

# **Release Notes for Robust Control Toolbox™**

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*Release Notes for Robust Control Toolbox™*

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## R2012b

system command for multiobjective tuning with soft and hard constraints .....	2
H <sub>2</sub> performance, stability margin, pole location, and disturbance rejection requirements .....	3
Robust tuning of one controller against a set of plant models .....	4
Option to constrain tuned parameter values and to restrict some tuning requirements to a frequency band .....	5
ltiblock.pid2 and loopswitch objects for tuning two-degree-of-freedom PID controllers and marking loop opening sites for open-loop requirements .....	6
TuningGoal.MaxGain and GainLimit property renamed ..	7
Options in hinfstructOptions and looptuneOptions renamed or removed .....	8

## R2012a

Parallel Computing Support for looptune and hinfstruct ..	10
Faster and More Accurate H-infinity Norm Computation Using SLICOT Algorithms .....	11

## R2011b

looptune Tunes Fixed-Structure Control Systems .....	14
Control System Tuning for Simulink Models with looptune or hinfstruct Using sLTunable Interface .....	15
wcgainplot for Visualizing Worst-Case Gains .....	16
Functionality Being Removed or Changed .....	17

---

**R2011a**

Enhanced Workflow for H-Infinity Synthesis of Fixed-Structure Control Systems .....	22
--	----

---

**R2010b**

New Commands for H-Infinity Synthesis of Fixed-Structure Control Systems .....	24
---	----

---

**R2010a**

---

**R2009b**

New Option to Improve Robust Performance by Accounting for Real Uncertain Parameters .....	28
New Command to Linearize Simulink Models with Uncertainty .....	29
New Interface for Simulating Effects of Uncertainty in Simulink Models .....	30
New Command to Model Multiple LTI Responses as One Uncertain System .....	31
New and Updated Demos .....	32
Functions, Properties and Blocks Being Removed .....	33

**R2009a**

|

**R2008b**

|

**R2008a**

|

Ability to Use LOOPMARGIN with Simulink ..... 40

**R2007b**

|

No New Features or Changes

**R2007a**

|

New Simulink Blocks ..... 44

**R2006b**

|

New Function ltiarray2uss ..... 46

**R2006a**

|

No New Features or Changes

## **R14SP3**

No New Features or Changes

## **R14SP2**

mussvunwrap Is Renamed .....	<b>52</b>
New Functions actual2normalized and normalized2actual .....	<b>53</b>

# R2012b

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Version: 4.2  
New Features: Yes  
Bug Fixes: Yes

## **systemtune command for multiobjective tuning with soft and hard constraints**

The new `systemtune` command allows automated tuning of fixed-structure control systems to high-level tuning objectives.

To use `systemtune`, you specify tuning objectives such as reference tracking, disturbance rejection, or stability margins. You can specify both soft requirements (objectives) and hard requirements (constraints). `systemtune` automatically tunes the parameters of your control system to meet the requirements.

You can use `systemtune` to tune control systems modeled in either MATLAB® or Simulink®.

For more information, see:

- “Tuning Control Systems with SYSTUNE”
- “Tuning Control Systems in Simulink”
- “Automated Tuning”
- The `systemtune` reference page



## H<sub>2</sub> performance, stability margin, pole location, and disturbance rejection requirements

New `TuningGoal` requirement objects allow you to specify a variety of tuning objectives for automated tuning of fixed-structure control systems with `systune` and `looptune`. New tuning requirements include:

- `TuningGoal.Margins` — Tune to stability margin requirements by specifying minimum gain and phase margins for any feedback loop in your control system.
- `TuningGoal.Poles` — Constrain closed-loop dynamics of your control system.
- `TuningGoal.StableController` — Constrain dynamics or ensure stability of tunable elements.
- `TuningGoal.WeightedGain` — Limit on frequency-weighted gain from specified inputs to specified outputs in your control system.
- `TuningGoal.Variance` and `TuningGoal.WeightedVariance` — Tune to H<sub>2</sub> performance requirements by minimizing or constraining variance amplification. `TuningGoal.Variance` specifies the maximum output variance for a unit-variance input signal from a specified input to a specified output in your control system. `TuningGoal.WeightedVariance` imposes a frequency-weighted variance amplification limit.

For more information about these `TuningGoal` requirement objects see the reference pages for each requirement object, and:

- “Using Design Requirement Objects”
- “Specifying Design Requirements for `systune`”
- “Performance and Robustness Specifications for `looptune`”

## **Robust tuning of one controller against a set of plant models**

The new `system` command can simultaneously tune the parameters of multiple models or control configurations. This feature allows you, for example, to tune a single controller against a range of plant models, to help ensure that the tuned control system is robust against parameter variations. As another example, you can tune for reliable control by simultaneously to multiple plant configurations that represent different failure modes of a system. In either case, `system` finds values for tunable parameters that best satisfy the specified tuning objectives for all models.

For more information, see “Tune Controller Against Set of Plant Models”.

## Option to constrain tuned parameter values and to restrict some tuning requirements to a frequency band

You can now optionally impose lower and upper bounds on tunable parameters when tuning fixed-structure control systems using `sys tune`, `looptune`, or `hinfstruct`. For example, you can constrain a gain to always be positive, or impose a maximum value on a filter time constant.

To impose bounds on tunable parameters, set the `Maximum` and `Minimum` properties of the parameter in the corresponding Control Design Block. For example, create a scalar gain block and constrain the gain to be positive:

```
gainblock = ltiblock.gain('gainblock',1,1);  
gainblock.Gain.Minimum = 0;
```

Then, use `gainblock` as a component in a tunable `genss` model of the control system. When you tune the control system, the tuning command enforces the constraint.

Additionally, you can limit the range of frequencies in which almost any `TuningGoal` requirement is enforced for fixed-structure control system tuning with `sys tune` or `looptune`. The only exceptions are `TuningGoal.Variance` and `TuningGoal.WeightedVariance`.

For example, you can enforce a stability margin requirement in a frequency band extending for one decade on each side of the target gain crossover frequency.

To limit the range of frequencies in which a requirement is enforced, use the `Focus` property of the `TuningGoal` requirement object. For example, create a requirement that limits the gain from an input `du` to an output `u` to 10. Limit enforcement of the requirement to the frequency range 10–1000 rad/s.

```
Req = TuningGoal.Gain('du','u',10);  
Req.Focus = [10 1000];
```

## **ltiblock.pid2 and loopswitch objects for tuning two-degree-of-freedom PID controllers and marking loop opening sites for open-loop requirements**

New Control Design Blocks in Control System Toolbox™ allow you to specify more control structures and more types of constraints for fixed-structure control system tuning in MATLAB:

- `ltiblock.pid2` — Tunable two-degree-of-freedom PID controller
- `loopswitch` — Control Design Block for specifying feedback loop opening locations in a tunable `genss` model of a control system

For more information, see the `ltiblock.pid2` and `loopswitch` reference pages.

## **TuningGoal.MaxGain and GainLimit property renamed**

### **Compatibility Considerations: Yes**

The tuning requirement `TuningGoal.MaxGain` is now called `TuningGoal.Gain`. Additionally, the `GainLimit` property of that tuning requirement is now called `MaxGain`.

For more information, see the `TuningGoal.Gain` reference page.

### **Compatibility Considerations**

Replace instances of `TuningGoal.MaxGain` in your code with `TuningGoal.Gain`. Replace references to the `GainLimit` property with `MaxGain`.

## **Options in `hinfstructOptions` and `looptuneOptions` renamed or removed**

**Compatibility Considerations: Yes**

The following options in `hinfstructOptions` and `looptuneOptions` are changed:

- `SpecRadius` is now called `MaxFrequency`. Additionally, `NaN` is no longer a supported value for this option. For an unconstrained `MaxFrequency` value, use `Inf`.
- `StableOffset` is now called `MinDecay`.
- `StableRadius` option has no effect.
- `StableExclude` option of `hinfstructOptions` has no effect. `hinfstruct` now automatically excludes from stability tests Control Design Blocks such as weighting functions or multipliers. These blocks do not affect the closed-loop stability of the actual control system to tune.

For more information about these options, see the `hinfstructOptions` and `looptuneOptions` reference pages.

### **Compatibility Considerations**

If you use any of the affected options in your code, update your code to reflect the current names and supported values.

# R2012a

---

Version: 4.1  
New Features: Yes  
Bug Fixes: Yes

## **Parallel Computing Support for looptune and hinfstruct**

If you have Parallel Computing Toolbox™ software installed, you can use parallel computing to speed up tuning of fixed-structure control systems with the `looptune` or `hinfstruct` commands. When you run multiple randomized `looptune` or `hinfstruct` optimization starts, parallel computing speeds up tuning by distributing the optimization runs among MATLAB workers.

For more information about using parallel computing to speed up `looptune` or `hinfstruct` tuning, see:

- Speed Up Tuning with Parallel Computing Toolbox Software in the Robust Control Toolbox™ documentation.
- The Robust Control Toolbox demo Using Parallel Computing to Accelerate the Tuning Process.

For more information about tuning fixed-structure control systems with `looptune` or `hinfstruct`, see Tuning Fixed Control Architectures in the Robust Control Toolbox documentation.



## **Faster and More Accurate H-infinity Norm Computation Using SLICOT Algorithms**

$H_\infty$  norm calculations now use the SLICOT library of numerical algorithms. These algorithms improve the speed and accuracy of functions such as `hinfstruct` and `looptune`.

For more information about the SLICOT library, see <http://slicot.org>.



# R2011b

---

Version: 4.0  
New Features: Yes  
Bug Fixes: Yes

## **looptune Tunes Fixed-Structure Control Systems**

Use `looptune` to tune fixed-structure control systems to meet your requirements. To use `looptune`, specify design requirements such as loop bandwidth, stability margin, setpoint tracking, or target loop shape. `looptune` automatically tunes the parameters of your controller to meet the specified requirements.

The requirements objects `TuningGoal.MaxGain`, `TuningGoal.Tracking`, and `TuningGoal.LoopShape` let you express your design requirements directly. You do not have to first convert them to weighting functions or mathematical constraints on an optimization problem.

You can use `loopview` to validate the performance the performance of the tuned control structure against your specified design requirements.

For more information, see [Tuning Fixed Control Architectures](#) and the [looptune](#) and [loopview](#) reference pages.

## Control System Tuning for Simulink Models with looptune or hinfstruct Using sITunable Interface

If you have Simulink Control Design™ software, you can use tuning commands, such as `sITunable.looptune` and `hinfstruct`, to tune control systems modeled in Simulink. The `sITunable` object provides an interface between your Simulink model and these commands.

Use `sITunable` to specify information about your control structure and parametrization. `sITunable` also automates tasks such as linearizing the Simulink model, parametrizing the tunable blocks of your system, and applying tuned parameter values to the model. After you create and configure an `sITunable` object for your control architecture, you can tune the control system using `sITunable.looptune` or `hinfstruct`.

For more information, see [Tuning Fixed Control Architectures](#) and the following demos:

- [Tuning of a Digital Motion Control System](#)
- [Decoupling Controller for a Distillation Column](#)
- [Tuning of a Two-Loop Autopilot](#)
- [Tuning of Cascaded PID Loops](#)
- [Loop Shaping Design with HINFSTRUCT](#)
- [Fixed-Structure Autopilot for a Passenger Jet](#)

## **wcgainplot for Visualizing Worst-Case Gains**

`wcgainplot` plots the nominal, sampled, and worst-case gains of uncertain systems as a function of frequency. Use `wcgainplot` for visual analysis of uncertain systems.

For more information, see the `wcgainplot` reference page.

## Functionality Being Removed or Changed

Compatibility Considerations: Yes

Functionality	What Happens When You Use This Functionality?	Use This Instead	Compatibility Considerations
umat object can no longer contain ultidyn or udyn uncertainty.	<ul style="list-style-type: none"> <li>• Presence of ultidyn or udyn uncertain elements forces model type to uss or ufrd rather than umat.</li> <li>• Mixing ureal or ucomplex models with udyn or ultidyn objects produces uss instead of umat.</li> </ul>	Expect a model type of uss or ufrd instead of umat when working with udyn or ultidyn uncertain elements.	Update code to work with uss or ufrd instead of umat when udyn or ultidyn elements are present.
uss(sys_frd), where sys_frd is a frd model object no longer converts sys_frd to ufrd.	Errors.	ufrd(sys_frd).	Replace uss(sys_frd) with ufrd(sys_frd).
ufrd(udat, freq, ...) no longer constructs an uncertain frd model from the umat object udat.	Converts udat to a ufrd object with frequencies freq.	Use frd(udat, freq, ...) to construct an uncertain frd model from the umat object udat.	Replace ufrd(udat, freq, ...) with frd(udat, freq, ...).
frd(sys_uss,w) where sys_uss is a uss model.	Warns; returns frd model containing data based on nominal response of sys_uss.	ufrd(sys_uss,w) to obtain a ufrd model.	Replace frd(sys_uss,w) with ufrd(sys_uss,w).

<b>Functionality</b>	<b>What Happens When You Use This Functionality?</b>	<b>Use This Instead</b>	<b>Compatibility Considerations</b>
Nominal value of ultidyn object.	Nominal value is <code>ss</code> model object.	None.	Update code to work with <code>ss</code> model objects when working nominal value of <code>ultidyn</code> .
<code>usubs</code> .	Applied to array of uncertain models, default substitution is <code>'-once'</code> .	Use <code>'-batch'</code> to perform batch substitution on uncertain model arrays.	Replace <code>usubs(...)</code> with <code>usubs(..., '-batch')</code> .
	<code>usubs(M, {a1;a2;...}, {v1;v2;...})</code> returns error.	<code>usubs(M, a1, v1, a2, v2, ...)</code> .	Replace <code>usubs(M, {a1;a2;...}, {v1;v2;...})</code> with <code>usubs(M, a1, v1, a2, v2, ...)</code> .
<code>usample(sys, 'a', na, 'b', nb)</code> where uncertain element <code>b</code> does not exist in <code>sys</code> .	Returns <code>na</code> -by- <code>nb</code> array with constant values across <code>nb</code> dimension, instead of <code>na</code> -by-1 array.	None.	Update code to reflect correct dimensionality.
<code>wcgopt</code> .	Still runs.	<code>wcgainOptions</code> or <code>wcmarginOptions</code> .	Replace <code>wcgopt</code> with <code>wcgainOptions</code> or <code>wcmarginOptions</code> .



<b>Functionality</b>	<b>What Happens When You Use This Functionality?</b>	<b>Use This Instead</b>	<b>Compatibility Considerations</b>
robuststab and robustperf.	For ufrd models, BadUncertainValues field of Info output returns Nf-by-1 struct array, where Nf is the number of frequency points.	None.	Update code to work with Nf-by-1 struct array for BadUncertainValues instead of Nf-by-1 cell array.
	For nominally unstable models, performance margin is zero (instead of a negative value).	None.	Update code to reflect correct performance margin .
robopt.	Still runs.	robuststabOptions or robustperfOptions.	Replace robopt with robuststabOptions or robustperfOptions.
actual2normalized.	First output argument is normalized uncertain block value. The second output argument is normalized distance between block value and nominal value.	[NV,ndist] = actual2normalized(BLK,AV).	Use second output argument ndist for normalized distance.

<b>Functionality</b>	<b>What Happens When You Use This Functionality?</b>	<b>Use This Instead</b>	<b>Compatibility Considerations</b>
<code>reshape(unc_sys,S)</code> .	S does not include the I/O size of the models in the array <code>unc_sys</code> . For example, if <code>unc_sys</code> is a 6-by-1 array of 2-output, 4-input models, <code>reshape(unc_sys,[2 3])</code> converts <code>unc_sys</code> to a 2-by-3 array.	None.	Remove I/O size dimensions from <code>reshape</code> on uncertain model arrays.
<code>diag(uss_sys)</code> where <code>uss_sys</code> is a <code>uss</code> model.	Errors.	None.	Remove <code>diag(uss_sys)</code> .

# R2011a

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Version: 3.6  
New Features: Yes  
Bug Fixes: Yes

## Enhanced Workflow for H-Infinity Synthesis of Fixed-Structure Control Systems

New Generalized LTI models in Control System Toolbox allow you to model control systems with tunable parameters. Using these models simplifies controller tuning with `hinfstruct`. You can model a closed-loop transfer function, including tunable parameters, as a generalized state-space (`genss`) model and directly tune the parameters to minimize the closed-loop gain. The `hinfstruct` command can tune any fixed-structure SISO or MIMO control system using  $H_\infty$  synthesis techniques.

Additionally, new `realp` and `genmat` objects let you create parametric expressions. You can use such expressions to create custom tunable components. For example, you can define a low-pass filter parametrized by its cutoff frequency, or an observer-based controller parametrized by the state-feedback and observer gains.

For more information about creating tunable Generalized LTI models, see *Models with Tunable Coefficients* in the *Control System Toolbox User's Guide*.

For more information about  $H_\infty$  tuning with `hinfstruct`, see *Tuning Fixed Control Architectures* in the *Robust Control Toolbox Getting Started Guide*.

For examples of designing controllers for several different architectures using `hinfstruct`, see the following updated and new demos:

- Loop Shaping Design with HINFSTRUCT (updated)
- Tuning of a Two-Loop Autopilot (updated)
- Decoupling Controller for a Distillation Column (updated)
- Multi-Loop PID Control of a Robot Arm (updated)
- Fixed-Structure Autopilot for a Passenger Jet (new)

# R2010b

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Version: 3.5  
New Features: Yes  
Bug Fixes: Yes

## New Commands for H-Infinity Synthesis of Fixed-Structure Control Systems

New commands in this release allow you to tune fixed-structure SISO and MIMO control systems using the techniques of  $H_\infty$  synthesis.

The new `hinfstruct` command lets you use the frequency-domain methods of  $H_\infty$  synthesis to tune control systems with a broad range of architectures and controller structures. For example, you can tune:

- Fixed-order, fixed-structure controllers, such as pure gains, PID controllers, or fixed-order transfer function or state-space models
- Single feedback-loop architectures with multiple tunable elements, such as a PID controller plus a filter
- Multiple feedback-loop architectures with multiple tunable elements

Specify the tunable elements of your system using the new parametrized Control Design blocks `ltiblock.gain`, `ltiblock.pid`, `ltiblock.tf`, and `ltiblock.ss`.

For examples of designing controllers for several different architectures using `hinfstruct`, see the following new demos:

- Loop Shaping Design with HINFSTRUCT
- Tuning of a Fixed-Structure Autopilot
- Decoupling Controller for a Distillation Column
- Multi-Loop PID Control of a Robot Arm

For more information, see Tuning Fixed Control Architectures in the *Robust Control Toolbox Getting Started Guide*.

# R2010a

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Version: 3.4.1  
New Features: No  
Bug Fixes: Yes





# R2009b

---

Version: 3.4  
New Features: Yes  
Bug Fixes: Yes

## **New Option to Improve Robust Performance by Accounting for Real Uncertain Parameters**

You can now improve robust performance by accounting for real uncertain parameters when designing controllers using  $\mu$ -synthesis. The user-defined options you use in the `dksyn` command now includes a new option `MixedMU`. Set this option to 'on' to account for real uncertain parameters in your system. For more information, see the `dkitopt`, and `dksyn` reference pages.

## **New Command to Linearize Simulink Models with Uncertainty**

If you have Simulink Control Design software installed, you can take model uncertainty into account when linearizing a Simulink model. You can then use the resulting uncertain linearized model (uss object) to perform linear analysis and robust control design.

If your model already contains Uncertain State Space blocks, use the new `ulinearize` command to obtain an uss model. If you want to account for uncertainty in your linear analysis without using Uncertain State Space blocks, you can specify individual Simulink blocks to linearize to an uncertain variable. For more information, see "Computing Uncertain State-Space Models from Simulink Models" in the *Robust Control Toolbox User's Guide*.

## **New Interface for Simulating Effects of Uncertainty in Simulink Models**

This version of the product provides a new interface to simulate the effects of uncertainty in Simulink models. The interface includes the following:

- **Uncertain State Space** block to specify uncertain system in Simulink. You should replace **USS System** blocks in your existing models with the **Uncertain State Space** block. To do so, run the `slupdate` command on your models.
- `ufind` command to extract all uncertain variables from a Simulink model.
- `usample` command to generate random values of these uncertain variables.

For more information on simulating the effects of uncertainty using the new interface, see "Simulating Effects of Uncertainty" in the *Robust Control Toolbox User's Guide*.

## **New Command to Model Multiple LTI Responses as One Uncertain System**

This version of the product includes a new `ucover` command that lets you model a family of LTI responses as one uncertain system. For more information, see the `ucover` reference page.

## New and Updated Demos

The following new and updated demos illustrate use of the new features:

- "Control of Spring-Mass-Damper Using Mixed  $\mu$ -Synthesis" shows use of the new `MixedMU` option and `dksyn` command for mixed- $\mu$  synthesis.
- "Linearization of Simulink Models with Uncertainty" shows how to compute uncertain state-space models using `ulinearize` and Simulink Control Design software.
- "Robustness Analysis in Simulink" uses the new interface for simulating effects of uncertainty in Simulink models.
- "Simultaneous Stabilization Using Robust Control" and "Modeling a Family of Responses as an Uncertain System" show use of the `ucover` command.
- "First-Cut Robust Design" shows use of the `usample`, `ucover` and `dksyn` commands.

To access the demos, type

```
demo('toolbox','robust control')
```

## Functions, Properties and Blocks Being Removed

Compatibility Considerations: Yes

Function, Property or Block Name	What Happens When You Use Function or Property?	Use This Instead	Compatibility Considerations
usiminfo	Still runs	ufind	See “New Interface for Simulating Effects of Uncertainty in Simulink Models” on page 30.
usimfill	Still runs	ufind	See “New Interface for Simulating Effects of Uncertainty in Simulink Models” on page 30.
usimsamp	Still runs	usample	See “New Interface for Simulating Effects of Uncertainty in Simulink Models” on page 30.
USS System block	Still runs	Uncertain State Space block	See “New Interface for Simulating Effects of Uncertainty in Simulink Models” on page 30.
ltiarray2uss	Still runs	ucover	See “New Command to Model Multiple LTI Responses as One Uncertain System” on page 31.





# R2009a

---

Version: 3.3.3  
New Features: No  
Bug Fixes: Yes



# R2008b

---

Version: 3.3.2  
New Features: No  
Bug Fixes: Yes



# R2008a

---

Version: 3.3.1  
New Features: Yes  
Bug Fixes: No

## **Ability to Use LOOPMARGIN with Simulink**

This version of Robust Control Toolbox software lets you analyze the robustness of nonlinear Simulink models using the LOOPMARGIN command.

If you have the Simulink Control Design product installed, you can perform stability margin analysis of a Simulink model by passing the model name and a point within that model to the LOOPMARGIN command.

# R2007b

---

Version: 3.3  
New Features: No  
Bug Fixes: No

No New Features or Changes





# R2007a

---

Version: 3.2  
New Features: Yes  
Bug Fixes: No

## **New Simulink Blocks**

- **USS System** — This Robust Control Toolbox version introduces a new Simulink block, USS System. You can use this block to import uncertain systems into Simulink models.
- **Multiplot Graph** — Plot multiple signals in one figure.

# R2006b

---

Version: 3.1.1  
New Features: Yes  
Bug Fixes: No

## **New Function `ltiarray2uss`**

This Robust Control Toolbox version introduces a new function, `ltiarray2uss`. This function constructs an uncertain state-space model from an LTI array.

# R2006a

---

Version: 3.1  
New Features: No  
Bug Fixes: No

No New Features or Changes



# R14SP3

---

Version: 3.0.2  
New Features: No  
Bug Fixes: No

No New Features or Changes





# R14SP2

---

Version: 3.0.1  
New Features: Yes  
Bug Fixes: No

## **mussvunwrap Is Renamed**

mussvunwrap has been renamed. It is now called mussvextract.

## **New Functions `actual2normalized` and `normalized2actual`**

This Robust Control Toolbox version introduced two new functions:

- `actual2normalized` — Calculate normalized distance between nominal value and given value for uncertain atom.
- `normalized2actual` — Convert value for atom in normalized coordinates to corresponding actual value.