

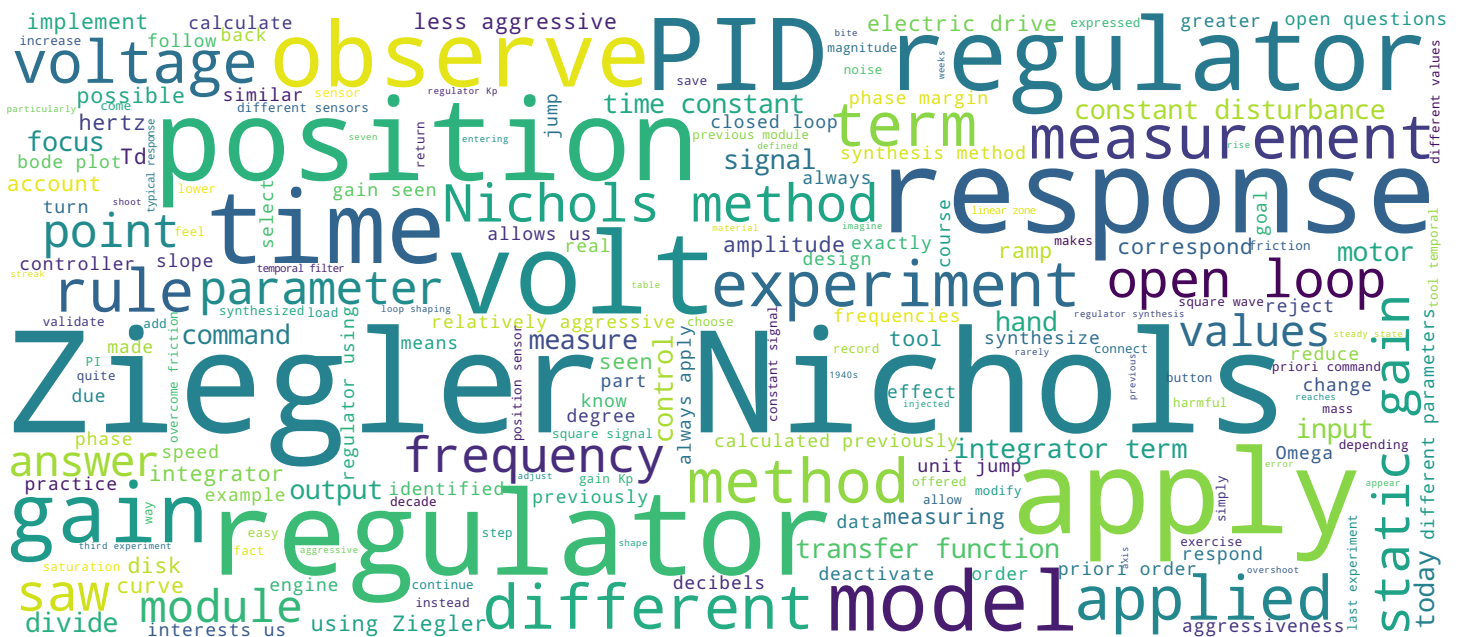
Synthèse du régulateur

Contrôle en position avec Ziegler-Nichols

Controls Systems' Hand on Sessions

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Automatic Control Lab



Search MOOC



Video





- Contrôle en position vs vitesse
- Synthèse - 1^{ère} méthode de Ziegler-Nichols
- Calcul des paramètres
- Règle des deux
- Exercices et validation

TP Control Systems

Bonjour. In this module, we will focus on to control the position of the electric drive. We were previously interested in the speed control of this system. For this, we will use the method of Ziegler-Nichols to synthesize the regulator. We will see how to calculate the different parameters. We will also look at the rule of two which allows you to make a regulator calculated by Ziegler-Nichols that is less aggressive. Finally, we are going to do some exercises to validate the regulators that we have synthesized by the Ziegler-Nichols method.

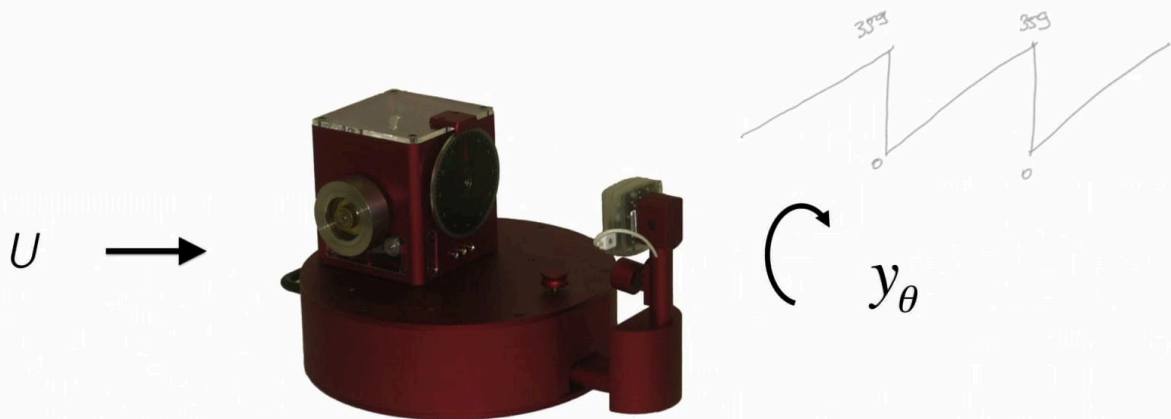
Notes

Summary



0m 04s

Mesure en position



La position est remise à zéro à chaque tour

TP Control Systems

In this module, we will use the same electric drive as in the previous modules. However, instead of measuring the angular velocity of the mass, we will focus on the position of the disk. We will always apply a voltage U to the system and this time we will measure the position of the disk through a sensor. The measurement is the angle θ that we see here, therefore the output y_θ . This output is expressed in volts, between plus or minus 5 volts and as the system runs infinitely, the voltage will rise, go up then when it reaches for example 359 degrees, it will return to zero and then go back up and so on. Another dash here.

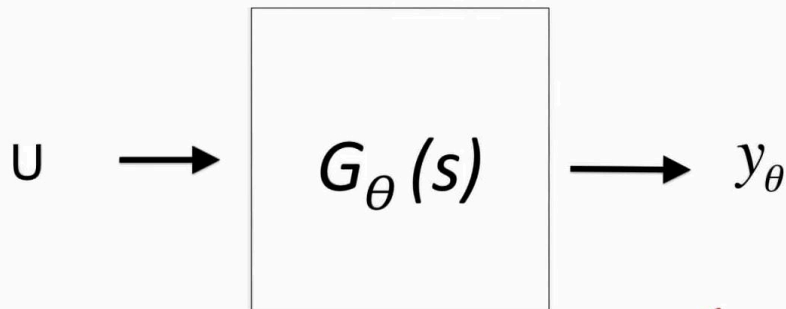
Notes

Summary



Fonction de transfert en boucle ouverte

$$G_{\theta}(s) = \frac{\gamma_{\theta}}{s(\tau s + 1)}$$



$$\gamma_{\omega} \neq \gamma_{\theta}$$

TP Control Systems

The transfer function of our open loop system is very similar to the one we had for the speed system. Only we see here an integrator term which is due to the measurement of the position. We also see here that we have the static gain like before. The gain is the gain seen by the position sensor and the greater the gain seen by the speed sensor. So the static gain that we had previously is not at all equal to the static gain we have for the position. On the other hand, the time constant, it is similar to the one we had previously. Intuitively, we feel that the time constant of the system should look like the one we have previously. Nothing changes. On the other hand, the measurement that we do through two different sensors implies that the static gain is different.

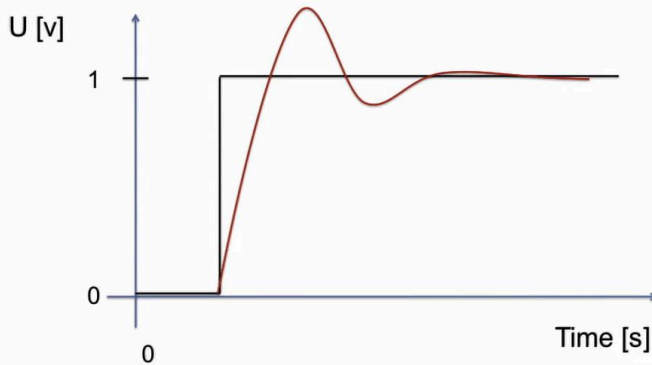
Notes

Summary



1m 27s

Synthèse - 1^{ère} méthode de Ziegler-Nichols



- Facile à implémenter
 - Appliquer un saut en boucle ouverte
 - Pas de connaissances a priori nécessaires
- “Agressive”
 - Réduire le gain
- Dépassement
 - Ne convient pas à tous les systèmes, par ex. commande d'axe de machine outil

TP Control Systems

The regulator synthesis method that we will see today is the first Ziegler-Nichols method. It is a method that was defined in the 1940s. This figure represents a typical response to a unit jump for a system which was synthesized using Ziegler-Nichols. This method is relatively simple and easy to implement. Just apply an open loop jump to the system to be able to find the information necessary for the design of the PID regulator. There is no a priori knowledge to have. On the other hand, what we see is that the answer is relatively aggressive. There is an overshoot which can be harmful in certain cases. Just imagine that you are going to control the axis of a machine tool and if you have an overshoot like that, you're going to bite into the material. In a few weeks we will see how to reduce the aggressiveness of the regulator designed by Ziegler-Nichols.

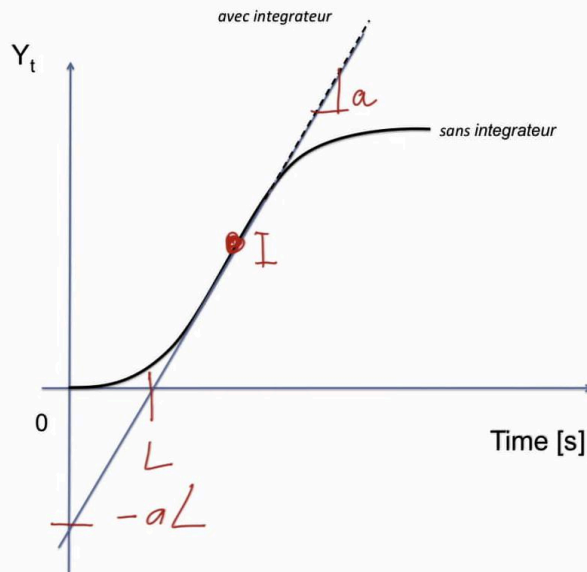
Notes

Summary



2m 23s

1^{ère} méthode de Ziegler-Nichols



Z-N 1^{ère} méthode

- Appliquez un saut en boucle ouverte
- Identifiez les paramètres clés a et L
- Calculez les paramètres des régulateurs P, PI, PID à l'aide de la table de Z-N

TP Control Systems

The first Ziegler-Nichols method works as follows. Here you have the answer of a system either with an integrator, either without an integrator and we will focus on a few key parameters. The first parameter that interests us is the slope of this curve here. We see that here we have our inflection point I and the slope of our curve here which we define as a . There is also the other point that interests us, it is this value L , this is when the line intersects the time axis. We also have here the value minus a times L . Once we have identified these values a and L , we can, using a table provided by Ziegler-Nichols, calculate the parameters of the different P, PI or PID regulators.

Notes

Summary



Table – 1^{ère} méthode de Ziegler-Nichols

Contrôleur	K_p	T_i	T_d
P	$1/aL$	-	-
PI	$0.9/aL$	$3 L$	-
PID	$1.2/aL$	$2 L$	$L/2$

- En pratique, l'amplitude du saut de tension est souvent différente de 1
- Il faut en tenir compte et diviser a par l'amplitude du signal appliqué

TP Control Systems

Here you have the table for the first Ziegler–Nichols method by entering your different values a and L and depending on the regulator you find, you can find the values of the different parameters K_p , T_i or T_d . In practice, it is rarely a unit jump that you have applied to your system. So you need to take that into account and divide a to account for of the amplitude of the signal that is applied.

Notes

Summary



4m 12s

Expérimentation 1 – PID avec Z-N



En boucle ouverte et mesure de la **position**

- Appliquez un saut dans la zone linéaire ($\sim 0.7 - 2$ [V]) et sauvez le résultat
- Utilisez l'outil de fit-temporel, chargez la réponse du saut et ajustez le modèle pour identifier les valeurs a et L
- Employez la table de Z-N's pour trouver les coefficients du régulateur PID

TP Control Systems

In this first experiment, we will synthesize into a regulator using the Ziegler-Nichols method. To do this, we will first do an open loop measurement. by measuring the position response of the system. We will apply a jump in the linear zone between about zero-seven and two volts and we're going to record the result. Next, we will use the tool temporal filter. We will select the model that corresponds to the one we have and we will adjust the values of a and L . Once we find these two parameters a and L , we will look in the Ziegler-Nichols table which corresponds to the first method to find the gains of a PID regulator.

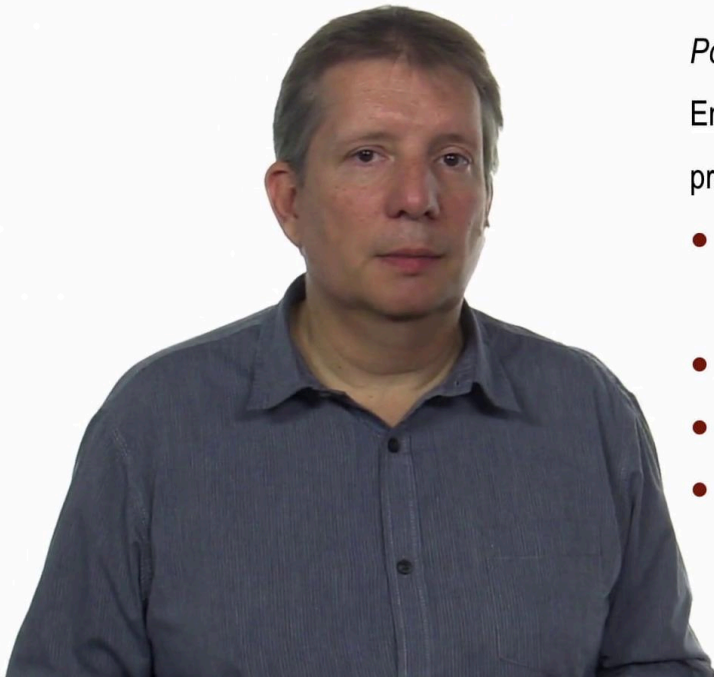
Notes

Summary



4m 37s

Expérimentation 2 – validation avec une rampe



Poursuite d'une rampe sans trainée

En utilisant le régulateur PID calculé précédemment (expérimentation 1)

- Appliquez une **rampe** entre -1 et 1 [v], avec une fréquence de 0.05 [Hz]
- Observez la réponse
- Désactivez le terme intégrateur du contrôleur
- Observez la réponse

TP Control Systems

The goal of this experiment is to continue a ramp without drag. We will use the previous PID regulator. We are going to apply a ramp between plus or minus one volt with a frequency of 0.05 hertz and you will observe the response. Does your system correctly follow the ramp that is injected? Secondly, you will deactivate the integrator term and you will observe the response. Normally a streak should appear.

Notes

Summary



5m 17s

Expérimentation 3 – PID & signal carré



En utilisant le régulateur PID calculé précédemment

- Appliquez un signal carré entre -1 et 1 [v], avec une fréquence de 0.05 [Hz]
- Observez la réponse (commande)
- Désactivez les termes D et I du régulateur
- Observez la réponse (commande)

TP Control Systems

In this third experiment, you will always use the same PID regulator, but this time with a square wave, always between zero and one volt. And you will observe the response of the system and more particularly the command that is applied to the system. You will then deactivate the d term and the I term of the regulator and you will observe the command again. You will then answer the open questions which are offered in this module.

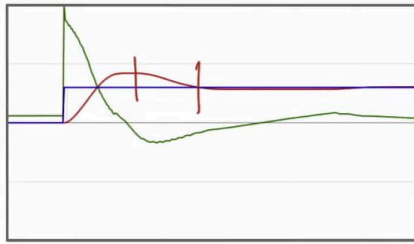
Notes

Summary

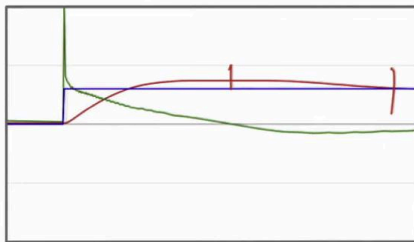


5m 44s

"Règle des deux"



Sans règle des deux



Avec règle des deux

- La règle des deux est une solution empirique pour rendre moins agressif un régulateur défini à l'aide de Z-N.
- Elle divise K_p par 2 et multiplie T_i et T_d par 2

TP Control Systems

Synthesis of a regulator using Ziegler-Nichols product often a regulator that is very aggressive. One method to make him less aggressive is the rule of two. It is an empirical rule that divides the gain K_p by two and which multiplies T_i and T_d by two. Here we see the first system with a Ziegler-Nichols response. We see that we have a fairly steep slope, strong overruns, but on the other hand, time here is quite fast. Here we see the response of the same system, but this time, we applied the rule of two to the different gains of the PID regulator and we see that here the establishment time is much greater by the amplitude here is much lower than that which we had here. Our regulator is less aggressive, but it is also slower.

Notes

Summary



6m 07s

Expérimentation 5 – PID & rejet de perturbations



Une perturbation constante peut être simulée en appliquant une commande a priori

En position, utilisez le régulateur PID (avec la règle des deux) calculé précédemment

- Appliquez un signal constant de 1 [v]
- Changez la commande a priori (U_0) de 0 à 2 [v]
- Observez la réponse
- Désactivez le terme intégrateur
- Observez la réponse

TP Control Systems

In this fourth experiment, we will implement the rule of two. For this, we will use the regulator which we calculated previously using Ziegler-Nichols. We will always apply a square signal between -1 and 1 volt with a frequency of 0.02 hertz. We will look at the answer. Then, we will apply the rule of two and modify the parameters of the PID regulator, K_p , we're going to divide it by two and we're going to multiply T_i T_d by two. You will then observe the response to be able to respond to the green questions of the current module. In this last experiment, we will see how a PID regulator for the system in position can reject a constant disturbance. This constant disturbance, we will simulate it using an a priori command that we apply to the system. We saw that the term I made it possible to compensate for the friction of the engine, but we will see which also allows us to reject a constant disturbance.

Notes

Summary



6m 54s

Expérimentation 5 – PID & rejet de perturbations



Une perturbation constante peut être simulée en appliquant une commande a priori

En position, utilisez le régulateur PID (avec la règle des deux) calculé précédemment

appliquez un signal constant de 1 [v]

changez la commande a priori (U_0) de 0 à 2 [v]

servez la réponse

activez le terme intégrateur

servez la réponse

TP Control Systems

For this, we will take the PID regulator that we calculated previously, we will apply a constant signal of 1 volt, then, we will change the a priori order U_0 going from 0 to 2 volts. Then you will turn off the PID term and observe the effect on the response. You can then respond to the various open questions relating to this experience.

Notes

Summary



7m 53s

Conclusions

Qu'ai-je appris aujourd'hui ?

- Le système en position a un intégrateur
- La première méthode de Ziegler-Nichols définit un contrôleur *agressif*
- Le terme intégrateur permet de vaincre les frottements et de rejeter une perturbation constante

TP Control Systems

Today we saw that the system in position to an integrator who is already present. We also saw the Ziegler-Nichols synthesis method which defines a regulator that is relatively aggressive. We have seen the method of both which makes it possible to reduce the “aggressiveness” of this regulator. We have also seen that the integrator term allows us to overcome friction and also to reject constant disturbance.

Notes

Summary



8m 10s