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Calculation of Control Circuits in Time Domain using Scilab/ Xcos Environment

The paper presents the computing of control circuits in time domain, starting from the mathematical model of the control path described by differential equation's with constant coefficients, whose solution can be obtained through Laplace transform and transfer functions. In the field of electric drives, the control circuits can be reduced to elements of PT1 and PT2 type, for which, the responses obtained from step and impulse function in the test process, are analyzed. The presented calculation, done in Scilab, highlights the test responses of the process and, the speed control circuit implemented as block diagrams in Xcos, reveals the improve of the process parameter through the control loop.

Keywords: mathematical model, transfer function, impulse and step response, Scilab / Xcos environment

1. Introduction

The control circuits in time domain have transfer elements with concentrated or distributed parameters and the testing signal are continuous in time. In case of transfer elements with concentrated parameters, those are described through differential linear equation, being solved with Laplace transform [4]. The Scilab files that implements the transfer function, offers the possibility to analyze graphic the step and impulse response. [1] The Xcos file represents the control block diagram for speed control allowing also obtaining the step and impulse responses.

2. Mathematical model, step and impulse response using Scilab / Xcos

We consider the Scilab files that implement the impulse and step response for PT1 and PT2 type elements that often represents the mathematical model for electric drive controlling. Considering the transfer functions [3]:

$$H_{PT1}(s) = \frac{K_{p1}}{1 + sT_1} \quad (1)$$

$$H_{PT2}(s) = \frac{K_{p2} \xi_0^2}{s^2 + 2D\xi_0 s + \xi_0^2} \quad (2)$$

The relations (1) and (2) have following parameters: amplification factors K_{p1} , K_{p2} , own pulsation ω_0 and D – amortization factor.

The simulation of time response of linear system is computed in Scilab through the 'csim' function, represented by the calling sequence: `csim(u,t,sl)`, with the arguments u – function, list or string (control), t – real vector specifying time, sl – SIMO linear system in continuous time [5].

For impulse and step response the control string is substituted with "imp" and "step" [6].

Table 1 contains the Scilab script under which the impulse response function, figure 1, is computed for PT1 – and PT2 elements.

Table 1. Scilab Script – File computing impulse answer

```

Kp1=1; T1=4; // gain and time constant
Kp2=1; w0=0.5; D=0.25 // Parameter
s=%s;
num1=Kp1; // numerator
den1=s*T1+1; // denominator
tf1=num1/den1; // transfer polynomial

num2=Kp2*(w0^2); // numerator
den2=(s^2)+2*D*w0*s+w0^2; // denominator
tf2=num2/den2; // transfer polynomial

// create a Scilab-usable continous system
ansys1=syslin('c',Kp1/(T1*s+1));
ansys2=syslin('c',tf2);

// create a time axis (start, end, numberOfSteps)
t=linspace(0,20,50);

impresp1=csim('imp',t,ansys1); // compute impulse response
impresp2=csim('imp',t,ansys2);

xset('window',1); // create window for subplots
plot2d (t,impresp1); xgrid();
plot2d (t,impresp2); xgrid();
xtitle ('Impulse answer','time [s]','h(t)');

```

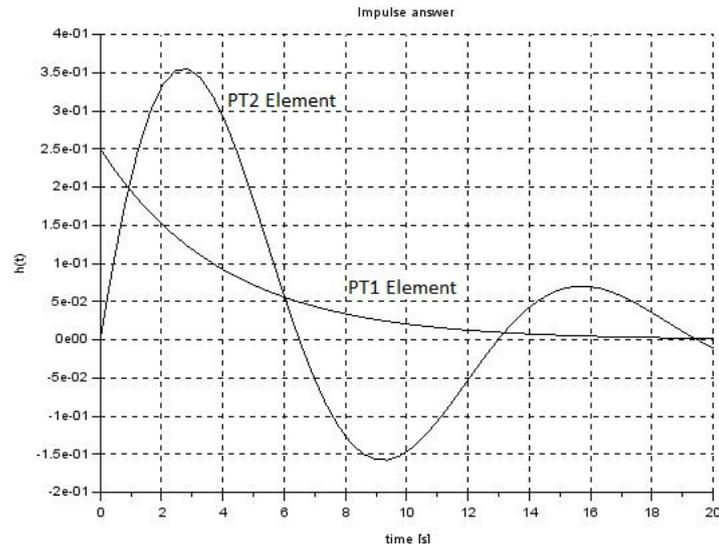


Figure 1. Impulse response for PT1 and PT2 elements

The Scilab – Script for computing the step response, figure 2, of PT1 – and PT2 elements is presented in Table 2.

Table 2. Scilab Script – File computing step answer

```

Kp1=1; T1=4;           // gain and time constant
Kp2=1; w0=0.5; D=0.25 // Parameter
s=%s;
num1=Kp1;             // numerator
den1=s*T1+1;         // denominator
tf1=num1/den1;       // transfer polynomial

num2=Kp2*(w0^2);     // numerator
den2=(s^2)+2*D*w0*s+w0^2; // denominator
tf2=num2/den2;       // transfer polynomial

// create a Scilab-usable continuous system
ansys1=syslin('c',Kp1/(T1*s+1));
ansys2=syslin('c',tf2);

// create a time axis (start, end, numberOfSteps)
t=linspace(0,20,50);

stepresp1=csim('step',t,ansys1); // compute step response
stepresp2=csim('step',t,ansys2);

```

```

xset('window',1);           // create window for subplots
plot2d (t,stepresp1); xgrid();
plot2d (t,stepresp2); xgrid();
xtitle ('Unit step response','time [s]','h(t)');

```

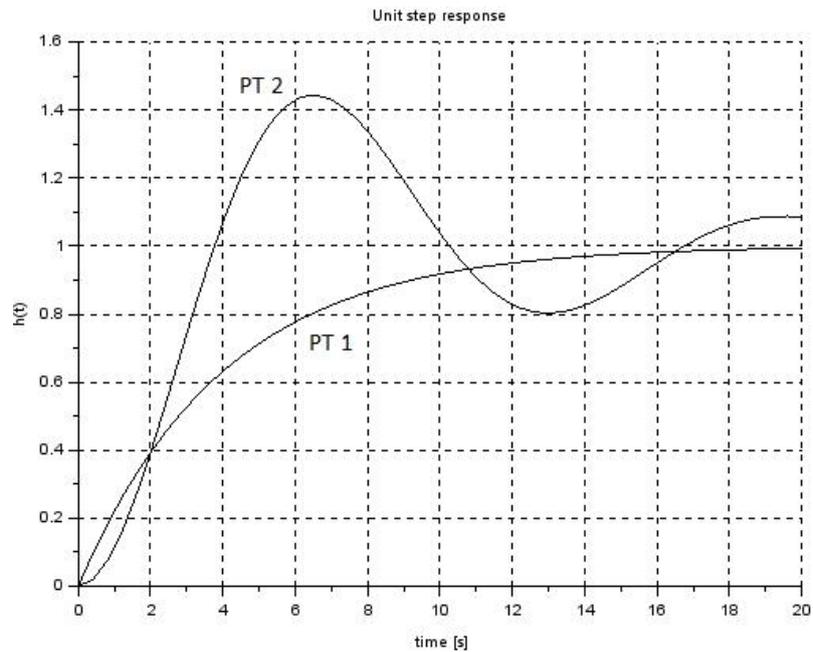


Figure 2. Unit step response for PT1 and PT2 elements

The PT1 and PT2 presented elements can be found in the majority of control systems [5]. The step response characteristic of a speed control for electric drives is illustrated using Xcos, figure 3 [2]. For the electrical and mechanical control path, each a PT1 element is identified.

The step response, figure 4, is obtained considering the step and impulse signal starting at $t_0 = 0$ being applied for 0.02 sec. Based on the obtained responses, the parameters of the control loop can be adapted to ensure the systems performance.

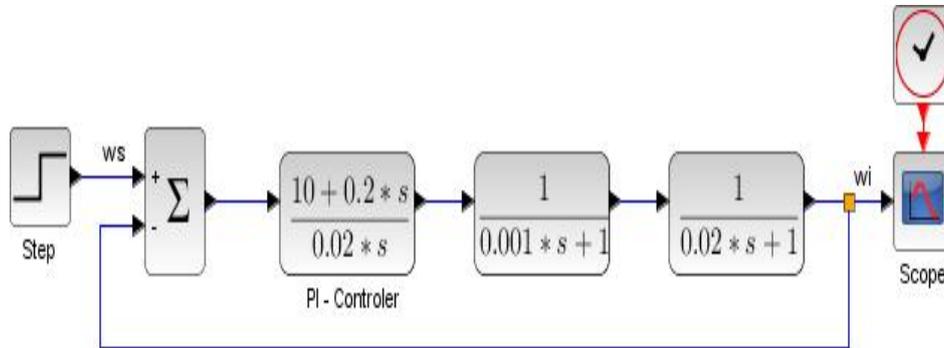


Figure 3. Xcos block diagram [3]

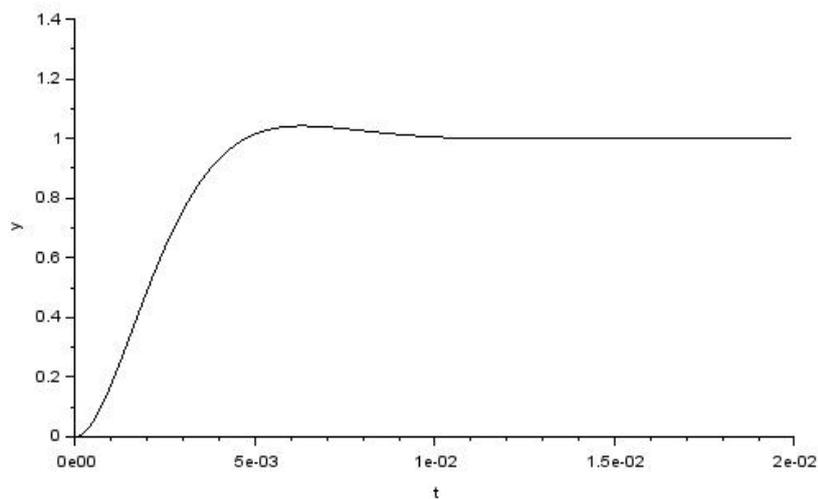


Figure 4. Unit step response for the speed control of an electric drive

4. Conclusion

Based on those illustrated in the work, various control circuits can be calculated in time domain using the Scilab & Xcos environment. Such was shown how Scilab files are implemented for PT1 and PT2 systems using specific functions of impulse and step type and the obtained response. As well the simulation using Xcos based on a block diagram for speed control was used to obtain the step and impulse response, too.

The Scilab / Xcos modeling and simulation programming language offers an effective practice instrument to compute the control circuits in time domain.

References

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