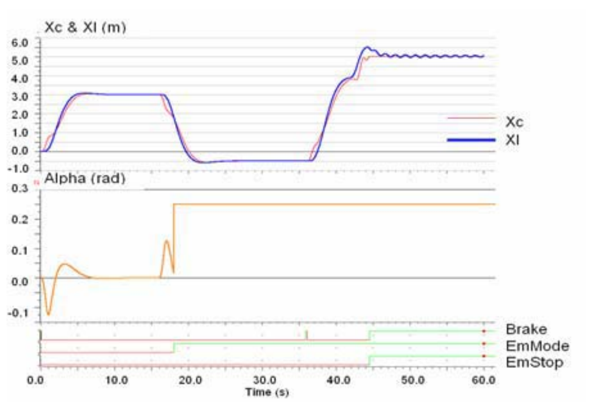


Figure 3: Simulation results for Task c.

**C13 Classification: Hybrid Approach**

**Simulator: SystemVision Version 3.2**