Next Week: Circuit Design Tools

Monday Lecture: 1:00-1:50 pm (April 23).

→ Morton 341 computer lab.

Tuesday Lab Section: 2:00-7:00 pm (April 24).

→ Tyler 105 computer lab.

Wednesday Lab Section: 1:00-6:00 pm (April 25).

→ Jones 203 computer lab.

Free downloads of design software will be made available on Wednesday evening.

Feedback Control Theory

Outline:

- Motivation: Why study feedback theory?
- System Model, Feedback Model
- PID feedback control theory
- How well does it work?
- Back to Fourier space.
- PID with electronics.

Why is feedback important?

Answer: *Feedback is used in most devices to achieve very high levels of stability to external influences.*

The idea of using feedback to regulate a systems behavior has been around for a long time (for example, centrifugal governor, circa 1780's)

The quantitative use of **feedback** is one of the primary engineering developments of the 20th century.

Harold S. Black invented negative feedback to stabilize and linearize the gain of telephone amplifiers (at Bell Telephone Laboratories).

"Our patent application was treated in the same manner as one for a perpetual-motion machine"

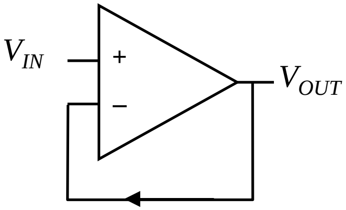
Feedback Applications

Engineering:

[image from www.yorku.ca]

F-16 Falcon
[image from www.nellis.af.mil]

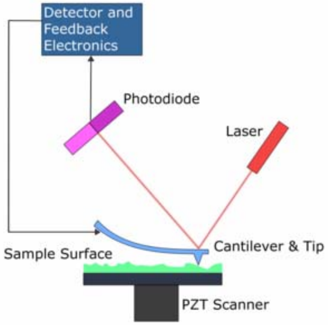
Electronics:



Physics:

CERN: Stochastic Cooling

Laser locking

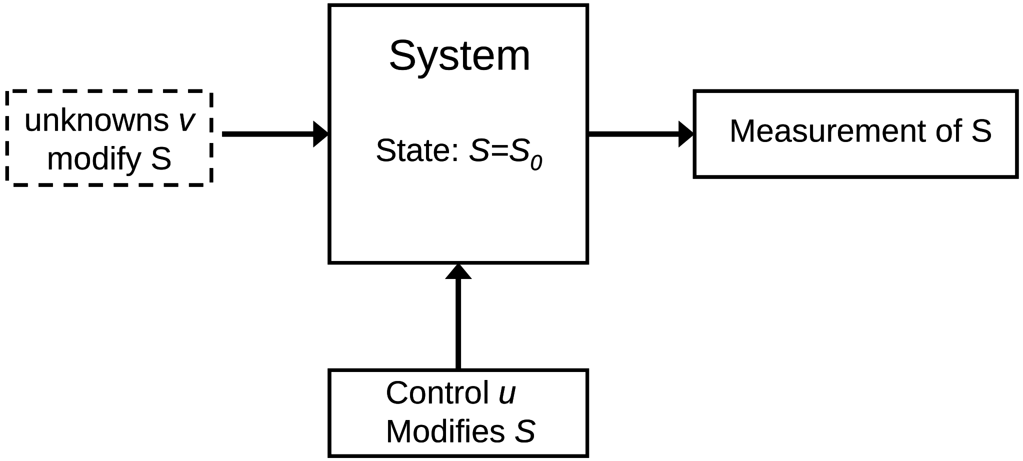


Atomic force microscope
[figure from content.answers.com]

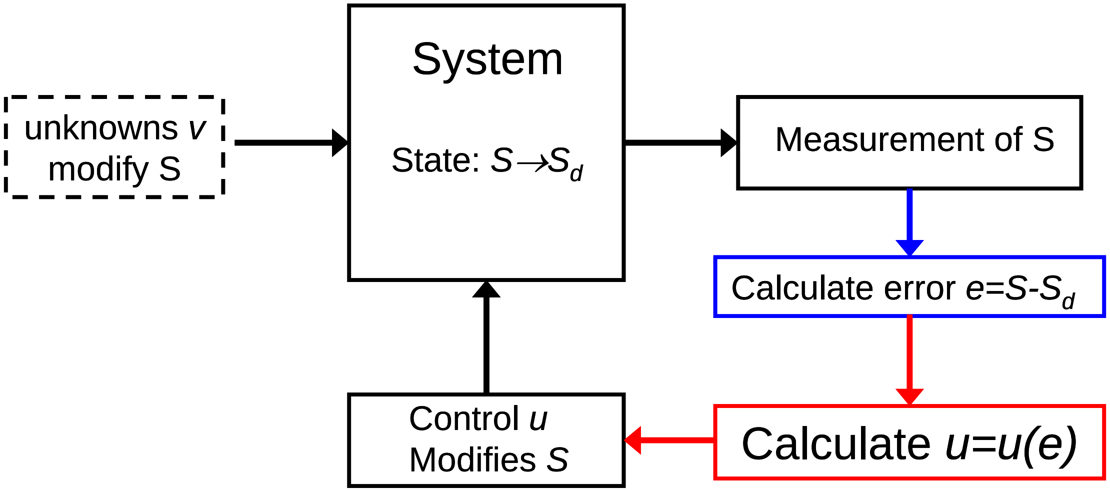
Biology: anything alive.

Feedback Model

System with no feedback:

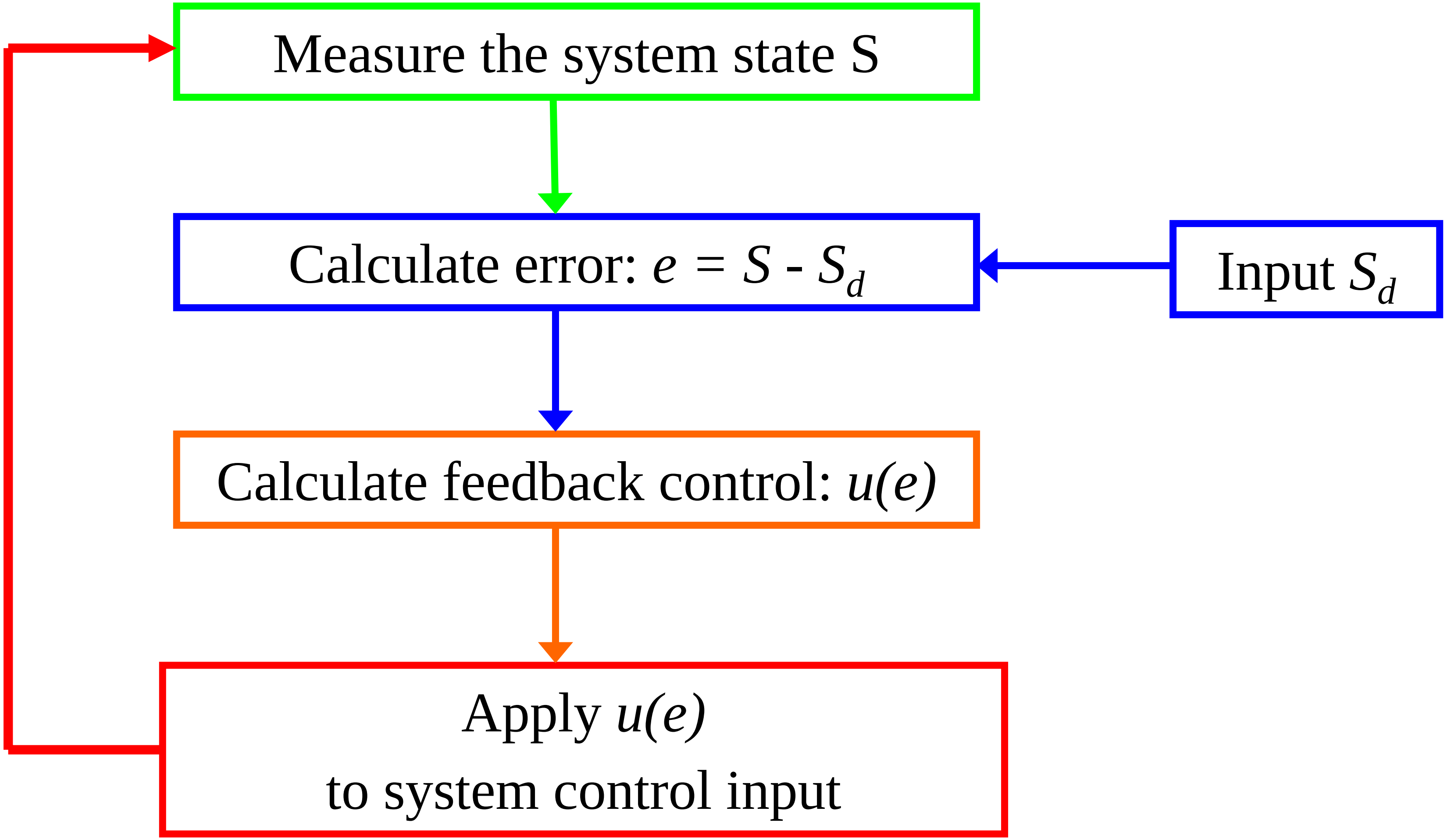


System with feedback:



Claim: system will converge to system state S_d, if *u(e)* is chosen appropriately.

Feedback Algorithm



PID feedback control
-- how to calculate *u(e)* --

Based on a survey of over eleven thousand controllers in the refining, chemicals and pulp and paper industries, 97% of regulatory controllers utilize PID feedback.

L. Desborough and R. Miller, Honeywell.
Sixth International Conference on Chemical Process Control. *AIChE Symposium Series Number 326* (Volume 98), 2002.

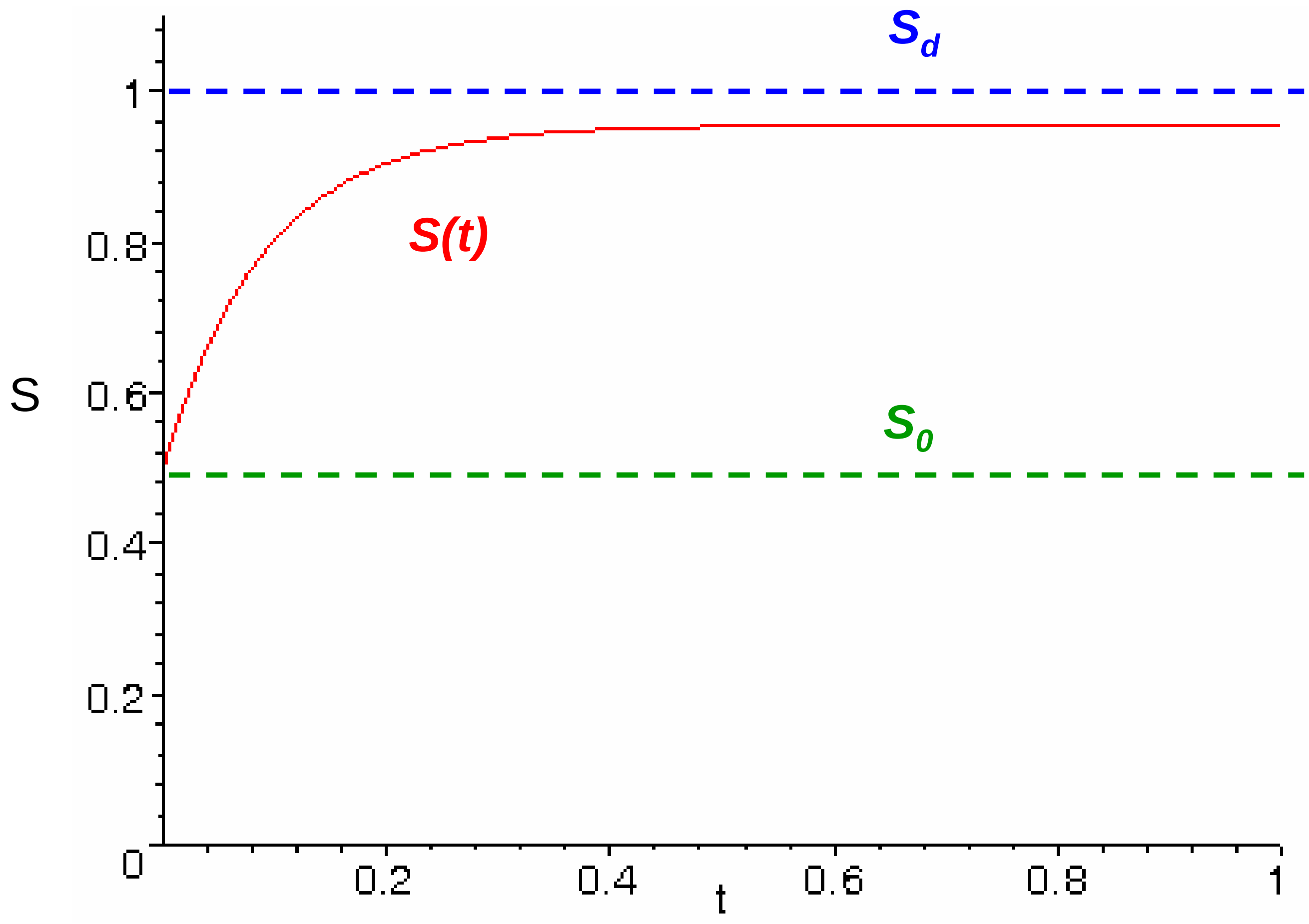
Proportional gain: corrects for errors based using the *Present*.

Integral gain: corrects for errors based using the *Past*.

Derivative gain: corrects for errors based on the anticipated *Future*.

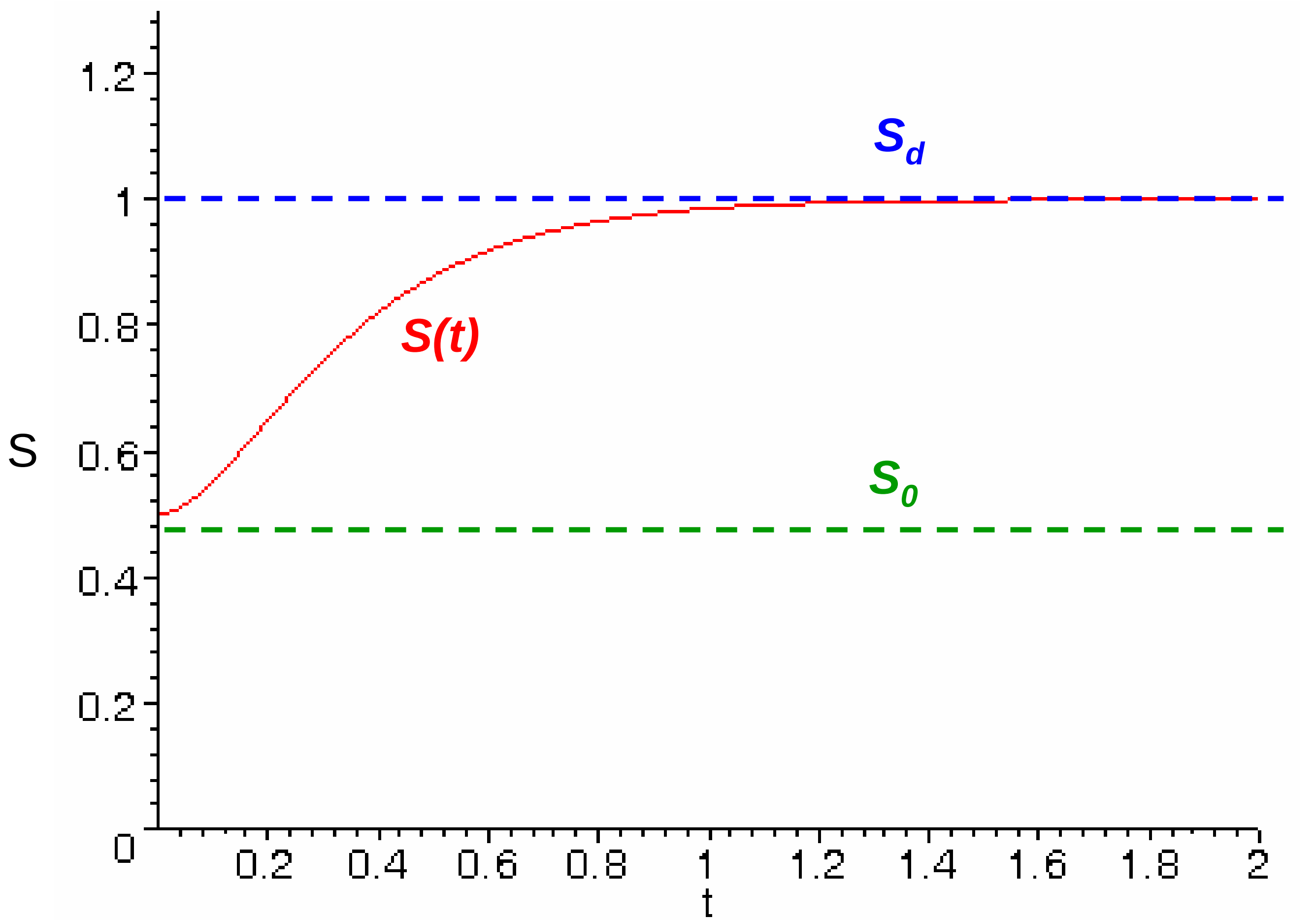
How well does it work?

Proportional Gain:



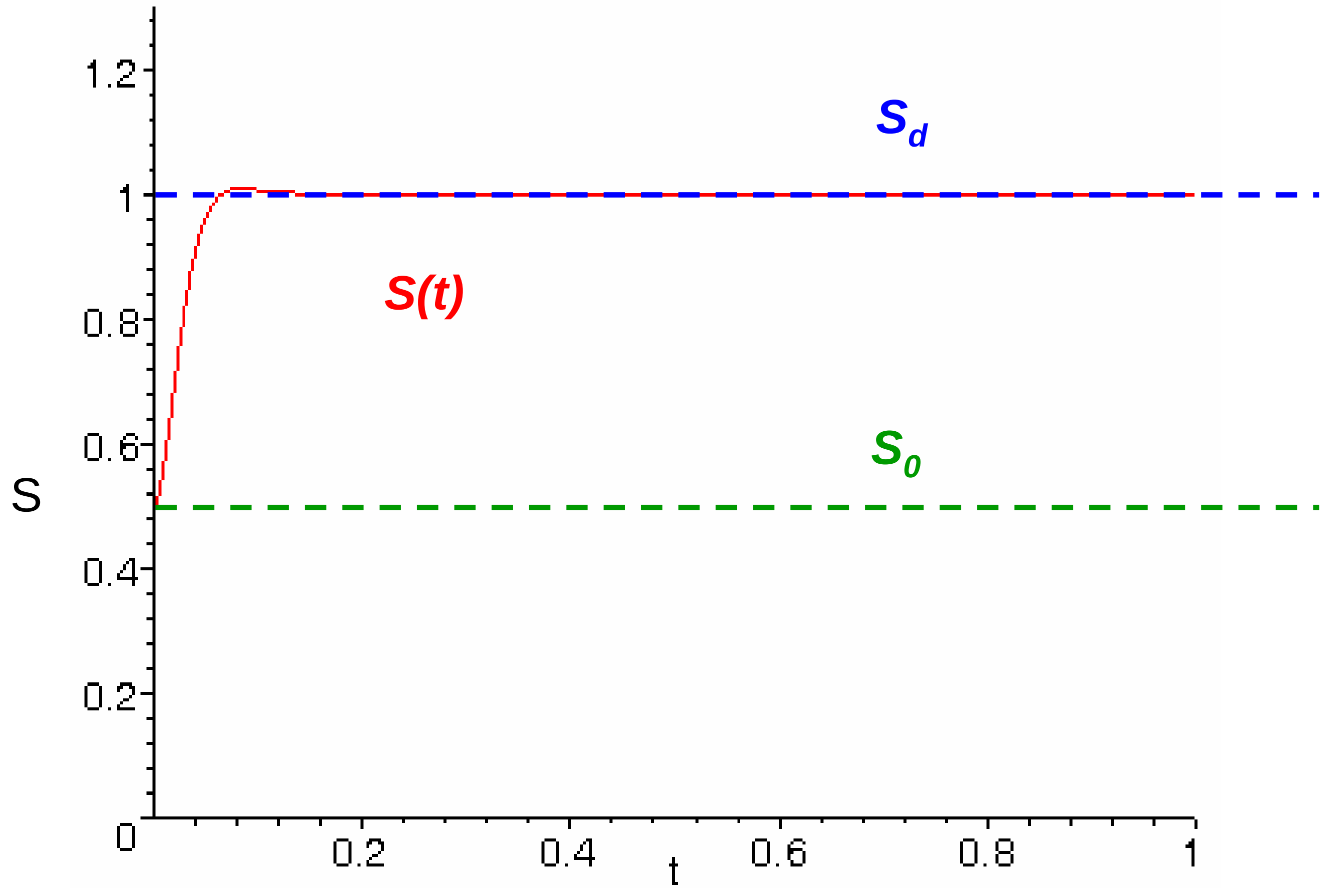
How well does it work?

Proportional – Integral Gain: g_p=-10, g_I=-30, τ=1



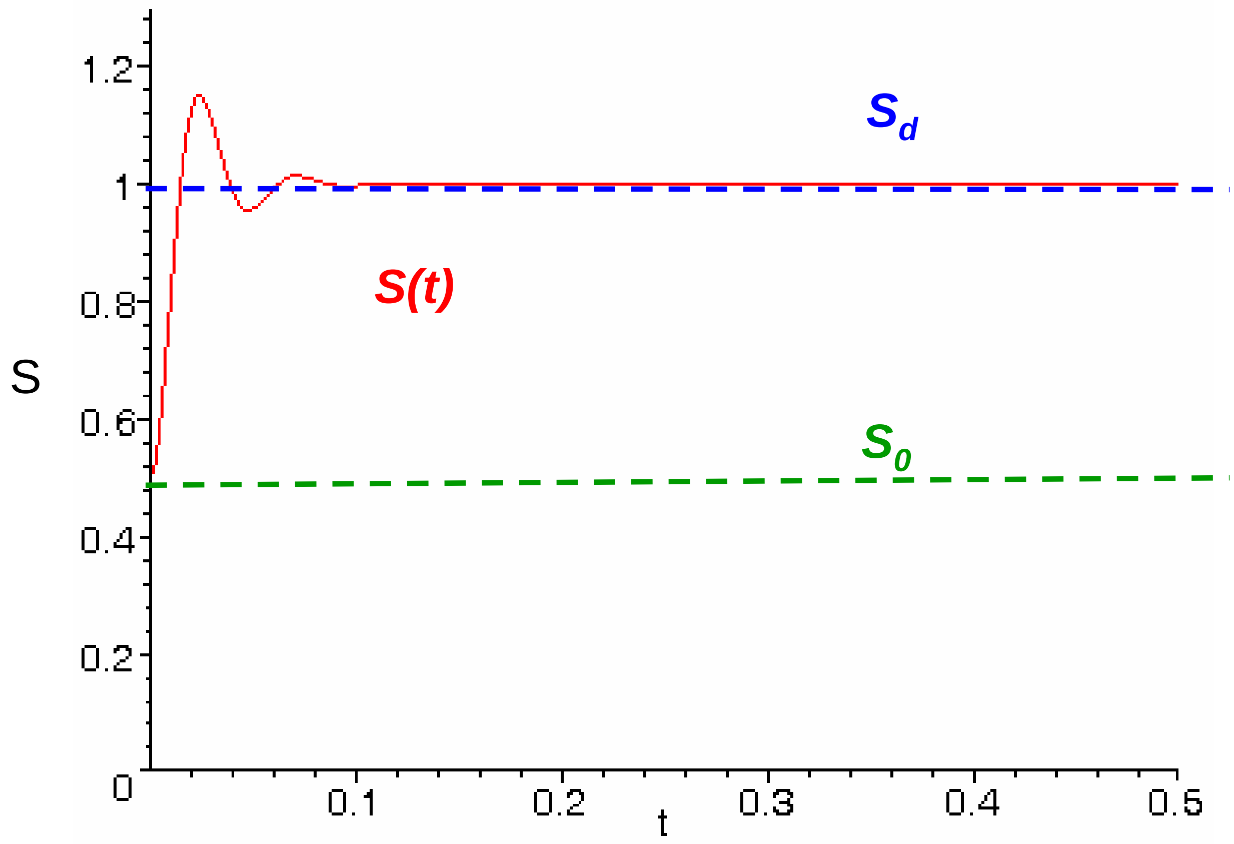
How well does it work?

Proportional – Integral Gain: g_p=-100, g_I=-4000, τ=1



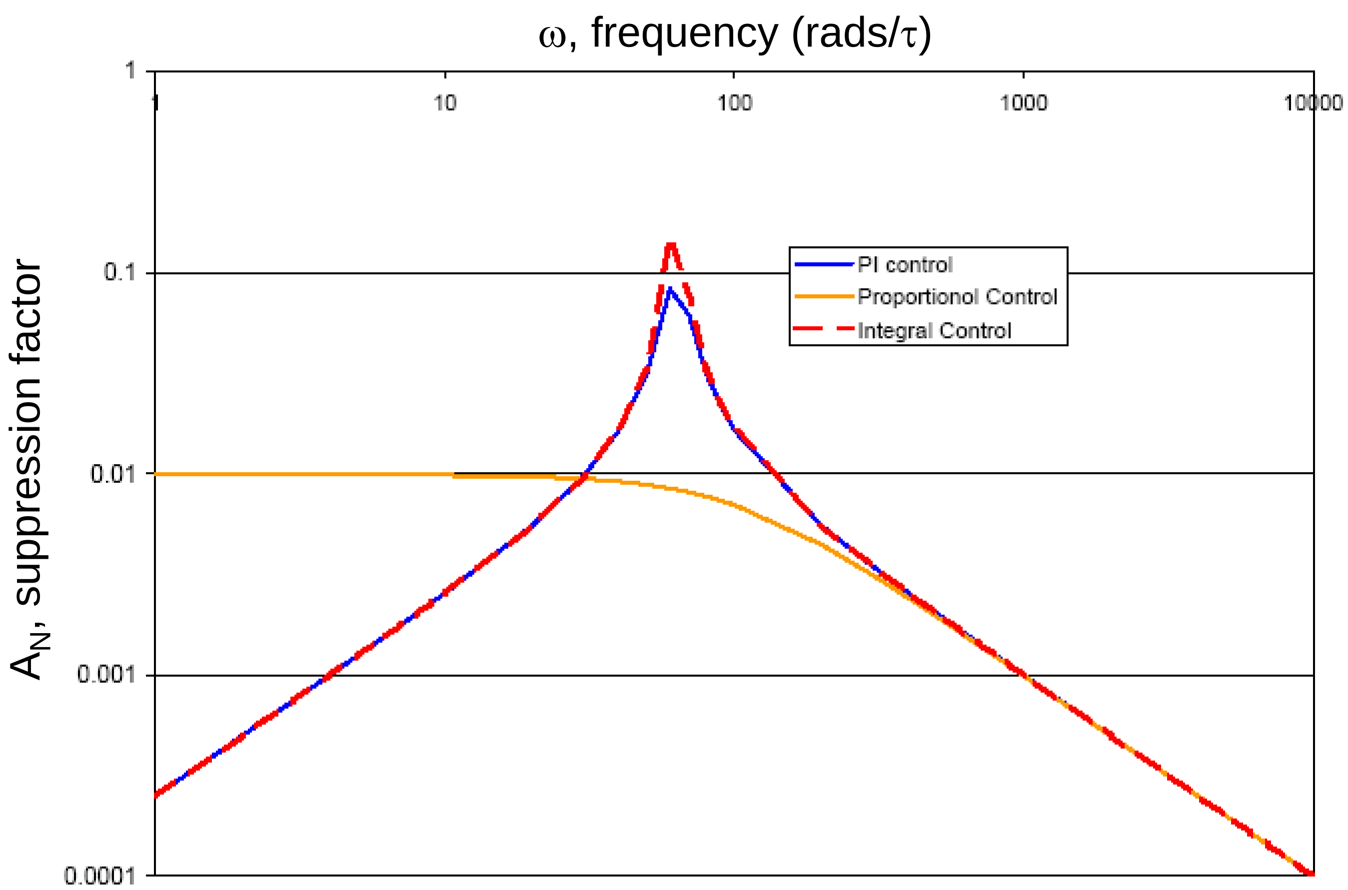
How well does it work?

Proportional – Integral Gain: g_p=-100, g_I=-20,000, τ=1



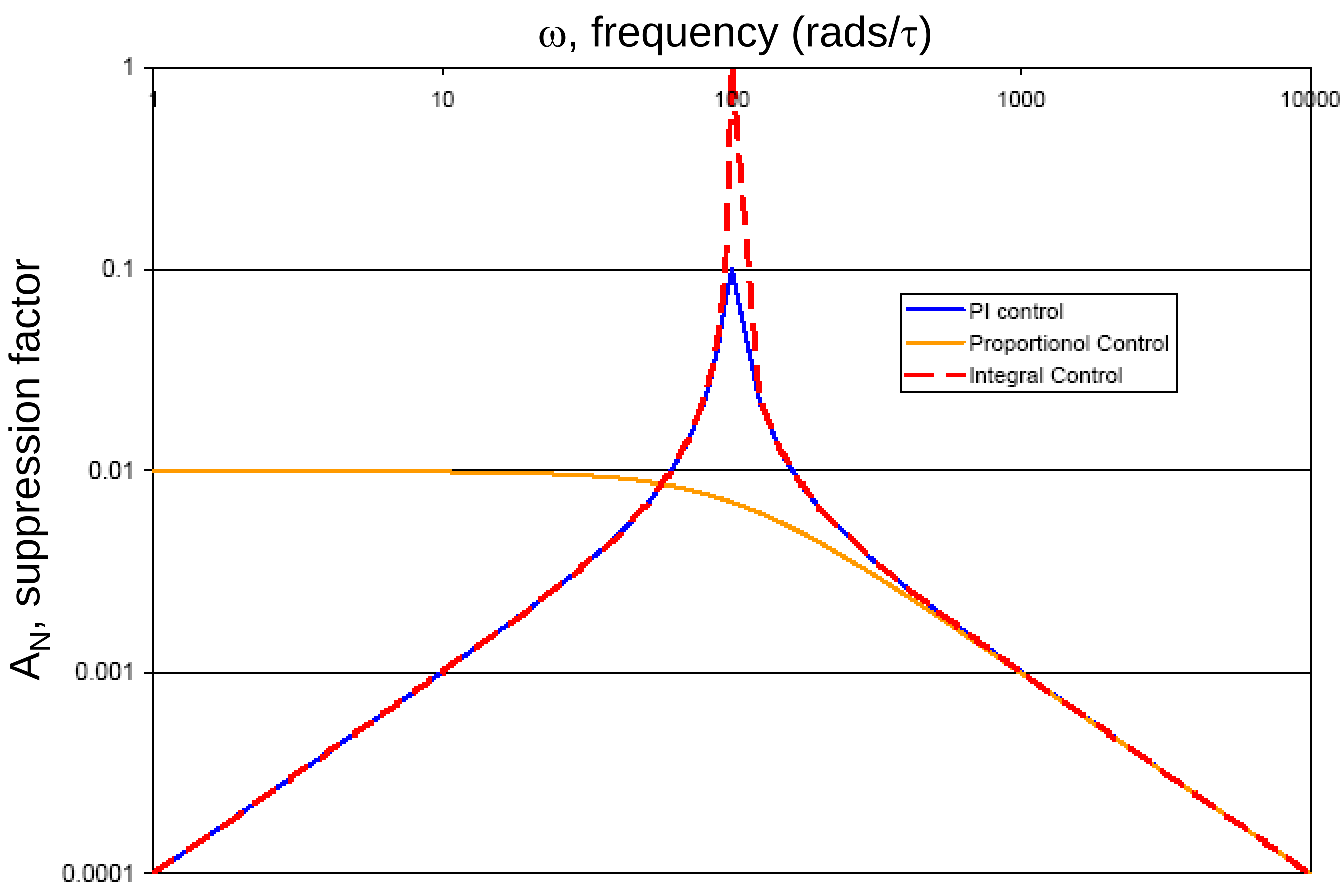
Fourier space: Noise suppression

Proportional – Integral Gain: g_p=-100, g_I=-4000, τ=1

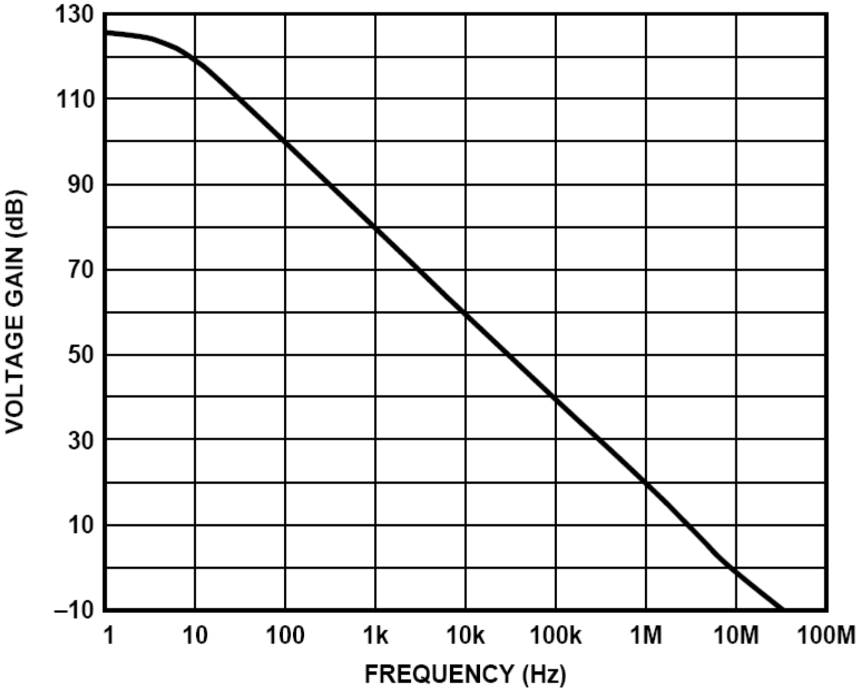


Fourier space: Noise suppression

Proportional – Integral Gain: g_p=-100, g_I=-10,000, τ=1



Reality: Gain is not flat



[From the OP27 datasheet]