1. Feedback Stabilization

* https://open4416.medium.com/passivity-and-its-connection-to-h-stability-2d91377b422f
  1. Passivity Control
* Passivity : remind

The system (9.8) is **passive** if semidefinite storage function such that

And the system (9.8) is zero-state observable if no solution of can stay identically in the set other than the zero solution In this section, is assumed **positive** definite.

* Theorem 9.1 If the system (9.18) is

1. Passive with a radially unbounded **positive** storage function and
2. Zero-state observable

then the origin can be **globally stabilized** by where is any locally Lipschitz function such that and

* Proof

Let the storage function as a Lyapunov function candidate for the closed loop system,

Then the derivative of is given by

Which is negative semi definite. By Lasalle’s theorem,

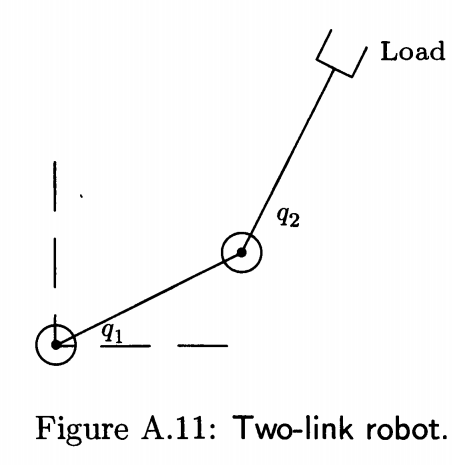
Hence the origin is asympt.stable. – The EnD-

* Ex.9.14

With

Select , then

And if with , . Hence the origin is asympt. stable by Theorem 9.1

* Ex.9.15

angle

: control (torque) input

a symmetric positive definite inertia matrix

centrifugal / Coriolis forces, viscous damping, gravity

1. Problem

Design such that

: to converge to zero, regulate to a constant reference

1. Design input : select

the controlled system is

The sum of kinetic energy and potential energy is,a storage function,

The derivative is

Since is a skew symmetric, (i.e,. A is a skew symmetric if ) , is a symmetric and positive semidefinite

Let us select and if , then

So that

Which is strictly output passive. For zero—state observable, with ,

🡪 , from

which is zero-state observable.Hence with the feedback

will stabilize the closed loop system asymptotically.

1. Analysis:

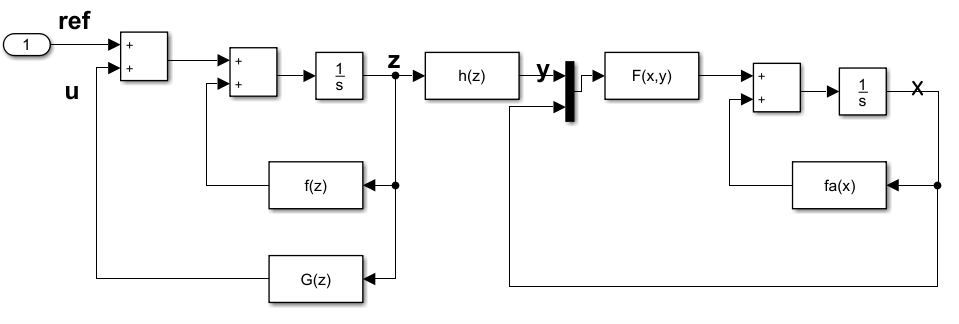
The original system is

With the controller

* such that
* These give a lot of design possibilities !!
* The difficulties to handle this problem is due to the non-linearity

However if is a skew symmetric, the controller does not depend on these non-linearity. WONDERFUL!!

* The other thing is the “damping ” or “viscosity “ D which is not one of the control parameters. You may think this damping will attributed the stability, however, if it is positive definite, then it does not matter to stabilize using “ passive controller”.
* Cascade system feedback passivation : Consider



Assume:

- Driving system : passive with a positive definite storage function

- Driven system: stable with a Lyapunov function

So that

* Theorem 9.2 (cascade feedback passivation)

Suppose

1. (9.24)-(9.25) is zero-state observable and passive with a positive definite storage function.
2. The origin of is asympt.stable with a Lyapunov function such that

Then with a controller

the system is stabilized.

* Ex. 9.16 Consider

First, consider is passive with and zero-state observable. The second , is globally exponential stable with Hence by the Theorem 9.2 the controller

-The EnD-

* 1. Control Lyapunov Function – skip