A Description of MATLAB/Simulink MCSim 2019

The MATLAB/Simulink MCSim 2019 version by B. L. Steinsvik, mainly based on the MATLAB/Simulink MCSim 2018 version, by A. H. Brodtkorb. Altered for autonomous docking during the spring of 2019.

Below is a brief explanation of what the different files and modules in the MCSim 2019 contain. All subfolders must be added to the matlab path.

A.1 Initialization files

InitBLS.m initializes the simulation. Here the chosen method for unberthing is set (Unb). The position of the quay, the time spent at quay and the desired vessel position for docking is decided under *Quay configuration*. The following files are called:

- **SimulationParameters:** sets parameters that are related to the environment, and enables/disables blocks. Here enabling/disabling the observer and controller are set.
- **Load_vessel_data:** loads the vessel data, currently Cybership 3 with updated model parameters.
- **ObserverParameters**: Sets observer parameters for the nonlinear passive observer. It also contains some other observer parameters below, but these are not included in the Simulink diagram.
- **SensorModule:** Adds noise and bias on measurements. The sensor module is enabled at the top of this file.
- **ControlParamters:** Sets the control parameters from the PID controller. P, I and D action can be enabled/disabled. The magnitude of the bias in the berthing controller is set here.
- **Log:** Enables/Disables vessel and sensor logging. The controller and observer settings are always logged within the "vessel controller" Simulink module.
- **ReferenceModel:** Sets parameters for the vessel model. The setpoints "pos_d1", "pos_unb" and "pos_d2" are added.

A.2 Simulink block diagram

In the Environment module waves, current, wind and ice time series are created. These are based on parameters from the SimulationParameters.m file. Within the Vessel module is where the vessel dynamics and controller live. The vessel module is displayed in Figure A.1 and the modules within are explained below.

Vessel Dynamics

This is where the vessel motion is calculated. It consists of a low-frequency (LF) part and a wave-frequency (WF) part, which are added to get the total vessel motion.

- Vessel WF 6 DOF: calculates the wave-frequency motion for N_wave number of wave components based on the motion transfer functions. The module is enabled/disabled from the SimulationParameters file.
- Vessel LF 6DOF: calculates the low-frequency vessel motion. (The model we use for control design is a simplified version of this model.)

Sensor module

Adds realistic values for sensor noise and bias. Measurements that are typically available on a ship:

- GNSS position (North, East) – a down measurement is also available, but is of lower quality
- Compass heading
- Gyrocompass angular rates (roll, pitch, yaw rates)
- IMU linear accelerations (surge, sway, heave accelerations)
- Wind sensor (wind direction and magnitude)

Vessel controller

Inputs: 6 DOF measured position, velocity, acceleration and wind (Eta_meas, Nu_meas, Acc_meas, Wind_meas), low-frequency position, velocity and acceleration (EtaLF, NuLF, AccLF), and the applied thrust (tau)
Outputs: Commanded thrust tau_c

- Nonlinear passive observer: model-based observer that estimates 3DOF (surge, sway, yaw) eta, nu and bias force.
- Controllers: Hybrid control is implemented with a DP controller, berthing controller, unberthing controller, supervisor and a switch. The controller module is shown in Figure A.2.
- Reference model: 3rd order filter
- Logging: sends parameters from the vessel controller to workspace for plotting

Comments about the inputs: The measurements can be down-sampled to more realistic sample rates by clicking the manual switch. When the observer is not used in closed loop, the low frequency states are used in the control law.

Thruster module

Contains first-order model that emulates that it takes some time before the commanded thrust is produced by the thrusters. There is no model of the thrusters in this version of MCSim.

Quay Module

Contains a step-function with a quayforce being $\approx$ infinty to avoid the vessel going beyond the quay. Rotation to the body-frame is implemented

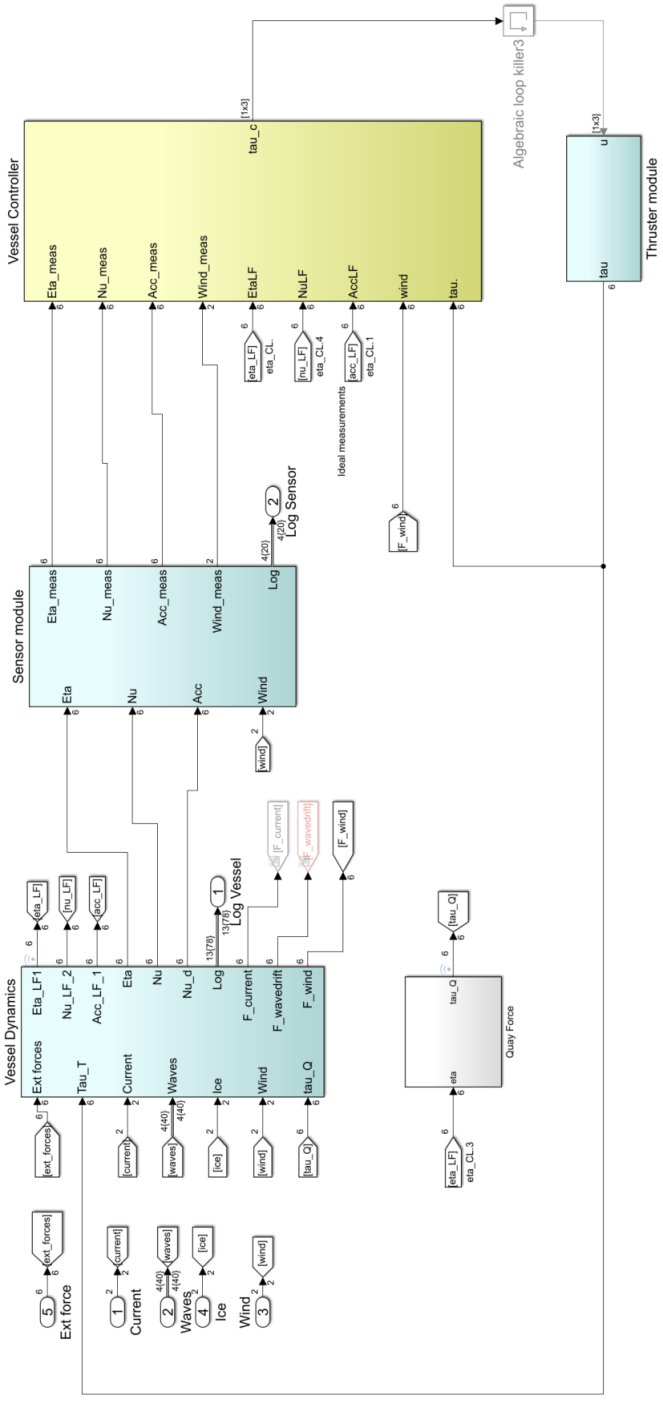

Figure A.1: Vessel module in MCSim. Showing the interaction between the vessel dynamics, sensor module, vessel controller, thruster module and quay module.

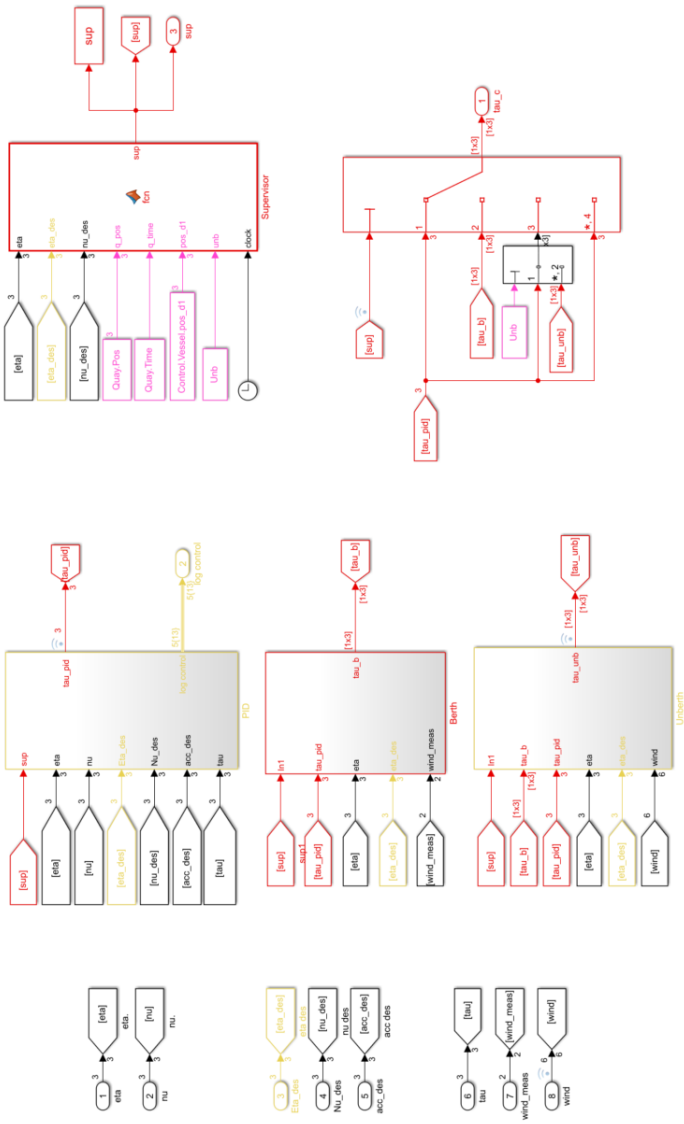

Figure A.2: Setup of the hybrid controller in Simulink. Displayed are the controllers for DP, berthing and unberthing in addition to the supervisor and the switch. The colors of the signals display the type of signal, where black is continuous, red is discrete, yellow is hybrid and pink is constant.