

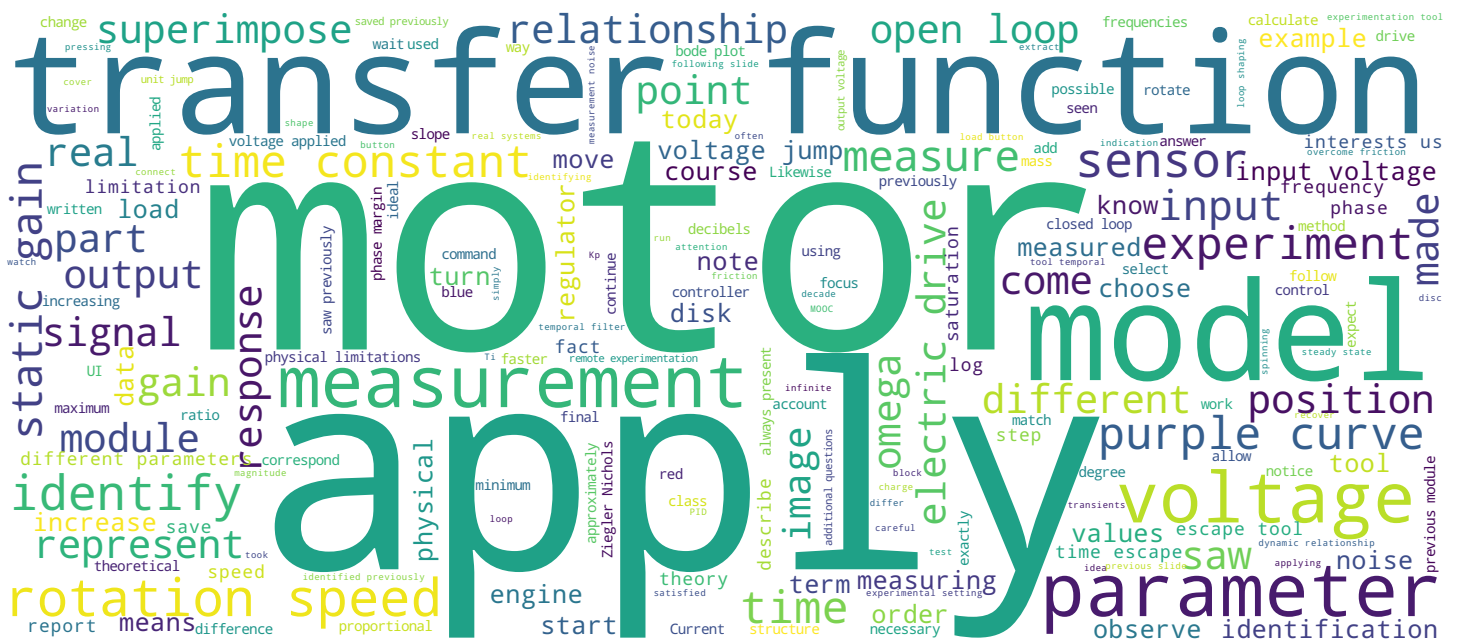
System Modeling

Parameters identifications using step response

Controls Systems' Hand on Sessions

Christophe Salzmann & Colin Jones

Automatic Control Lab



Search MOOC



Video





- Introduction to electrical drive
 - Differences between physical system and theoretical model
- Structure of model & transfer function
- Step response experiments
- Parameter identification

TP Control Systems

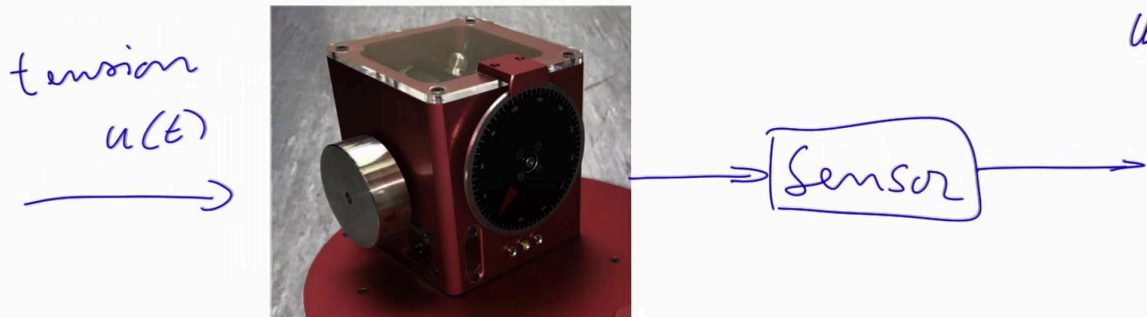
Good morning ! Welcome to this module which will cover the identification of a model. What we would like to model today, This is the electric drive that we saw in the previous module. We will focus on the structure of this model as well as the transfer function which will describe this model. In this transfer function, there will be different parameters that we will identify... And to identify them, we will apply a step to the open loop system and thus, we will be able to extract the different parameters that interest us. And you will be able to test all of this on the real system and you will see that there is a difference between the theory you saw in class and the actual parameters that you will identify. It will be necessary to pay attention to certain physical limitations of the system which differs from theory where we often have an ideal system.

Notes

Summary



0m 04s



TP Control Systems

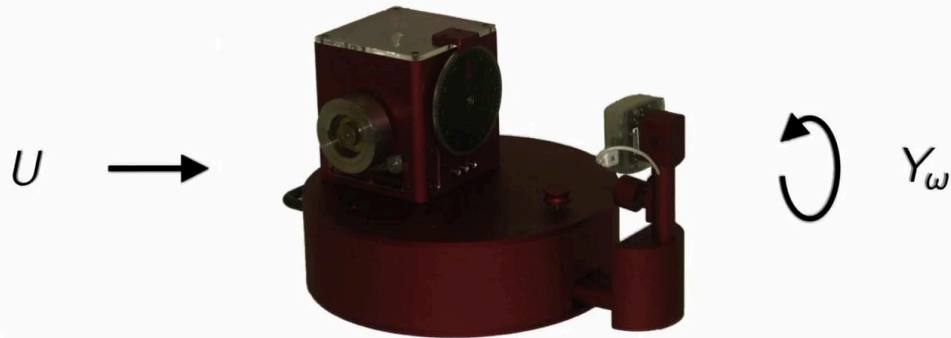
Here we have the electric drive that we saw previously. On this system, I apply a voltage U . This voltage will turn the motor. You will see the disk here, spinning, as well as the mass, the charge which will also rotate. Here you have a sensor which measures either the rotation speed, or the position of the disk. In fact, you have two sensors. And at the sensor output, you have a voltage U which is proportional to the rotation speed of the system for example, or the position of the disc.

Notes

Summary



0m 56s



What is the dynamic relationship between input [volt] and output speed [volt]?

TP Control Systems

What interests us is the relationship between the input voltage that I apply to the motor and the voltage that I measure on the sensor which is an image of the rotation speed of the motor. So it is this relationship that interests us and it is this relationship that we are going to describe through a transfer function.

Notes

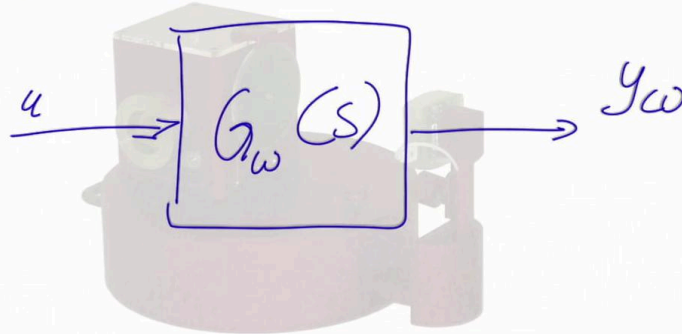
Summary



1m 37s

Model transfer function

$$G_w(s) = \frac{\gamma_w}{1 + sT}$$



What is the dynamic relationship between input [volt] and output speed [volt]?

TP Control Systems

I can represent the dynamic relationship between input voltage and output voltage through a transfer function. So the block that I have here, I'm going to represent it through a transfer function between the attention I apply and the image, here, Y_ω . The omega indicates that I am measuring the rotation speed, this transfer function. I have omega of S, can be written like that. Here you have a first parameter which is the static gain on a plus S. You have two settings here. The first which represents the static gain of the system, We will see what this corresponds to in the following slide. And here you have another parameter which represents the time constant of the system.

Notes

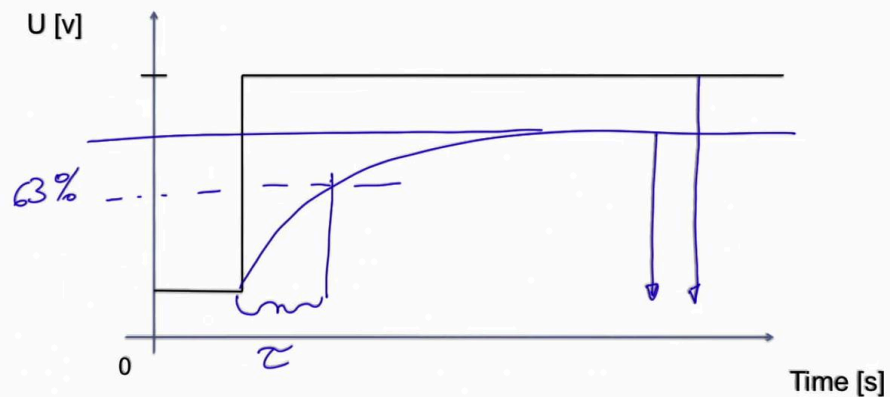
Summary



1m 58s

Model parameters

γ
 τ



TP Control Systems

The system transfer function has two parameters. We have the static gain and the time constant. It is possible to identify these two parameters by applying a unit jump to the input of our electric drive and measuring the signal response. The answer will be like this and we will see what these two values correspond to. The first, the static gain, is the ratio between the input value and the output value of the signal after the transients are over. Likewise, the time constant is measured at 63% of the final value of the system. Here we have approximately 63%. and the time constant represents this time here... You see here, a graphical representation of the two parameters of the transfer function seen previously.

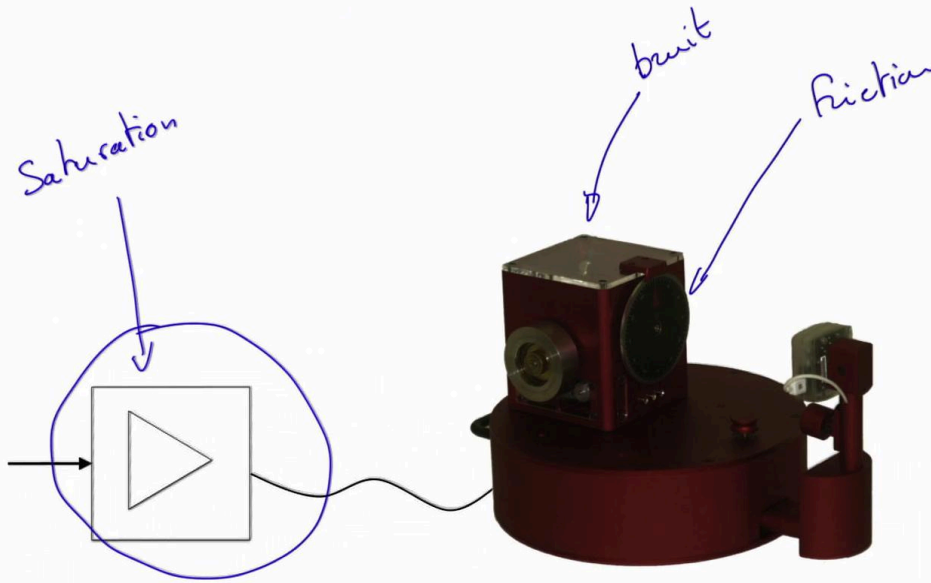
Notes

Summary



3m 00s

Physical system



TP Control Systems

In this MOOC, you will work with a physical system and this physical system has limitations. The first limitation you will have, it comes from the system power supply. This supply is not infinite. You cannot apply 100,000 volts across the motor terminals. So here, you will have a first limit, saturation at the system level. Likewise, here, as we saw in the previous slides, there are lots of mechanical parts and you will have several kinds of friction and rubbing on your system. Currents and drives, and so on. And there is a third difference between a theoretical system and the physical system, is that here we have sensors and these sensors have measurement noise. And you will see it in your different experiences that the noise is always present or almost always present. In any case when you measure the rotation speed of the motor. You can't avoid this noise. It comes from the technology that is used to make the sensor.

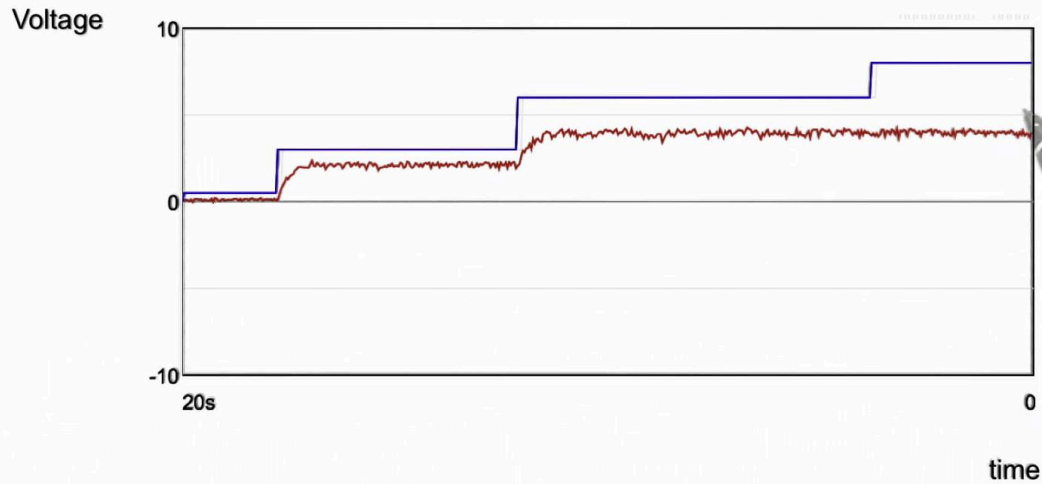
Notes

Summary



3m 56s

Physical system



TP Control Systems

Here you have a measurement made on the real system. In blue, it is the voltage applied to the motor and in red, it is the image of the rotation speed of the motor. We see that here, when the voltage is low, even if the voltage applied to the motor is different from zero, the motor does not turn and the measurement is always at zero. This means that the applied voltage is not strong enough to overcome friction. Then the voltage increases, the motor starts to spin faster and faster as the tension increases. But at the last increase in tension, the motor always runs at the same speed and we see here that we have reached saturation of the system.

Notes

Summary



5m 03s

Experimentation 1 – Identify linear range



- Connect to the system
- Select the open-loop & speed mode
- Increase the motor voltage, starting from 0[V]
- Observe when the disc starts to turn
Take note of the applied voltage
- Keep increasing the voltage until saturation
Take note of the applied voltage when reaching the saturation
- Report the linear range

TP Control Systems

So now it's going to be up to you to do your first experiment on the real system. You will log in to the system, you will choose the remote experimentation tool, you will be careful to be an open loop and measure the rotational speed of the motor and you will start your experiment by increasing the rotation speed, starting from zero and going up to maximum speed. You will gradually increase the speed and watch when the engine will start to run. When you will note this value and you will continue to increase the voltage that you apply to the motor until a variation in the input voltage no longer influences the rotation speed of the motor. And thus, you will have an indication of the saturation value of the engine. You will note these two values and you will report it in the NX interface.

Notes

Summary

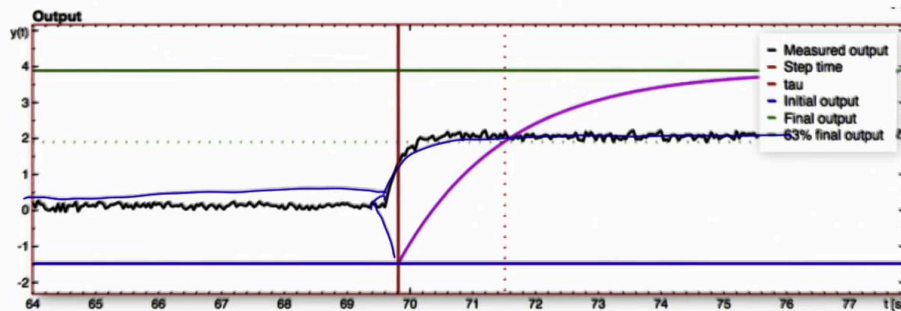


5m 39s

Parameters identification via model fitting

Idea:

- Superimpose a simulation (pink) on the top of the measurements
- Interactively change the shape of the curve to modify the simulation parameters
- When the two overlap (within experimental error), we have a reasonable system model



TP Control Systems

Now we will move on to identifying the parameters of the response. The idea here is to superimpose a theoretical model which is represented by the purple curve, here, above the measurement you made and saved previously. You will load a measurement that you have made and you're going to move this purple curve so that she comes here to follow the signal perfectly that you measured. Once the purple curve overlays your measurements, you will know that the purple curve simulation parameters will match the experimental settings of your system.

Notes


Summary



6m 32s

Experimentation 2 – Step response



- Connect to the system
- Apply step input within linear range
- Observe response
 - Is it within the linear range ?
 - Is the response what you expect ?
 - ⇒ If not, redo the experiment !
- Save measurements for the next step by clicking in  your UI

TP Control Systems

This second experiment aims to identify the parameters of the system. To do this, we will apply an impulse jump to the system. In this first part, we will apply this voltage jump which will be included in the linear domain that we identified previously. To do this, we will log into the system, wait until it's our turn, apply a voltage jump between a minimum and maximum value. We will observe the response. Is this what we expect? If yes, we will save the data to be able to recover them in the time escape tool.

Notes

Summary



7m 08s

Experimentation 3 – Temporal model fitting



- Select the temporal-fit tool
- Load saved measurements using
- Select the model to fit
- Fit the model
 - When satisfied, note the parameters
- Report the parameters and answer the additional questions

TP Control Systems

In this second part, we will superimpose a model of the system on the measurements we made. To do this, we will select the time escape tool. We are going to load the measurements that we made previously by pressing the load button. We will choose the model that we want to superimpose and we will superimpose the purple curve on the measurements we took. You will notice that the purple curve settings, static gain and time constant change in your UI. Once you are satisfied with your overlay, you will note the two parameters and report them in the EDX interface as well as answer additional questions.

Notes

Summary



7m 42s

Conclusions

What you have learned today

- An electric drive can be reasonably approximated as a first order model
- Two parameters to fit : time constant and steady-state gain
- Parameter identification by fitting a simulated model to experimental measurements
- Physical limitations must be considered when estimating a model

TP Control Systems

We have seen that to identify these two parameters, you can apply a voltage jump to the system and then use the tool temporal filter to identify them. In future modules, we will see other methods of identification. Finally, we have seen that these real systems have physical limitations and that we must take this into account during our experiments.

Notes

Summary



8m 23s