



Level control with DeltaV using MPC

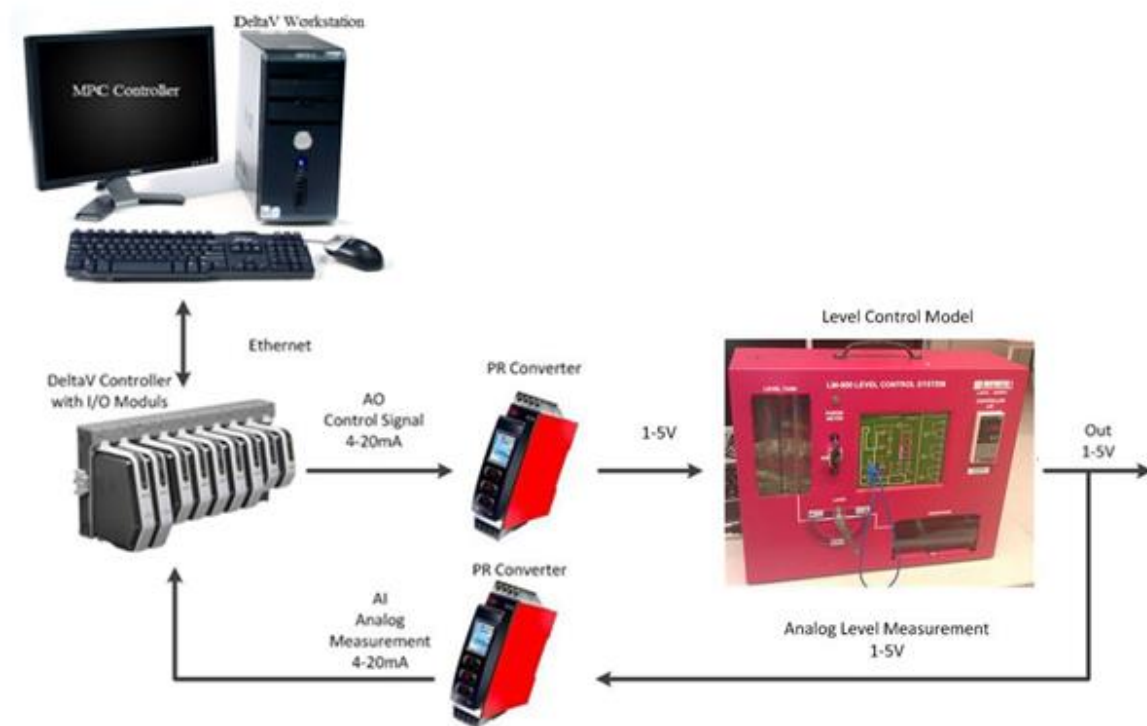


TABLE OF CONTENTS

TABLE OF CONTENTS	3
1 Introduction.....	4
2 Creating the program	5
2.1 Step 1: Creating a new database.....	5
2.2 Step 2: Creating a MPC control module in an area	5
2.3 Step 3: Connecting I/O to the MPC_LOOP.....	6
2.4 Step 4: Creating a Kalman filter.....	11
2.5 Step 5: Activate I/O configuration.....	16
2.6 Step 6: Assigning area to alarm and events and continuous historian	17
2.7 Step 7: Downloading the program.....	18
3 Modelling and validation.....	19
3.1 Step 1: Connecting the Level Tank process	19
3.2 Step 2: Creating the MPC model.....	20
3.3 Step 3: Verification of the MPC model	23
3.4 Step 4: Validation of the MPC controller	26
4 Creating the HMI.....	28
4.1 Step 1: Creating a new picture.....	28
4.2 Step 2: Creating picture interface using dynamos	29
4.3 Step 3: Creating names and datalinks.....	31
4.4 Step 4: Creating faceplate- and MPC operator interface buttons	32
5 Operating the Level Tank system.....	34

1 INTRODUCTION

In this tutorial you will learn how to:

- Create a program to control level in a Level Tank with MPC and Kalman filter using DeltaV Database Administration, -Explorer, -Control Studio and -I/O Configuration.
- Create a MPC model for a Level Tank and do validation using DeltaV Predict, -MPC Operate and -MPC Simulate.
- Create a HMI for a Level Tank using DeltaV Operate Configure.
- Control and tune the level performance of a Level Tank system using the MPC controller in DeltaV Operate Run.

Figure 1.1 shows the Level Tank system.



Figure 1.1 Level Tank system

Equation (1-1) is the mathematical calculation of the volume in the tank.

$$A\dot{x} = K_p(u - u_0) - F_{out} \quad (1-1)$$

Where:

- $x[\text{cm}]$ is the level in the tank
- $u[\text{v}]$ is the control signal to the pump
- u_0 is the bias voltage needed to get any flow (with u less than u_0 there is no flow into the tank).
- $A[\text{cm}^2]$ is the cross-sectional area
- $K[(\text{cm}^3/\text{s})/\text{V}]$ is the pump gain
- $F_{out}[\text{cm}^3/\text{s}]$ is the outflow through the valve

2 CREATING THE PROGRAM

In this section you will learn how to create the program used to control the level in the Level Tank model using DeltaV Database Administration, -Explorer, -Control Studio and -I/O Configuration.

2.1 Step 1: Creating a new database

Before we start to program in DeltaV we would like to start on an empty program where no inputs or outputs are assigned to the hardware controller. This is easily done with the use of database. To avoid adding all the hardware configurations each time there has been premade a database that is empty, but contains the hardware configurations we need.

The first thing you need to do is log on to the DeltaV station with username: **Administrator** and password: **deltav**. When this is done choose DeltaV Desktop. Click on the start-menu and Database Administration. Double click on the icon Copy Database, choose Student1 and write your name in the Copy to field. Figure 2.1 is showing you how it should look like.

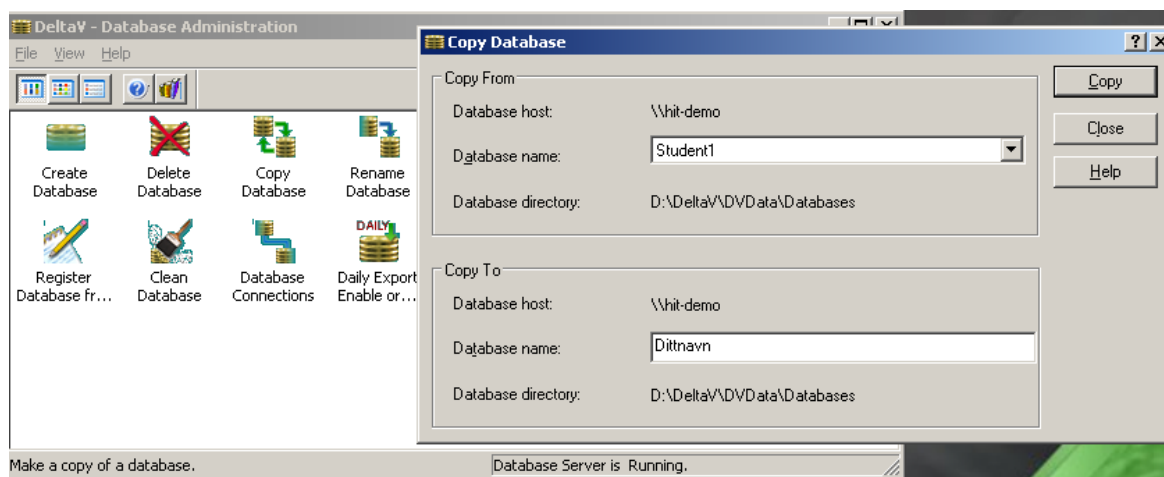


Figure 2.1 How to set up your database using Database Administration.

Now set the database you just made active with the Set Active Database button. This button is found in the Database Administration window. Select the database you just made and press ok.

Your database is now created and active.

2.2 Step 2: Creating a MPC control module in an area

Go back to the start menu and run DeltaV Explorer.

Right click on “Control Strategies” and select “New Area”. Name your new Area LEVELTANK.

We now have a new area called LEVELTANK. Now we just need to configure a control module.

Grab a MPC module from the library by choosing Library → Module Templates → Analog Control. Select the MPC_LOOP and drag and drop it down to your Area called LEVELTANK, see Figure 2.2.

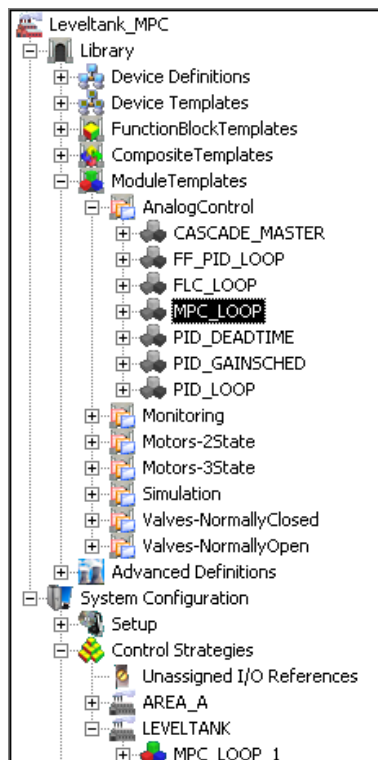


Figure 2.2 Control module MPC_LOOP_1 from library.

You will find the MPC loop you just added in your LEVELTANK area.

2.3 Step 3: Connecting I/O to the MPC_LOOP

Right click the MPC_LOOP_1 and choose open with Control Studio, see Figure 2.3.

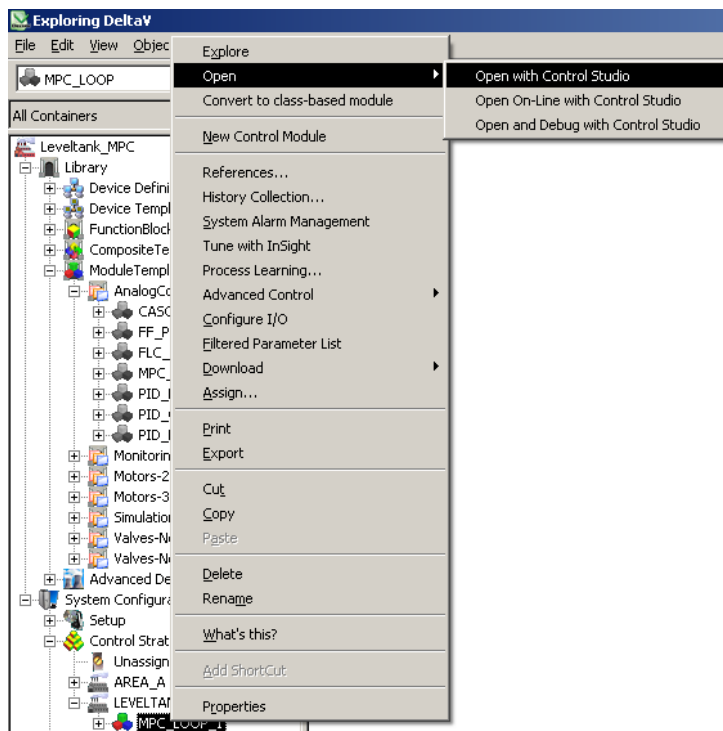


Figure 2.3 Open control module in Control Studio.

From Control Studio we see that we have a MPC block. In addition we have one analog in block and one analog out block, for our case being the controlled variable (CV) for the level and manipulated variable (MV) to the pump respectively. These IO needs to be assigned to the hardware controller and IO modules. Since the level is measured in percent, then we also need to scale this value into cm.

Drag and drop a Scaler block found under the Analog Control tab, see Figure 2.4. Wire a connection from the AI block to the Scaler block and from the Scaler block to the CNTRL1 on the MPC block. Mark the Scaler block and double click OUT_SCALE in the property section to the left, and write 20 under 100% scale. Then, press OK.

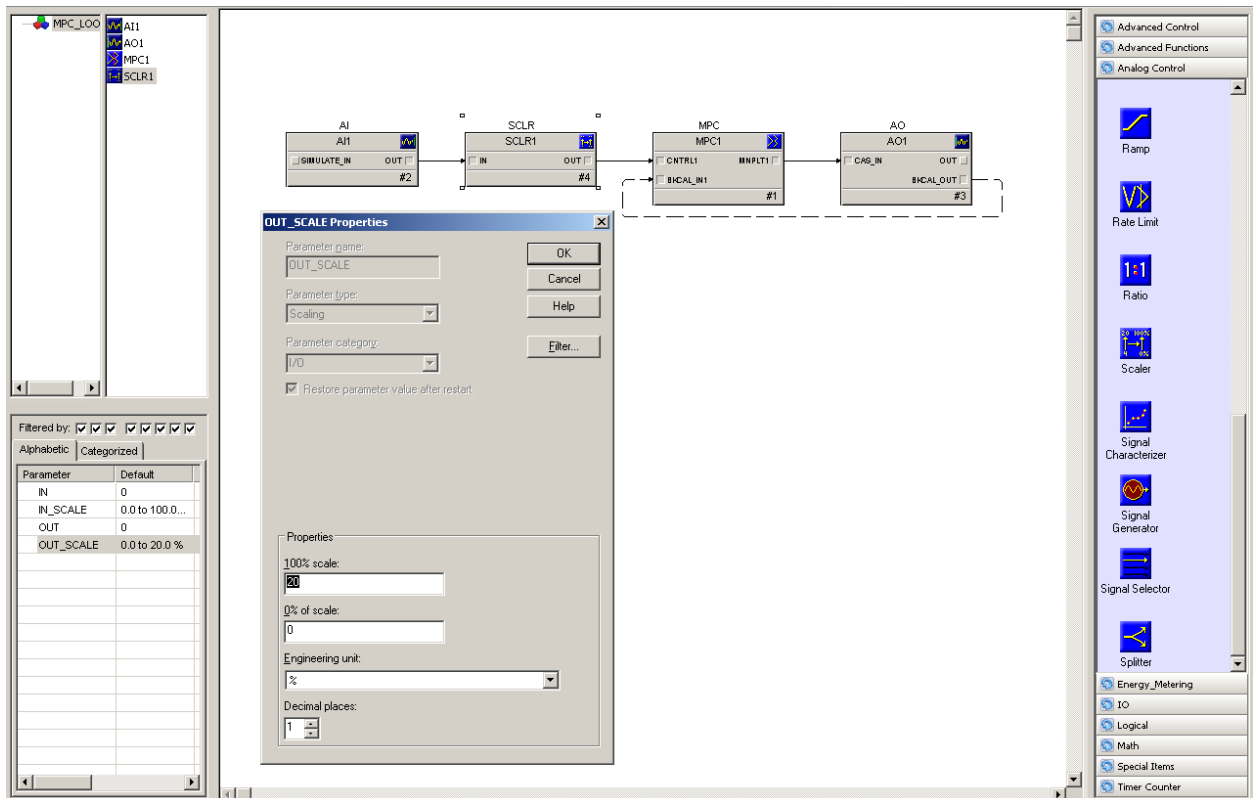


Figure 2.4 Connecting AI and Scaler block to the MPC block.

Right click the AI block and choose Assign I/O → To Signal Tag. An IO_IN Properties window will then appear, see Figure 2.5.

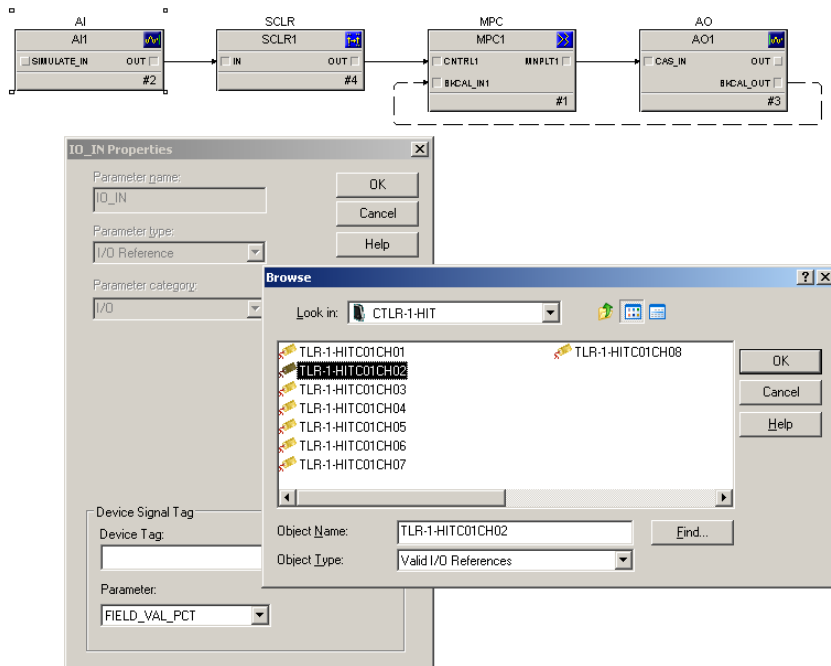


Figure 2.5 Assign I/O to Signal Tag.

Browse Device Tag, double click on CTRL and choose TLR-1-HITC01CH02. This is the second IN on the analog input module (CH02). Press ok until you are back to the MPC loop.

Now, right click the AO block and choose Assign I/O → To Signal Tag, and double click IO_OUT. Browse Device Tag, double click on CTRL and choose TLR-1-HITC02CH01. This is the first OUT on the analog out module (CH01). Press OK and then close. We have now connected the I/O to the MPC controller.

In addition, for MPC training purposes we will also include constraints (AV) on the level, and disturbance (DV) being the outflow. These are typical variables in a process and often affect the performance. To include them we need to add these parameters to the MPC block. Right click the MPC block and choose Extensible Parameters. Then double click on NOF_DSTRB and add 1 to the Modify Extensible Parameter - NOF_DSTRB, see Figure 2.6. Click OK and add 1 to the NOF_CNSTR. Again click OK and Yes until you are back to the MPC loop.

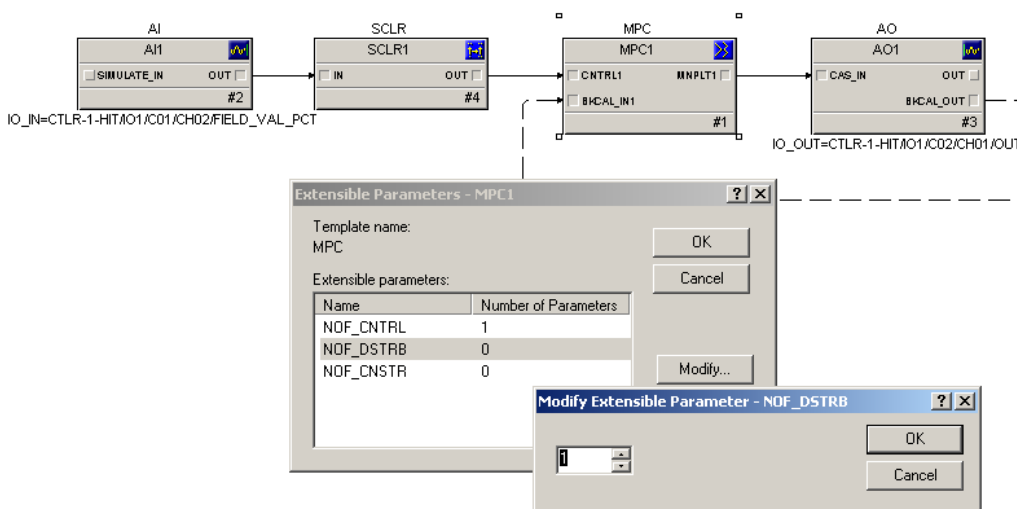


Figure 2.6 Adding constraint and disturbance variables.

Next step is to set the properties for the parameters.

Right click the MPC block and choose properties. A MPC1 Properties window appears for all the parameters. Double click the first row under the Controlled tab and type e.g. a tag-name in the Description field, see Figure 2.7. Also, enter 20 under SP high limit. Then press OK.

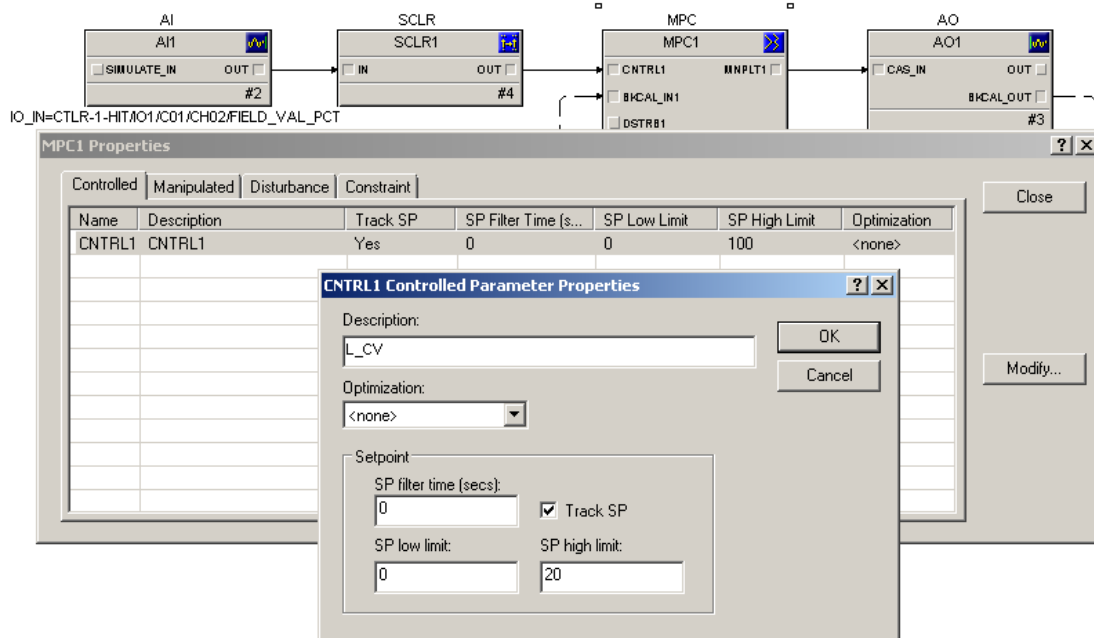


Figure 2.7 Set parameter properties for the MPC variables.

Do the same with the other parameters. For the Constraint parameter, also include CNTRL1 under Related CV, and add a Low limit and High Limit being 5 and 15 cm respectively. When finished close the property window.

The level is the constrained parameter and then we need to connect the Scaler block OUT to the CNSTR1 input on the MPC block, see Figure 2.9.

Since we don't have any hard-sensor measured disturbance we will in section 2.4 create a Kalman filter in a different control module to estimate the disturbance outflow. However, before we do that we will finish up the blocks needed in MPC_LOOP_1.

Add an Input Parameter from the Special Items tab, see Figure 2.8. A New Parameter Properties window will appear. Write a Parameter name, and choose External Reference under Parameter type since we want to get this value from a different module.

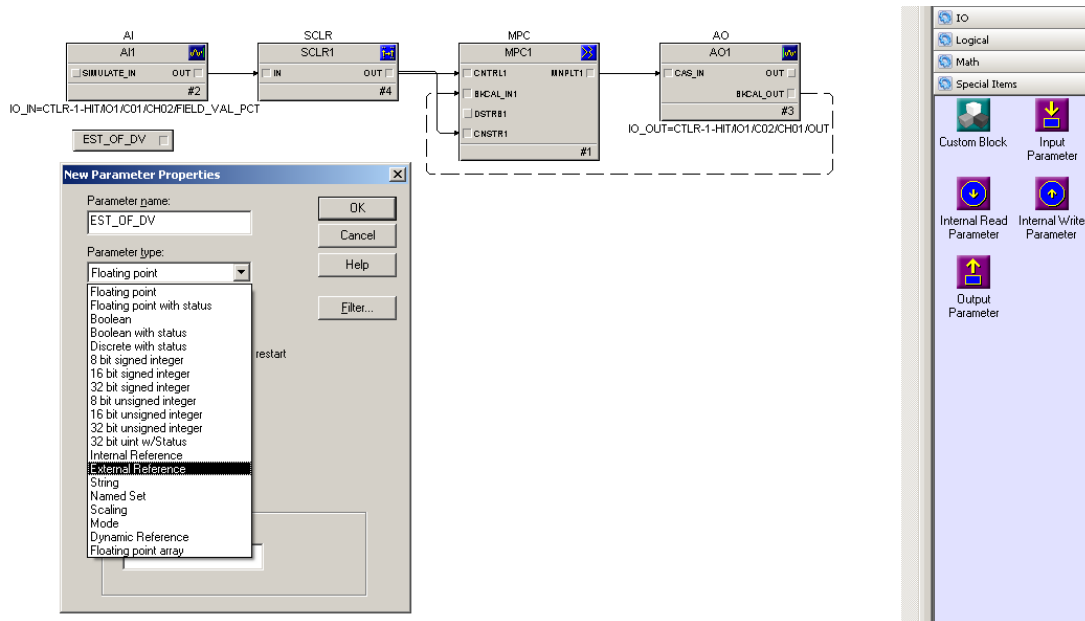


Figure 2.8 Adding an Input Parameter from the Special Items tab.

Since the MPC block requires an OUT_SCALE as an input then we also need to add a Scaler block found under the Analog Control tab. Connect the Input Parameter and Scaler block to the MPC block as seen in Figure 2.9.

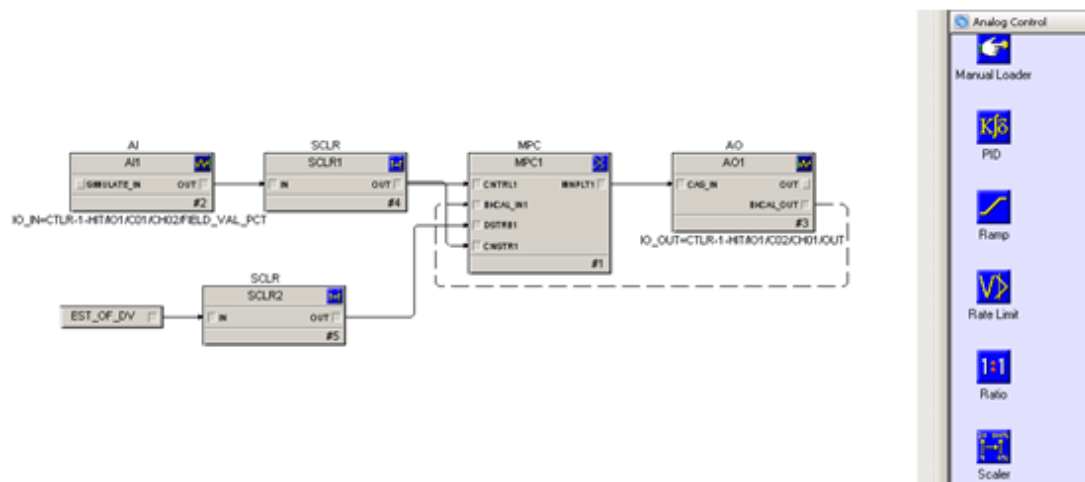


Figure 2.9 Constraint and disturbance parameters connected to the MPC block.

For the Kalman filter we will use scaled values and therefore we also need to scale the control signal into volt output.

Add an Output Parameter from the Special Items tab. Give the Output Parameter a name when the New Parameter Properties window appears.

Add a new Scaler block from the Analog Control tab. Mark the Scaler block and double click OUT_SCALE in the property section to the left. Write 5 under 100% scale and 1 under the 0% of scale, see Figure 2.10. Then, press OK.

Finally, connect the MPC block to Scaler block, and the Scaler block to Output Parameter, see Figure 2.10.

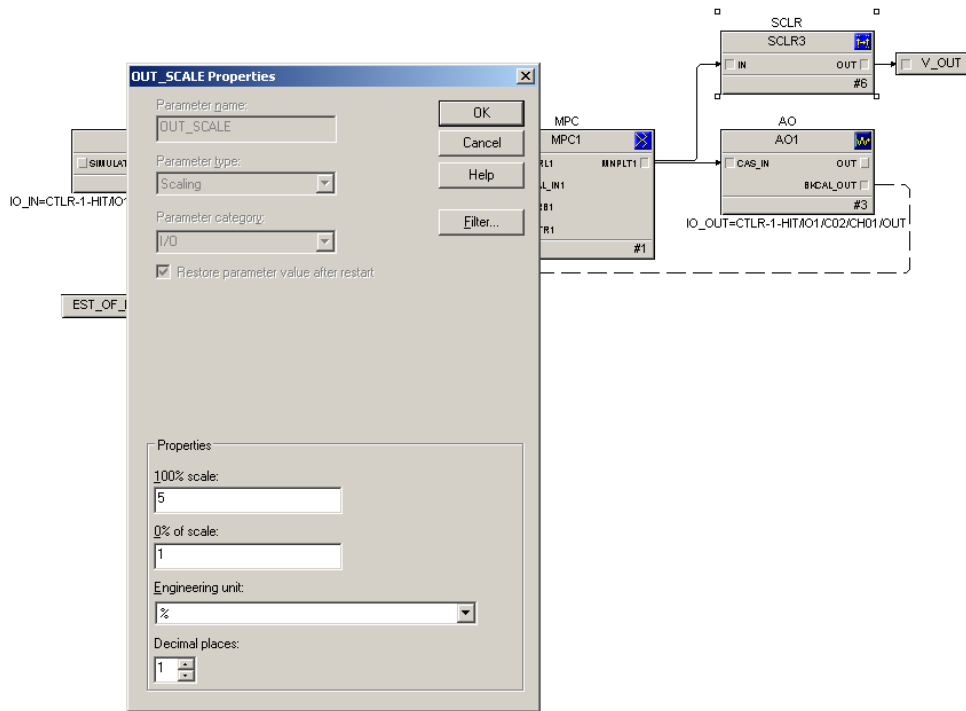


Figure 2.10 Adding scaled control signal.

2.4 Step 4: Creating a Kalman filter

Note! If there for some reason should be any difficulties creating the Kalman filter, and or in estimation performance, then alternatively the disturbance can be set to a constant value. See f.ex. “Temperature Control with DeltaV using MPC” training tutorial of how this done.

From equation (1-1) the model can be written as follows:

$$\dot{x} = \frac{1}{A}(K_p u - F_{out})$$

A discrete state space model must be developed to implement the Kalman filter. With $x_1=x$ and $x_2=F_{out}$, then the state space model is as follows:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & -\frac{1}{A} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} \frac{K_p}{A} \\ 0 \end{bmatrix} u$$

$$y = [1 \ 0] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Using forward Euler

$$\dot{x} \approx \frac{x_{k+1} - x_k}{T_s}$$

then the discrete state space model becomes as follows:

$$\begin{bmatrix} x_{1,k+1} \\ x_{2,k+1} \end{bmatrix} = \begin{bmatrix} 1 & -\frac{T_s}{A} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_{1,k} \\ x_{2,k} \end{bmatrix} + \begin{bmatrix} K_p T_s \\ 0 \end{bmatrix} u_k$$

$$y_k = [1 \ 0] \begin{bmatrix} x_{1,k} \\ x_{2,k} \end{bmatrix}$$

We then have the following Kalman filter algorithm:

Measure estimate:

$$y_p = x_{1_p}$$

Estimator deviation:

$$e = y - y_p$$

Corrected state estimates:

$$x_{1_c} = x_{1_p} + k_1 e$$

$$x_{2_c} = x_{2_p} + k_2 e$$

Predicted (future) state estimates:

$$x_{1_{p_1}} = x_{1_c} + \frac{T_s}{A} (K_p u - x_{2_c})$$

$$x_{2_{p_2}} = x_{2_c}$$

Where k_1 and k_2 is the Kalman filter gains.

To get a more structured program we want to separate the Kalman filter into its own control module and later use an external reference for the estimated outflow in the MPC_LOOP_1 module.

Go to DeltaV Explorer and right click on your area LEVELTANK. Then choose New → Control Module, see Figure 2.11.

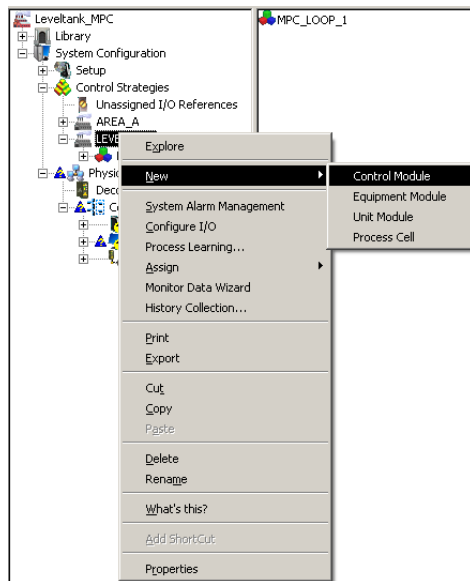


Figure 2.11 Control module for the Kalman filter.

Name the Object name KALMAN_FILTER, see Figure 2.12, then press OK.

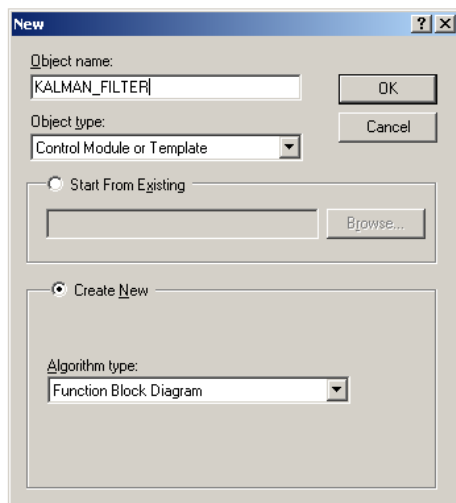


Figure 2.12 Naming the Kalman filter control module.

Right click your new control module KALMAN_FILTER, and then choose Open → Open with Control Studio.

Drag and drop a Calc/Logic block from Analog Control tab. W.r.t. the derived Kalman filter algorithm we now need 9 inputs and 6 outputs on the Calc block. Right click the block and choose Extensible Parameters. Double click IN and OUT, and write 6 and 9 inputs and outputs respectively, see Figure 2.13.

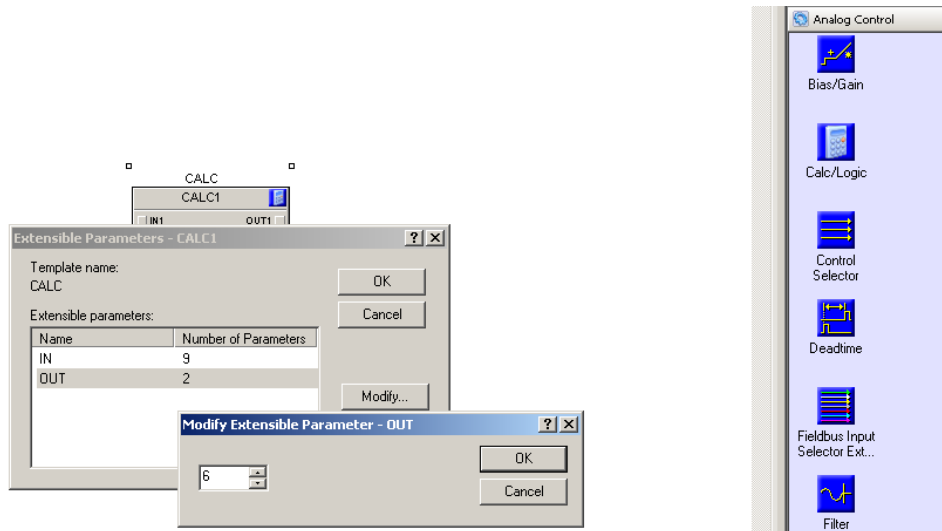


Figure 2.13 Adding inputs and outputs to the Kalman filter Calc block.

Now, drag and drop 9 Input Parameters and 6 Output Parameters from the Special Items tab and connect them to the Calc block, see Figure 2.14.

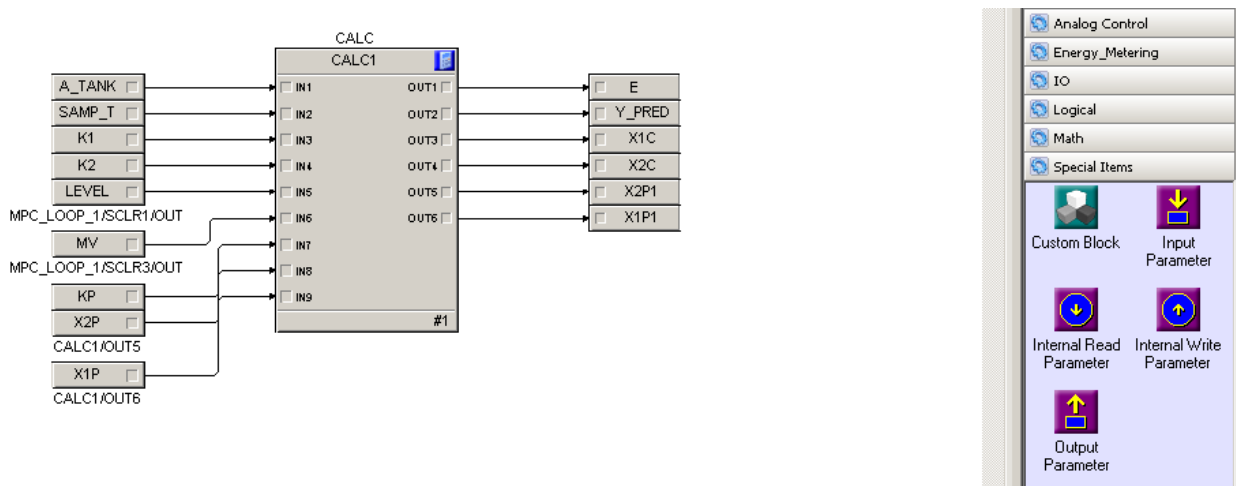


Figure 2.14 Connecting Input and Output Parameters to the Calc block.

For each and one of the parameters a New Parameter Properties window will appear, e.g. similar as in Figure 2.8. For all the output parameters enter only Parameter name, e.g. as shown on the parameters in Figure 2.14. Table 2.1 explains necessary settings you should enter for the input parameters.

Table 2.1 Input Parameters

Parameter name:	Parameter type:	Value:
A_TANK	Floating point	78.5
SAMP_T	Floating point	0.1

K1	Floating point	0.27
K2	Floating point	-2.68
LEVEL	External Reference	MPC_LOOP_1/SCLR1/OUT
MV	External Reference	MPC_LOOP_1/SCLR3/OUT
KP	Floating point	16.5
X2P	Internal Reference	CALC1/OUT5
X1P	Internal Reference	CALC1/OUT6

Note! Values given in Table 2.1, e.g. for K1, K2 and KP, are found using LabVIEW doing different experiments with trial and error. They have proved to be acceptable. However, you may want to adjust these values yourself if the estimation performance is not satisfactory.

From the Kalman filter algorithm we now need to enter the expressions into the CALC block. Right click the CALC block and choose Expression. Then write the expression as shown in Figure 2.15, either by typing it directly or using the toolbar above the expression area.

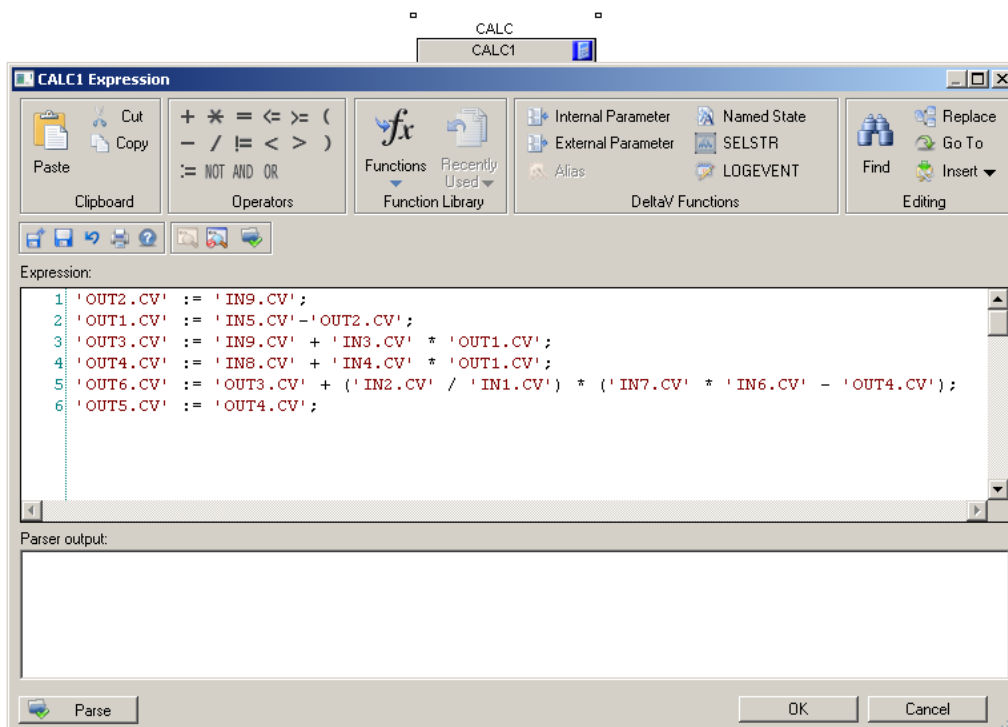


Figure 2.15 Inserting expression for the Kalman filter algorithm.

The last thing we need to do now is to insert a reference to the estimated outflow parameter in the MPC_LOOP_1.

Open the MPC_LOOP_1 control module in Control Studio. Double click the EST_OF_DV parameter and Browse under External parameter path: KALMAN_FILTER →CALC1 →OUT4, see Figure 2.16.

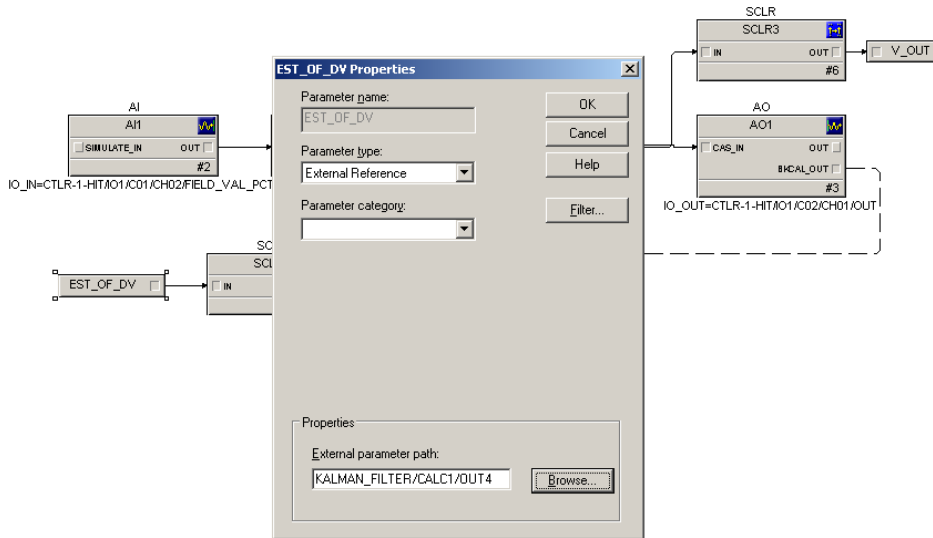


Figure 2.16 Inserting a reference to the estimated outflow parameter in the MPC_LOOP_1.

The Kalman filter is now finished and connected as an estimator for the disturbance to the MPC controller.

2.5 Step 5: Activate I/O configuration

Now we need to activate the I/O. This is done in Exploring DeltaV. Choose applications → I/O configuration. See Figure 2.17.

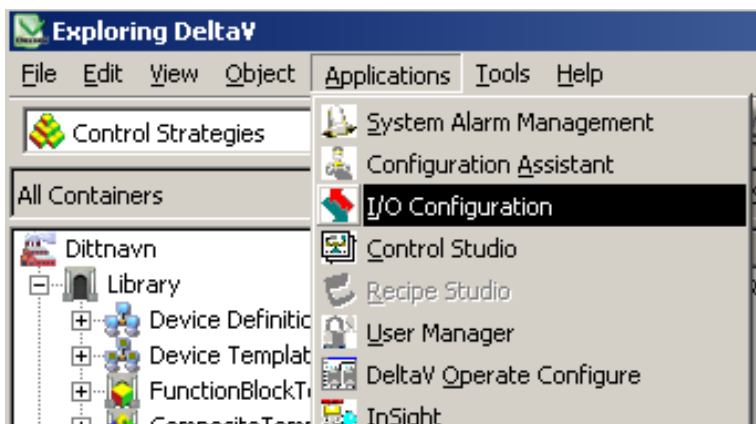


Figure 2.17 I/O Configuration from Exploring DeltaV.

Here we can see all the modules that are connected to the station. See Figure 2.18. Choose C01 and right click the CH02 and enable it. Do the same with C02→CH01. CH02 under C01 and CH01 under C02 should now be activated.

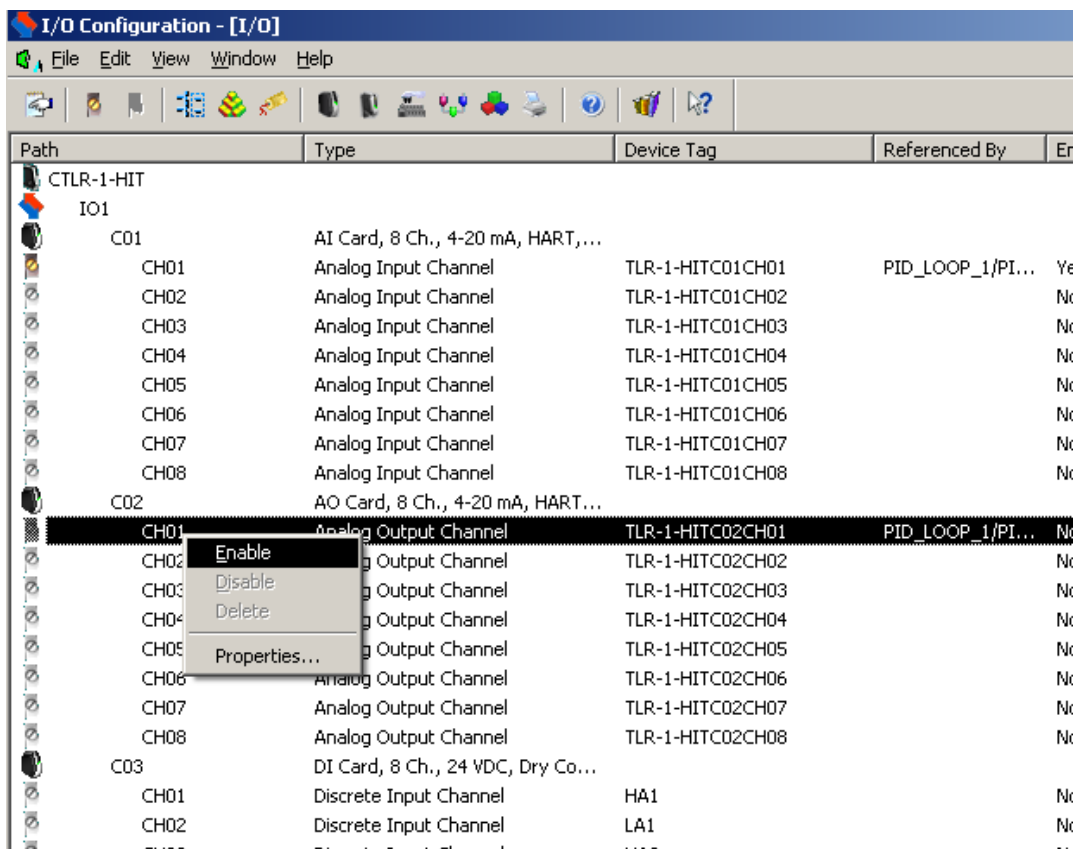


Figure 2.18 Activating I/O configuration.

2.6 Step 6: Assigning area to alarm and events and continuous historian

Now we need to return to Control Studio and download our program for both the MPC_LOOP_1 and KALMAN_FILER modules. This is done by pressing the arrow called Download, see Figure 2.19. You will then get a question box that asks if you want to assign the module. Press yes, choose CTLR-1-HIT, press Ok, and yes on the Control Studio box. After that, press ok and yes on everything until you have downloaded. If you get any error messages just press Ok and proceed.

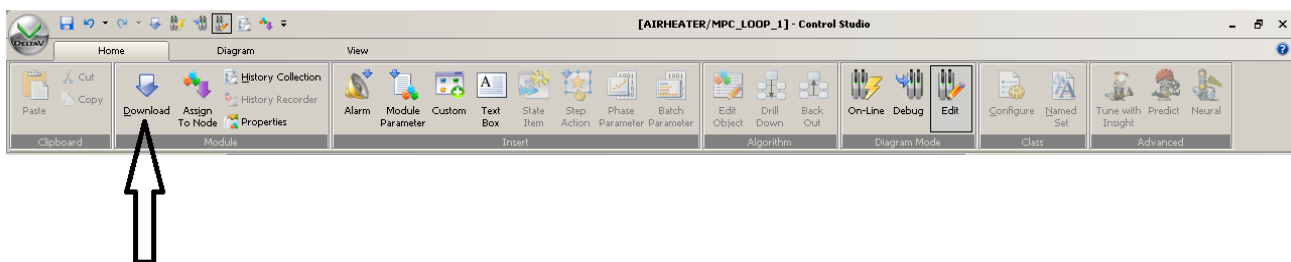


Figure 2.19 Downloading the program in Control Studio.

The control modules and I/O is now connected to the hardware module. For alarms and events and data collecting to work we need to connect this to the history module that's premade in DeltaV.

Go to Exploring DeltaV, choose your area LEVELTANK under Control Strategies and drag and drop it down to Alarms And Events, see Figure 2.20. Also, since we need to collect input/output

data to create a model as in section 3, then drag and drop the area to Continuous Historian as well.

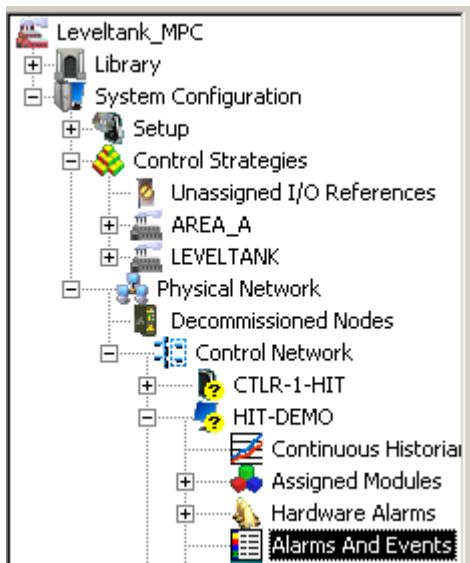


Figure 2.20 Assigning LEVELTANK area to Alarms and Events and Continuous Historian.

2.7 Step 7: Downloading the program

The last thing that needs to be done before we start making the model is to make sure everything is downloaded. Right click on Physical network and choose Download physical network. Whenever there has accrued changes in the physical network this need to be downloaded again. If minor changes, e.g. setup data, then instead of downloading the whole physical network there could be more appropriate to right click the physical network and download Setup Data, see Figure 2.21.

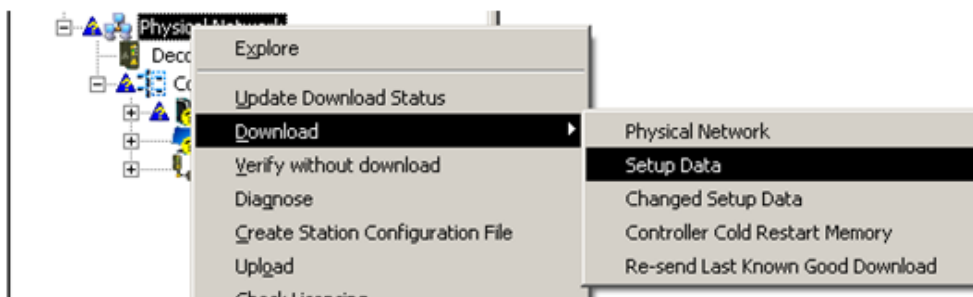


Figure 2.21 Downloading the program in Explorer.

Also, every time you make a change in a program in Control Studio this need to be saved and downloaded again as well, see Figure 2.19.

After the downloading, the program should now be ready.

3 MODELLING AND VALIDATION

In this section we will learn how to create a MPC model for the MPC controller and do validation of the model, using DeltaV Predict, -MPC Operate and MPC Simulate.

3.1 Step 1: Connecting the Level Tank process

Since the MPC block has an inbuilt feature making a model from input/output system identification, we first need to physically connect the Level Tank to DeltaV. Figure 3.1 shows a sketch of how the model is to be wired.

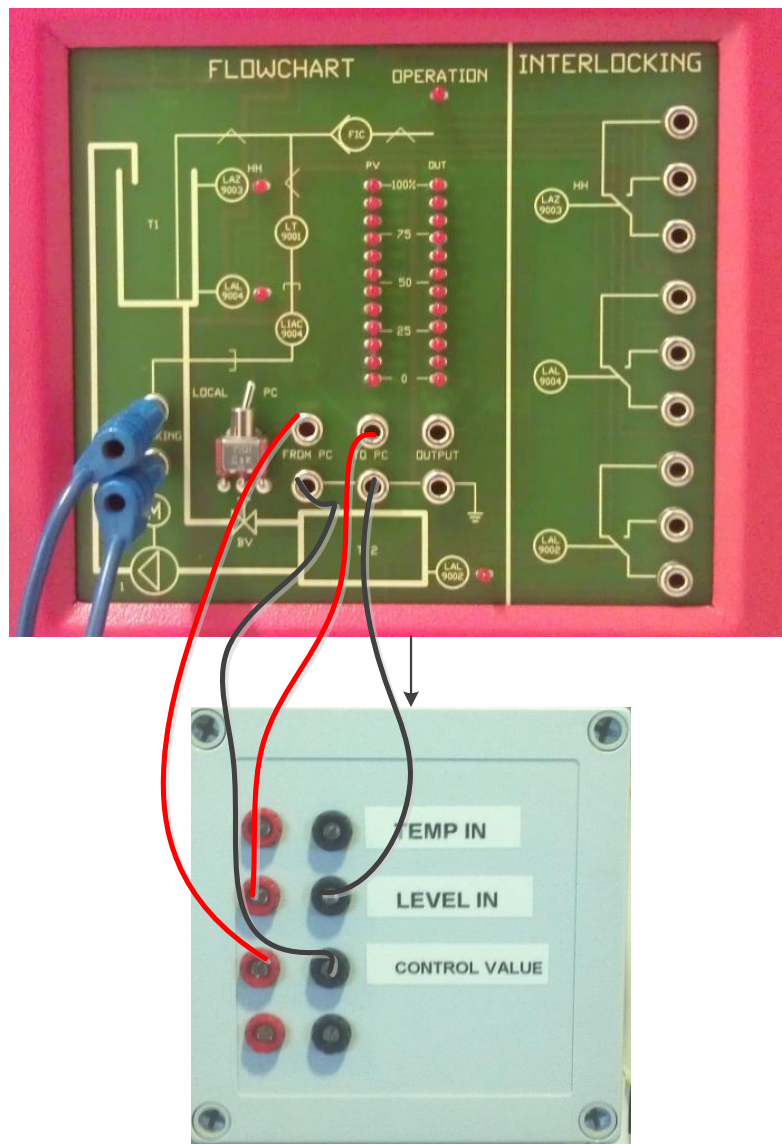


Figure 3.1 Connecting the Level Tank model to the DeltaV system.

3.2 Step 2: Creating the MPC model

The application where we create the model is called DeltaV Predict. Go to the MPC_LOOP_1 in Control Studio and right click the MPC block and choose Advanced Control → Predict, see Figure 3.2.

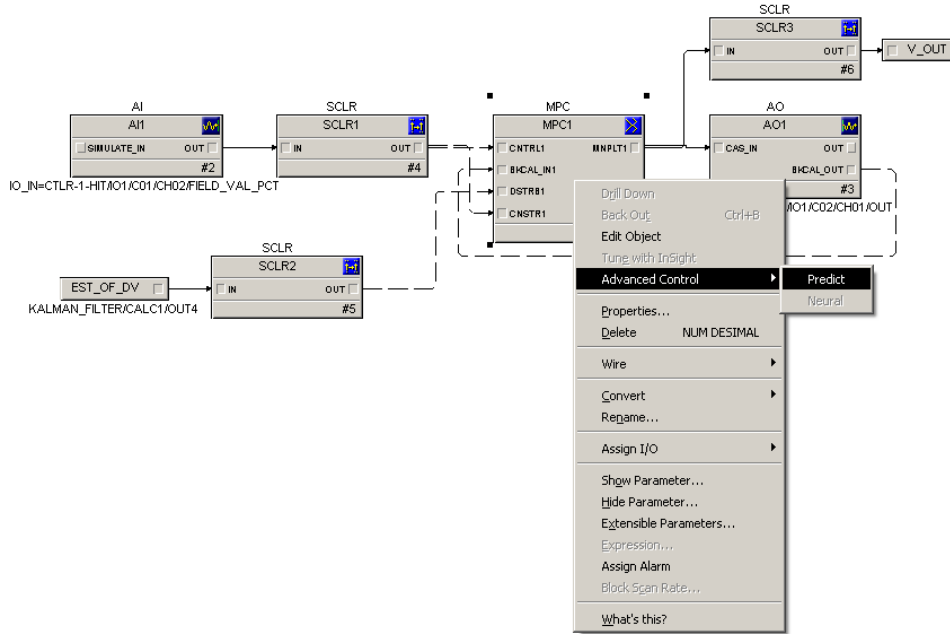


Figure 3.2 Opening DeltaV Predict application.

The application then appears similar to as seen in Figure 3.3.

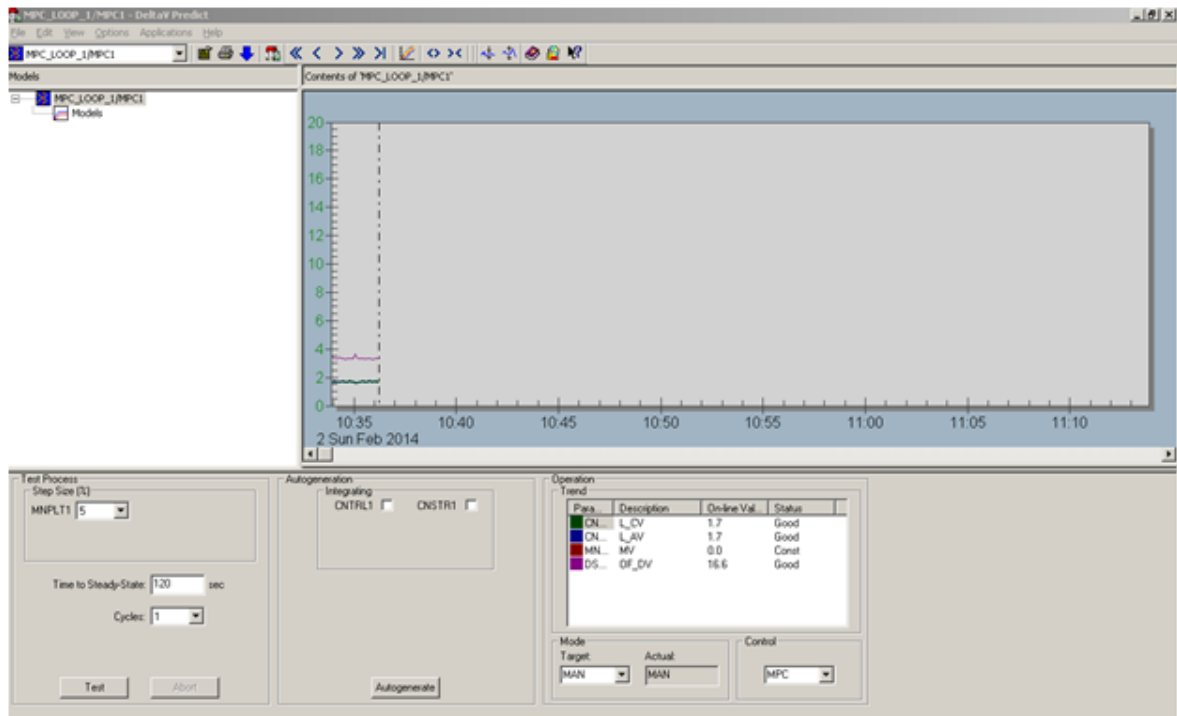


Figure 3.3 DeltaV Predict application.

Start by going to Options in the application menu and chose Expert. This gives additional features which we want to use.

From the Figure 3.3, the upper left part is where the model hierarchy is found. On the upper right is a trending picture which shows the MPC parameters configured, and chosen by double-clicking the respective parameter under Operation and Trend. The lower left part is for modelling configuration and the lower middle is for model generation.

Before we start modelling we want to find a preferred operational point, e.g. around 10 cm.

Click Application in the application menu and choose MPC Operate.

A new application appears, and with the physical process connected we have the choice to run the MPC control either in manual or in auto mode. Since we do not have a model yet only the manual mode will work.

On the bottom in the MPC Operate application all the MPC parameters are shown.

Start by marking all the parameter check boxes in the bottom of the figure. Click on the manipulated variable (MV). At the left side a slide-bar for the parameter is then shown. Adjust the slide-bar so that the level gets steady and about 10 cm, see Figure 3.4.

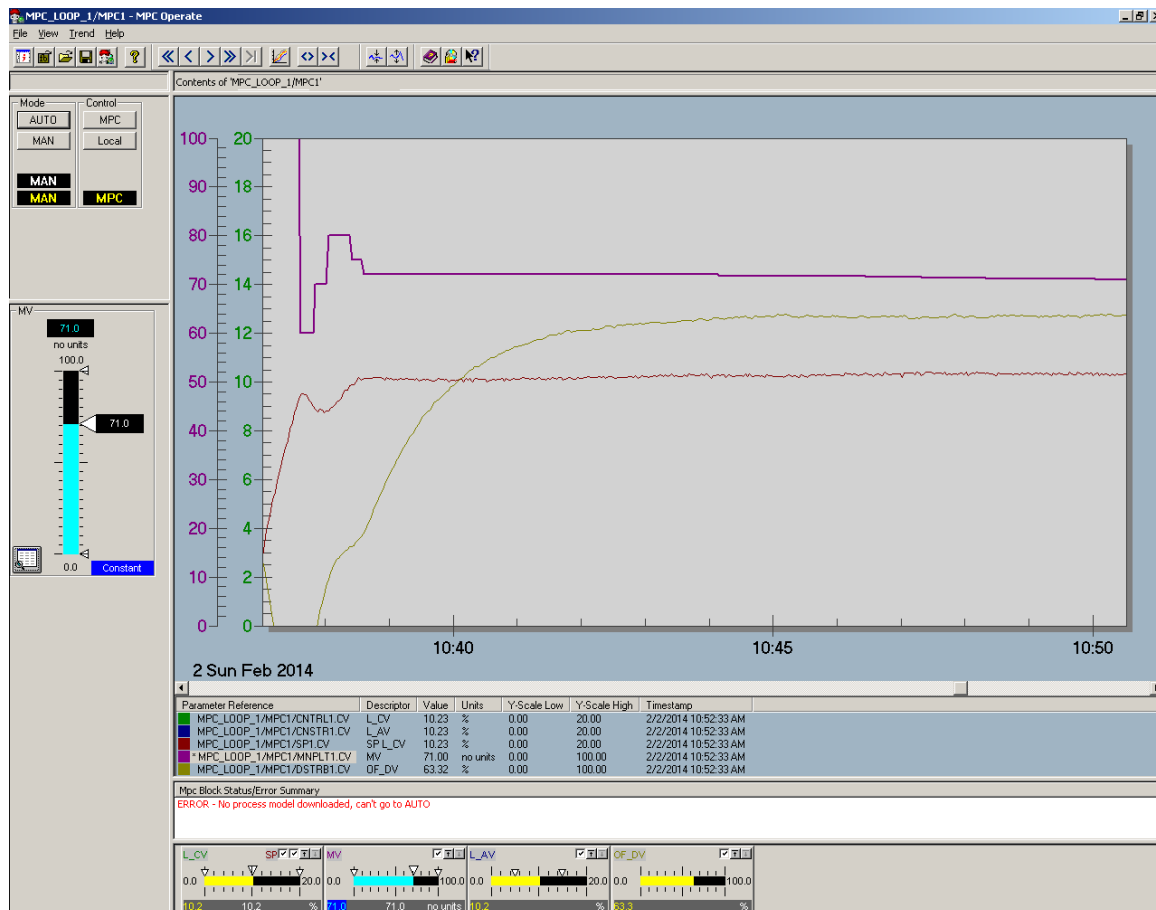


Figure 3.4 Adjusting level manually in MPC Operate.

When you have the operational point steady around 10 cm, go back to the DeltaV Predict application and set the Test Process parameters Step Size to 5 %, Time to Steady-State to 180 s and Cycles to 2, as seen in Figure 3.5. Also, set the flow handle on the physical Level Tank to 45°. Then press the Test button.

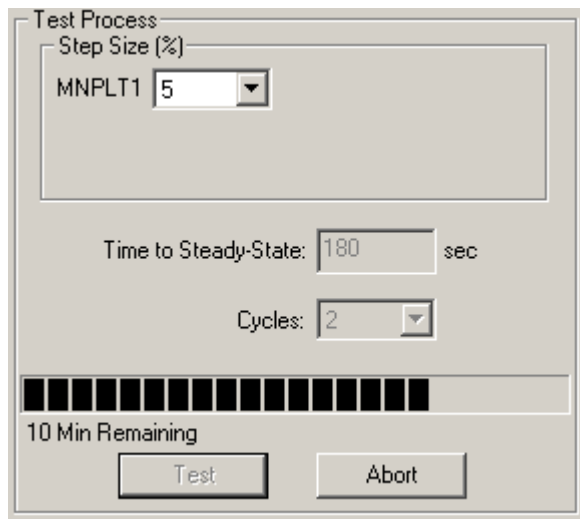


Figure 3.5 Test Process parameters.

The application is now starting to collect input/output data to create the model. For the above Test Process settings it will take some time to finish this test process. This will be indicated by a blue progression bar under Test Process.

When the test process is finished this is indicated by the green area layered on the period of data collection seen on the trend picture and as in Figure 3.6.

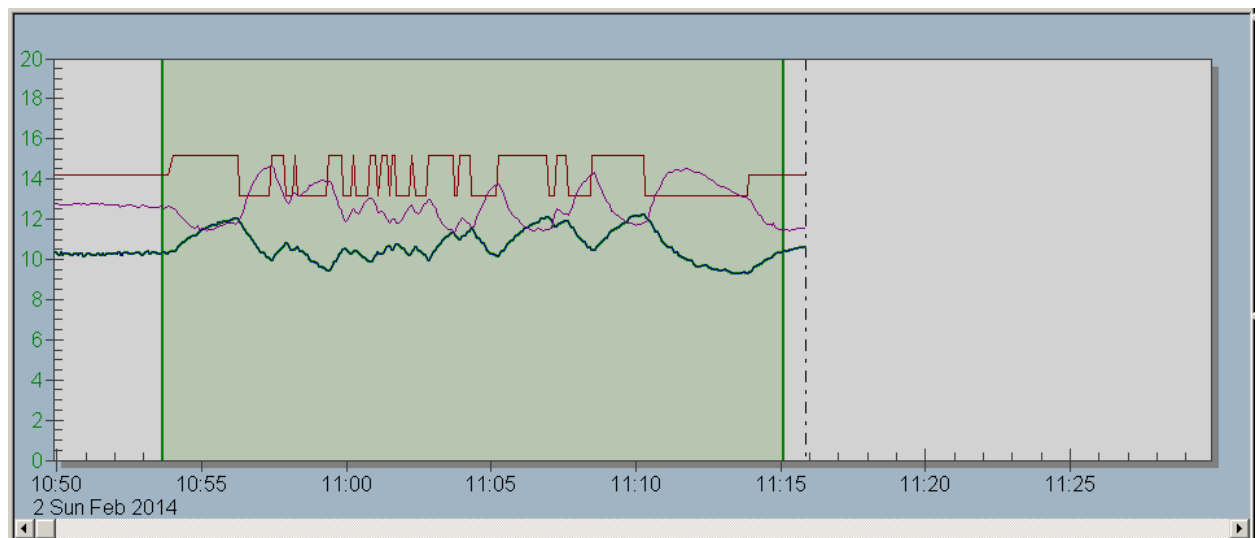


Figure 3.6 Period of data collection.

Click the Autogenerate button to generate the model.

The model will then be generated and all step responses for the inputs and outputs can be seen as in Figure 3.7. The step responses may be investigated in further details by choosing the different input/output relations in the model hierarchy under Models.

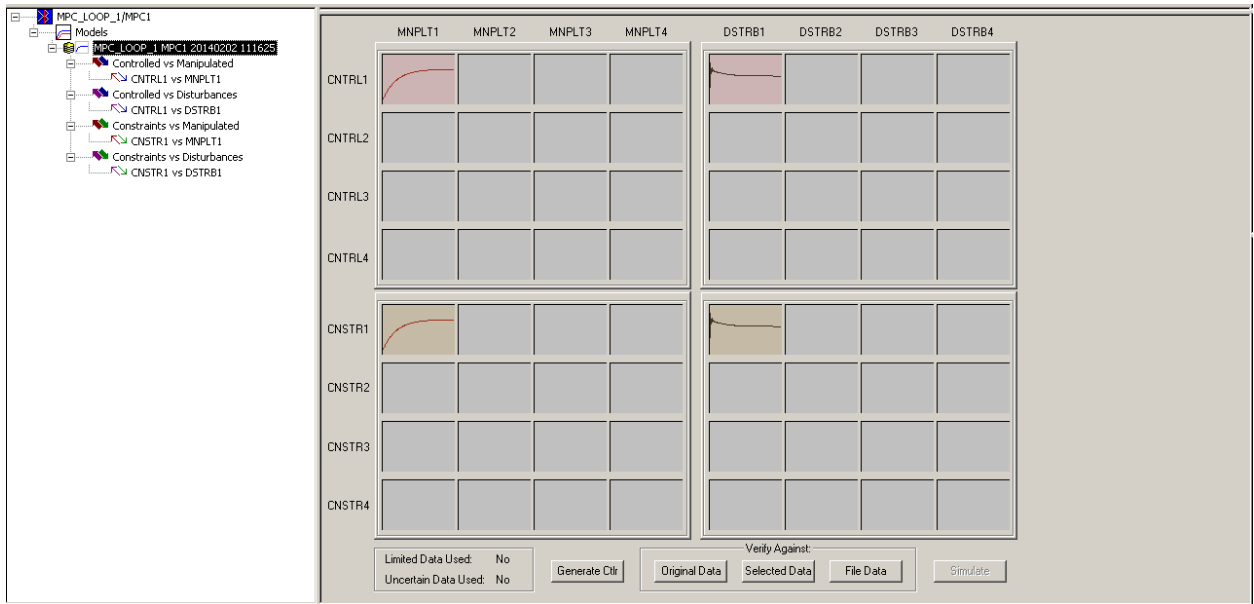


Figure 3.7 Generated model and step responses.

3.3 Step 3: Verification of the MPC model

To verify the model we first want to e.g. check the actual measurement vs the predicted. Click the Original Data button seen in Figure 3.7 (be sure to have chosen Expert under Options to get these buttons available). A Model Verification window, as in Figure 3.8, will then appear. This may give a good indication of how the model is, preferable having smallest possible deviation, and smallest possible Squared Error and R-Squared. The graph in Figure 3.8 seems to show a somewhat ok model. By choosing Actual vs. Predicted the corresponding best fit line can also be investigated.

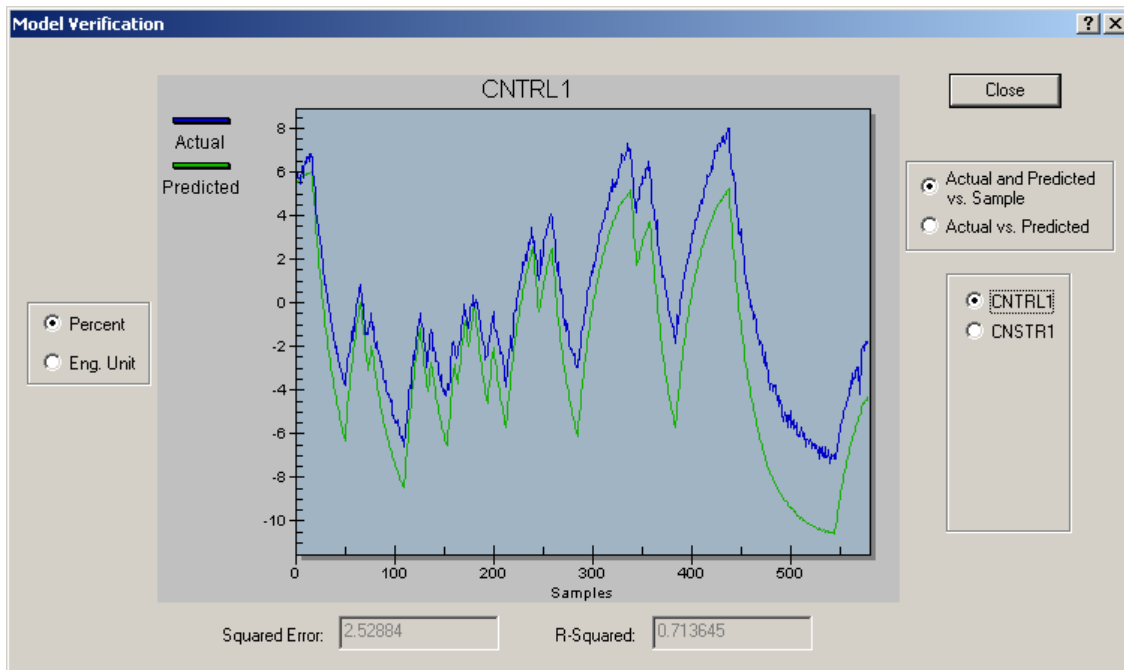


Figure 3.8 Model verification of the actual measurement vs the predicted.

To possibly improve the model, e.g. remove uncertain data, we may adjust the period of data collection as seen in Figure 3.6. However, note that doing this may also worsen your model, and should be done with cautiousness.

If you want to adjust the period of data collection, then click on and adjust the edges of the green layered area, see Figure 3.9. From the figure the data seems to correlate (negative) better within the new green area.

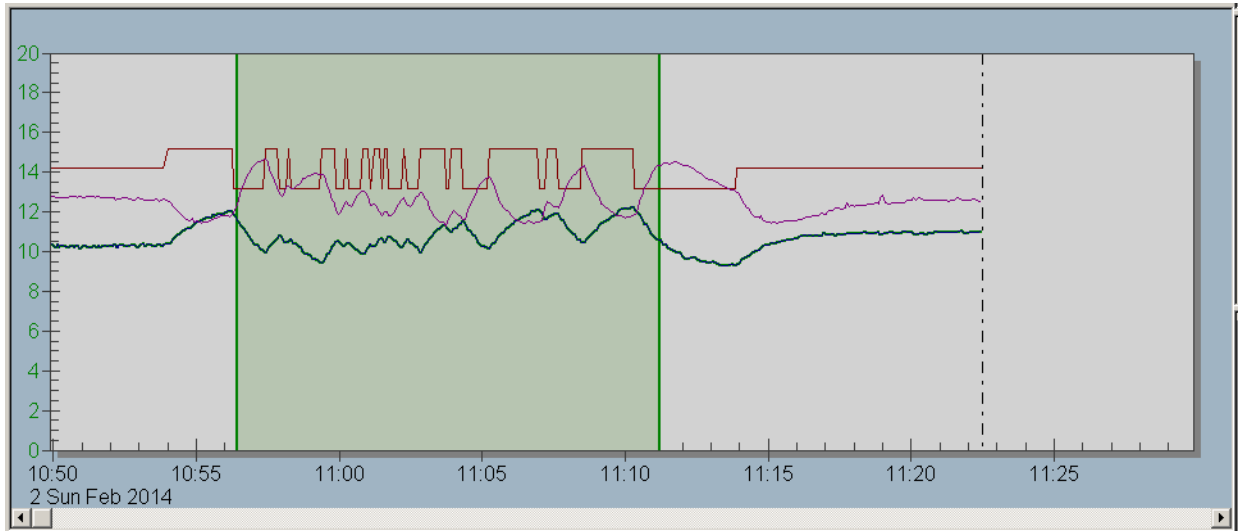


Figure 3.9 Adjusting the period of data collection.

As before click the Autogenerate button to generate the model.

Do the verification again and see if the model may have been improved. Figure 3.10 indicates improvement in the model.

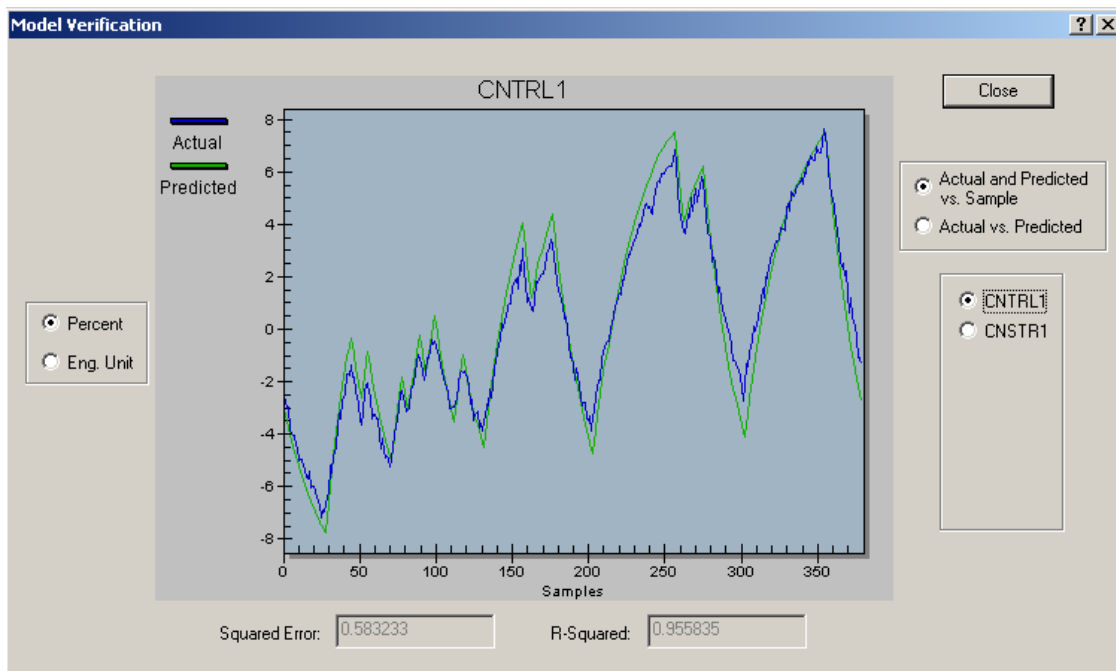


Figure 3.10 New model verification of the actual measurement vs the predicted.

Once you are satisfied that the model fairly reflects the process dynamics, select Generate Ctrlr to update the MPC configuration for the new model.

When the control is generated from a selected model, control parameters used to generate the control are displayed and shown in Figure 3.11. Here we can somewhat tune the controller. Normally only the Penalty On Move (PM) and Penalty On Error (PE) should be adjusted. In short:

- Increase the PM value (in fifty percent increments) for any manipulated variables that are moving more than the acceptable limits.
- Decrease the PM for manipulated variables that are not responsive. It is recommended that they do not go below the default minimum PM values (the PM min = 3).
- Increase or decrease the PE, depending on process control requirements.

We might want to wait to do this kind of tuning since we have not tested the controller yet. However, normally the default values give a good performance.

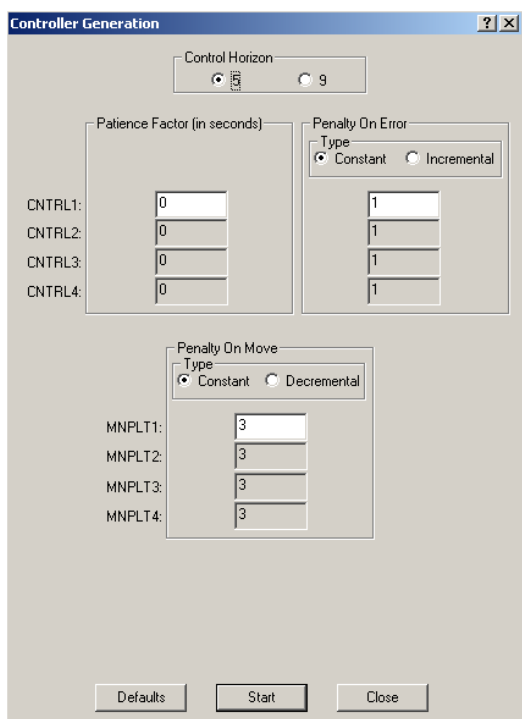


Figure 3.11 Controller generation and tuning parameters.

Now, press Start to continue, and then Close after the progression bar has finished.

To download the MPC controller click the blue arrow in the DeltaV Predict application as seen in Figure 3.12.



Figure 3.12 Downloading the MPC controller.

3.4 Step 4: Validation of the MPC controller

Next step is to simulate the performance of the generated controller. This can be done in the MPC Simulate application.

Press the Simulate button, seen in Figure 3.7, to open the application. Figure 3.13 shows the simulation environment.

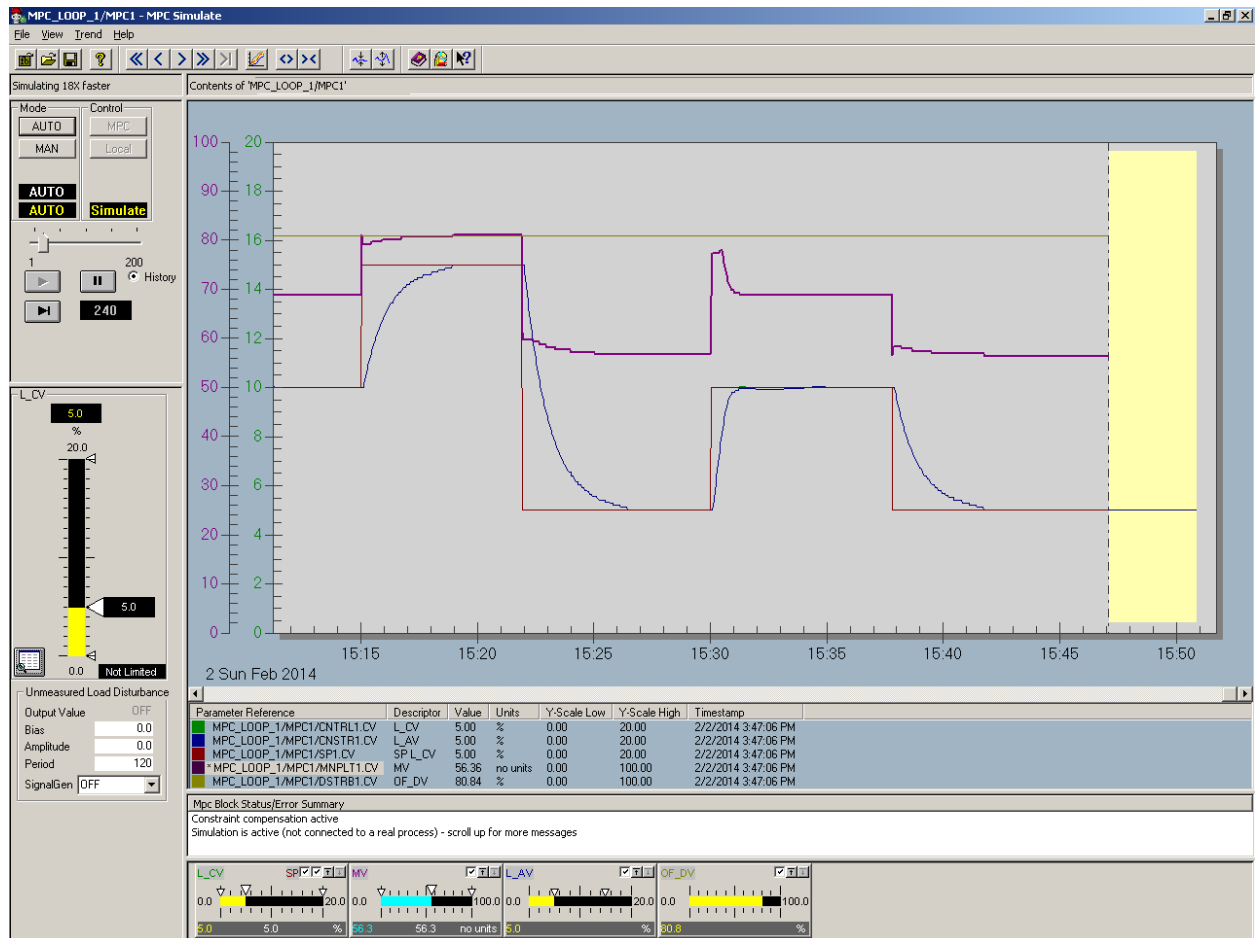


Figure 3.13 Simulation in MPC Simulate.

Start by marking all the parameter check boxes in the bottom of the figure.

Then select AUTO under Mode, and start the simulation by clicking the play button.

Now you can adjust the controlled variable using the slide-bar to the left and see the simulation performance of the MPC controller. If you want the simulation to go faster you can do so by adjusting the horizontal slide-bar above the play button. The yellow area in the trend is the predicted future measurement.

If the performance is satisfactory then you can test it on the Level Tank, e.g. using the MPC Operate application in the same manner as in the simulation environment, and see if the response is similar. The green area in the trend is the predicted future measurement. Figure 3.13 vs Figure 3.14 shows that the response is fairly similar. Note that in the simulations the disturbance is constant. The constant value is set w.r.t. the average value of the earlier collected disturbance data.

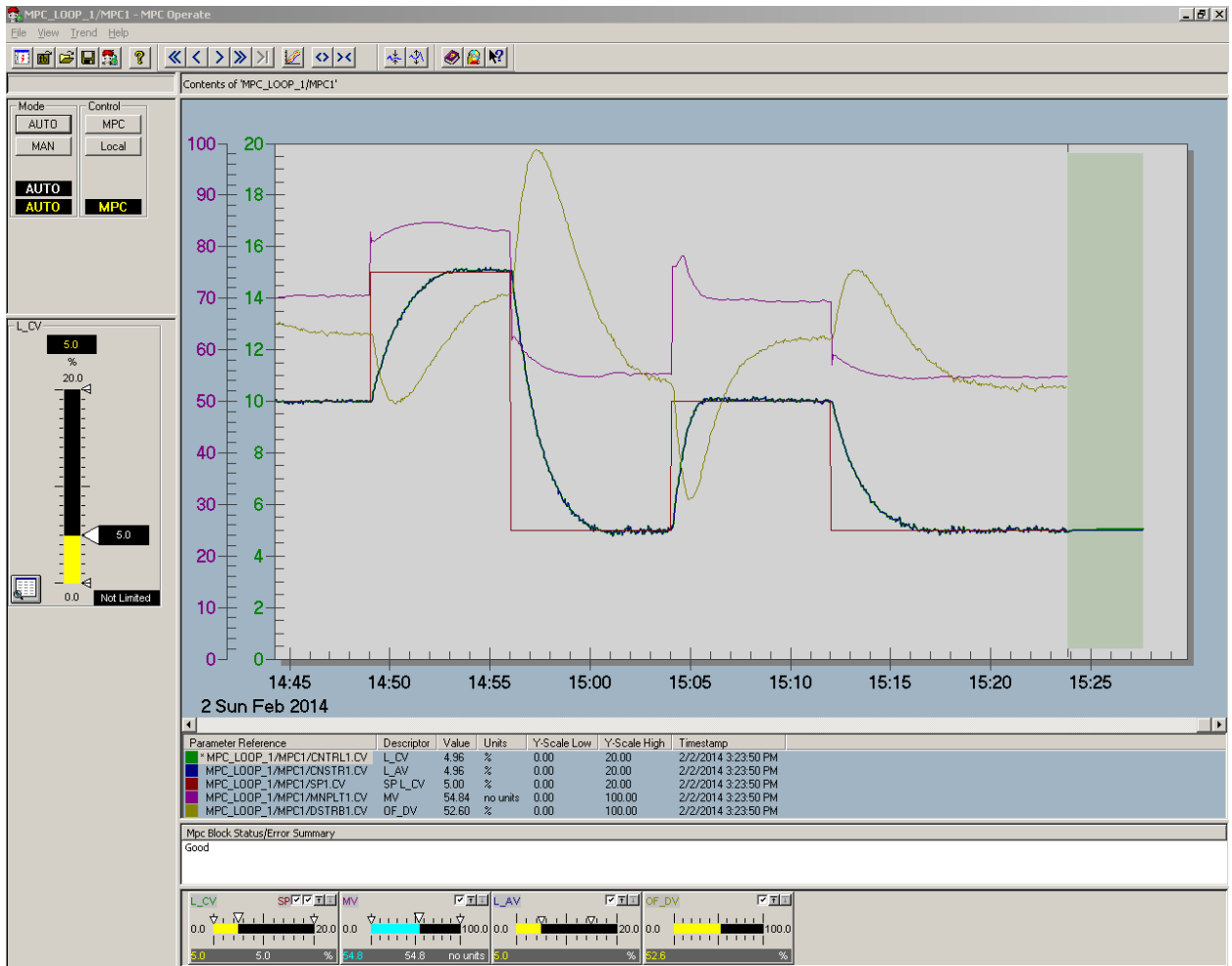


Figure 3.14 Testing the MPC controller in MPC Operate.

Note! If your model or simulations doesn't look to good it could be a good idea doing the test process again and possible change the test process parameters, e.g. try to vary the period of testing w.r.t. number of samples.

4 CREATING THE HMI

In this section we will learn how to create a HMI to be able to monitor and control the Level Tank system, using DeltaV Operate Configure.

4.1 Step 1: Creating a new picture

When you are in Exploring Deltav, go to Applications and choose DeltaV Operate Configure, see Figure 4.1.



Figure 4.1 Exploring DeltaV

Press the +sign on the folder Pictures → Templates and double click on main. You will then get a standard template picture, see Figure 4.2.

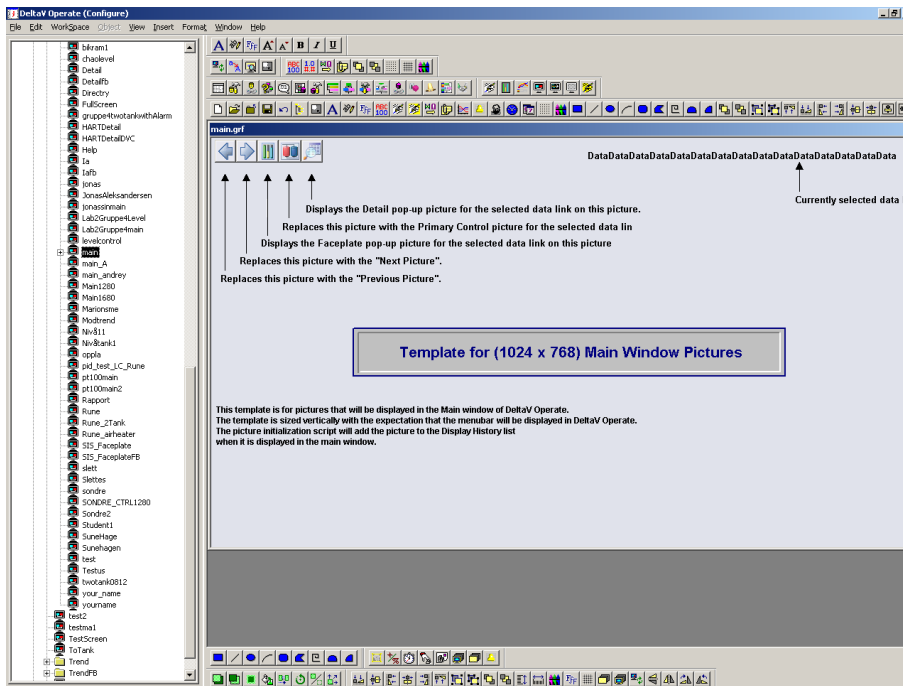


Figure 4.2 Using main picture template.

Mark and delete all the text on the picture so you get a blank picture like the one below, see Figure 4.3.

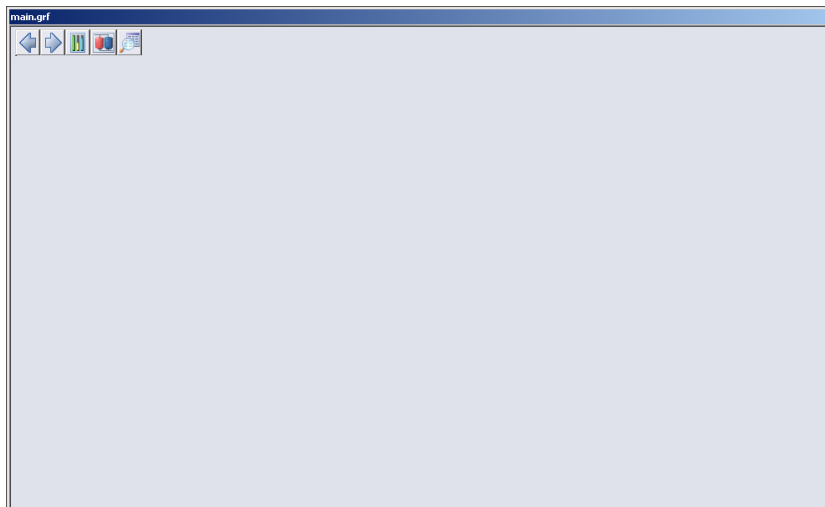


Figure 4.3 Crating blank picture.

Next, go to File in the menu and choose Save As. Save the picture with yourname.grf.

4.2 Step 2: Creating picture interface using dynamos

Now we can begin creating our interface. In the left column you can find many premade dynamo components. We will need a tank, a pump and some pipes.

Choose Dynamo Sets → TanksAnim. Drag and drop the tank to our picture, see Figure 4.4. This tank needs to be connected to our I/O to be able to simulate the level.

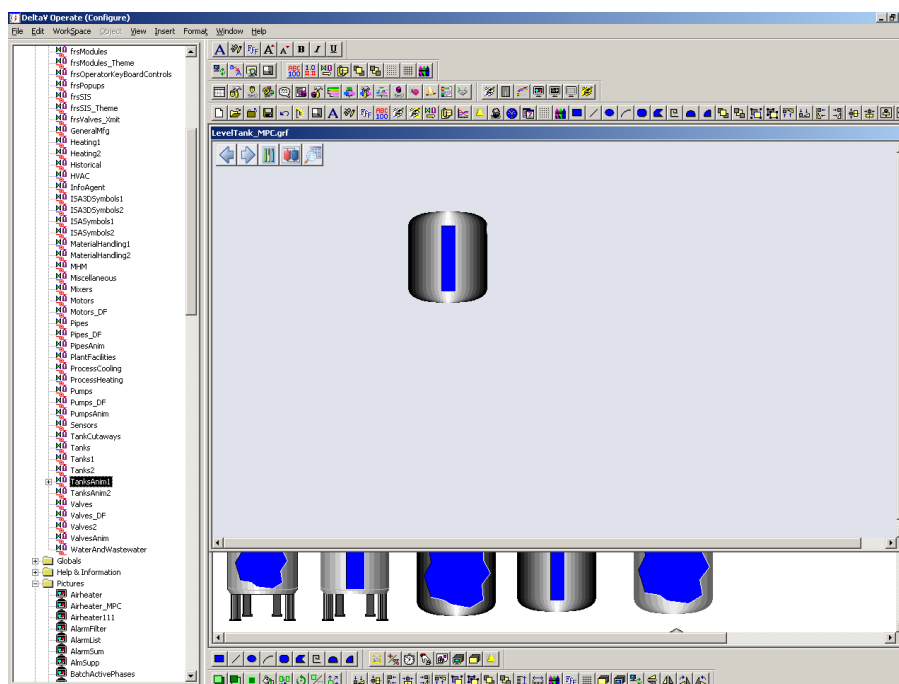



Figure 4.4 Adding a tank to the picture interface.

A Dynamo box will appear after you have placed your tank, as shown in Figure 4.5. Start by entering 20 (cm) in Highest Input Value under Input Ranges. Press the  button, then press Browse DeltaV Control Parameters → LEVELTANK → MPC_LOOP_1 → MPC1 → CNTRL1 → CV.

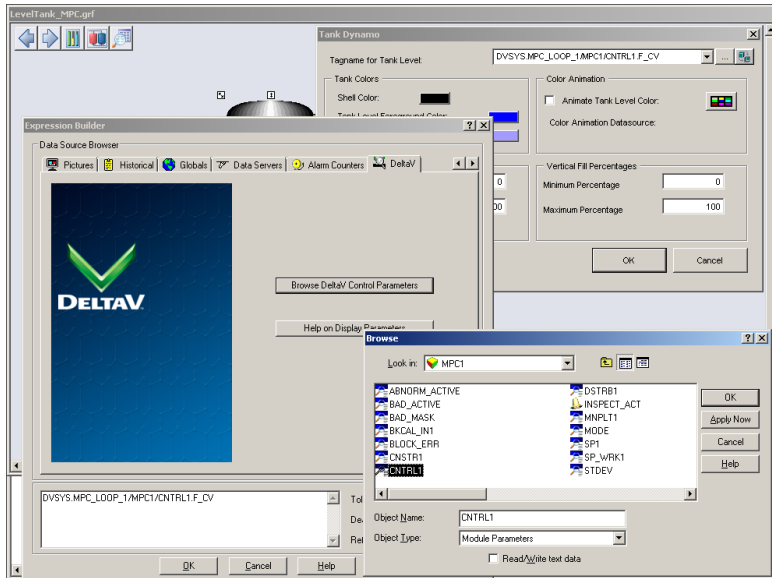



Figure 4.5 Linking level data to the tank.

Press ok until you get back to the picture.

We will now find a pump. Choose a suitable pump from the Dynamo Sets, e.g. from Pumps_DF, and drag and drop it onto the drawing board.

This can be connected to the I/O. Check the box for Animate Pump Color. Press the  button and do exactly the same as you did when connecting the tank, except that you will choose MNPLT1 instead of CNTRL1.

We can also choose what kind of color the pump will have at different values. Choose green color when the pump is running, see Figure 4.6.

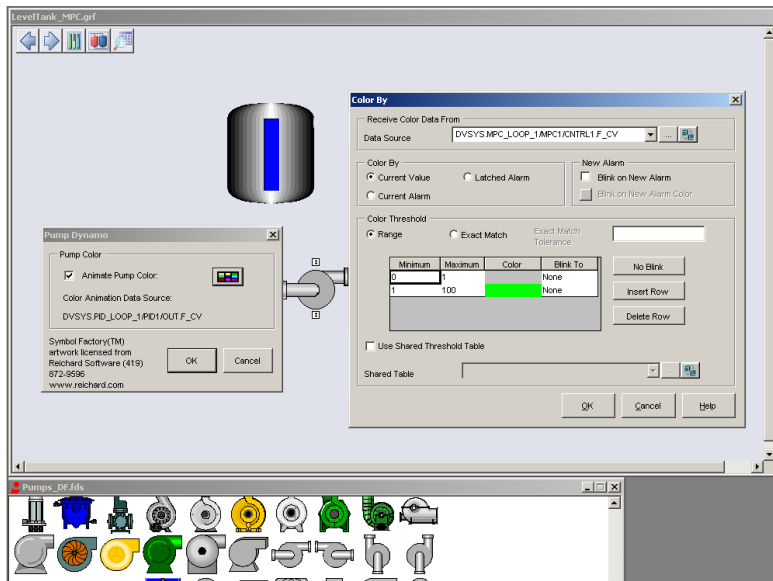


Figure 4.6 Linking control signal by data to the pump and adding animation color.

Now we need to add a reservoir tank and some pipes. Drag and drop a tank and some pipes into the drawing board and adjust them similar to as seen in see Figure 4.7. The tank is found in Tanks2 and pipes are found in Pipes_DF, under Dynamo Sets.

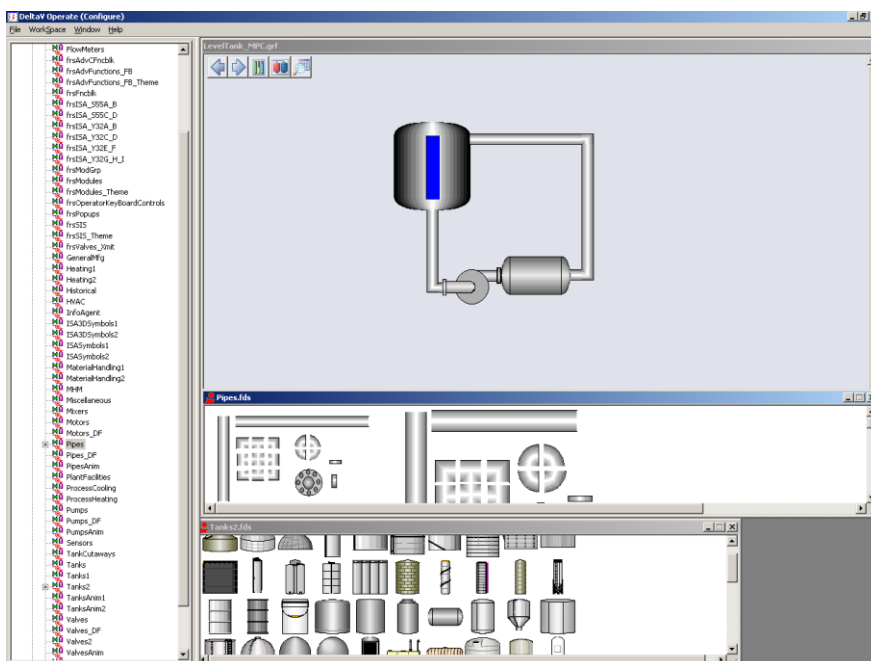


Figure 4.7 Pipe dynamics.

4.3 Step 3: Creating names and datalinks

Now we need to create names and datalinks for some variables. Let's make one for the CV, SP, MV and DV. Here we use the tool bar above the picture. Press the big A and write the different variable names we need, see Figure 4.8. These variables need to be connected to our MPC controller.

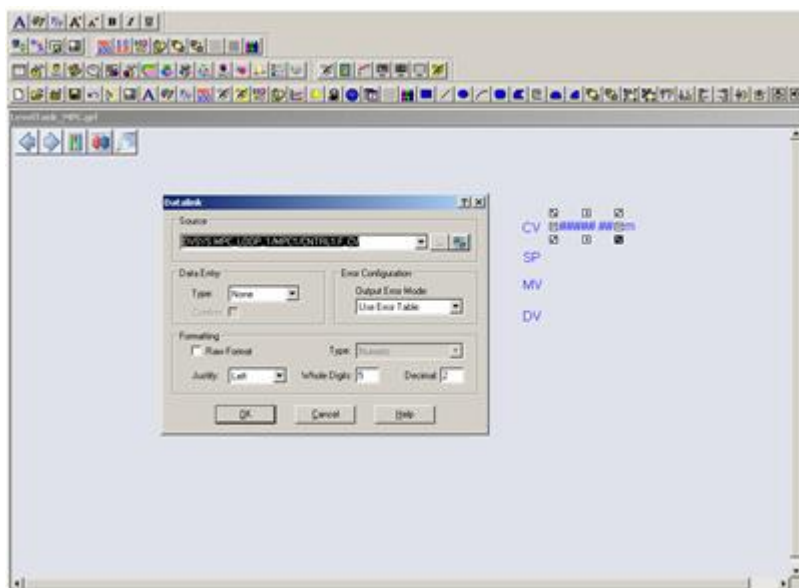



Figure 4.8 Creating names and datalinks for the variables.

Let's start with the CV. Press "ABC100" that you can find in the toolbar. Then press the  button. Browse DeltaV Control Parameters → LEVELTANK → MPC_LOOP_1 → MPC1 → CNTRL1 → CV. Then press ok until you get back the Datalink box. Here, change Type to Numeric and press ok. Place the variable next to CV, see Figure 4.8.

Do exactly the same for SP, but choose SP1 instead of CNTRL1, and in Datalink box we need to choose in-place on the data entry to be allowed to change the variable. Place it next to SP.

For the MV, do exactly the same procedure as we did with SP, except that we choose MNPLT1. Place the variable next to MV.

The only datalink left is the DV. Do exactly the same procedure as when we did with CV, except that we choose DSTRB. Place the variable next to DV.

4.4 Step 4: Creating faceplate- and MPC operator interface buttons

First we will make a button to open a faceplate to our controller when the program is running. First create the text Open Faceplate, then choose a circle from the toolbar and place it next to the text, see Figure 4.9.

Double click the circle. Under command make sure to activate click.


Double click on DeltaV Open Faceplate, press the  button and choose Browse DeltaV Control Parameters. Then choose LEVELTANK → MPC_LOOP_1 → MPC1 → CNTRL1 → CV and press OK until you are back to your picture.

Figure 4.9 is showing you how to configure the button to open the faceplate.

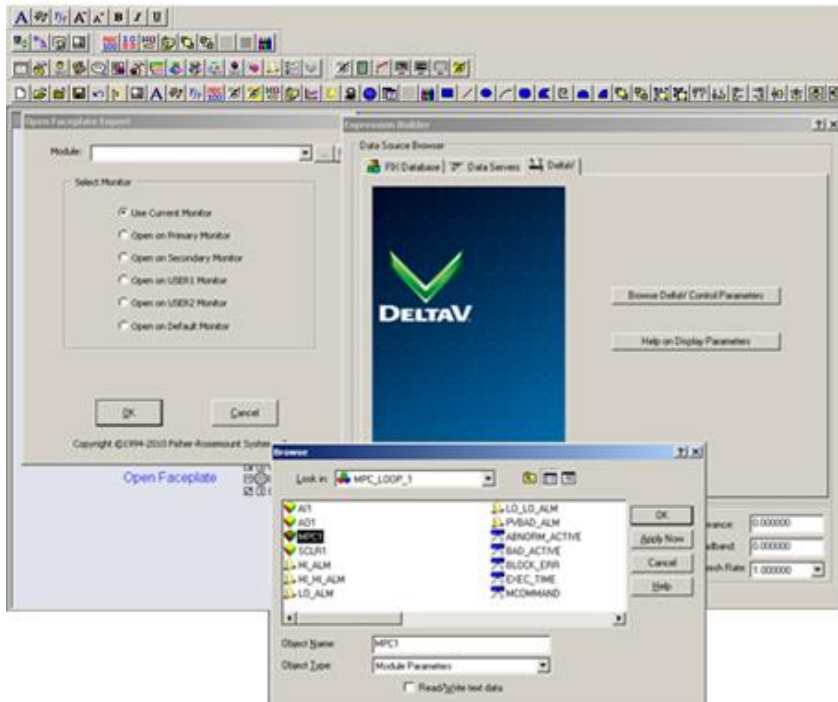


Figure 4.9 Creating a button to open the MPC-controller faceplate.

We have now made it possible to open a faceplate to our controller. Also, we want to create a button that opens the MPC Operate interface. Choose Dynamo Sets and double click frsAdvCFncblk. Then drag and drop MPCOperMode into the picture, see Figure 4.10.

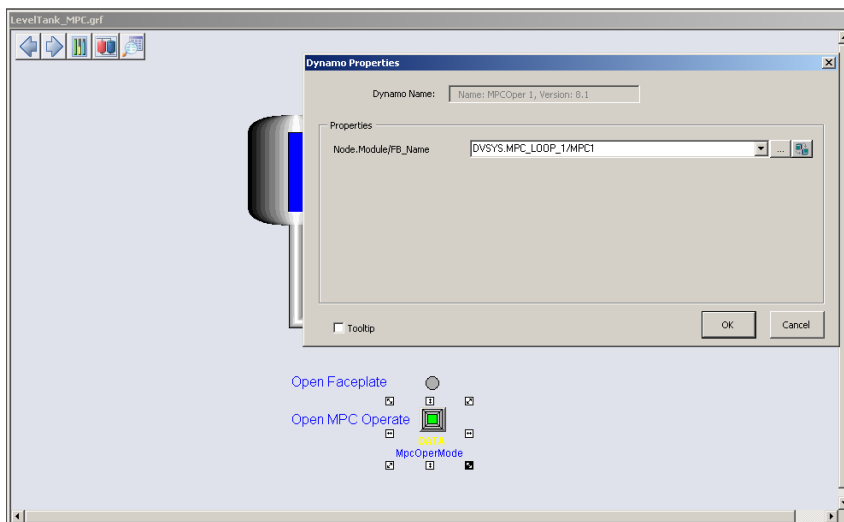



Figure 4.10 Button to open the MPC Operate interface.

A Dynamo Properties window appears. As for the faceplate press the  button and choose Browse DeltaV Control Parameters. Then choose LEVELTANK → MPC_LOOP_1 → MPC1 → CNTRL1 → CV and press OK until you are back to your picture.

You have now made the interface that can be used to control the temperature for the Level Tank. If you haven't already saved your picture then do this now by choosing Save As under File. Save the picture with yourname.grf.

5 OPERATING THE LEVEL TANK SYSTEM

To operate the Level Tank system we need to physically connect it to DeltaV. Wire up the model as shown in section 3.1.

When the model is connected press Ctrl + w in the previous HMI picture you created to enable the run mode, DeltaV Operate Run. The model is now ready to be controlled.

The running application can be seen in Figure 5.1.

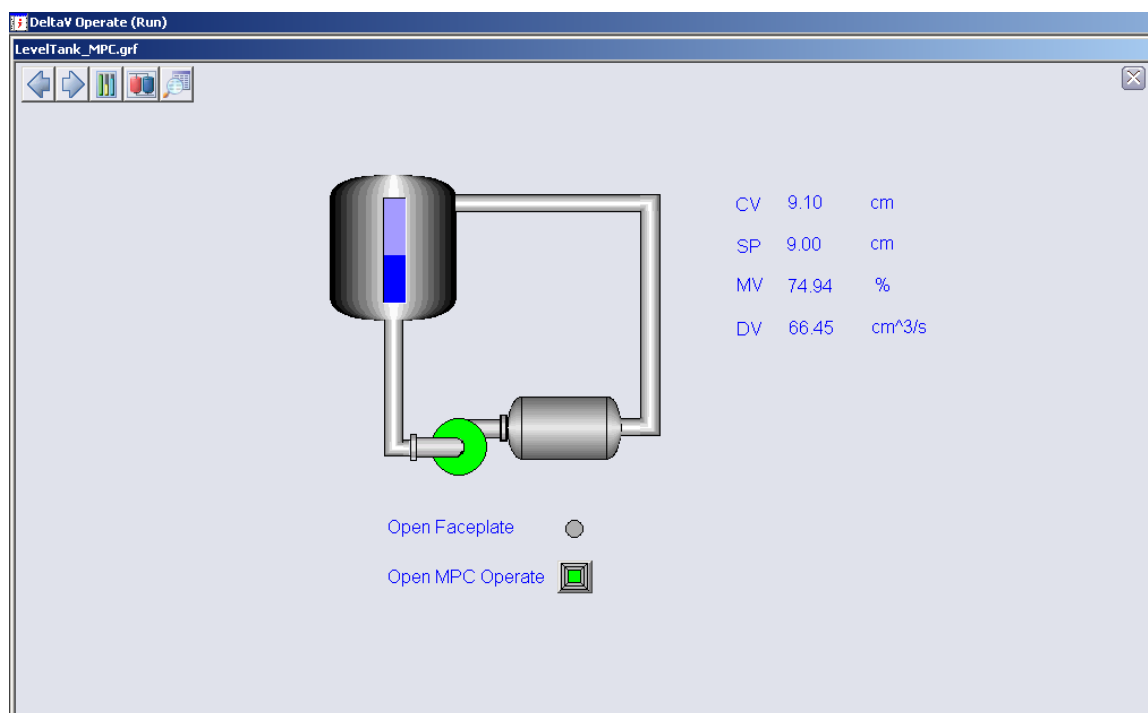


Figure 5.1 Running Level Tank system in DeltaV Operate Run.

To open the MPC Operate application just press the Open MPC Operate button you created. You can then control the Level Tank as explained in section 3.

Press the Open Faceplate button to open the faceplate. Alternatively you can mark either SP or MV and then press the faceplate button in upper left corner. Here you have the options to control the process manually or set it to auto.

You can see the trend of the variables by pressing the button that looks like a graph in the faceplate. You will then see the CV, SP, MV and DV.

If you press the button with the magnifying glass in the faceplate, a detail window will appear. Here you can e.g. try to do further tuning changing the SP Filter Time. If your controller f.ex. has too fast control response, then by increasing the setpoint filter time the response will be relaxed.

Figure 5.2 shows the running model with its associated faceplate and detail window.

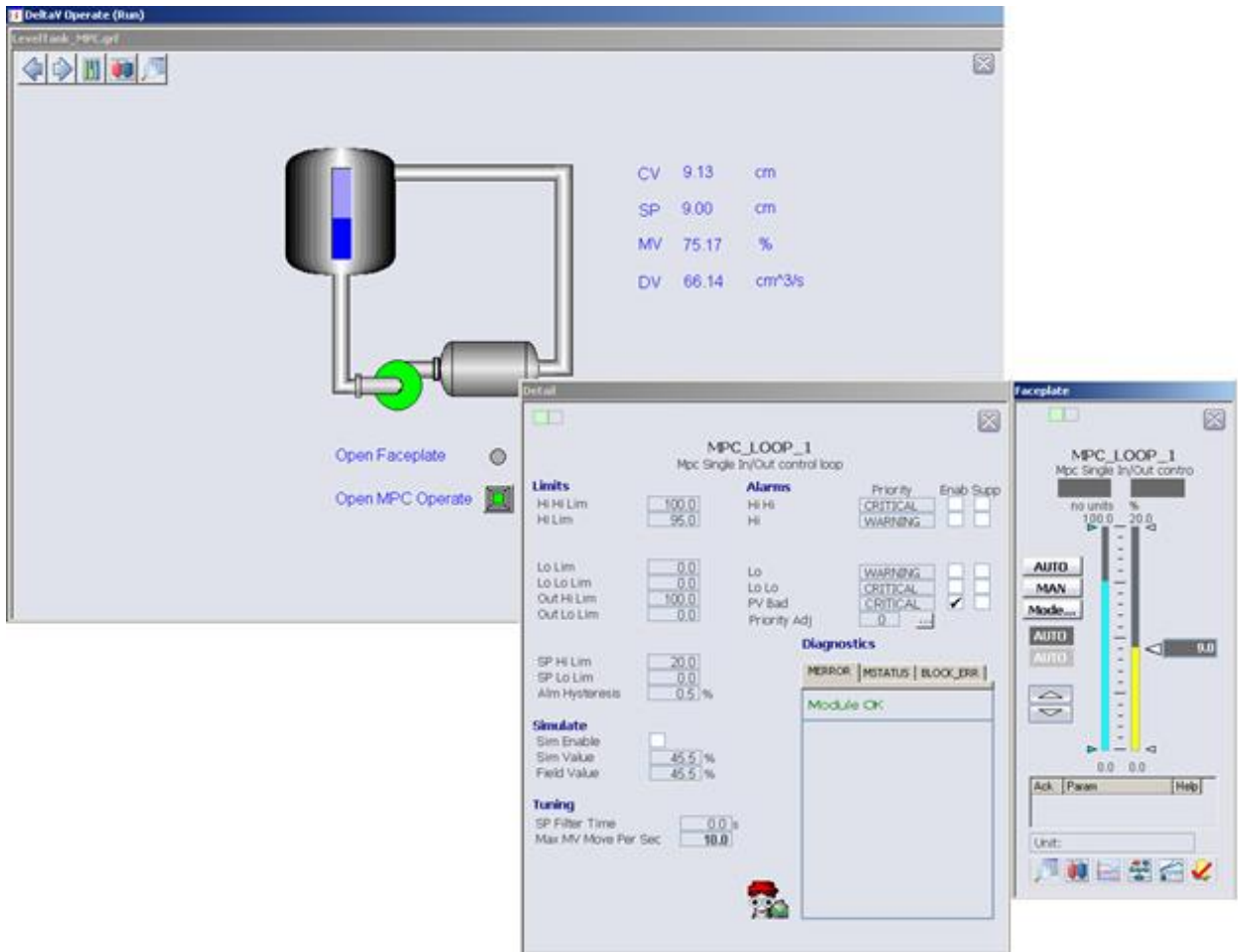


Figure 5.2 Running the Level Tank system in DeltaV Operate Run with associated faceplate and detail window.

Further tuning can be done changing the PM and PE by pressing the Generate Ctrl button in the DeltaV Predict application, and explained in section 3.3. Feel free to experiment and try to find values that might improve the performance.

In Auto mode, try to set the setpoint to 20- or 0 cm, starting from e.g. an operational area around 10 cm, and see what happens. Hint: The controller should respect the constraints set 5- and 15 cm respectively.

Try also to adjust the handle on the physical Level Tank, and see both the performance of change in the estimated disturbance and controller.