FACULTY OF
ELECTRICAL ENGINEERING AND
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Handout
Identification methods
Tangent method and method of Schwarze

1 Introduction

The objective is to use the tangent method and the method Schwarze to identify a PT_2-System as shown in Figure 1.

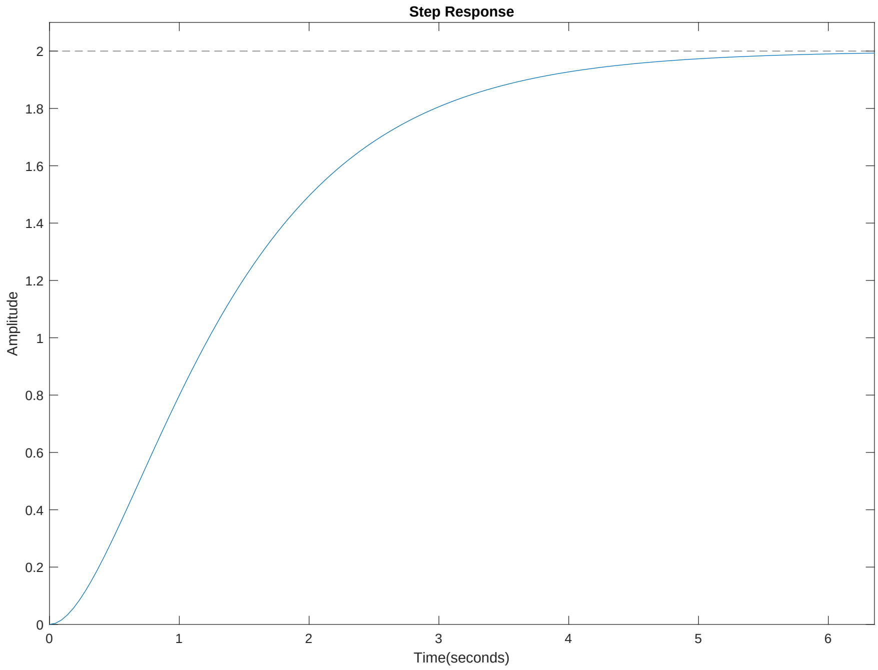

Figure 1: Typical step response of a PT_2-System.

2 Tangent method

In order to calculate the transfer function using the tangent method, an inflectional tangent of the step response is drawn as shown in Figure 2.

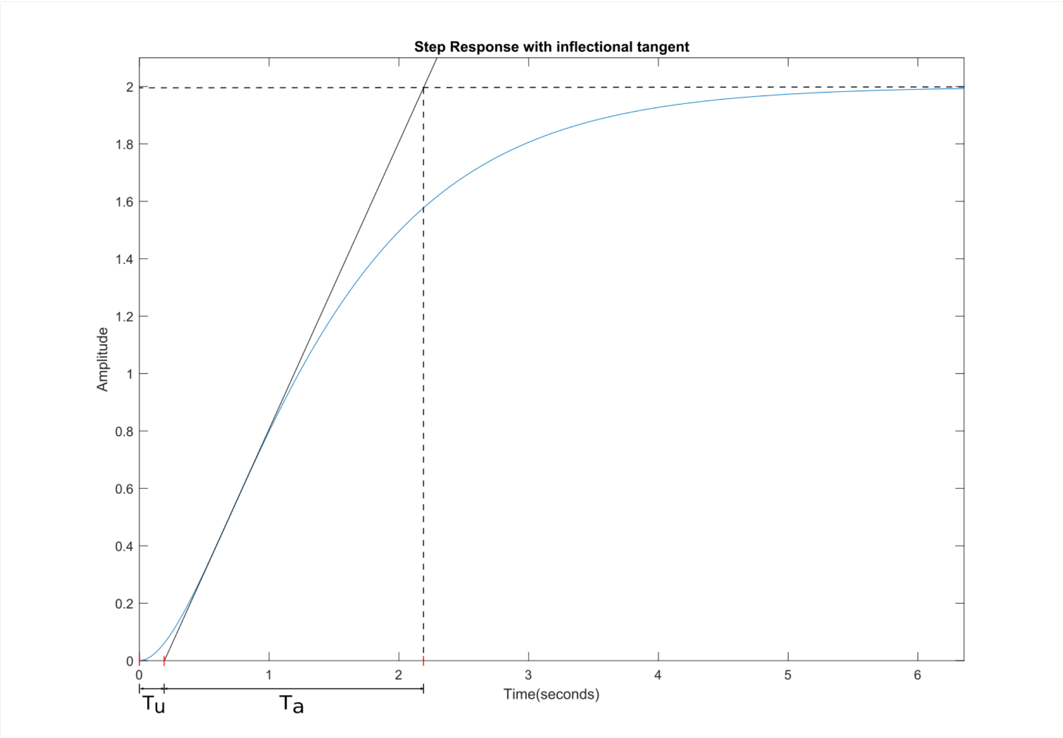

Figure 2: Step response of a PT_2-System with inflectional tangent.

The values of the delay time T_u and the rise time T_a are used to determine the transfer function as follows:

1. The order n of the system is determined with the factor $\frac{T_a}{T_u}$ using Table 1.

   After verifying that $n = 2$, the structure of a second order system

$$G(s) = \frac{K_S}{(1 + T_1 s) \cdot (1 + T_2 s)}. \tag{1}$$

   is used subsequently.

2. For the calculation of the missing factor K_S the following equation is used

$$K_S = \frac{x_a}{x_e}. \tag{2}$$

Table 1: System order identification.

n	T_a/T_u
2	9.65
3	4.59
4	3.13

Regarding the example in Figure 2, where a unit step is applied, i.e. $x_e = 1$, we obtain

$$K_S = \frac{2}{1} = 2. \tag{3}$$

3. For the calculation of the time factors T_1 and T_2 calculate the ratio $\frac{T_a}{T_u}$ and use Table 2. Select the row where the value in the third column is closest to the result of $\frac{T_a}{T_u}$.

Table 2: Relation between the factors.

T_2/T_1	T_a/T_1	T_a/T_u
2.0	4.00	10.35
3.0	5.20	11.50
4.0	6.35	12.73
5.0	7.48	13.97
6.0	8.59	15.22
7.0	9.68	16.45
8.0	10.77	17.67
9.0	11.84	18.88

3 Method of Schwarze

In order to calculate the transfer function using the method of Schwarze, time percentage values are determined. These are obtained from the step response as shown in Figure 3.

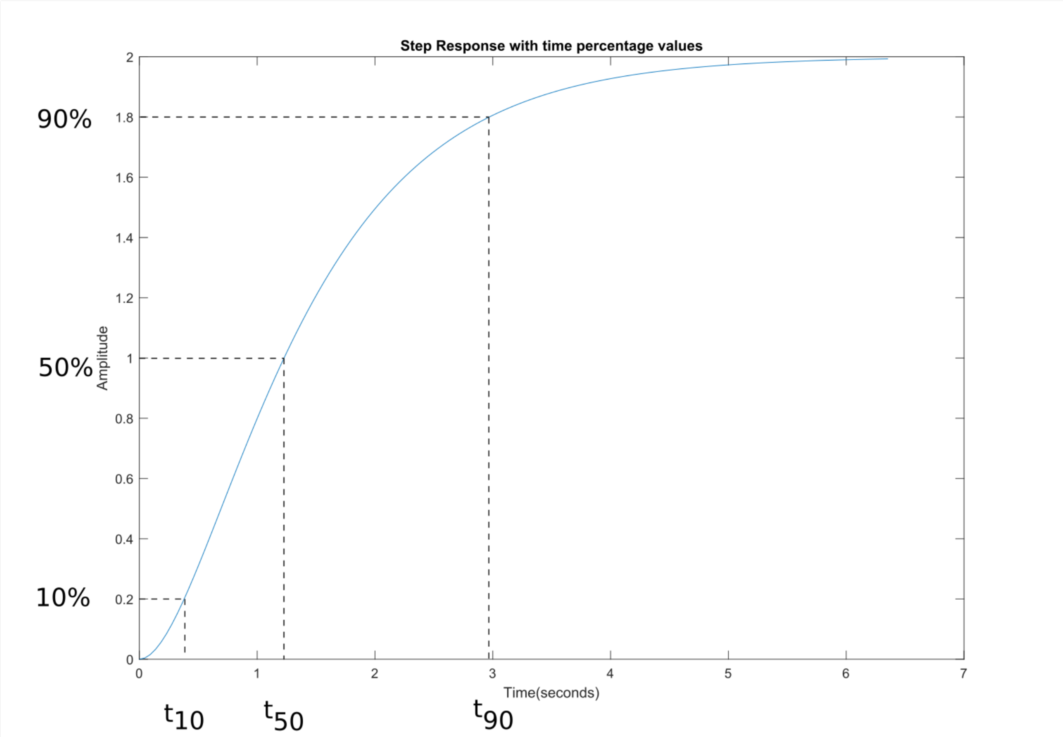

Figure 3: Step response of a PT_2-System with time percentage values

It is considered to be a transfer function of the form

$$G(s) = \frac{K_S}{(1+Ts)^n}. \tag{4}$$

1. The factor K_S is calculated exactly as in the first method.
2. For the calculation of the time factor T, the percentage values of the final value from the step response are used. In case of Figure 3

$$\begin{aligned} 10\% &\rightarrow 0.2 \rightarrow t_{10} = 0.4 \\ 50\% &\rightarrow 1.0 \rightarrow t_{50} = 1.2 \\ 90\% &\rightarrow 1.8 \rightarrow t_{90} = 2.95 \end{aligned} \tag{5}$$

3. Identify the system order using ratio

$$\mu = \frac{t_{10}}{t_{90}} \tag{6}$$

and Table 3.

Table 3: System order identification.

n	μ
2	0.137
3	0.207
4	0.261

4. Knowing the order, identify percentage-based parameters τ_{10}, τ_{50} and τ_{90} from Table 4

Table 4: Percentage-based parameter identification.

n	τ_{10}	τ_{50}	τ_{90}
1	0.105	0.693	2.303
2	0.532	1.678	3.890
3	1.102	2.674	5.322
4	1.745	3.672	6.681

5. Calculate time factor T according to

$$T = \frac{1}{3} \cdot \left(\frac{t_{10}}{\tau_{10}} + \frac{t_{50}}{\tau_{50}} + \frac{t_{90}}{\tau_{90}} \right). \tag{7}$$