C13 Crane and Embedded Control - MATLAB

Numerical Simulation / Event-oriented Model

Simulator: MATLAB is a widely used software tool based on numuerical vector and matrix manipulation. Simulink is a graphical extention for block oriented simulation. S-functions provide a mechanism for extending the capabilities of Simulink by adding user defined blocks. The functionality of these blocks is defined in m-code or some programming language.

The model: The mechanics of the linear system and the DC-motor were implemented directly with Simulink, whereas the nonlinear model was programmed as an s-function. The 'Discrete-State-Space'-block of Simulink was used for the controller.
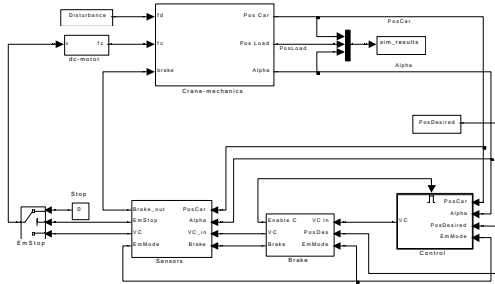

Figure 1: Simulink Model

Task I: The following table lists the differences of linear and nonlinear model in x_l:

Disturbance	Δx_l (lin-nonlin)
-750	-0.0062
-800	-0.0521
-850	-0.0383

Task 2: Brake-control was programmed with an s-function that offers a comfortable way to define descret logic:

```
function sys=mdlUpdate(t,x,u,VClimit,TEmMode,
TNotEmMode) …
% release brake if there is a new PosDesired
if u(3) ~= x(3)
    sys(3)=u(3);sys(2)=0;sys(1)=t;
% check cond. for brake, set x(2), hold if set
elseif (u(2) & (t-x(1)>TEmMode)) | x(2)
    sys(2)=1; sys(3)=x(3);
elseif (~(u(2)) & (t-x(1)>TNotEmMode))
    sys(2)=1; sys(3)=x(3);
else            % no brake
    sys(2)=0; sys(3)=x(3);
end
```

Figure 2 shows the diagrams for `PosCar`, `PosLoad`, `Angel` and `brake`. The brake switches on at `t=13.302`, `29.472` and `56.752 sec`.

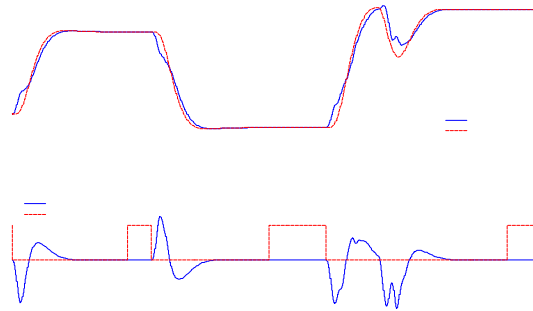
Figure 2: Crane with Controller

Task 3: Figure 3 shows the transient diagrams, the lower one gives the status of `Angle`, `Brake`, `EmergencyMode` and `EmergencyStop`. Diagnosis was implemented with an s-function that is called every millisecond. The status of the angle sensor (`valid=0, not valid=1`) is stored in a vector of length 100. With each call the content of the vector is shifted by one and the freed cell updated with the present status of the sensor. If the sum of ones in the vector is greater than 50 `EmergencyMode` is triggert.

The system switches to Emergency-Mode at `t=18.054` and continues the processing of jobs. Emergency Stop is triggered at `t=44.524`. The car stops and the load carries on moving like a pendulum.
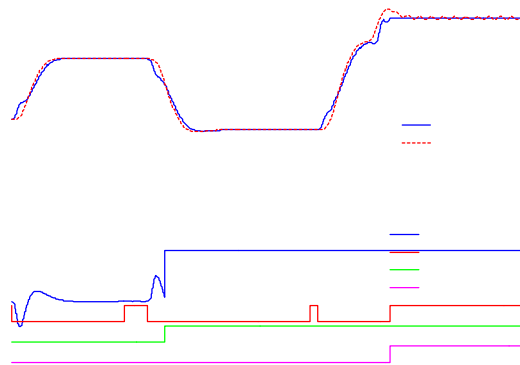

Figure 3: Emergency Mode and Emergency Stop

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