TMR4240 Project Part 1: Design of Dynamic Positioning System *Control System Design*

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General Information

The assignment must be submitted on It's Learning by October 13, 2015, including a zip file containing the report in PDF format and executable Matlab/Simulink code/Diagrams.

The project Part 1 will be evaluated, so the quality of the answer and of the final presentation (later this year) will be important. Special importance should be given to how the output data is presented.

It is mandatory to give one single answer for each group for the Project Part 1.

Any information about the system that might be missing shall be asked directly to the TA.

The main objective of the first part in this project is to get you familiar with the matlab / simulink system.

System overview

This project is developed based on the MarPowSim (Marine Power Simulator), version 1.0. The MarPowSim is a work in progress, being developed by five PhD students at NTNU. The files for this simulator will be found at ItsLearning, and every feedback is welcome, as well as any proposed extension for the actual implementation.

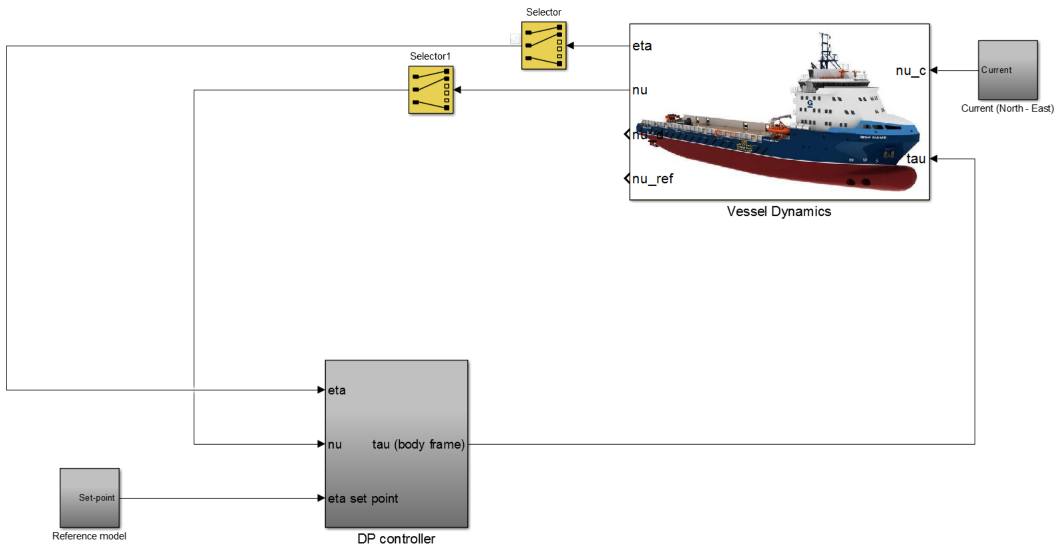

Figure 1: Overview of the Marine and electric simulator

Don't be afraid to modify the existing components present on the simulator, since it's code is being provided for the TMR4240 course and it is intended for the students to modify anything that is necessary to reach the desired goals.

The provided files will present you a supply vessel without the control part, where you will implement it.

Assignment Task

This assignment (Project 1) consists of designing and validating the following systems for a DP positioned supply vessel:

- Current load
- Controller
- DP Reference model

You are free to use any reasonable methodology to design the mentioned subsystems.

The system overview (as well as the Simulink main diagram) is presented in figure 1. Note that the blocks that need to be implemented are the gray blocks in the diagram.

Getting started

It is necessary to install the mss toolbox before trying to run the MarPowSim simulator. The download files can be found at `"http://www.marinecontrol.org/"` under the "*download page*".

To run the MarPowSim simulator go to the MarPowSim Folder and open the "$/Project/Part1$" folder. To initialize the data you might run the "$initProject1.m$" and to run the simulink model just open the file "$project1.slx$" and run it. Those two files are the only ones in the simulator folders that you will need to modify.

1 Current velocities

The first part discussed is the implementation of the current drag effects on the vessel. The current shall be defined in the NED frame, but only the North and East coordinates are needed (the current average down component will always be 0).

The current block is shown in figure 1. Note that the actual state of this block just gives a constant zero value in both directions.

The effects of the current don't need to be calculated, since the vessel model already accounts for the drag effects.

2 Controller

The controller shall be responsible for the vessel dynamic positioning. It takes the vessel to the desired set-point and then keep it on the right position, given the environmental loads (which are typically unknown to the DP).

This block shall receive information about the vessel actual position (North, East and heading), set-point (also N, E and Ψ) and calculate the desired forces in surge and sway as well as Ψ moment. All units shall follow the SI (N and $N \cdot m$).

It is up to you what type of controller will be implemented (linear, nonlinear, hybrid, etc...).

hint: Remember that you are working with two different reference frames in this block, so it is important to not mix up NED with body frame.

3 Reference model

It is necessary to generate a reference model for the DP control system, in case that the set-point is changed or the vessel is following a track instead of station keeping.

The initial reference model is just a constant value, it shall be filtered to accept step values as inputs.

4 Mandatory tests and report

Several tests are required to show that your system is working properly. They are described in the following sections.

4.1 Simulation 1

For the first simulation, show the DP capabilities of your DP system. With the DP set-point set to [0m 0m 0rad] and current set to 1m/s, going to southeast. Plot the results for at least 200s.

4.2 Simulation 2

Now, make the current vary linearly from [1 0] to [0 1] while keeping the vessel at the origin. Plot the results for at least 200s.

4.3 Simulation 3

Compare the different results for a vessel position over time for initial position $\eta_0 = [0\ 0\ 0]$ and $\eta_{SP} = [10\ 10\ 3 * \pi/2]$, with and without a reference model.

4.4 Simulation 4

The last mandatory simulation is go trough the following set-points:

- $\eta_0 = [0m\ 0m\ 0rad]$
- $\eta_1 = [10m\ 0m\ 0rad]$
- $\eta_2 = [10m\ 15m\ \frac{\pi}{2}rad]$
- $\eta_3 = [0m\ 15m\ \pi rad]$
- $\eta_4 = [0m\ 0m\ \frac{3\pi}{2}rad]$

5 Extra simulation

In this section, some "extra work" is proposed. This is a simple tasks that you can include in your answer if you are aiming to do a better work. Do the following task ONLY if you have already done the mandatory tasks. Those tasks can help you to achieve a better grade IF NEEDED and can give you more hints about useful features that you may end up developing in your future professional life.

You can try to face one or more of the following tasks if you want.

5.1 Extra simulation: Optimum heading

Implement a controller that automatically finds what is the optimum heading (the heading that will lead to minimum load from the DP system). To prove that the vessel is converging to the ideal heading, plot the response of a system with initial condition $\eta_0 = [0\ 0\ 0]$ and current coming from northeast. Two methodologies are suggested (but if you want, you can implement another one as well):

- WOPC - Developed by professor Fossen
- ZPC-W - Developed by Miyazaki

Logging data

There are three common methods to log data, and you are free to chose the one that works best for you, but only two of them are suggested in this project. They are:

- Simulation data inspector (most recommended)
- Export to workspace
- Scope (not recommended)

In this document I will give a brief introduction to the simulation data inspector, since the other methods were already described in assignment 4.

Simulation data inspector

To use this method you need to follow two simple steps:

- Enable signal logging
- Define which signals are logged.

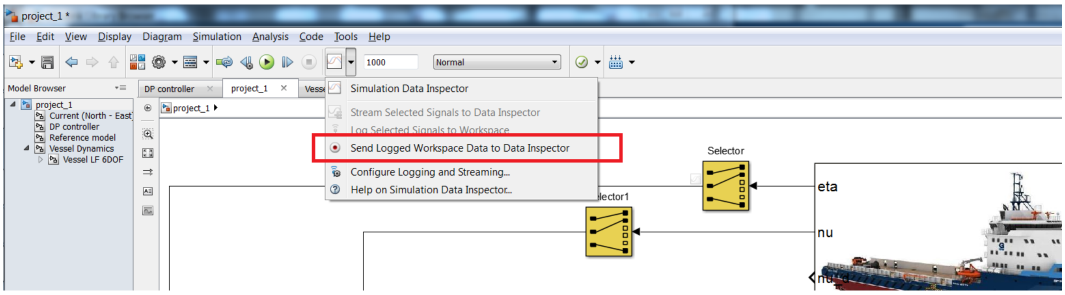

Figure 2: Enabling signal logging, the "Send Logged Workspace Data to Data Inspector" shall be selected.

To enable signal logging you have to check the following option:

After you make sure that the signal logging is enabled (there will be a recording symbol on top of the simulation data inspector symbol), you have to define which signals you will log. Keep in mind that you can log as many signals as you want, but if your system is too big and too many signals are logged, it might take too much time to run and too much space to save the logged data (I already had systems with more than 30GB of logged data). Right click the line that you want data to be logged and after opening the properties menu you should name the signal and check the option "log signal data".

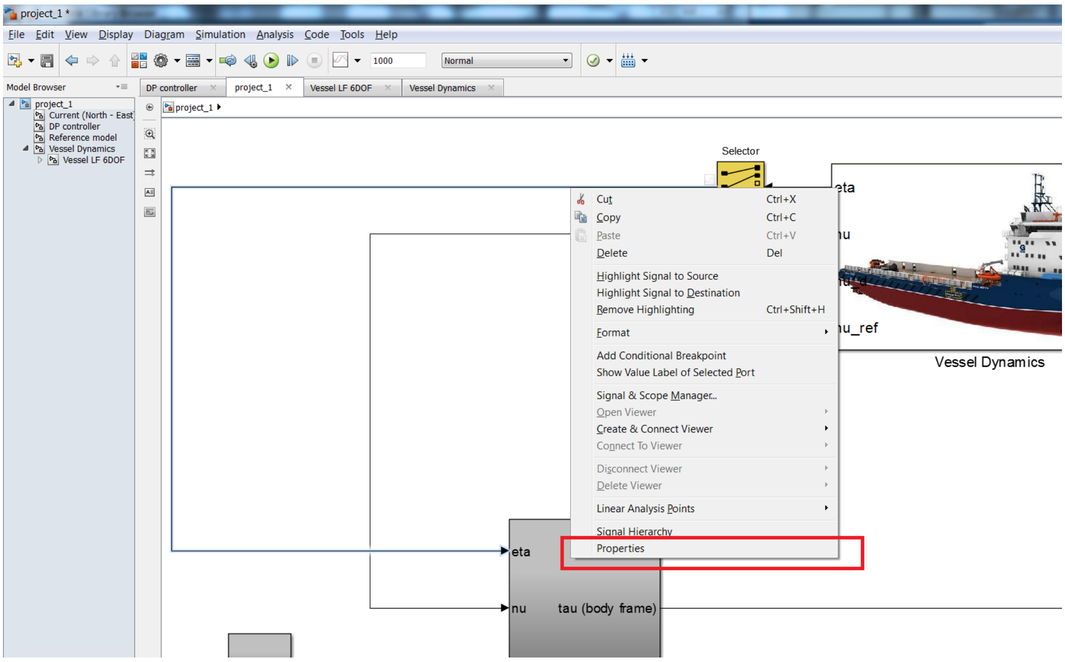

Figure 3: Open the line properties. Note that you will log the data going trough the selected line.

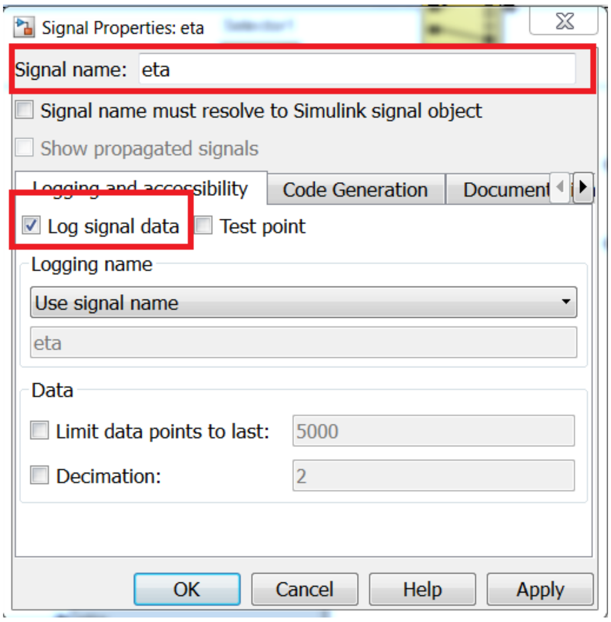

Figure 4: Name the selected signal (with a name that you will remember later) and check the field "log signal data".

After selecting the signals to be logged, your system will show a small blue antenna on the logged lines, as shown in figure 5. Remember, you can have as many as those as you need.

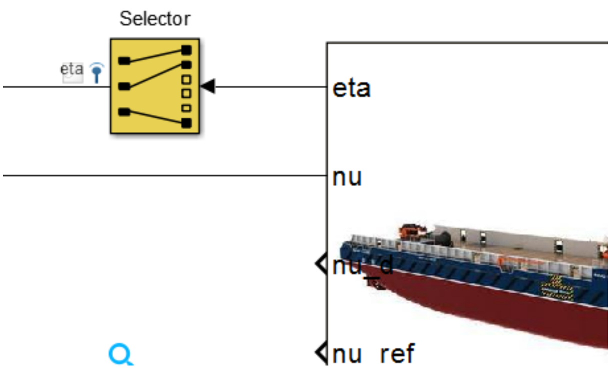

Figure 5: If everything was done correctly, you will see the "blue antenna" symbol close to the signal name.

Finally, the data can be accessed trough the simulation data inspector (the button on the top with the graph symbol). The output should look like the one in figure 6. You can compare as many simulations and signals as needed.

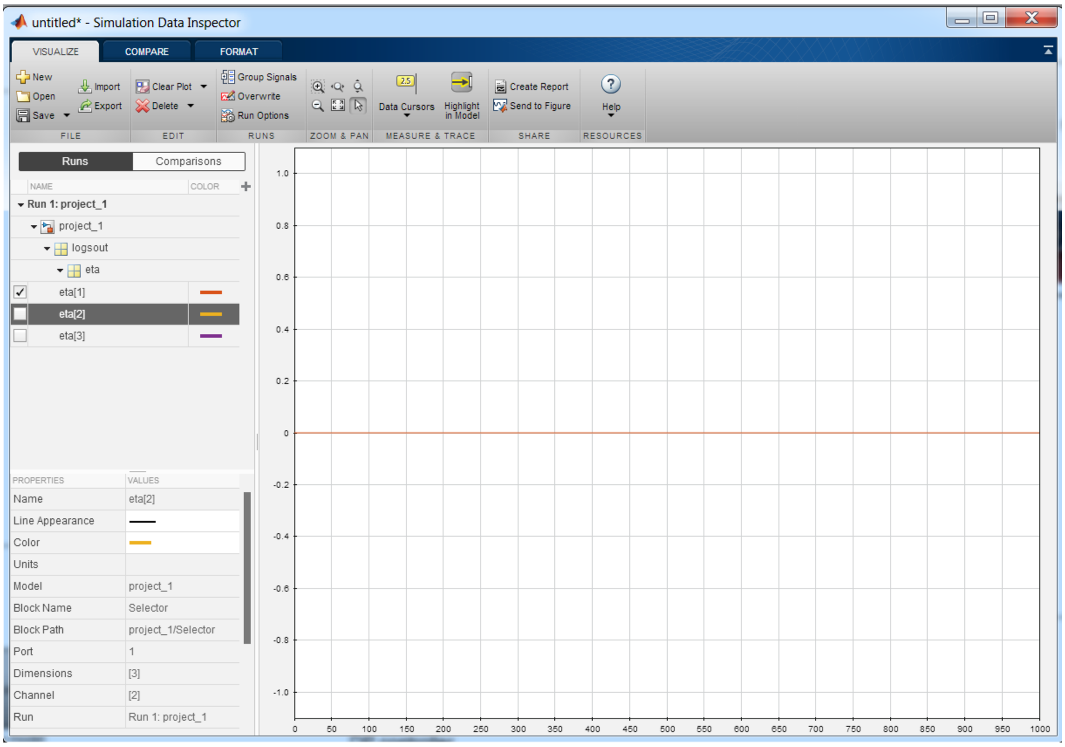

Figure 6: After your simulation is done you can open the simulation data inspector and see all the logged signals, in this example the vessel NORTH position was constant at the origin.

Final tips

- Even though you are in a group of four students, remember that you have other duties as well, so don't try to start solving this project on the last weekend (or last day), since it might be surprisingly time consuming.
- Do not try to solve everything at once. When you develop a big system like this one, work block by block.
- One of the goals for this project is to be similar to what you might find in your professional life. With this in mind, remember that it is not only important to develop a good product, but it is also important to present it properly, with a suitable user interface and well written report.
- Since this simulator is a work in progress, remember that it might misbehave. If you have any sign of a software bug (not caused by you), contact the TA immediately, so you save time.