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Q1:



So, the first equation express as:



Laplace transform (assume the initial conditions is 0):



Because  , we can get:



Then, we can get two equations as follow:



The state-space representation of the system:



( ,  ,  )

First, let’s calculate  and 







Then, we can get the state-space representation of the sampled system.



Assuming the initial conditions is 0



Then, we can get 







,  is a unit step

Q2:

1. This system is not stable, because it has a multiple pole ‘0’.
2. No. Because the zero of the transfer function is ‘1’.

No.

If the pole is before sampling, after sampling, the pole will become  . So, if is not stable,  won’t stable.

Yes, after sampling, there may be a stable inverse.



Z domain:



There are two zeros:



Q3:

The eigenvalues of  are:. Not all the poles are negative, the system is not stable.



 is non-singular, so the system is controllable.



 is non-singular, so the system is observable.

Assuming all initial conditions are zero.





Input-output difference equation:









This equation has no solution. No matter what K is, this system is unstable.





If this is a stable system, according to the final value theorem, the final state is:



But the system is unstable, so we try to calculate 





Then, we can calculate the value of A, B, C







No matter what K is,  and  can not be the stable poles at the same time.

Q4:





There is a multiple positive pole ‘z=1’, the system is not stable.

There is a multiple positive zero ‘z=1’, the inverse system is not stable

Observable Canonical Form:



Then we can get controllability matrix and observability matrix:



. This is an observable but not controllable form.

No, we can’t realize this system controllable but not observable.

Controllable Canonical Form:



Then we can get controllability matrix and observability matrix:



.

But the in controllable canonical form, the transfer function is change. We can get three equations from the above state-space.



Since, it follows that





Therefore, the state-space model is corresponding to the transfer function , instead of 

No, the reason is same as c). Although  is both controllable and observable, we can’t get the conclusion that the original system is controllable and observable.