

PID tuning and parameter relations.

In this document described, how to tune your PID controller manually and discussed typical step response diagrams.

A PID controller has three tunable parameters called Proportional, Derivative and Integral terms.

Tuning the system means to get the required control quality for the application. Under „required control quality” there are many things, the most important are settling time, overshoot value, stability.

Step response analysis.

With step response analysis user can gather information from the control quality. With the configurator program it is easy to generate step response graph, make conclusions and change parameters if required.

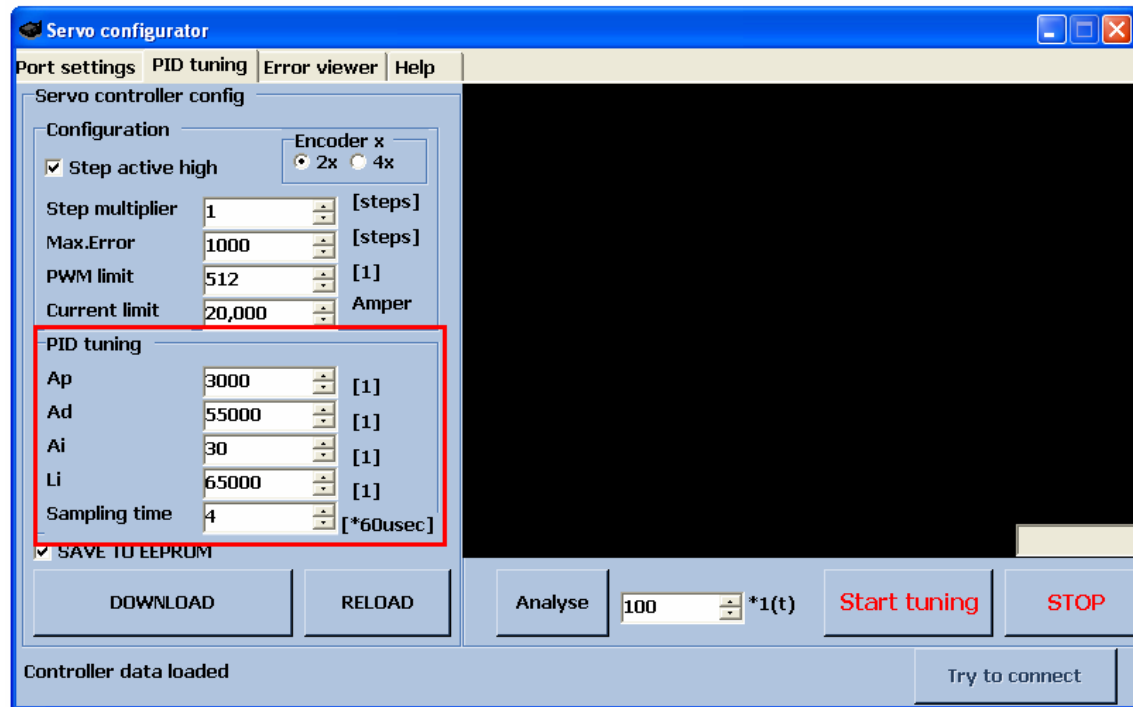
There are three different and well known step response waveform types and some sub-types of these.

- **Over damped**
- **Under damped**
 - **Decreasing amplitude**
 - **Constant or growing amplitude**
- **Critically damped**

Setting up the controller:PID tuning

User should tune PID controller inside the servo controller to an optimal value for the servomotor.

All parameters are 16bit wide from 0 to 65535 in value.



-Ap (Proportional term)

This term is for set the system response fast and dynamic.

There's linear relation between A_p * position error and PWM output.

Increasing this value makes the response time better but makes the system more unstable. This term is also known as „gain”.

-Ad (Differential term)

This term is for make the system damped, in other words it will helps to accelerate and decelerate faster.

There's linear relation between A_d *motor's speed and PWM output.

Increasing this value makes the stability of the system better and makes the response time longer. This term is also known as „damping”.

-Ai (Integral term)

This term is for trimming out the following error to 0 and reach the position accurately.

Increasing this value makes faster settling time but increases instability.

-Li (Integral limit)

User may limit the integral term to eliminate windup near 0 point, but it is not advised to limit it too low, because it may causes following error. Leave this value to maximum is the optimal.

-Sampling time

Most of servo controllers does not support sampling time adjustment, we think, that it is important and the controller can be tuned for wide range of servomotors, because these parameters are settable.

The optimal value for most of the servomotors is between 3 and 15.

Setting up the controller:downloading data to EEPROM

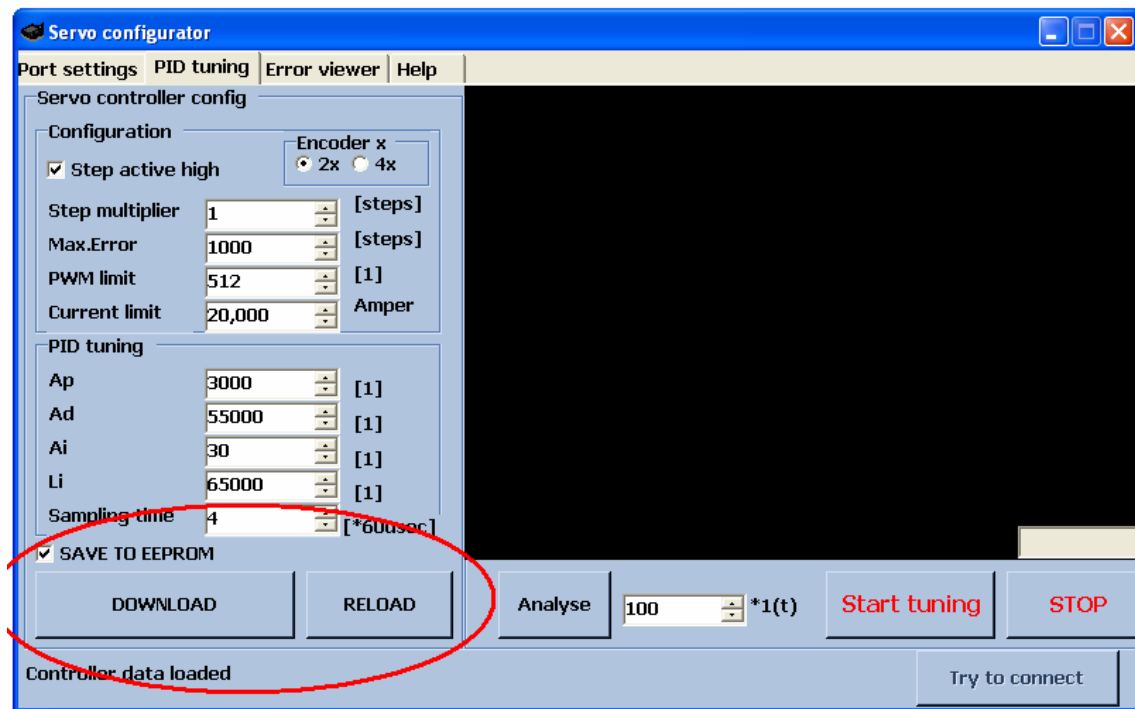
The servo controllers have volatile RAM and non-volatile data EEPROM onboard.

User can select where to store parameters by by checking the „save to EEPROM” bokx
If the bokx is not checked, values will be downloaded to RAM and they will be stored only while controller is switched on. **This downloading mode is only for testing parameters.**

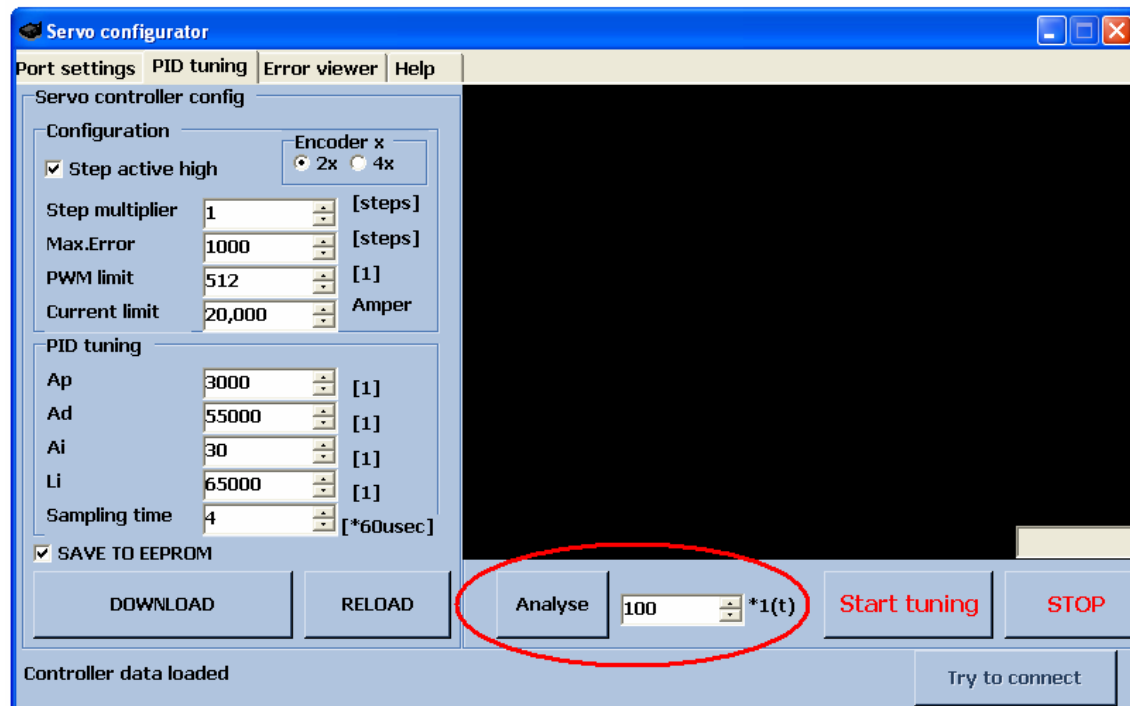
If box is checked, values will be stored in EEPROM and they be will be also reloaded at next startups of the controller. EEPROM can be also reprogrammed.

Download the data to the controller by simply clicking the „DOWNLOAD” button.

Data can be reloaded to the screen from EEPROM by simply clicking on the „RELOAD” button.



-Setting up the controller:Analyse step response



With analyse function user can check step response quality of the control loop tuning.

By clicking the ANALYSE button, commanded signal change to actual position + number of steps wrtitten into the textbox next to the button.

In other words, commanded position changed immadiately. In this situation controller commands the motor to pick up new position, the servo error signal is monitored and drawn graphically onto the black windows above the button.

Changing PID parameters

1. If you have changed any of the parameters, first click on the **DOWNLOAD** button to download the new parameters into the controller's memory.
2. Click on the **Analyse** button to check new waveform with the new parameters!

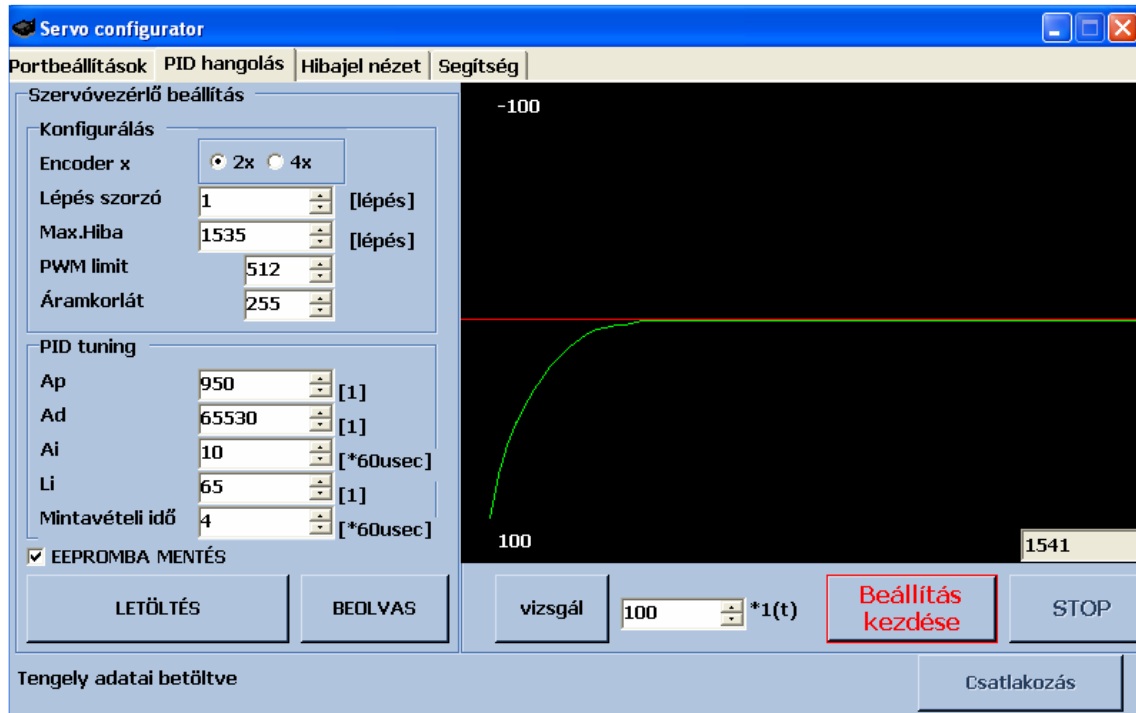
Step response waveforms and tuning advices

There are three diffrent and well known step response waveform types and some sub-types of these.

- **Over damped**
- **Under damped**
 - **Decreasing amplitude**
 - **Constant or growing amplitude**
- **Critically damped**

Overdamped system properties:

- Too much settling time
- No overshoot



Tuning advices:

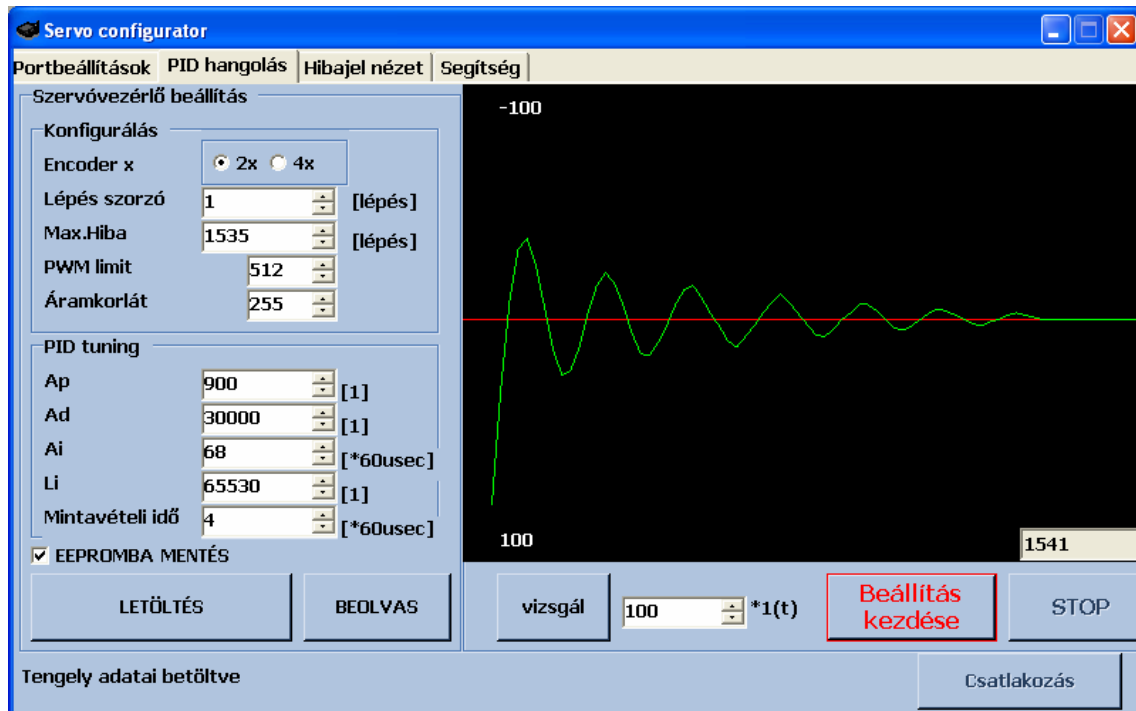
- Increase Ap (+ 300) or
- Decrease Ad (- 3000) or
- Increase Ai (+ 5)
- Increase Li (**It should be 65535 in normal case.**)

Underdamped system properties:

Decreasing amplitude system(sub-type)

Properties:

- Big overshoot values, but amplitude decreasing and system settle after some waves.
- Slow settling after some over and undershoot.
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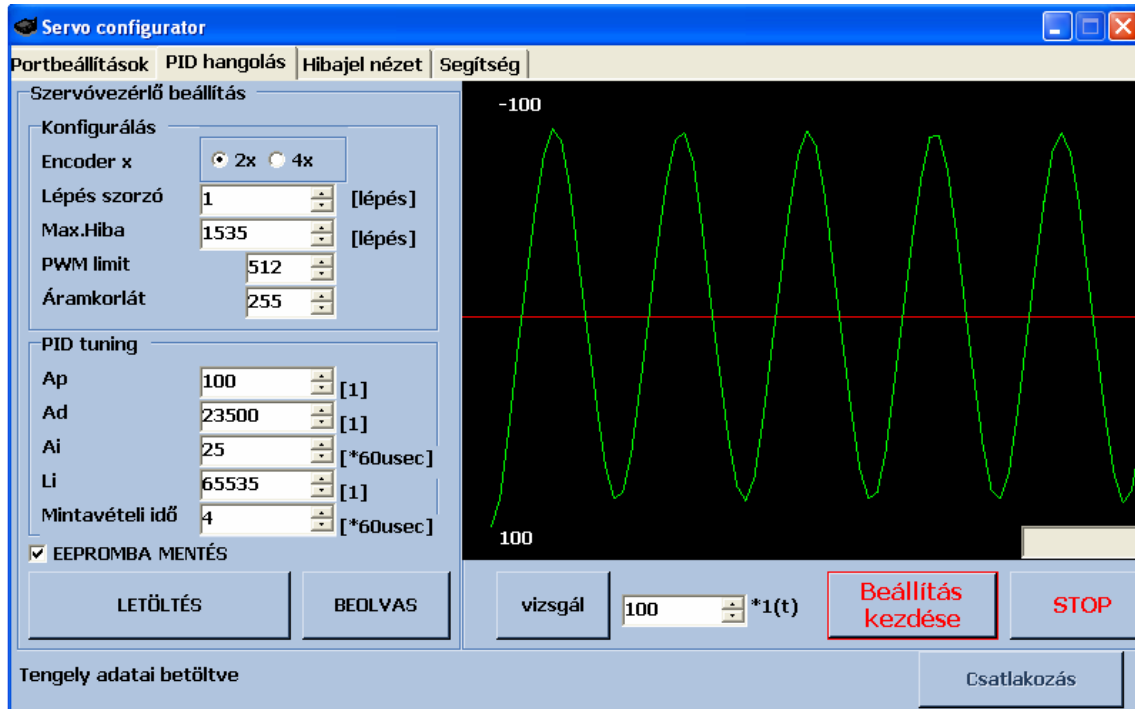
Tuning advices:

- Decrease Ap (- 300) or
- Increase Ad (+ 3000) or
- Decrease Ai (- 5)
- Decrease Li (**Only decrease Li, if it is really required! It should be 65535.**)

Constant or growing amplitude system (sub-type)

Properties:

- Big over and undershoots.
- No settling, the system is instabil.



Tuning advices:

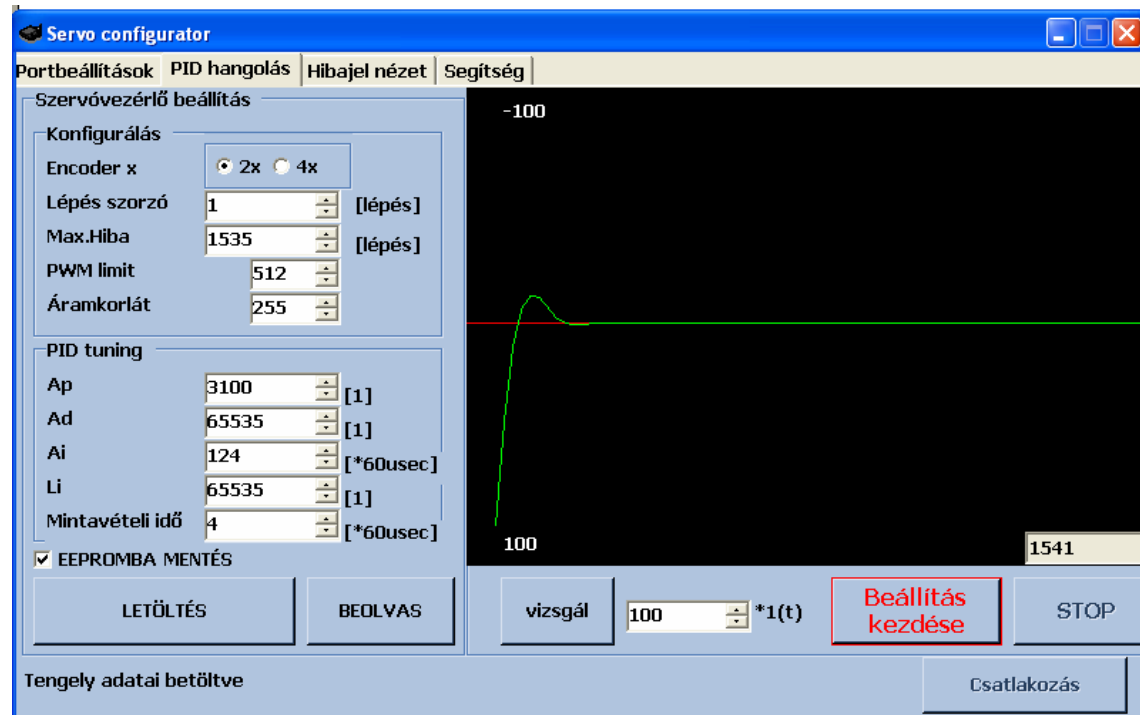
- Decrease Ap (- 300) or
- Increase Ad (+ 3000) or
- Decrease Ai (- 5)
- Decrease Li (**Only decrease Li, if it is really required! It should be 65535.**)

Critically damped system properties:

This is the ideal and well tuned system, this situation is required to reach.

Overshoot value is low.

Settling is fast, signal has high gradient.



Tuning advices:

Save parameters and do not change, try to tune softly if required.

More informations at:
www.CNCdrive.com