Fachhochschule Nordwestschweiz
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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 Step Function

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

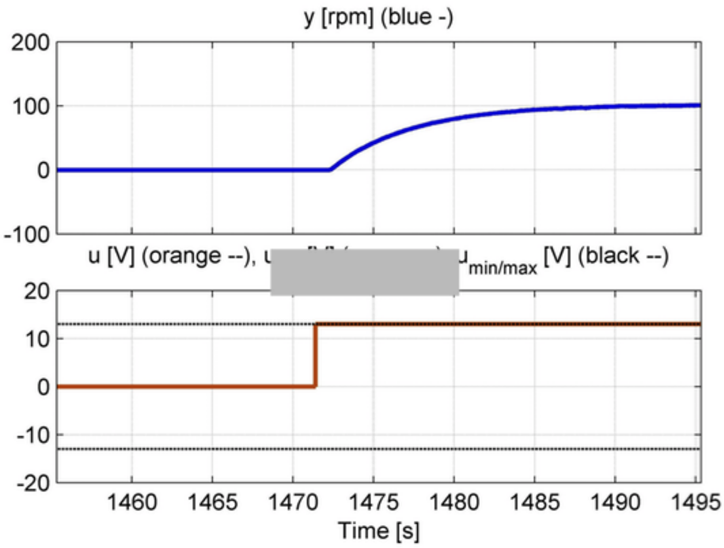

Figure 1: Step response of a PT_2 element

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

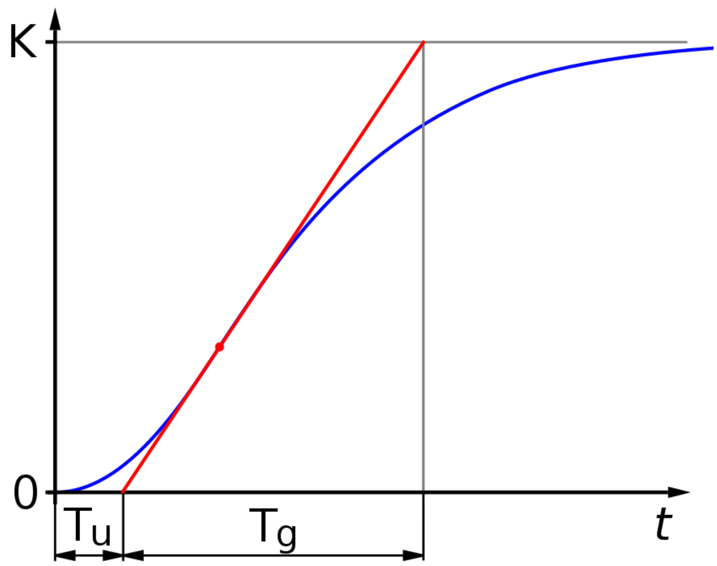

Figure 2: Step response of a PT_2 element

Parameters	Values
$T_u(sec)$	1
$T_g(sec)$	2
K_s	10

1.3 Oscillation Experiment

The figure below is the oscillation experiment out of which the critical gain and critical period were determined.

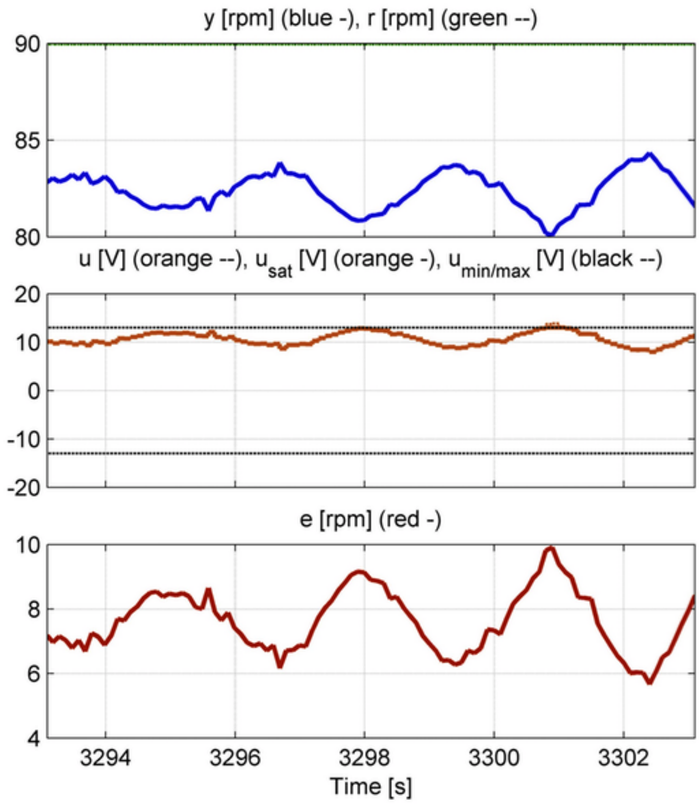

Figure 3: Critical gain $K_{P,crit}$ and τ_{crit}

2 Evaluation

3 Control Design

For the three types of controllers,different characteristic parameters are used. The procedure was carried on with various setpoints which portrayed the operating points. The graphs part show the different experiments:

3.1 P-Controller

The P-Controllers with the different parameters are illustrated graphically as follows: $K_{P,rule} = 0.7$

3.1.1 P-Controller

In the experiment using the P-controller shows that the deviation of the error decreases with the increasing of K_p

$$K_p = K_{P,rule} \cdot 0.2$$

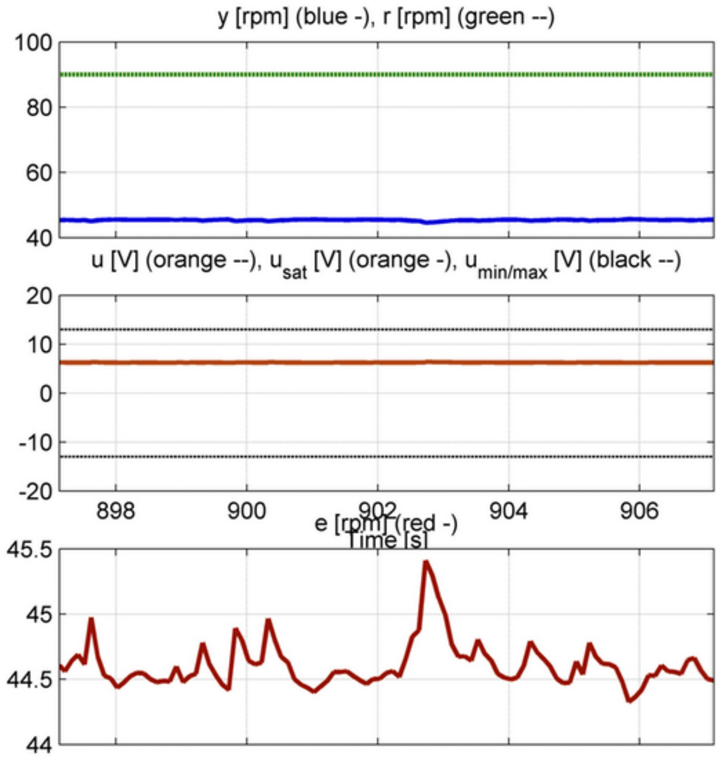

Figure 4: P-Controller of $K_{P,rule} * \cdot 0.2$

$$K_p = K_{P,rule}$$

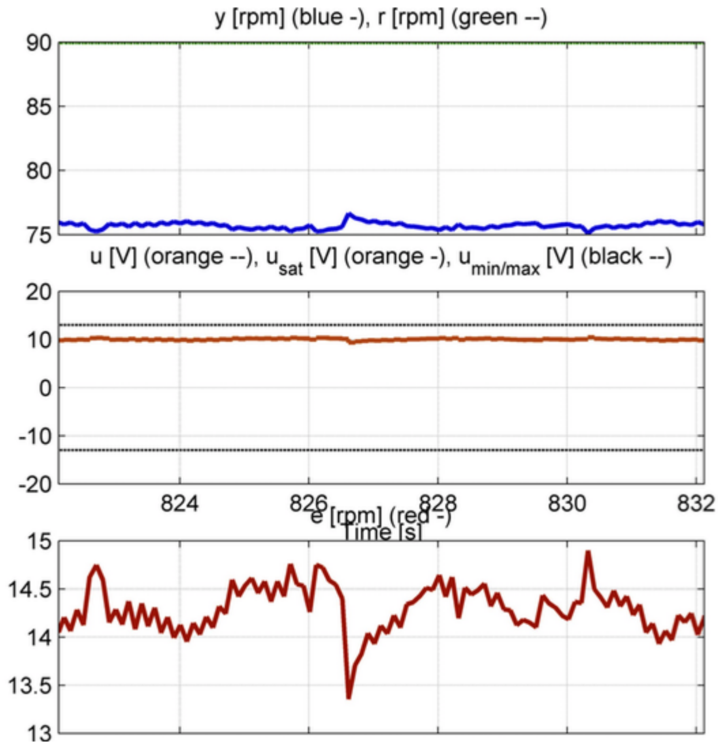

Figure 5: P-Controller of $K_{P,rule}$

$$K_p = K_{P,rule} \cdot 4$$

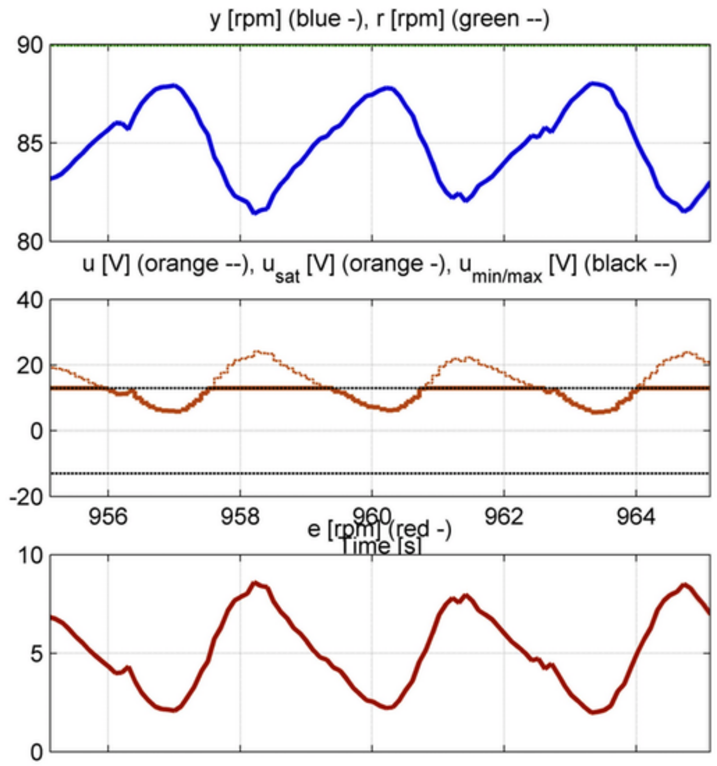

Figure 6: P-Controller of $T_{T,rule} \cdot 4$

3.2 PI-Controller

In this experiment, the increase of T_i reduces the overshoot which slows to reach the setpoint whereas the decrease of T_i generates high oscillation with fast rise time that forces the controller to reach the setpoint in short time.

$$K_p = K_{P,rule} \text{ and } T_{i,rule} \cdot 0.2$$

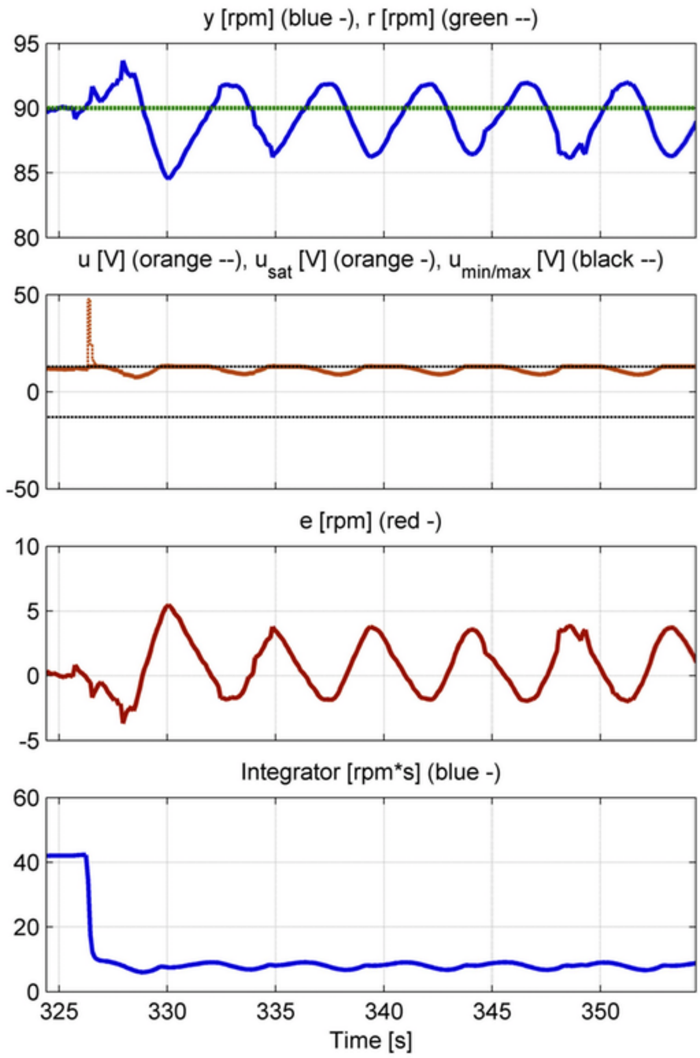

Figure 7: P-Controller of $T_{i,rule} \cdot 0.2$

The figure below is for the Rise time of the PI-Controller with parameter $T_i = 0.2 \cdot T_{i,rule}$

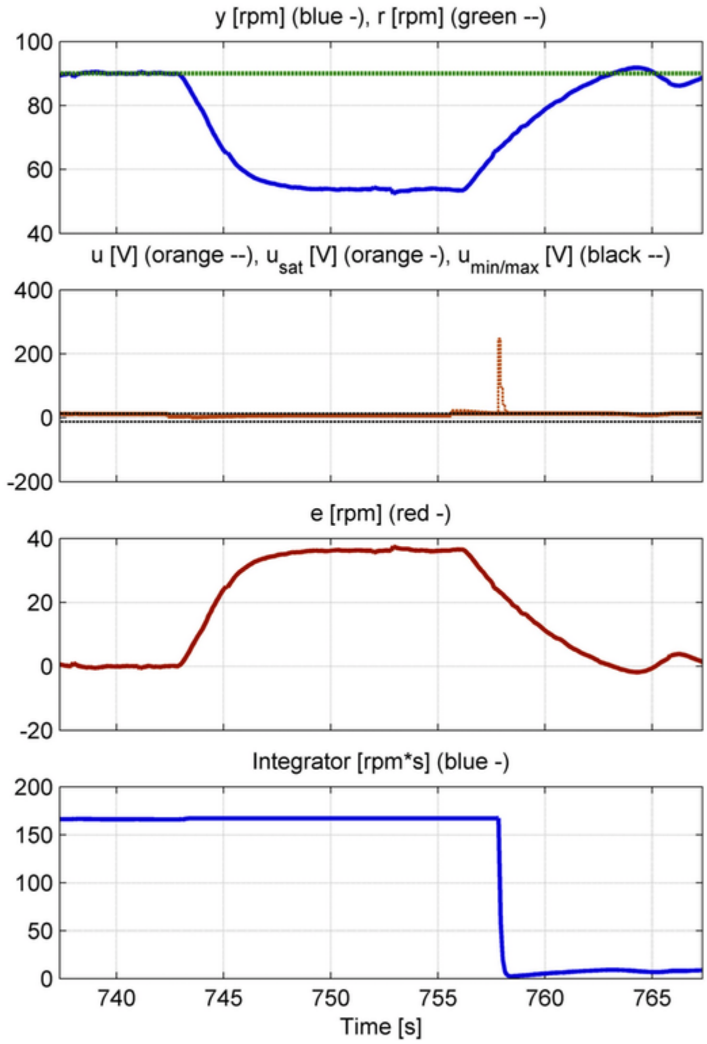

Figure 8: P-Controller of $T_{I,rule} \cdot 0.2$

$K_p = K_{p,rule}$ and $T_i = T_{i,rule}$

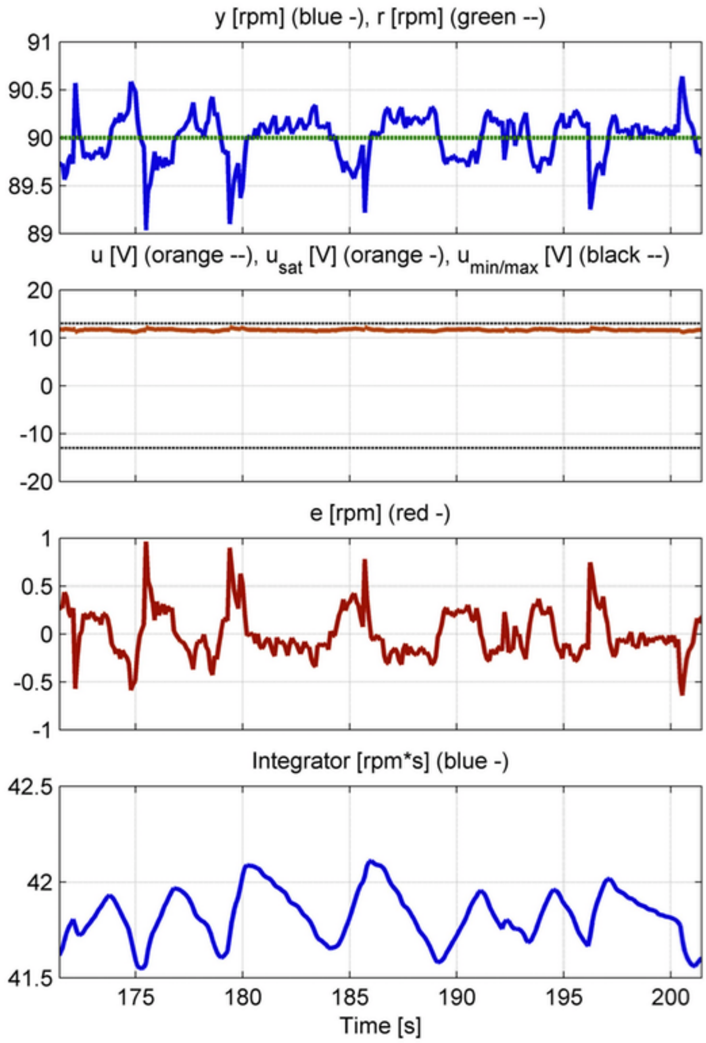

Figure 9: P-Controller of $T_{i,rule}$

The figure below is for the Rise time of the PI-Controller with parameter $T_i = T_{i,rule}$

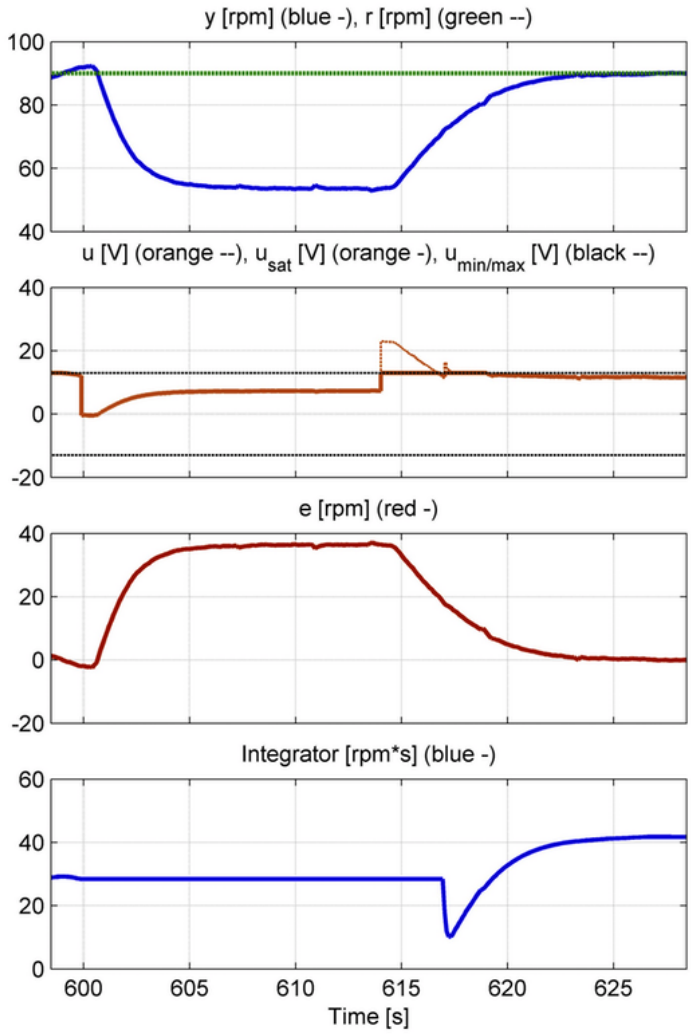

Figure 10: P-Controller of $T_{i,rule}$

$K_p = K_{P,rule}$ and $T_i = T_{i,rule} \cdot 4$

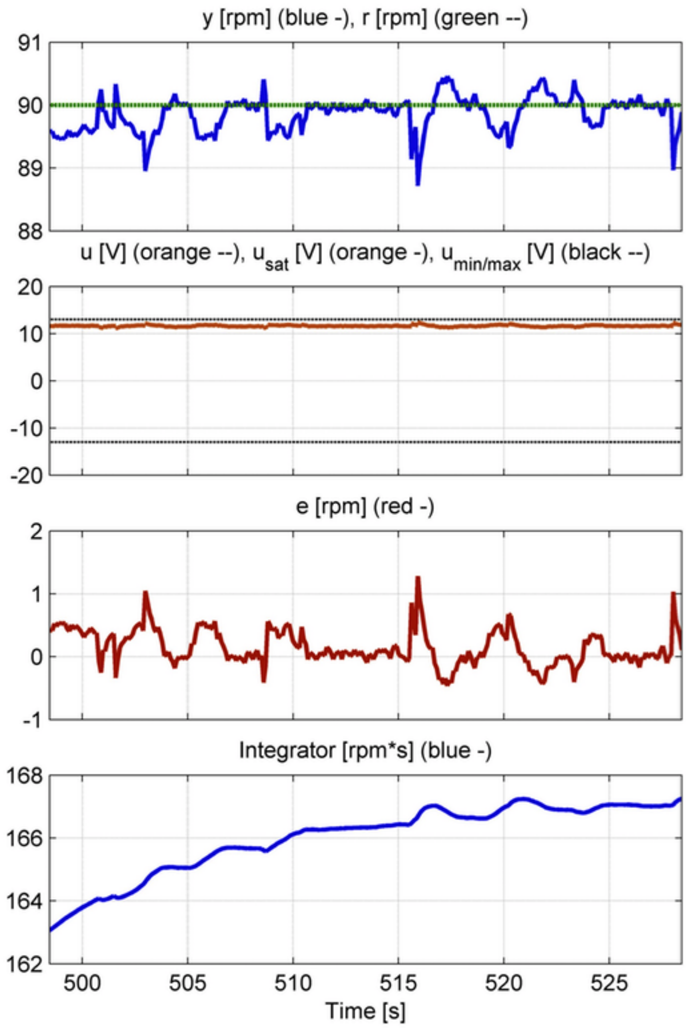

Figure 11: P-Controller of $K_{P,rule} \cdot 4$

The figure below is for the Rise time of the PI-Controller with parameter $T_i = 4 \cdot T_{i,rule}$

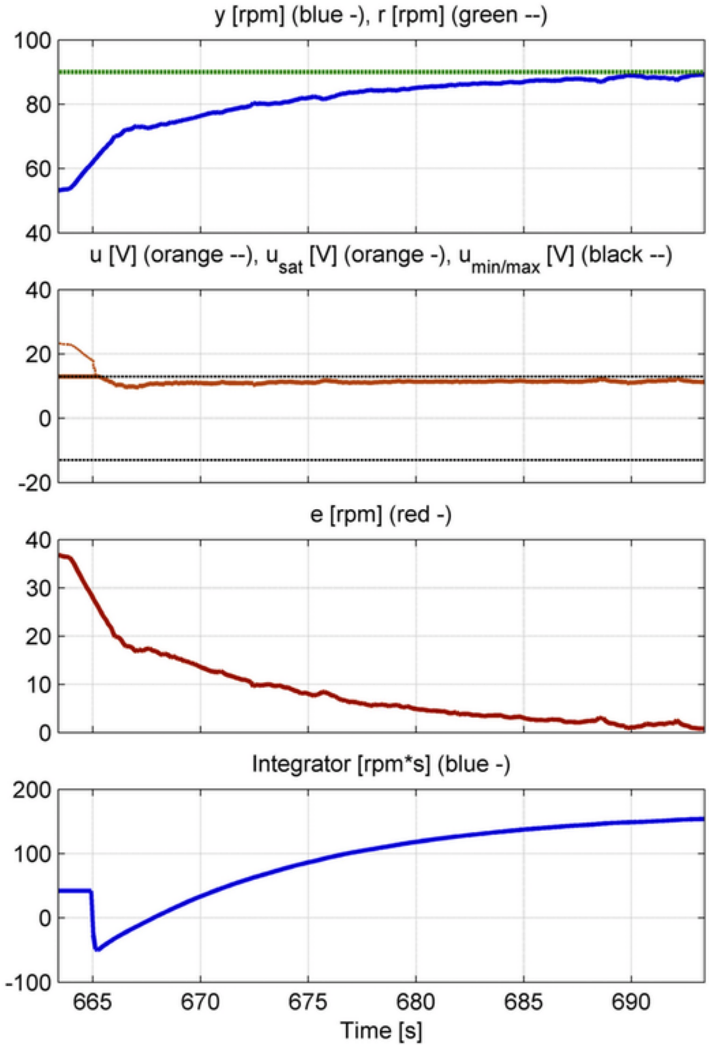

Figure 12: P-Controller of $K_{P,rule} \cdot 4$

3.3 PID-Controller

The Ziegler-Nichols and Chien-Hrones-Reswick methods of tuning PID controllers have been used for the following part of the experiment. The depiction shows clearly that the Chien-Hrones-Reswick is a lot faster than Ziegler-Nichols method.

Parameters	Values
$T_d(sec)$	0.32
$T_i(sec)$	1.33
K_p	0.84

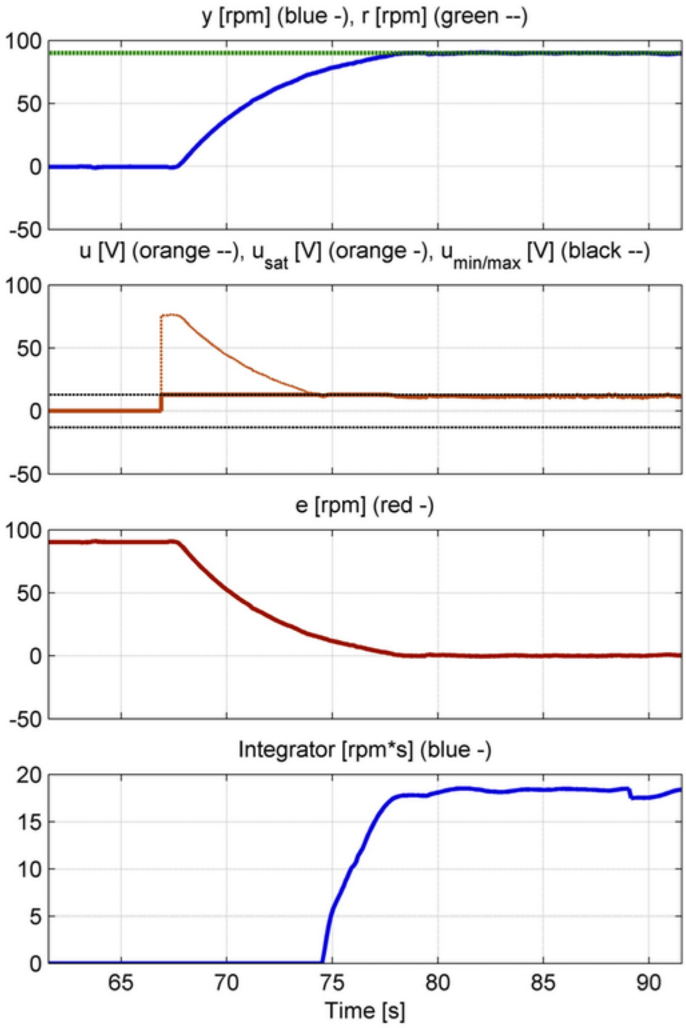

Figure 13: Chien-Hrones-Reswick tuning rule for T_i, T_d, K_P

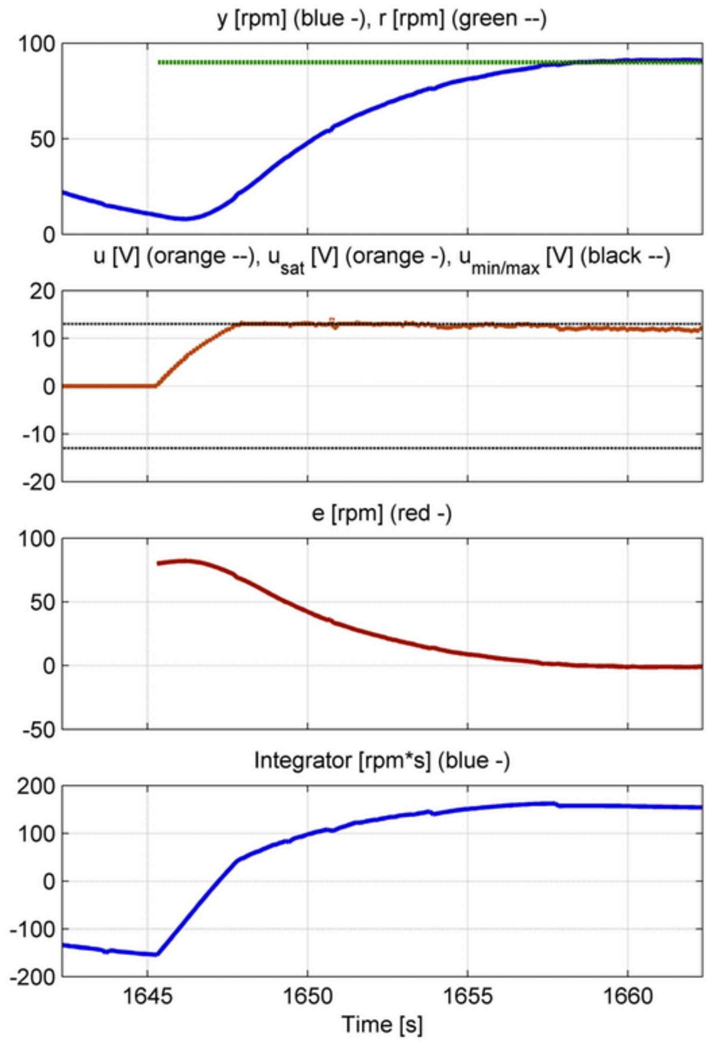

Figure 14: Ziegler-nichols tuning rule for T_i, T_d, K_P