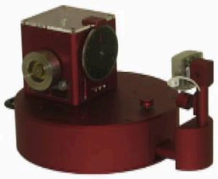
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE



Introduction

Controls Systems' Hand on Sessions

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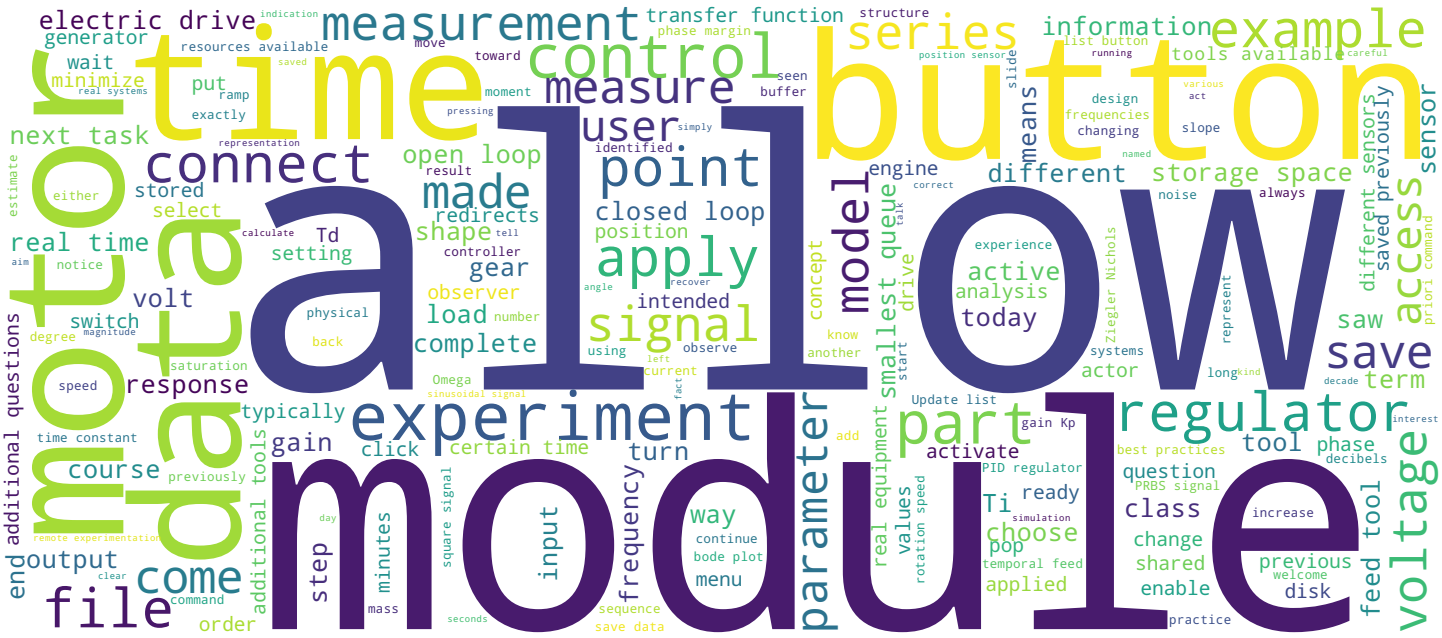
Automatic Control Lab



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Video

EPFL

Objectives

- Be able to apply automatic control concepts
  - Master the steps necessary to implement a PID controller
- One module: analysis/design, experimentation, validation and questions
- Remote experimentation on real equipment
- Additional tools for analysis
- Differences between physical system and theoretical model

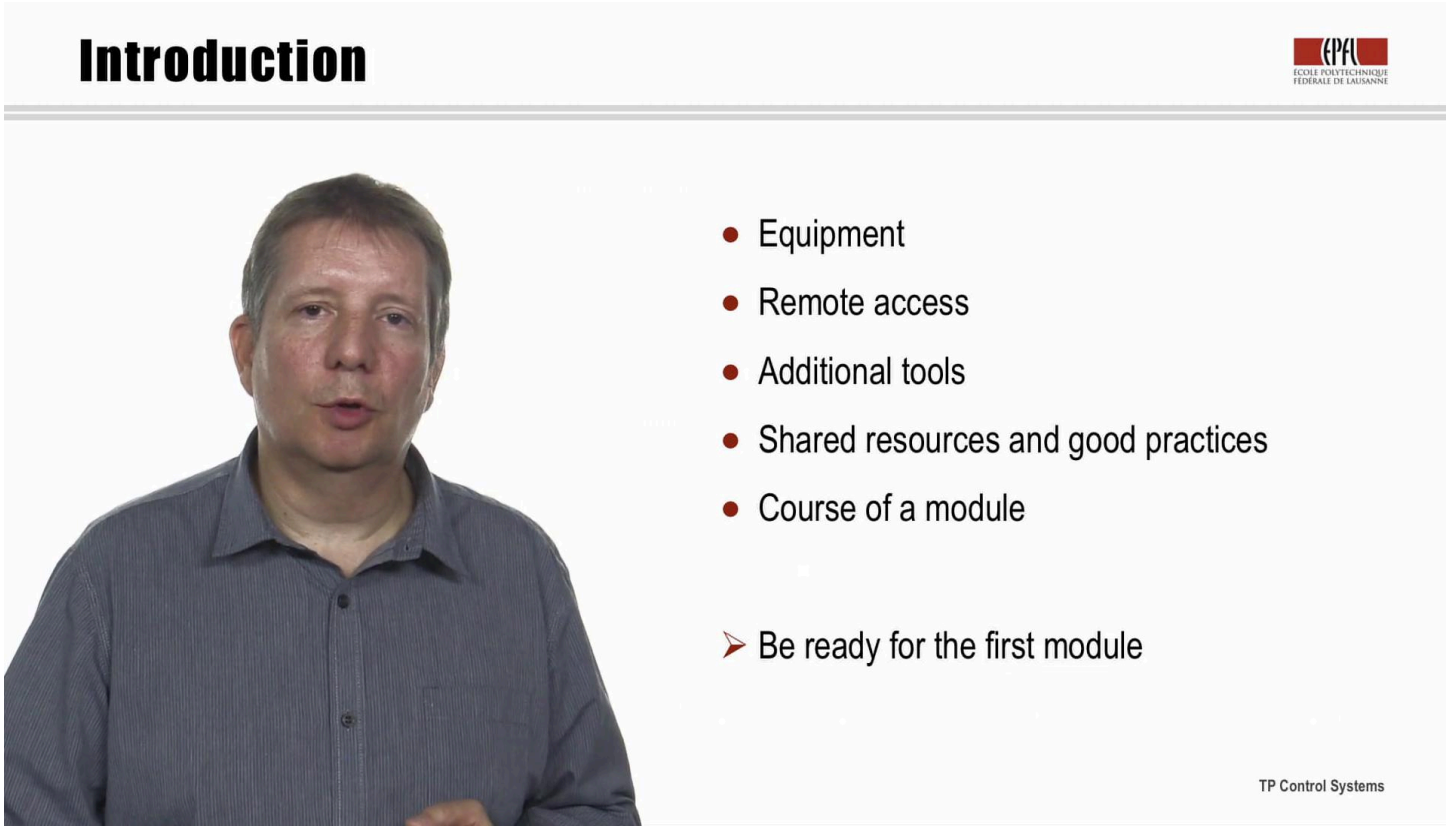
TP Control Systems

Hello and welcome to this series of modules intended for experimentation remotely for practical automation work. Each module is intended to enable you to put into practice a concept you learned in class or a series of concepts that you have seen in class. Each module, you will have a first part of analysis and design, a part of remote experimentation on real systems, as well as a validation part of your results and additional questions. Through these modules, you will access real equipment who are physically in our laboratories and you will be able to control them remotely. Likewise, you will have additional tools which will allow you to carry out analysis on the measurements that you made on real equipment. You will see, during these modules, an important difference between physical systems with their constraints and limitations, compared to the theoretical systems you saw in class.

Notes

Summary

0m 04s



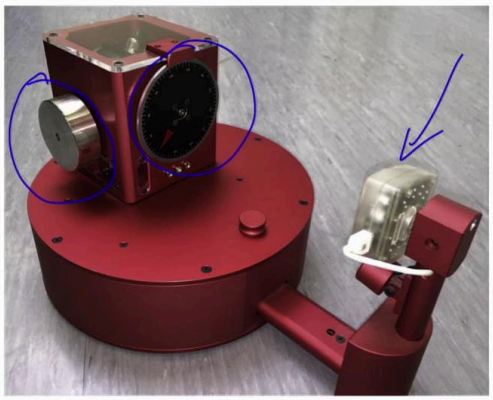
The aim of this first module is to familiarize you with the different tools available to enable you to complete these modules. We will see how you can access the different equipment remotely, additional tools which will allow you to analyze this data, I will also talk to you about how the resources available are shared between all users and give you some best practices. And we will end up explaining to you how a module works. At the end of this first module, you should be ready to complete the various other modules.

Notes

Summary

1m 00s

Electrical drive



- Two motors:
  - 1st motor drives a load
  - 2nd motor acts as a generator
- Visualization disc
- Position sensor
- Camera

TP Control Systems

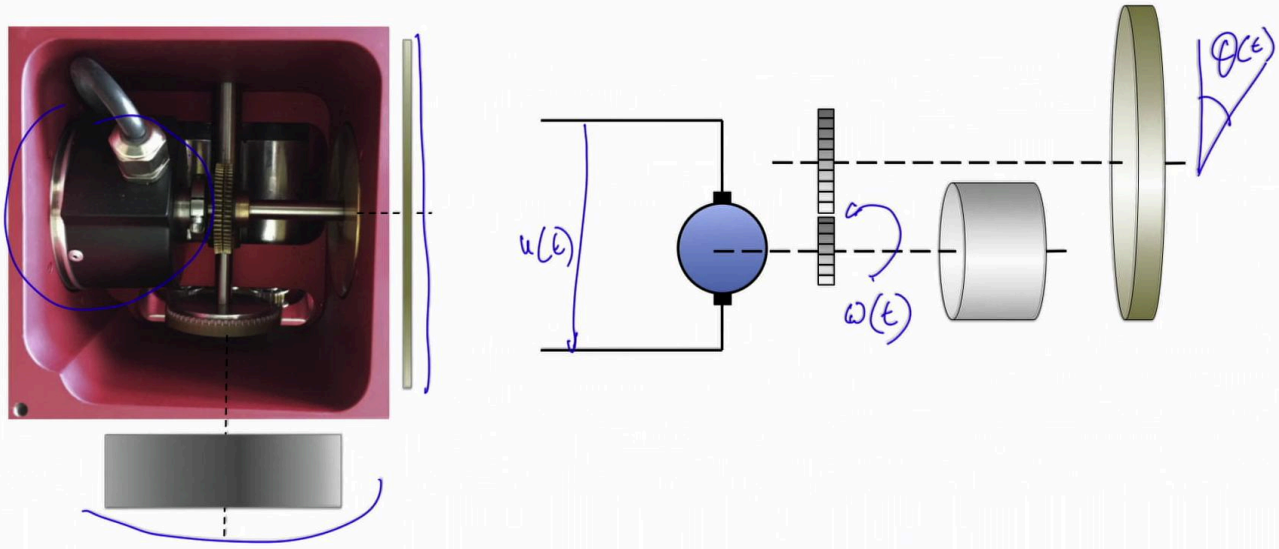
To begin, I will quickly introduce the system to you which you will connect to. It's an electric drive which is made up of two motors, you will see it in a moment. There is a viewing part through the disk that you have here which tells you the position and you also have a load that is connected to the motor, which is driven when the engine is running. You are also going to have different sensors internally, we will see it on the next slide, and you also have here a camera which films the system and which will give you a real-time image of what's happening on your system.

Notes

Summary

1m 31s

Electrical drive



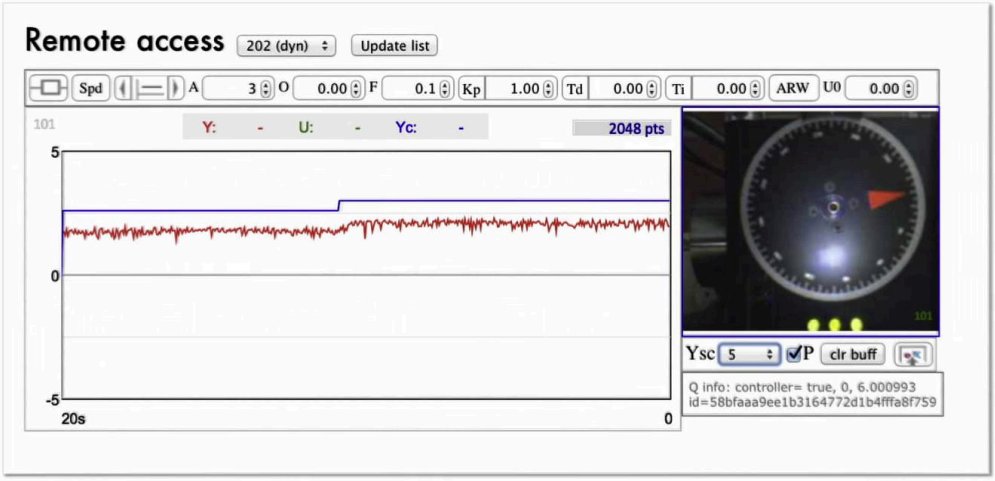
Here you have a top view of the system with a motor and a generator. It is a motor which is mounted as a generator. Here you see a belt that drives the axle with here, you have the mass and here you have a gear and here you have the viewing disk. Here, what you see here is the position sensor channel. Here you have a representation of the system. Here you have the engine. If I apply voltage to the motor at any given time, this motor drives a gear and you will drive the load. Here you have a sensor that measures you the rotation speed of the load. You have a gear and here you have the disk with a second sensor which will measure the angle of rotation of the system. That's for the physical system, Now we will see how this system is remotely interfaced.

Notes

Summary

2m 09s

Using a recent web browser



TP Control Systems

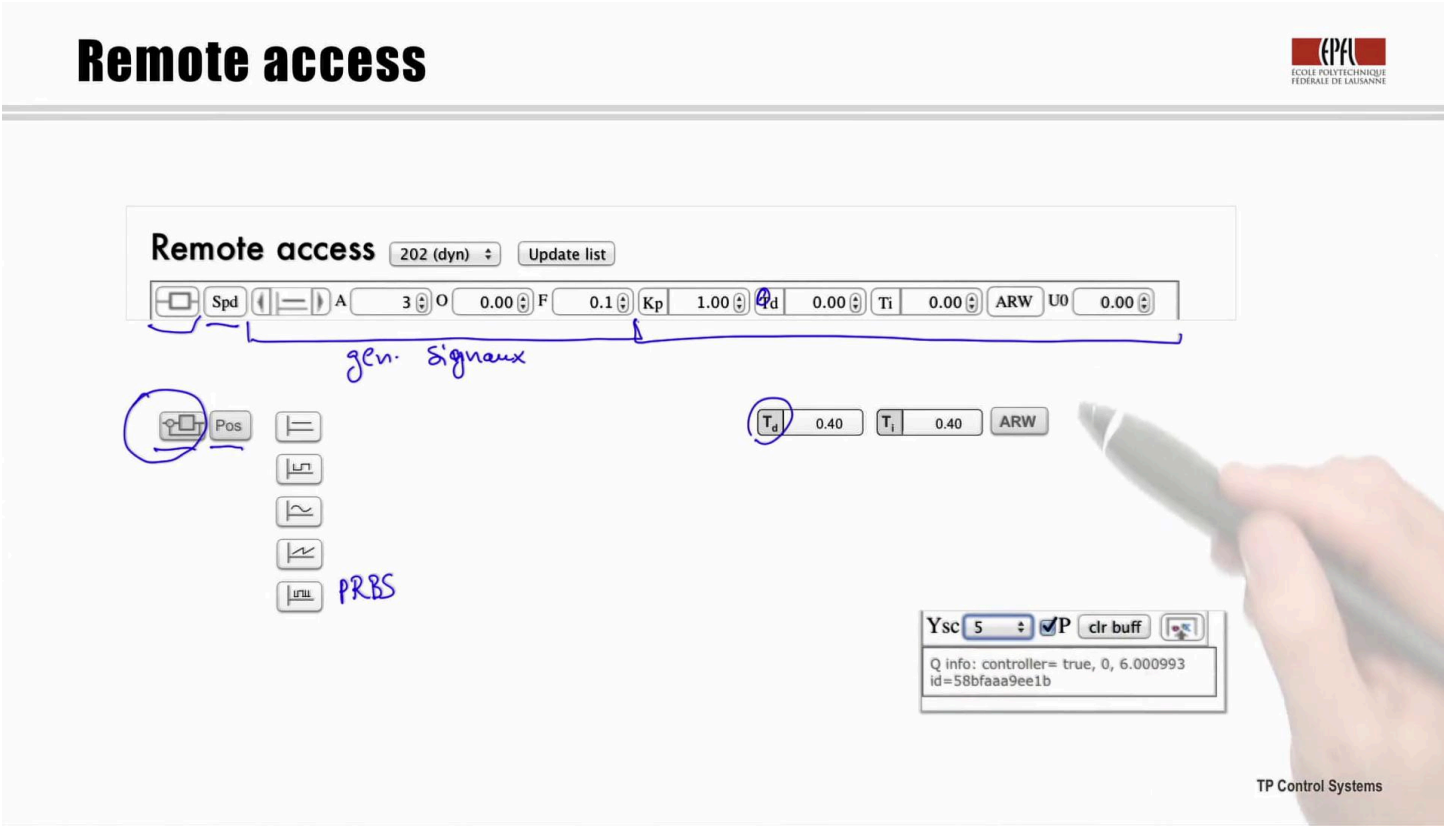
The standard interface for such a system is through a web browser. and you have here typically the interface that you are going to have with here, on the left, the video image in real time of the system you control. You have here a large part which represents a kind of stethoscope where you have the measurements made with the different sensors. Here you have a part that allows you to control the system remotely. So you can change them, settings of, for example, the voltage that is applied to the motor and the parameters of your regulators that you will calculate subsequently. Here you have your system number which is dynamically allocated as well as other features which will be explained in the following slide.

Notes

Summary

3m 10s

Remote access



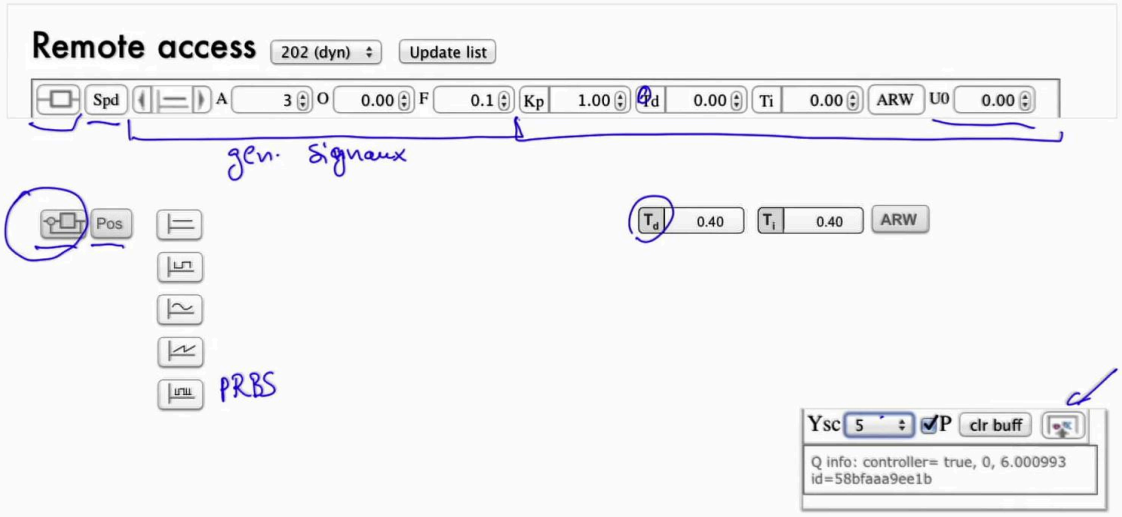
Here you have the same view as before, but you enlarged the part which allows you to remotely control the system. You have a first part here which allows you to choose the structure of the system, if you are in open loop or closed loop, likewise, you can decide to access to the sensor that measures speed or the sensor that measures position. This part here will allow you to control the signal generator. Here you can choose the shape of the signal. You have a signal at 0 volts, you have a constant signal, a square signal, a sinusoidal signal, a ramp, or a PRBS signal which will be used subsequently. And you can also control the signal amplitude, the signal offset and the signal frequency, as long as we need a frequency. This other set of buttons allows you to control the regulator. Of course, for these buttons to be active, you need to be in a closed loop here. And you have here typically the different values to enter the parameters of a PID regulator. You have the gain, Kp, the Td and the TI. For this Td and this Ti to be active, you have to come and click on this button and it will come grayed out as shown here. At that time, these values will be active.

Notes

Summary

3m 54s

Remote access



TP Control Systems

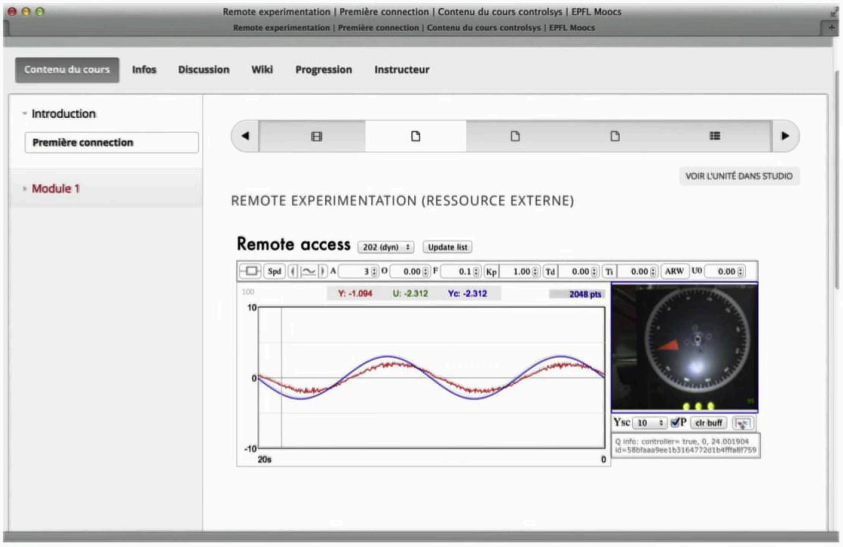
You also have the button to activate the anti-reset windup command and here, the last part, the a priori command that you can apply to the system. At the bottom right you have another set of buttons, the first button that allows you to save the data in the edX environment which allows you to save the measurements that you are going to make. Here you have a button that allows you to clear the display. Here you have a pop-up menu which allows you to choose the signal display scale and you have a button that allows you to display the internal states of the regulator or not. Here you also have some information on the system you are connecting to.

Notes

Summary

5m 17s

Remote access via edX



TP Control Systems

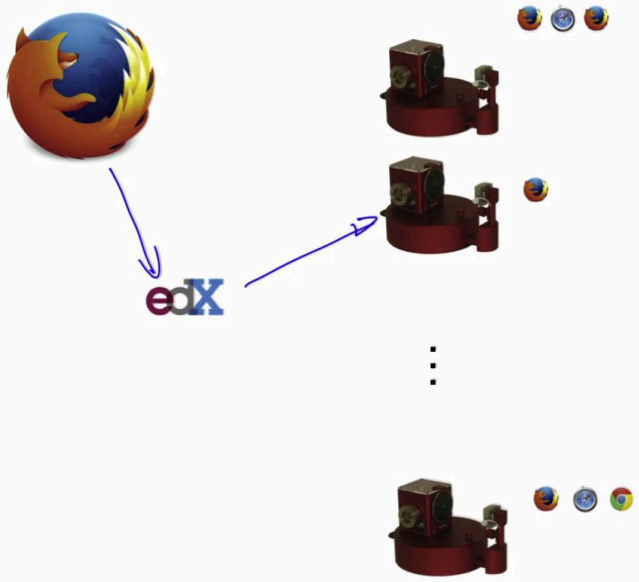
On this slide, you see the experimentation interface remote integrated into edX. The first video is the one you should see and then you have a series of modules that allow you to access remotely and you also have questions. To connect to the system, you need a recent browser, because we use WebSockets for transmission.

Notes

Summary

5m 58s

Resource sharing



- >20 devices are available
- There are more students than devices
- A load balancer spreads the load among available devices
- You will be directed to the device that has the least number of waiting users

TP Control Systems

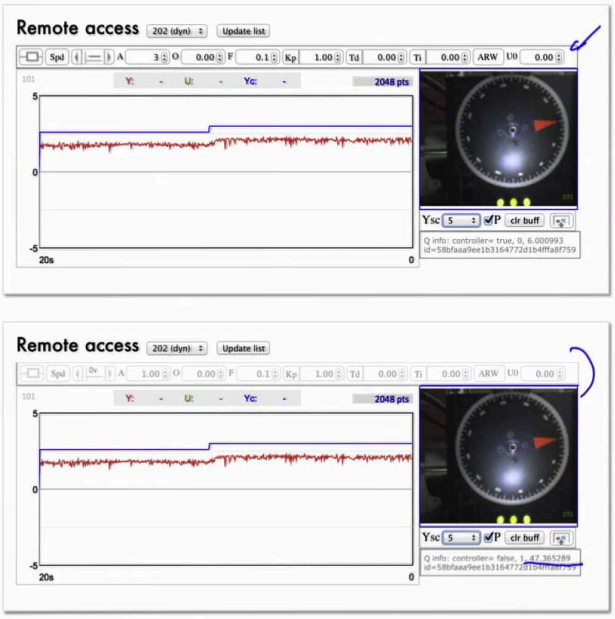
There are more than 20 electric drives, all identical, which are at your disposal. There are of course many more of you than these 20 workouts and we have set up a system that redirects you towards the electric drive which has the smallest queue. Here, when you connect through edX, edX queries the different modules in real time and redirects you to the one with the smallest queue.

Notes

Summary

6m 21s

Observer / controller mode



- On each device there can be
  - Many viewers/observers
  - One controller
- If you want to act on the device and if someone else is already using it, you will have to wait
- Experiments are meant to be short (1-3 min)
- Once you're done with your experiment, the next user will have controller role to act on the system. If no one else is waiting, you can continue

TP Control Systems

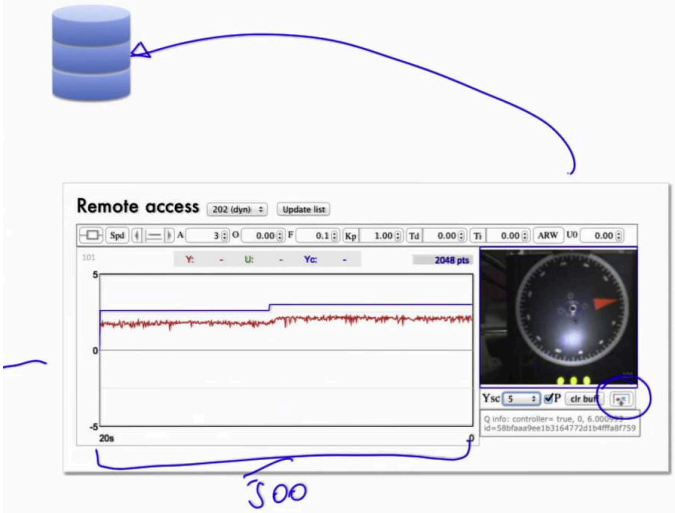
For each device, there can be several users. Among all users, there is only one who can act, it is in this example, the one at the top, and all other users will be observers. We notice here an observer because the control bar is gray. There is a twist, the person who is an actor can be an actor for a certain time, between one and three minutes, and users who are observant will have to wait a certain time and an estimate of this time is given here in seconds. All the experiments you are going to do on these systems are intended to be short, in one and three minutes. That means you won't have to wait long for your turn to come. Once your experimentation time is over, it will be up to the next user to control the system. If there is no one in the queue, you can continue to experiment on the current system.

Notes

Summary

6m 47s

Saving measurements



- Each registered user has a limited space available to temporally save measurements
- Remote experiment measurements can be saved in this space
- This space is personal and the only access to these data is through provided tools

TP Control Systems

To be able to record experimental data and reuse them with other tools, you have storage space available. This storage space is personal and you can access it only through the edX tools. To save data in storage space, you activate this button and the entire buffer that you have, that is to say the information which is there, which represents approximately 500 points, plus the points that are here, which were recorded previously, will be stored in an internal database. Here you have an indication of the buffer size. In this example here you have 2048 points stored in the buffer and that means you will have 2048 points which will be stored in your personal space, once you click on this button.

Notes

Summary

7m 40s

Analysis tools

- Other interactive tools are provided to analyse data/ measurements
- These tools can access your personal storage
- Your data are saved with the following format: Data_yyyymmdd-hhmmss.txt

TP Control Systems

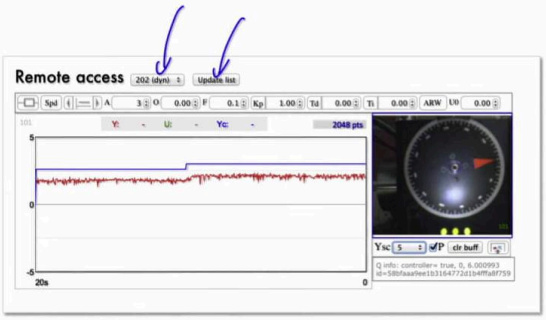
Other tools will allow you to access the data that you have stored. Typically, here you have the time feed tool and you see here, the temporal feed tool has identified you and he will come and take the data that you saved previously and you put this information in a pop-up menu. Here, the last file you saved and displayed, you can go and select the files you saved previously. Here you select your file, you press the Load button and here you see the measurements you have made on the system. You have the option to delete this file. Be careful, with this function, there is no possibility of going back. Once the file is deleted, it is lost for life. So that you can find your way through the files you saved, files are named with the following format: you have data and then a timestamp where you have the year, month and day of the recording, as well as the precise time to the second. You can thus precisely select the file that interests you.

Notes

Summary

8m 34s

Best practices



- Available resources are shared
- Once you have completed your experiment (and saved relevant data) switch to the next task to shorten the waiting time
- If you reload your page you'll be put at the end of the waiting queue
- The same applies if you switch to the next/previous task
- You can ask the load balancer to provide you with the list of available devices

TP Control Systems

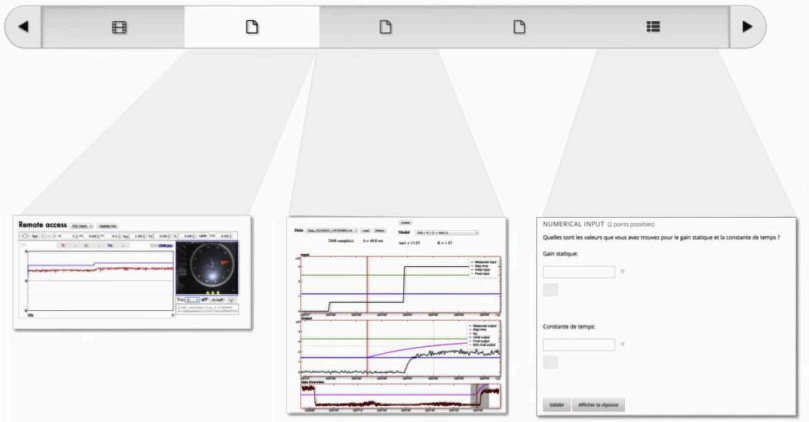
I will now give you some best practices for the use of the tools available. The resources available are shared between all users. You will therefore try to minimize the time that you spend on each experiment. One way to minimize this time is, once you have finished your experiment, to move on to the next task. However, you will not forget to save the data you have made. If you moved on to the next task and forgot to save data, you will be able to start your experience again. If you reload the page in your browser, you will find yourself at the end of the queue. Likewise, if you switch to the previous or next task in the edX module. At all times, you can press Update list button who will update the list for you which is located here equipment available. By default, you have been redirected to the system that has the smallest queue. By pressing the Update list button, you can dynamically update the list of available equipment and come and connect to specific equipment.

Notes

Summary

9m 38s

Course of a module



- Video
- Instructions
- Remote experimentation
- Analysis
- Validation
- Additionnal questions

TP Control Systems

The sequence of a module is more or less standard. First you have an introductory video, then you either have an experiment or a simulation. You also have some written instructions, then you have a series of questions to see if the settings you have, for example, identified on the system are correct. And then you have a series of additional questions.

Notes

Summary

10m 44s

Now it is your turn

- Connect to the electrical drive using the remote access interface
- Modify the signal applied to the motor
- Save your measurements in your data storage
- Display the stored measurements within the temporal-fit tool
- Delete the measurement file you have just saved

➢ Your are ready for module 1

TP Control Systems

There you go, now it's going to be your turn, you will connect to the system with the available interface, you will wait until it is your turn, modify, for example, the voltage that you are going to apply to the motor also changing the shape of the signal, you will save the steps you make in your storage space, you will switch to the temporal feed tool and you will recover your data. Once you have seen, visualized your data, you can erase them, like that you will have a clean place for your first module. Once you have successfully completed all these steps, you will be ready to complete the first module.

Notes

Summary

11m 10s