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Ziegler–Nichols method

The **Ziegler–Nichols tuning method** is a heuristic method of tuning a PID controller. It was developed by John G. Ziegler and Nathaniel B. Nichols. It is performed by setting the *I* (integral) and *D* (derivative) gains to zero. The "P" (proportional) gain, K_p is then increased (from zero) until it reaches the **ultimate gain** K_u, at which the output of the control loop has stable and consistent oscillations. K_u and the oscillation period T_u are used to set the P, I, and D gains depending on the type of controller used:

Ziegler–Nichols method[1]			
Control Type	K_p	T_i	T_d
P	$0.5K_u$	-	-
PI	$0.45K_u$	$T_u/1.2$	-
PD	$0.8K_u$	-	$T_u/8$
classic PID[2]	$0.6K_u$	$T_u/2$	$T_u/8$
Pessen Integral Rule[2]	$0.7K_u$	$T_u/2.5$	$3T_u/20$
some overshoot[2]	$0.33K_u$	$T_u/2$	$T_u/3$
no overshoot[2]	$0.2K_u$	$T_u/2$	$T_u/3$

These 3 parameters are used to establish the correction $u(t)$ from the error $e(t)$ via the equation:

$$u(t) = K_p \left(e(t) + \frac{1}{T_i} \int_0^t e(\tau)d\tau + T_d \frac{de(t)}{dt} \right)$$

which has the following transfer function relationship between error and controller output:

$$u(s) = K_c \left(1 + \frac{1}{T_i s} + T_d s \right) e(s) = K_c \left(\frac{T_d T_i s^2 + T_i s + 1}{T_i s} \right) e(s)$$

Evaluation

The Ziegler-Nichols tuning creates a "quarter wave decay". This is an acceptable result for some purposes, but not optimal for all applications.

This tuning rule is meant to give PID loops best disturbance rejection.[2]

It yields an aggressive gain and overshoot[2] – some applications wish to instead minimize or eliminate overshoot, and for these this method is inappropriate.

References

1. Ziegler, J.G & Nichols, N. B. (1942). "Optimum settings for automatic controllers" (http://staff.guilan.ac.ir/staff/users/chaibakhsh/fckeditor_repo/file/documents/Optimum%20Settings%20for%20Automatic%20Controllers%20(Ziegler%20and%20Nichols,%201942).pdf) (PDF). Transactions of the ASME. **64**: 759–768.
2. Ziegler-Nichols Tuning Rules for PID (http://www.mstarlabs.com/control/znrule.html), Microstar Laboratories

Bequette, B. Wayne. Process Control: Modeling, Design, and Simulation. Prentice Hall PTR, 2010. [1] (http://homepages.rpi.edu/~bequeb/edu.html)

- Co, Tomas; Michigan Technological University (February 13, 2004). "Ziegler-Nichols Closed Loop Tuning" (http://www.chem.mtu.edu/~tbco/cm416/zn.html). Retrieved 2007-06-24.

External links

- https://web.archive.org/web/20080616062648/http://controls.engin.umich.edu:80/wiki/index.php/PIDTuningClassical#Ziegler-Nichols_Method