looptune

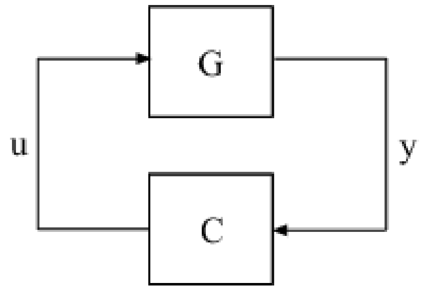
Tune MIMO control systems

Syntax

```
[G,C,gam] = looptune(G0,C0,wc)
[G,C,gam] = looptune(G0,C0,wc,Req1,Req2,...)
[G,C,gam] = looptune(...,options)
[G,C,gam,info] = looptune(...)
```

Description

`[G,C,gam] = looptune(G0,C0,wc)` tunes the feedback loop



to meet the following default requirements:

- Bandwidth — Gain crossover for each loop falls in the frequency interval `wc`
- Performance — Integral action at frequencies below `wc`
- Robustness — Adequate stability margins and gain roll-off at frequencies above `wc`

The tunable `genss` model `C0` specifies the controller structure, parameters, and initial values. The model `G0` specifies the plant. `G0` can be a Numeric LTI model, or, for co-tuning the plant and controller, a tunable `genss` model. The sensor signals `y` (measurements) and actuator signals `u` (controls) define the boundary between plant and controller.

`[G,C,gam] = looptune(G0,C0,wc,Req1,Req2,...)` tunes the feedback loop to meet additional design requirements specified in one or more tuning goal objects `Req`. Omit `wc` to use the requirements specified in the `Req` objects instead of an explicit target crossover frequency and the default performance and robustness requirements.

`[G,C,gam] = looptune(...,options)` specifies further options, including target gain margin, target phase margin, and computational options for the tuning algorithm.

`[G,C,gam,info] = looptune(...)` returns a structure `info` with additional information about the tuned result. Use `info` with the `loopview` command to visualize tuning constraints and validate the tuned design.

Input Arguments

`G0`	Numeric LTI model or tunable `genss` model representing plant in control system to tune. The plant is the portion of your control system whose outputs are sensor signals (measurements) and whose inputs are actuator signals (controls). Use `connect` to build `G0` from individual numeric or tunable components.
`C0`	Generalized LTI model representing controller. `C0` specifies the controller structure, parameters, and initial values. The controller is the portion of your control system that receives sensor signals (measurements) as inputs and produces actuator signals (controls) as outputs. Use Control Design Blocks and Generalized LTI models to represent tunable components of the controller. Use `connect` to build `C0` from individual numeric or tunable components.
`wc`	Vector specifying target crossover region `[wcmin,wcmax]`. The `looptune` command attempts to tune all loops in the control system so that the open-loop gain crosses 0 dB within the target crossover region. A scalar `wc` specifies the target crossover region `[wc/2,2*wc]`.
`Req`	One or more `TuningGoal` objects specifying design requirements. Available requirement

	types are: - TuningGoal.Tracking — Setpoint tracking requirement - TuningGoal.Gain — Limit on transfer function gain - TuningGoal.LoopShape — Target shape for open-loop response For a complete list of the design requirements you can specify, see Performance and Robustness Specifications for looptune.
options	Set of options for looptune algorithm, specified using looptuneOptions. See looptuneOptions for information about the available options, including target gain margin and phase margin.

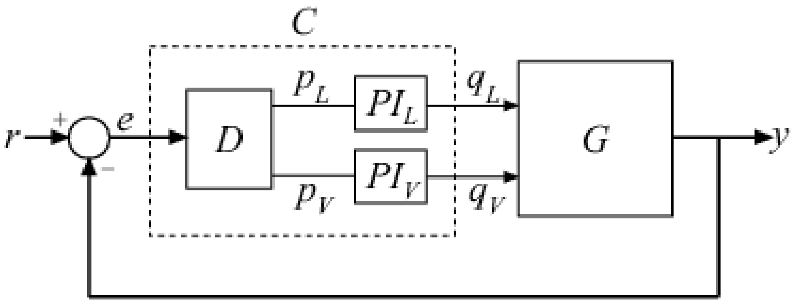
Output Arguments

G	Tuned plant. If G0 is a Numeric LTI model, G is the same as G0. If G0 is a tunable genss model, G is a genss model with Control Design Blocks of the same number and types as G0. The current value of G is the tuned plant.
C	Tuned controller. C is a genss model with Control Design Blocks of the same number and types as C0. The current value of C is the tuned controller.
gam	Parameter indicating degree of success at meeting all tuning constraints. A value of gam <= 1 indicates that all requirements are satisfied. gam >> 1 indicates failure to meet at least one requirement. Use loopview to visualize the tuned result and identify the unsatisfied requirement. For best results, use the RandomStart option in looptuneOptions to obtain several minimization runs. Setting RandomStart to an integer N > 0 causes looptune to run the optimization N additional times, beginning from parameter values it chooses randomly. You can examine gam for each run to help identify an optimization result that meets your design requirements.
info	Data for validating tuning results, returned as a structure. To use the data in info, use the command loopview(G,C,info) to visualize tuning constraints and validate the tuned design. info contains the following tuning data:

Di,Do	Optimal input and output scalings, returned as state-space models. The scaled plant is given by Do\G*Di.
Specs	Design requirements that looptune constructs for its call to systune for tuning (see Algorithms), returned as a vector of TuningGoal requirement objects.
Runs	Detailed information about each optimization run performed by systune when called by looptune for tuning (see Algorithms), returned as a data structure. The contents of Runs are the info output of the call to systune. For information about the fields of Runs, see the info output argument description on the systune reference page.

Examples

Tune the control system of the following illustration, to achieve crossover between 0.1 and 1 rad/min.



The 2-by-2 plant G is represented by:

$$G(s) = \frac{1}{75s+1}\begin{bmatrix} 87.8 & -86.4 \\ 108.2 & -109.6 \end{bmatrix}.$$

The fixed-structure controller, C, includes three components: the 2-by-2 decoupling matrix D and two PI controllers PI_L and PI_V. The signals r, y, and e are vector-valued signals of dimension 2.

```
s = tf('s');
G = 1/(75*s+1)*[87.8 -86.4; 108.2 -109.6];
G.TimeUnit = 'minutes';

D = ltiblock.gain('Decoupler',eye(2));
PI_L = ltiblock.pid('PI_L','pi');  PI_L.TimeUnit = 'minutes';
PI_V = ltiblock.pid('PI_V','pi');  PI_V.TimeUnit = 'minutes';
C0 = blkdiag(PI_L,PI_V)*D;

wc = [0.1,1];
options = looptuneOptions('RandomStart',5);
[G,C,gam,info] = looptune(-G,C0,wc,options);
```

The minus sign on the plant input to `looptune` accounts for the negative feedback in the control loop. C is the tuned controller, in this case a `genss` model with the same block types as C0.

You can examine the tuned result using `loopview`.

Alternatives

For tuning Simulink® models with `looptune`, see `slTunable` and `slTunable.looptune` (requires Simulink Control Design™).

More About

expand all

Algorithms

- Performance and Robustness Specifications for looptune

References

[1] P. Apkarian and D. Noll, "Nonsmooth H-infinity Synthesis." *IEEE Transactions on Automatic Control*, Vol. 51, Number 1, 2006, pp. 71–86.

[2] Bruisma, N.A. and M. Steinbuch, "A Fast Algorithm to Compute the H_∞-Norm of a Transfer Function Matrix," *System Control Letters*, 14 (1990), pp. 287-293.

See Also

`connect` | `genss` | `hinfstruct` | `loopmargin` | `looptuneOptions` | `loopview` | `slTunable` | `slTunable.looptune` | `systune` | `TuningGoal.Gain` | `TuningGoal.LoopShape` | `TuningGoal.Tracking`

Tutorials

- Tune MIMO Control System for Specified Bandwidth
- Tuning Feedback Loops with LOOPTUNE
- Decoupling Controller for a Distillation Column