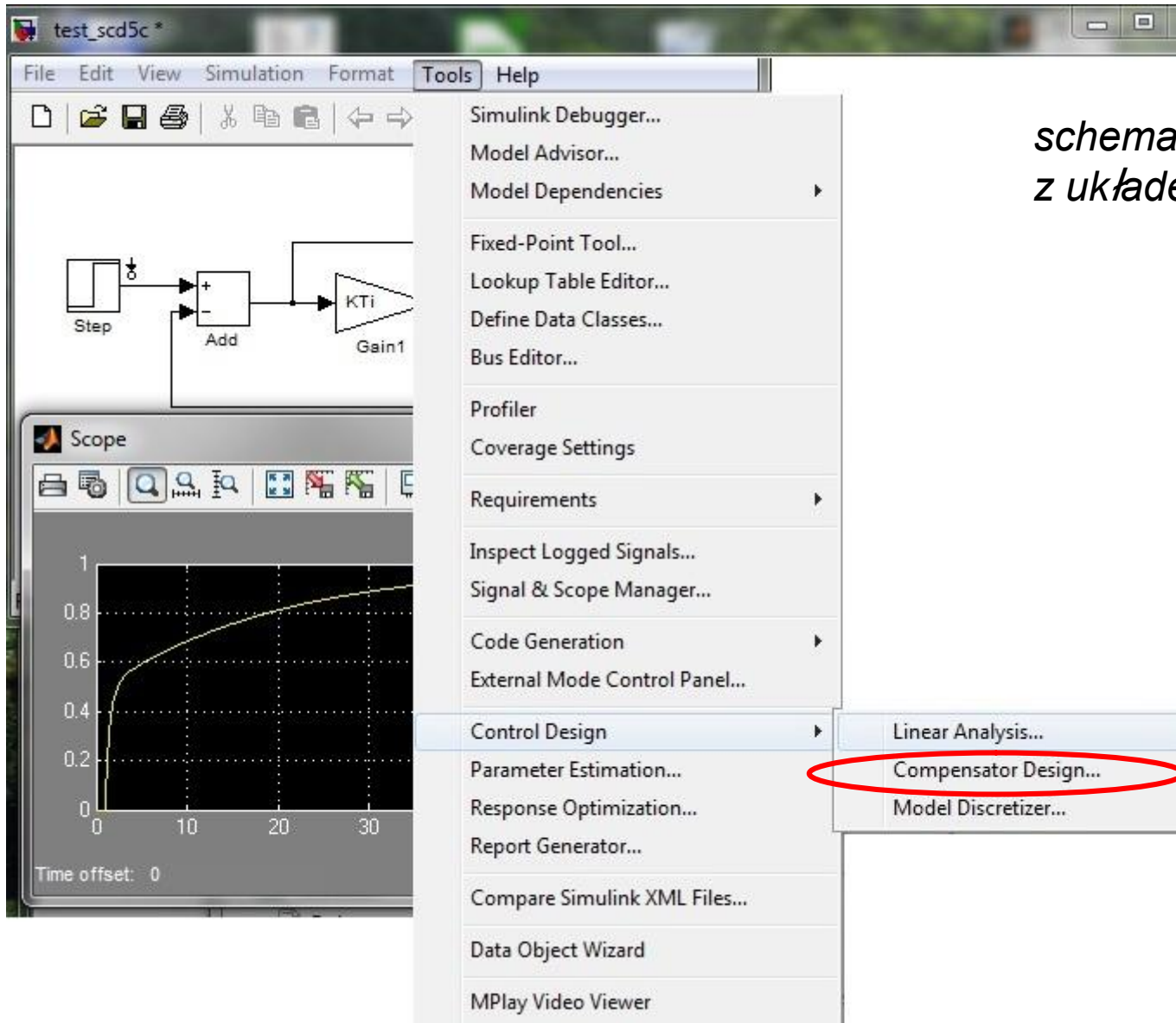


# SISO Design

*schemat* → *Tools* → *Control Design* → *Compensator Design*



*schemat = model obiektu wraz z układem regulacji*

*Matlab + Simulnik + Simulink Control Design*

# SISO Design

1.1) wskazanie bloków regulatora w układzie

The image displays a Simulink model window titled 'test\_scd5c' and the 'Control and Estimation Tools Manager' interface. The Simulink model shows a control loop starting with a 'Step' block, followed by an 'Add' block. The signal then passes through a 'Gain1' block (containing 'KTi'), an 'Integrator' block (containing '1/s'), and another 'Add' block. The output of the second 'Add' block goes through a 'Gain' block (containing 'K') and a 'Transfer Fcn' block (containing '1/(s+1)'), which is then connected to a 'Scope' block.

The 'Control and Estimation Tools Manager' window shows the 'Tunable Blocks' tab. A red circle highlights the 'Select Blocks...' button. Below it, a table lists the tunable blocks:

Tune?	Block
<input checked="" type="checkbox"/>	test_scd5c/Gain1
<input checked="" type="checkbox"/>	test_scd5c/Gain

A red arrow points from the 'Select Blocks...' button to a 'Select Blocks to Tune' dialog box. This dialog box shows a table of blocks available for tuning:

Tune?	Block Name
<input checked="" type="checkbox"/>	Gain1
<input checked="" type="checkbox"/>	Gain
<input type="checkbox"/>	Transfer Fcn

At the bottom of the dialog box, there is a 'Highlight Selected Block' button.

1) Bloki w subsystem nie są widoczne  
2) PID Controller jest widoczny

# SISO Design

1.2) wskazanie sygnałów IO w układzie

The image shows two windows from the MATLAB/Simulink environment. The top window, titled 'test\_scd5c', displays a Simulink block diagram of a control system. The diagram includes a 'Step' block, an 'Add' block, a 'Gain1' block (KT<sub>i</sub>), an 'Integrator' block (1/s), another 'Add' block, a 'Gain' block (K), a 'Transfer Fcn' block (1/(s+1)), and a 'Scope' block. Two red circles highlight the input signal to the first 'Add' block and the output signal from the 'Transfer Fcn' block. The bottom window, titled 'Control and Estimation Tools Manager', shows the 'Closed-Loop Signals' tab. It contains two tables: 'Input Signals' and 'Output Signals'. The 'Input Signals' table has one entry: 'test\_scd5c/Step' with 'Output Port' 1. The 'Output Signals' table has one entry: 'test\_scd5c/Transfer Fcn' with 'Output Port' 1. Red text annotations are placed over these tables: 'Sprawdzić, czy wskazane bloki są wejściami układu' (Check if the indicated blocks are system inputs) and 'Sprawdzić, czy wskazane bloki są wyjściami układu' (Check if the indicated blocks are system outputs). Buttons at the bottom include 'Highlight Selected Signal', 'Refresh Signal Names', 'Delete Selected I/O', 'Tune Blocks...', and 'Help'.

Workspace

- Project - test\_scd5c
  - Operating Points
  - Default Operating P
  - Simulink Compensator

Tunable Blocks **Closed-Loop Signals** Operating Points

Specify closed-loop signals for the design: right click on signals in your Simulink model using the Linearization Points menu.

Input Signals

Active	Block Name	Output Port	Signal Name
<input checked="" type="checkbox"/>	test_scd5c/Step	1	

*Sprawdzić, czy wskazane bloki są wejściami układu*

Output Signals

Active	Block Name	Output Port	Signal Name
<input checked="" type="checkbox"/>	test_scd5c/Transfer Fcn	1	

*Sprawdzić, czy wskazane bloki są wyjściami układu*

Highlight Selected Signal Refresh Signal Names Delete Selected I/O

Tune Blocks... Help

# SISO Design



*Od wersji 2013*

- ✕↑ Open-loop Input
- ↕✕ Open-loop Output
- ↕↑ Loop Transfer
- ✕- Loop Break
- ±⊖ Input Perturbation
- ↑ Output Measurement
- ±↕ Sensitivity
- ↕⊖ Complementary Sensitivity
- τ Trim Output Constraint
- ⓘ Help Me Select...

- Cut
- Copy
- Delete
- Highlight To Source
- Highlight To Destination
- Remove Highlighting
- Show Port Value
- Signal & Scope Manager...
- Open Viewer ▶
- Create & Connect Viewer ▶
- Connect To Existing Viewer ▶
- Disconnect Viewer ▶
- Disconnect & Delete Viewer ▶
- Signal Hierarchy
- Signal Properties...
- Linearization Points ▶

- Cut
- Copy
- Delete
- Highlight To Source
- Highlight To Destination
- Remove Highlighting
- Show Port Value
- Signal & Scope Manager...
- Open Viewer ▶
- Create & Connect Viewer ▶
- Connect To Existing Viewer ▶
- Disconnect Viewer ▶
- Disconnect & Delete Viewer ▶
- Signal Hierarchy
- Signal Properties...
- Linearization Points ▶

- Input Point
- Output Point
- Input-Output Point
- Output-Input Point
- Open Loop
- Output Constraint

- Output Point
- Input-Output Point
- Output-Input Point
- Open Loop
- Output Constraint

# SISO Design

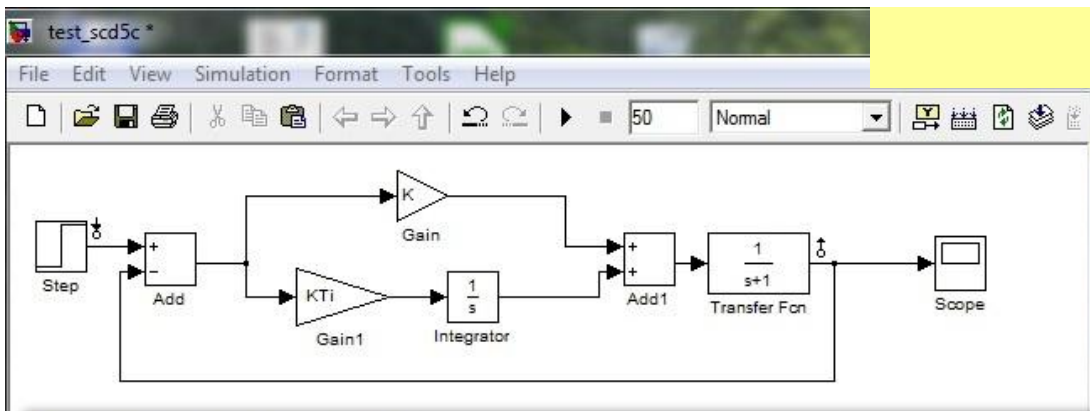
## 1.3) wskazanie punktu pracy

The image displays two windows from the MATLAB/Simulink environment. The top window, titled 'test\_scd5c', shows a Simulink model of a control system. The model starts with a 'Step' input block, followed by an 'Add' block. The signal then passes through a 'Gain1' block (labeled 'KT1'), an 'Integrator' block (labeled  $\frac{1}{s}$ ), and another 'Add' block (labeled 'Add1'). The output of 'Add1' goes through a 'Transfer Fcn' block (labeled  $\frac{1}{s+1}$ ) and finally to a 'Scope' block. There are also feedback paths from the output back to the 'Add' and 'Add1' blocks, with a 'Gain' block (labeled 'K') in the feedback path.

The bottom window is the 'Control and Estimation Tools Manager' dialog box. It has a 'Workspace' pane on the left showing a project named 'Project - test\_scd5c' with sub-items 'Operating Points', 'Default Operating Point', and 'Simulink Compensator'. The main area has three tabs: 'Tunable Blocks', 'Closed-Loop Signals', and 'Operating Points', with the latter being selected and circled in red. Below the tabs, there is a dropdown menu for 'Select operating point type:' set to 'Existing operating points'. Two radio buttons are present: the first is selected and labeled 'Linearize at the operating point currently specified in the Simulink model.', and the second is labeled 'Linearize at one of the following operating points:'. Below this is a table with two columns: 'Operating Point' and 'Description'. The table contains one row: 'Default Operating Point' and 'Model operating point'. At the bottom of the dialog, there are two buttons: 'New Operating Point...' and 'Edit Selected Operating Point...'. At the very bottom, there are two more buttons: 'Tune Blocks...' (circled in red) and 'Help'.



# SISO Design



**Design Configuration Wizard**

Introduction

### Single Input Single Output (SISO) Design Configuration

The Design Configuration Wizard guides you through the configuration of a compensator design in the SISO Design Tool.

- Pick design plots.** Design plots are interactive plots, such as root-locus, Bode, or Nichols, within the SISO Design Tool. You can use them to graphically tune the response of your system using either *open-loop* or *closed-loop* design methods. Within the plots you can tune gains and manually move, add, or delete poles and zeros of the tunable blocks in your model.  
Before picking design plots, think about which responses you want to tune, whether you want to use open- or closed-loop design methods, and which types of plots you want to use for the design. You can change these choices later in the SISO Design Task node that this wizard creates.
- Pick analysis plots.** Analysis plots such as step response plots, are plots that show the response or dynamics of a closed-loop system or tuned block. You can use the analysis plots to view responses within your model but you cannot directly edit them. However, the analysis plots will automatically update to reflect the effects of any changes you make in the tuned parameters.  
Before picking analysis plots, think about the responses you want to view and the types of plots you want to use to view them. You can change these choices later in the SISO Design Task node that this wizard creates.

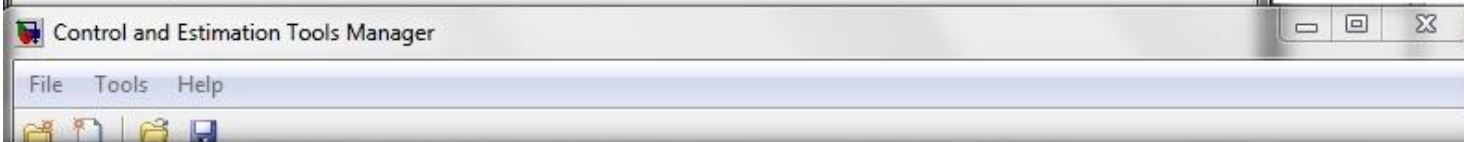
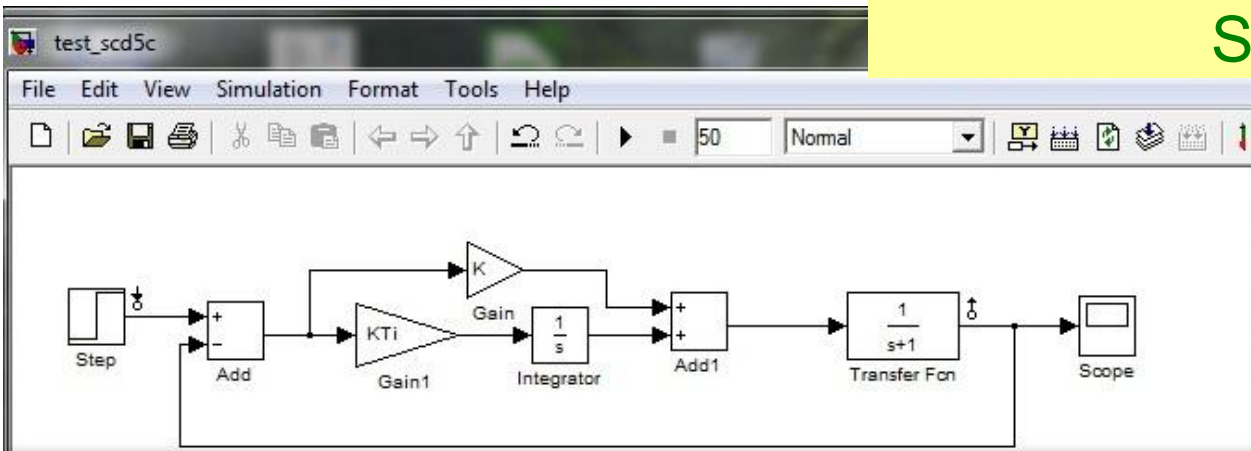
Buttons: Cancel, < Back, Next >, Finish

Buttons: Tune Blocks... (circled in red), Help

2) uruchomienie SISO Design

# SISO Design

3.1) SISO Design:  
wybór wykresów  
do projektowania  
(okno SISO Design)



Design Configuration Wizard

Step 1 of 2: Select the SISOTOOL Design Views

Plot	Available Open/Closed Loop to Tune	Plot Type
Plot 1	Open Loop 3	Open-Loop Bode
Plot 2	Open Loop 3	Root Locus
Plot 3	Open Loop 3	Nichols
Plot 4	Open Loop 1	None
Plot 5	Open Loop 1	None

Summary of available Open/Closed loops to tune:

Loop Name	Loop Description
Open Loop 1	Open Loop at output 1 of Gain
Open Loop 2	Open Loop at output 1 of Gain1
Open Loop 3	Open Loop at output 1 of Add1

*domyślnie pętle = wyjścia bloków regulatora (Tunable Blocks)*

*inne pętle*

Select New Open/Closed Loop to Tune ...

Configuring Design Plots

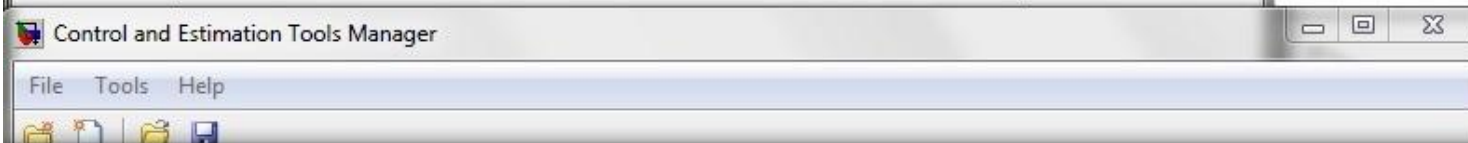
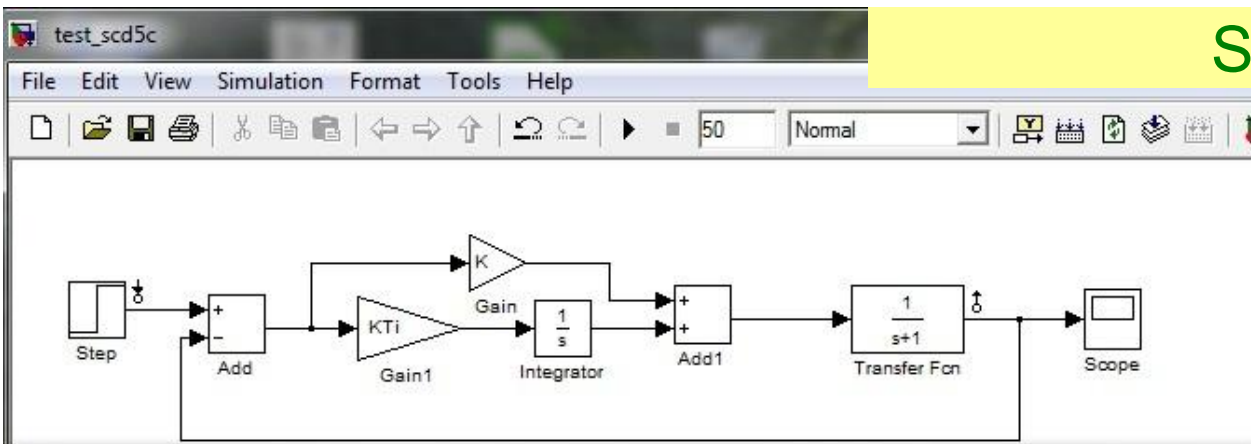
In this step, select the open- and closed-loop systems that you want to design in your model, and the corresponding design plots you want to use.

- What are design plots?
- What is open-loop design?
- What is an open-loop system?
- How are default open-loop systems specified?
- What is closed-loop design?
- How are closed-loop systems specified?
- How do I configure the open-loop and closed-loop design plots?
- Why can't I use a response plot such as

Cancel < Back Next > Finish

# SISO Design

3.2) SISO Design:  
wybór wykresów  
do analizy  
(okno LTI Viewer)



Design Configuration Wizard

Step 2 of 2: Select Analysis Plots

Analysis Plots

Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Plot Type: Step	Plot Type: Impulse	Plot Type: Bode	Plot Type: Nyquist	Plot Type: Nichols	Plot Type: Pole/Zero

Contents of Plots

Plots							Responses
1	2	3	4	5	6	All	
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Closed Loop from Step to Transfer Fcn

Add Responses ...

**Configuring Analysis Plots**  
In this step, select the closed-loop and tunable block responses that you want to view while designing your model, and the corresponding analysis plots you want to use to view them.

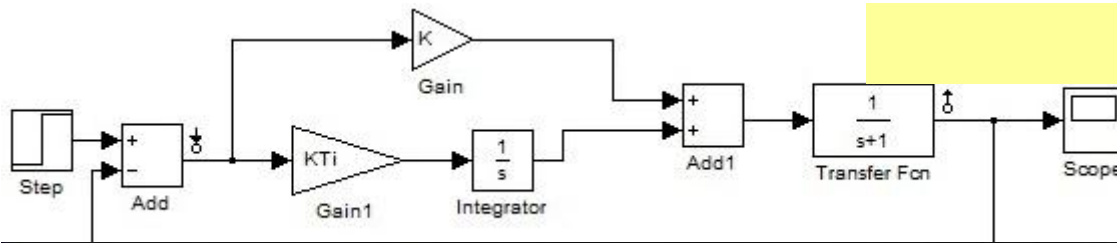
- ▶ [What are analysis plots?](#)
- ▶ [What can I use analysis plots for?](#)
- ▶ [What is closed-loop design?](#)
- ▶ [How are closed-loop systems specified?](#)
- ▶ [How do I view the response of a closed-loop system?](#)
- ▶ [How do I view the response of an open-loop system or a tuned block?](#)
- ▶ [How do I select analysis plots?](#)

Cancel < Back Next > **Finish**



# SISO Design

## 4.1) SISO Design - układ



Control and Estimation Tools Manager

File Edit Tools Help

Workspace

- Project - test\_scd5c
  - Operating Points
    - Default Operating P...
  - Simulink Compensator
    - SISO Design Task
      - Design History
      - Initial Design
      - Design Operatin...

Architecture Compensator Editor Graphical Tuning Analysis Plots Automated Tuning

Compensator Design Summary - test\_scd5c

Simulink Blocks to Tune:  
[test\\_scd5c/Gain](#)  
[test\\_scd5c/Gain1](#)

Closed Loop Input Signals:  
[test\\_scd5c/Step, output port 1](#)

Closed Loop Output Signals:  
[test\\_scd5c/Transfer Fcn, output port 1](#)

Loop Configuration... Configure additional loop openings for multi-loop design.

System Data ... Import data for compensators and fixed systems.

Sample Time Conversion ... Change the sample time of the design.

Multimodel Configuration ... Change the nominal plant and multimodel options.

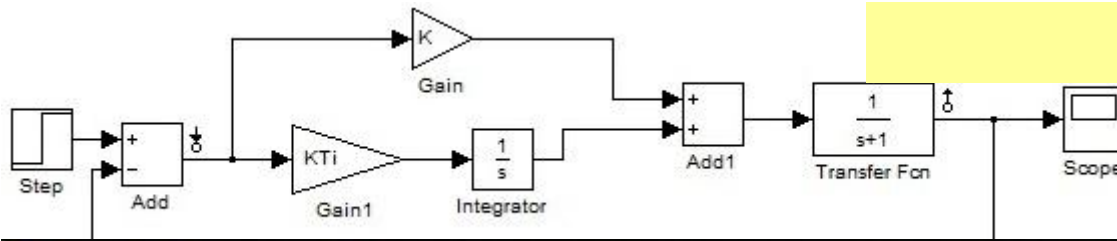
Store Design Update Simulink Block Parameters  Automatically update block parameters

SISO Design Task Node.

*Sprawdzić poprawność zdefiniowanej konfiguracji*

# SISO Design

## 4.2) SISO Design - regulator



Control and Estimation Tools Manager

File Edit Tools Help

Workspace

- Project - test\_scd5c
  - Operating Points
  - Default Operating F
  - Simulink Compensator
    - SISO Design Task
      - Design History
      - Initial Design
      - Design Operati

Architecture **Compensator Editor** Graphical Tuning Analysis Plots Automated Tuning

Compensator

All Gain Blocks x

Pole/Zero Parameter

Parameter	Value	Min Value	Slider	Max Value
test_scd5c/Gain	1	0.1		1
test_scd5c/Gain1	0.1	0.01		0.1

Select a parameter in the table and tune it manually

Store Design Update Simulink Block Parameters  Automatically update block parameters

SISO Design Task Node.

# SISO Design

## 4.3) SISO Design - projektowanie

Control and Estimation Tools Manager

File Edit Tools Help

Architecture Compensator Editor **Graphical Tuning** Analysis Plots Automated Tuning

Design Plots Configuration

Plot	Available Open/Closed Loop to Tune	Plot Type
Plot 1	Open Loop 3	Open-Loop Bode
Plot 2	Open Loop 3	Root Locus
Plot 3	Open Loop 3	Nichols
Plot 4	Open Loop 1	
Plot 5	Open Loop 1	

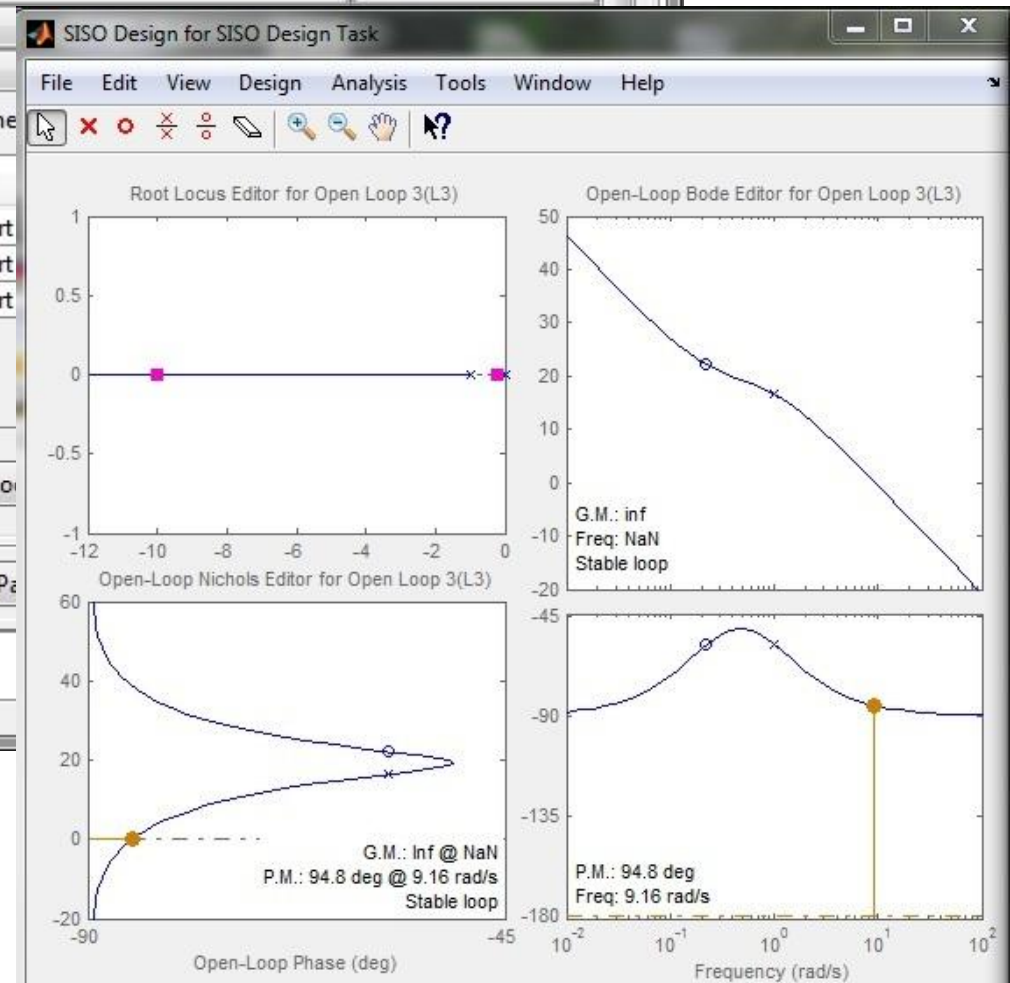
Summary of available Open/Closed loops to tune

Loop Name	Loop Description
Open Loop 1	Open Loop at output
Open Loop 2	Open Loop at output
Open Loop 3	Open Loop at output

Select New Open/Closed Loop

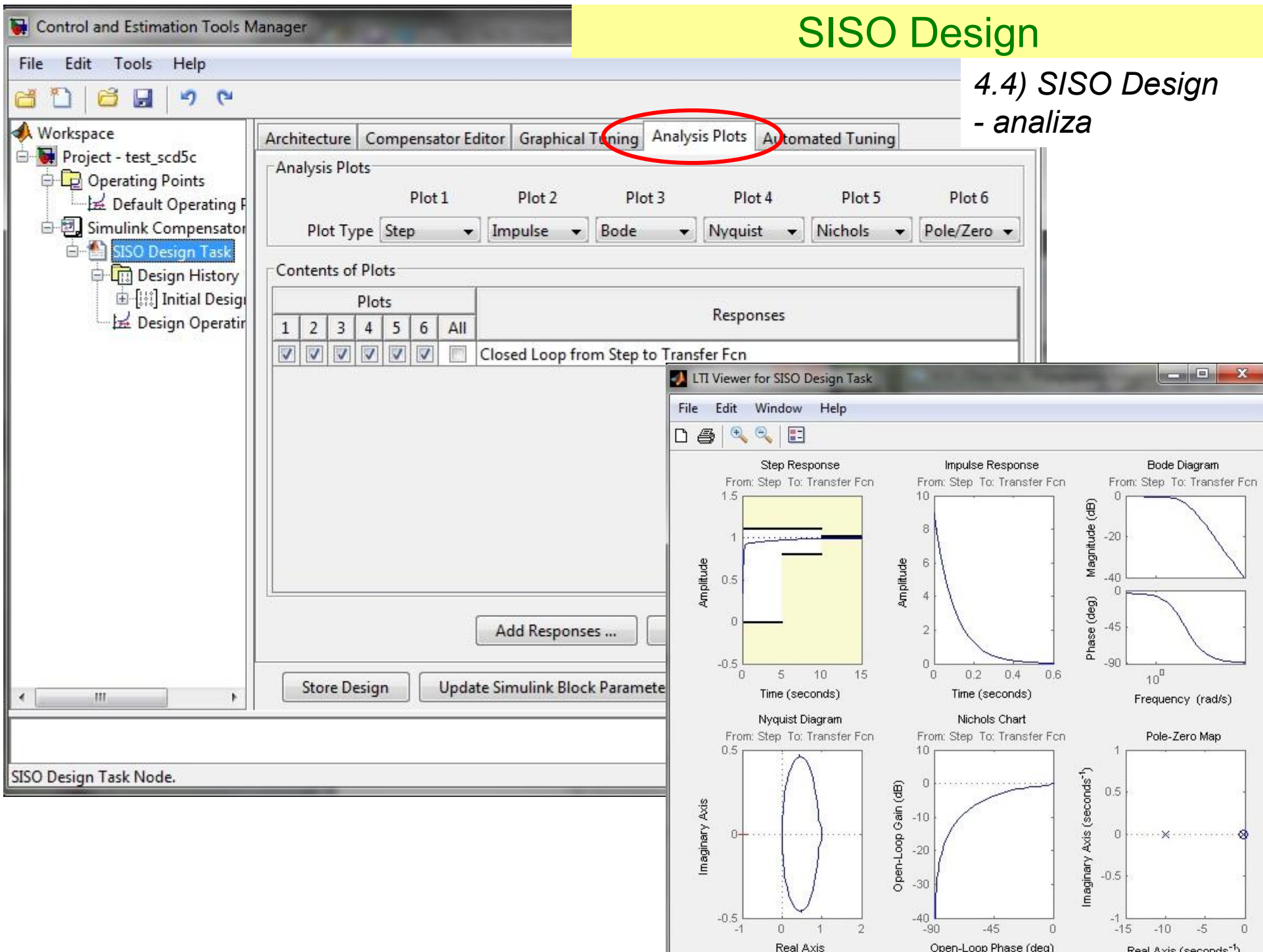
Store Design Update Simulink Block Pa

SISO Design Task Node.



# SISO Design

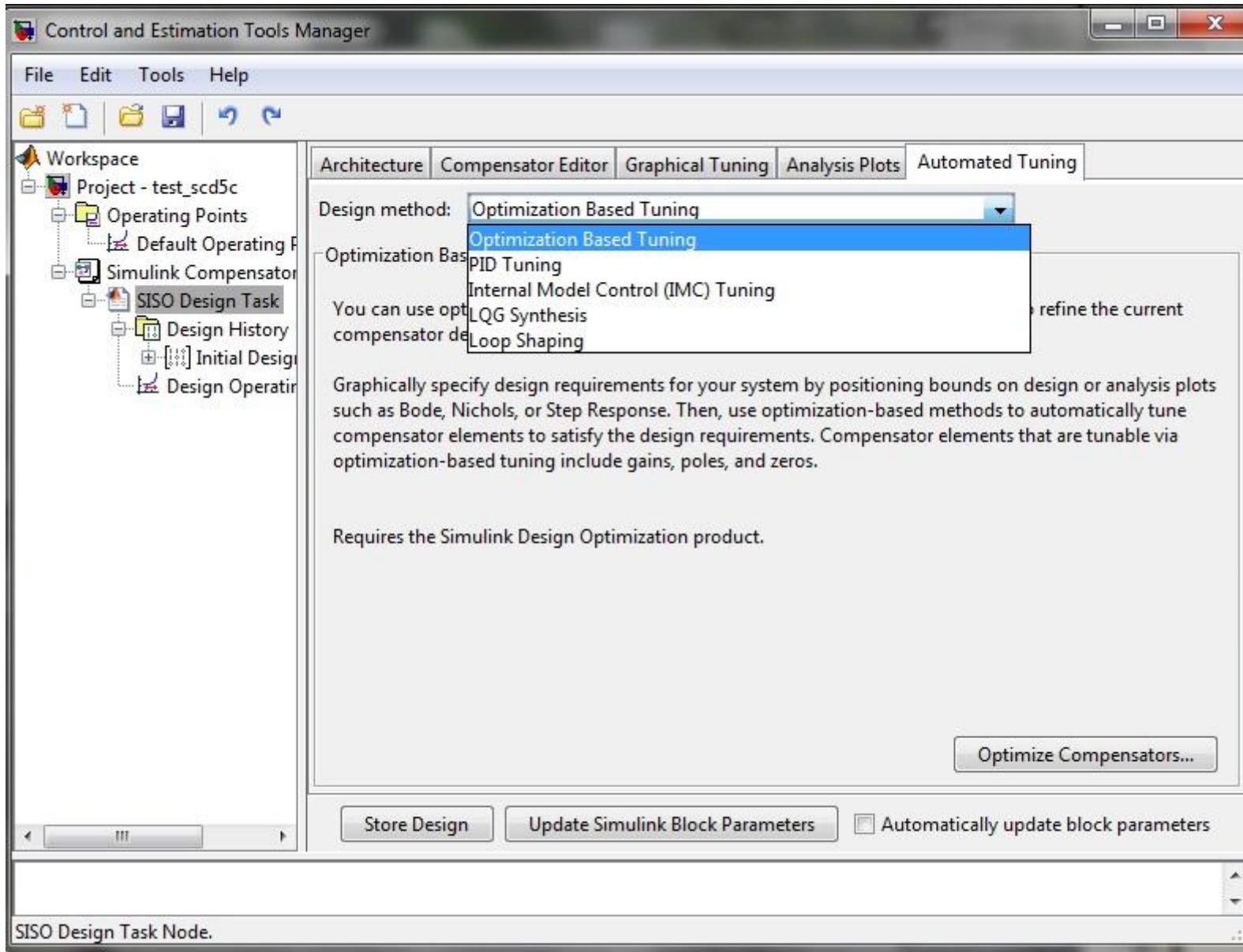
## 4.4) SISO Design - analiza





# SISO Design

## 5) SISO Design - strojenje



# SISO Design

## 5.1) SISO Design (strojenje) Optimization Based Tuning

The screenshots illustrate the SISO Design process in the Control and Estimation Tools Manager. The top screenshot shows a workflow diagram with three steps: Step 1 (Select compensators to optimize), Step 2 (Set optimization options and Optimize), and Step 3 (View results). The middle-left screenshot shows a table for selecting compensators to optimize. The middle-right screenshot shows a table for selecting design requirements to satisfy. The bottom-left screenshot shows a 'New Design Requirement' dialog box. The bottom-right screenshot shows an 'Optimization Progress' table and a log of optimization results.

Iteration	Eval-Cou...	Cost fun...	Constrai...	Step size	Procedure
0	5	0	0.2893		
1	10	0	0.1411	1.55	
2	15	0	0.06635	2.09	
3	20	0	0.02753	1.64	
4	25	0	0.009829	1.38	Hessian ...
5	30	0	0.002698	1.22	
6	35	0	0.0003753	0.641	

Constructing optimization problem...  
Optimization started 08-Apr-2013 12:45:06  
Optimization finished 08-Apr-2013 12:45:11  
Successful termination.  
Found a feasible or optimal solution within the specified tolerances.

Start Optimization Help

# SISO Design

## 5.2) SISO Design (strojenie) PID Tuning

The screenshot displays the 'Control and Estimation Tools Manager' window. The 'Workspace' pane on the left shows a project named 'Project - test\_scd4d' with a 'SISO Design Task' sub-item. The main workspace is divided into tabs: 'Architecture', 'Compensator Editor', 'Graphical Tuning', 'Analysis Plots', and 'Automated Tuning'. The 'Automated Tuning' tab is active, showing the following configuration:

- Design method: PID Tuning
- Compensator: test\_scd4d/PID Controller, with the transfer function 
$$= 1 \times \frac{(1 + s)}{s}$$
- Specifications: Tuning method: Robust response time
- Design options: Controller Type:  P  I  PI  PD  PID;  Design with first order derivative filter
- Design mode: Automatic (balanced performance and robustness)

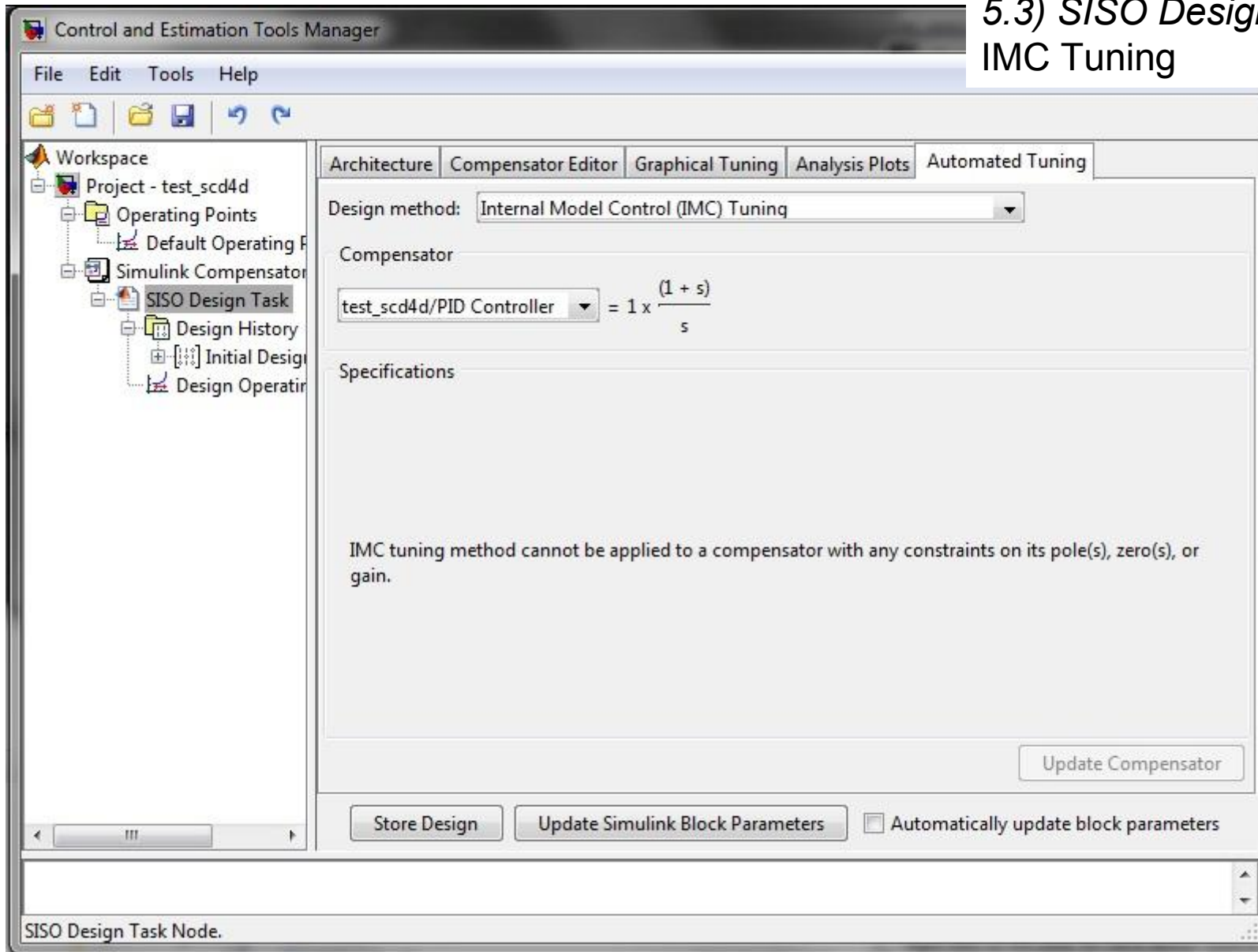
Buttons at the bottom include 'Store Design', 'Update Simulink Block Parameters', 'Update Compensator', and a checkbox for 'Automatically update block parameters'. A status bar at the bottom left reads 'SISO Design Task Node.'

*Metoda uruchamiana również za pomocą przycisku Tune w bloku PID Controller*

*Uwaga: Wymaga użycia na schemacie bloku PIDController*

# SISO Design

## 5.3) SISO Design (strojenie) IMC Tuning

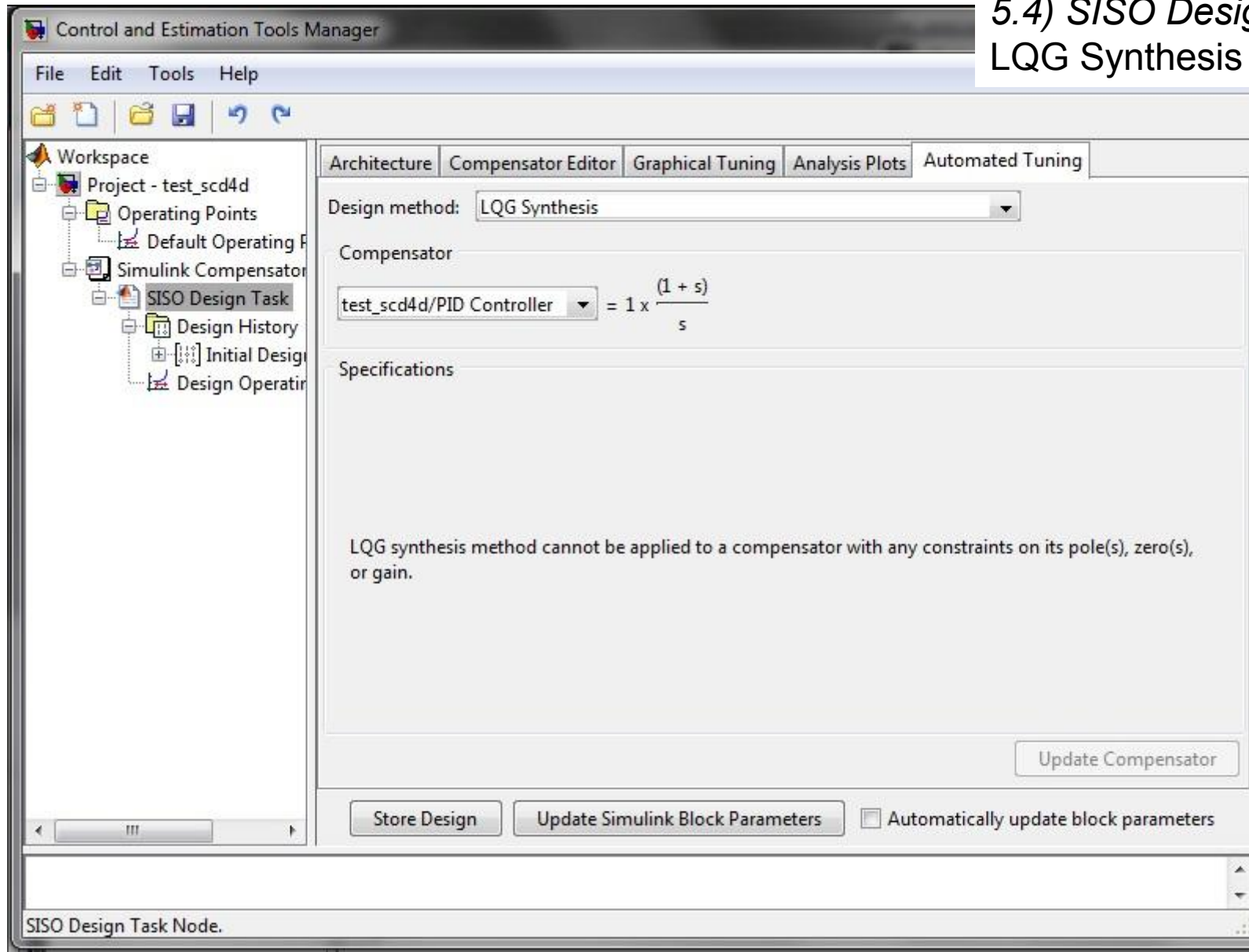


*Uwaga: Wymaga użycia na schemacie bloku PIDController*



# SISO Design

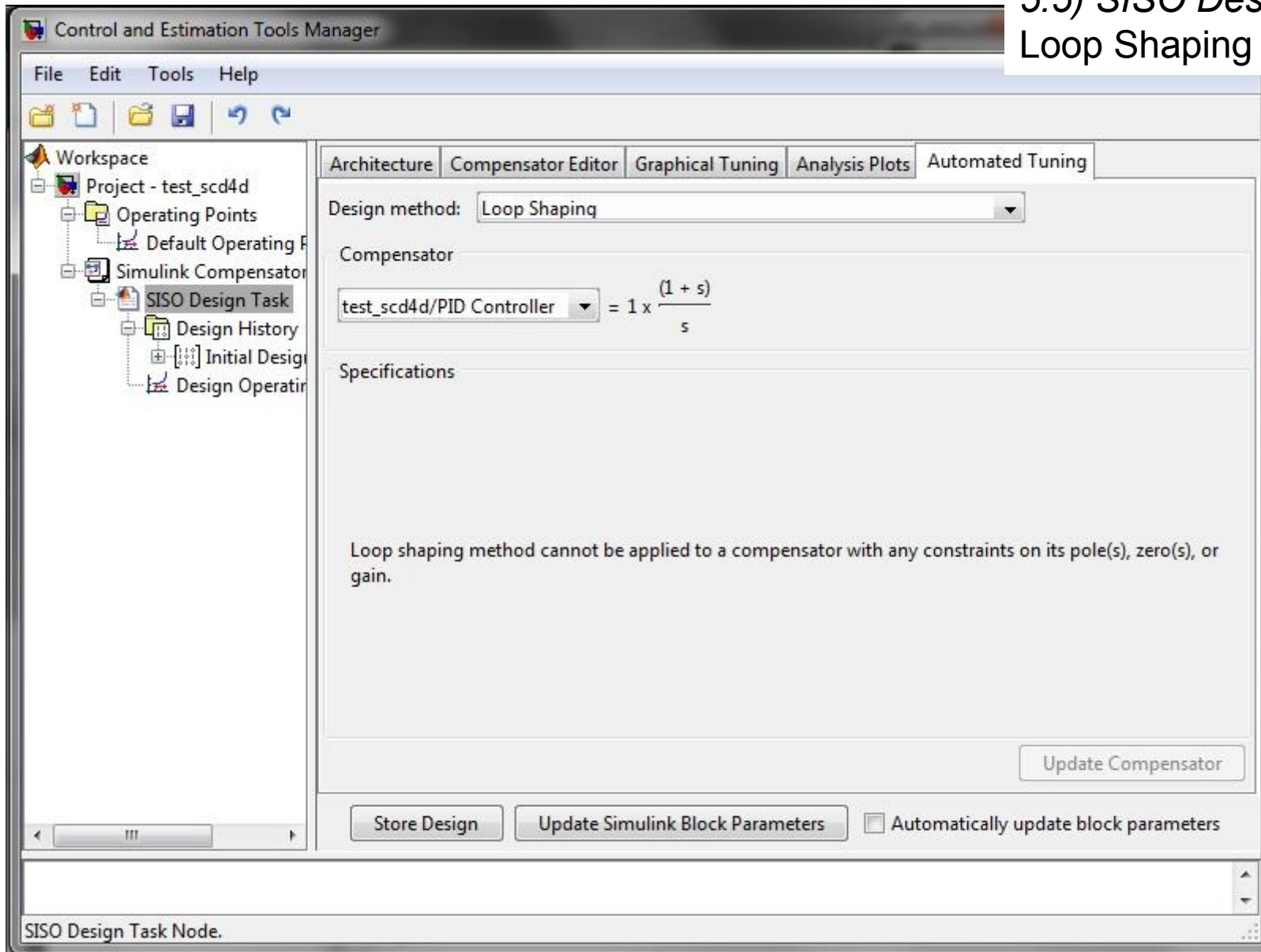
## 5.4 SISO Design (strojenie) LQG Synthesis



*Uwaga: Wymaga użycia na schemacie bloku PIDController*

# SISO Design

## 5.5) SISO Design (strojenie) Loop Shaping



*Uwaga: Wymaga użycia na schemacie bloku PIDController*

## Zastosowanie:

- schemat modelu obiektu
  - z własnym blokiem regulatora
  - z blokiem PID Controller
- definicja:
  - wskazanie bloków regulatora,
  - lub wybór typu regulatora
- automatyczny dobór nastaw
- wybór metody (ograniczenia)
- strojenie graficzne (optymalizacja)