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REPORT SYSTEM CONTROL LABORATORY

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1 Operating Basics

1.1 Introduction

To ensure a good understanding of controllers and controlling theory, a laboratory experiment was performed. As the plant, a motor was used whose speed had to be controlled. The step function was measured and analyzed at first. Knowing the step function it was very easy to implement a suitable PID controller.

1.2 Methods to dermine the controller parameters

There is many different approaches to determine the characteristics of the system and design a PID controller accordingly. For this experiment, the two described in the next two Sections were used.

1.2.1 Chien, Hrones, Reswick

To determine the characteristics of the system, a step is applied to the input. Then the output is observed.

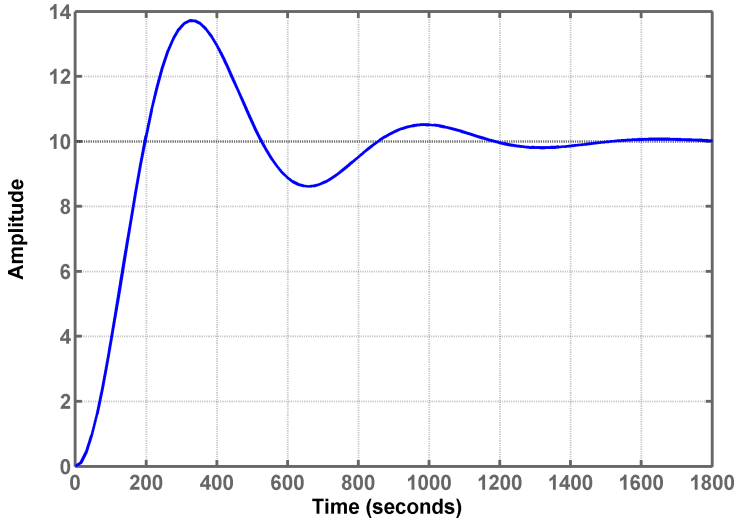

Figure 1: Step response of a PT_2 element

Using the turn tangent principle depicted in Figure 2, the parameters T_u, T_g and K_s were derived.

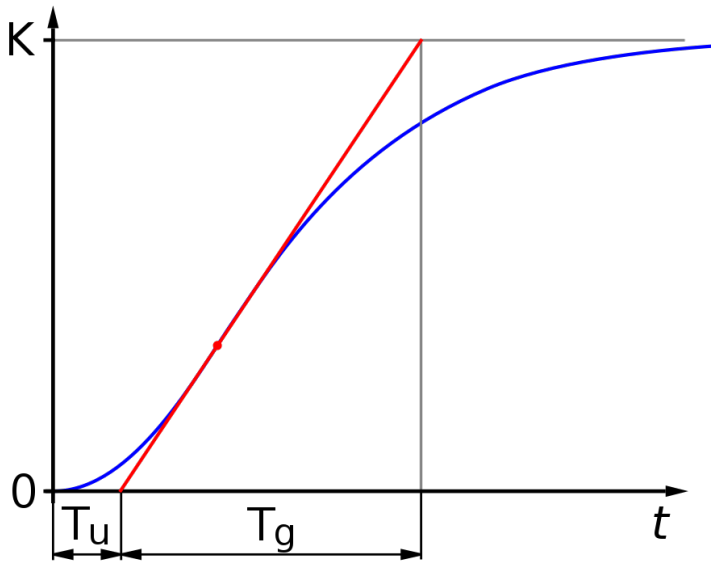

Figure 2: Turn Tangent Principle

Once those paramters are known, the PID parameters can be calculated as formulated in Table 1.

Controller Type	K_p	T_i	T_d
P	$0.3 * \frac{T_g}{T_u * K_s}$	-	-
PI	$0.35 * \frac{T_g}{T_u * K_s}$	$1.2 * T_g$	-
PID	$0.6 * \frac{T_g}{T_u * K_s}$	T_g	$0.5 * T_u$

Table 1: Chien, Hrones, Reswick Method

1.2.2 Ziegler-Nichols

To use this also called oscillation method the system characteristics are determined by bringing the system to the brink of oscillationby increasing K_p whilst the I and D parts remain zero. The parameters K_u and T_u are then the gain K_p and the period of the oscillating output.

The PID parameters then can be calculated according to Table 2.

Controller Type	K_p	T_i	T_d
P	$0.5 * K_{P.crit}$	-	-
PI	$0.45 * K_{P.crit}$	$0.85 * \tau_{crit}$	-
PID	$0.6 * K_{P.crit}$	$0.5 * \tau_{crit}$	$0.12 * \tau_{crit}$

Table 2: Ziegler-Nichols Method

2 Execution

2.1 Experimental setup

The experiment consisted of a motor that was to control, a tachometer and a controller. To make things more exciting, the system also featured disturbances, emulated by a switch coupling in some resistors.

The setup can be seen in Figure **??**. The block diagram characterizing the ytem is depicted in Figure 3.

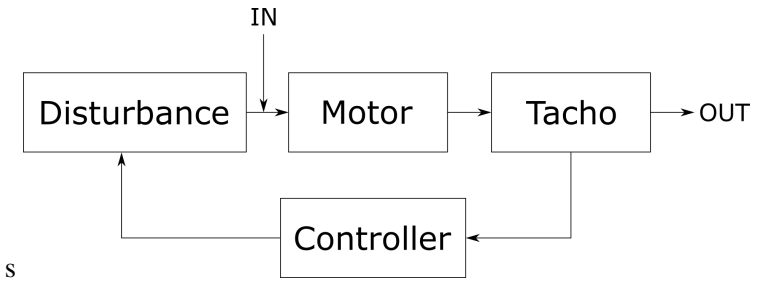

Figure 3: Block diagram of the system

2.2 Knowing the system

At first the characteristic curve of the system was recorded to learn more about the limitations of the system. This was done by measuring the outputs for a broad range of inputs.

The highest possible input was 13 Volts whilst the lowest was -13 Volts. This resulted in aproximately 101 turns per minute in either clockwise or counter clockwise direction. The characteristic curve is plotted in Figure **??**

Knowing the limits, an operating point of approcimately 7 Volts was chosen which results in around 50 turns. This operatng point as chosen since a system is hard to control at its boundaries. This value isn't to close to the upper limit and ensures that the controller has it's freedom.

Sadly a mistake was made with the settings and all the experiments were done at an operating point of 90 turns per minute. So this should be kept in mind in the further reading.

2.3 Carrying out the step experiment

To properly implement a PID using the Chien Hrones Reswick method, the curve seen in Figure **??** was analyzed and the parameters in Table 3 were determined:

Parameter	Value
K_s	10
T_u	$1s$
T_g	$2s$

Table 3: Chien, Hrones, Reswick Parameter

This was done using the approach of analyzing the step function of the system. This process is explained in Section 1.2.1.

2.4 Tinkering with the oscillation method

Using the oscillation approach, the parameters listed in Table 4 were determined.

Parameter	Value
$K_{P,crit}$	1.4
τ_{crit}	$8/3s$

Table 4: Ziegler-Nichols Parameter

Those parameters can be found by studying the curves seen in Figures **??** and **??** using the method explained in Section 1.2.2.