ANALELE UNIVERSITĂŢII
"EFTIMIE MURGU" REŞIŢA
ANUL XIII, NR. 1, 2006, ISSN 1453 - 7397

Gilbert-Rainer Gillich, Cristian Paul Chioncel, Florin Constantin Berinde

Analysis of Time Discretization and its Effect on Simulation Processes

The paper presents the influence of time discretization on the results of simulations of technical systems. In this sense the systems are modeled using the SciLab/SCICOS environment, using different time intervals. Ulterior the processes are simulated and the results are compared.

1. INTRODUCTION

The digital control systems are characterized through the use of digital computers and the signals from the control system are time and amplitude sampled. The discrete control system can be described by recurrent equation. If the equations are linear and time invariant, the solution can be obtained applying the *Z* transform.

The Scicos pallets allow implementation of digital control systems, choosing *Linear* from the pallet lists with blocks operating in discrete time. These blocks have at the output zero and first order hold, and the sample time can be chose for each in part.

2. Scicos Opportunities for Simulation of Digital Controlling

SCICOS (Scilab Connected Object Simulator) is free graphically-based modeling software for dynamical system, an environment for design, model and simulate reactive systems included in the SciLab engineering and scientific computation software. Based on an open formalism, SCICOS is a complete environment for construction of models, simulation and code generation; creates block diagrams and can be used to model and simulate the dynamics of hybrid dynamical systems and compile models into executable codes. SCICOS is used for signal processing and systems control. SCICOS allows simulation of different time discrete systems:

- Digital control with digital control elements and time discrete control loops. The control loop signals are time discrete only.
- Digital control with blocks, where each of them can be controlled by different sample times.
- Digital control with digital control elements and continuous elements.

For example, if we choose a PT1 element:

$$T_s \cdot \frac{dx(t)}{dt} + x(t) = K_s \cdot x_i(t) \quad (1)$$

with T_s = 1s and K_s = 1, it presents the step discrete response. Discretizieng the differential equation (1) with sample interval T, we get:

$$\frac{T_s}{T} \cdot (x_{k+1} - x_k) + x_k = K_s \cdot x_{i,k} \quad (2)$$

$$x_{k+1} = \left(1 - \frac{T}{T_s}\right) \cdot x_k + \frac{K_s \cdot T}{T_s} \cdot x_{e,k} \quad (3)$$

The *Z* transfer function:

$$x(z) = \frac{K_s \cdot T}{T_s} \cdot \frac{1}{z - \left(1 - \frac{T}{T_s}\right)} \cdot x_i(z), \text{ where } x_i(z) = \frac{z}{z-1} \quad (4)$$

$$x(z) = \frac{K_s \cdot T}{T_s} \cdot \frac{1}{z - \left(1 - \frac{T}{T_s}\right)} \cdot \frac{z}{z-1} \quad (5)$$

or, rearranging:

$$x(z) = K_s \cdot \left(\frac{z}{z-1} - \frac{z}{z - \left(1 - \frac{T}{T_s}\right)} \right) \quad (6)$$

The PT1 time sample element block scheme in SCICOS, figure 1, have been analyzed for T=0.2ms, figure 2.

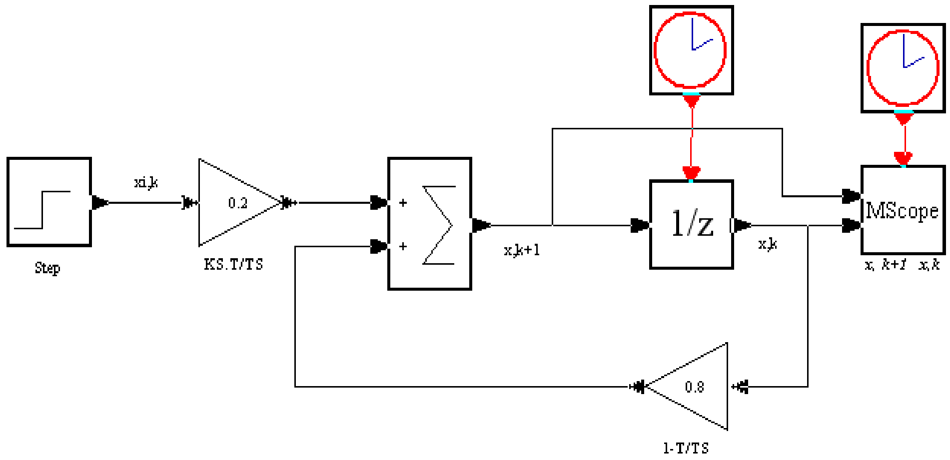

Figure 1. Time sampled PT1 element implemented in Scicos

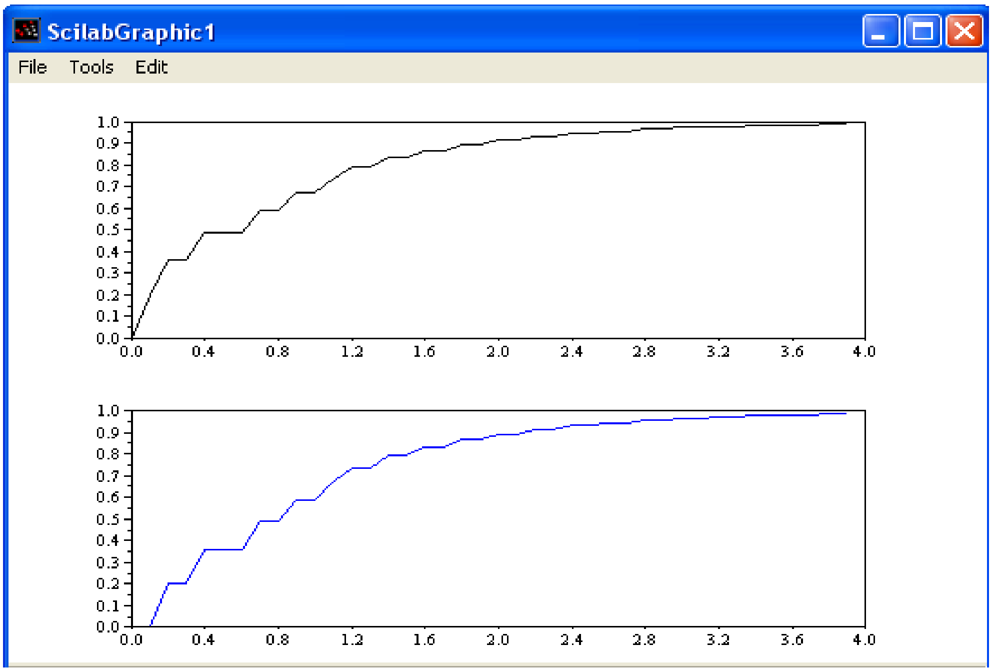

Figure 2. Simulation results of a discretized PT1 element

3. Digital Cascade Control with Variable Discretization Time

The block scheme of speed control for electrical drives with work machines are often cascade control schemes with two closed loops, one for speed control and the other one for torque. A digital P type controller is used to control the angle position and a PI type controller in the speed closed loop.

In the simulation model the current or torque circuit are represented through a PT type transfer element with the equivalent time constant T_{EM}. The PI speed controller is implemented with the integral type algorithm:

$$y_{v,k} = y_{v,k-1} + K_R \cdot \left[\left(1 + \frac{T_d}{T_N} \right) \cdot x_{dv,k} - x_{dv,k-1} \right] \tag{7}$$

The sample interval:

$$K_R = \frac{T_N}{2 \cdot K_s \cdot T_{EM}} = 10, T_N = T_M = 20ms \tag{8}$$

The corresponding *Z* transform is:

$$G_{R,v}(z) = \frac{y_v(z)}{x_{dv}(z)} = \frac{K_R \cdot \left[\left(1 + \frac{T_d}{T_N} \right) \cdot z - 1 \right]}{z - 1} = \frac{10.05 \cdot z - 10}{z - 1} \tag{9}$$

For the P type controller, results the speed gain factor:

$$v_{pos,k} = K_v \cdot x_{dp,k} = \frac{1}{8 \cdot T_{EM}} \cdot x_{dp,k} = 125 \cdot x_{dp,k} \tag{10}$$

and the sample period is T_i = 0.2 ms.

Figure 3 presents the Scicos simulation model. The time evolution of controlled output, v_{is}, is obtained for a step type input signal 0.01·E(t) and disturbed with an delayed step type 2·E(t-0.05s). Increasing the sample time, the damping position factor will decrease, figure 4.

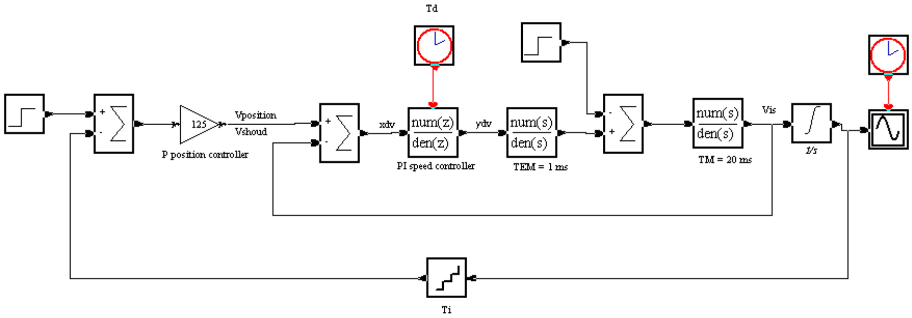

Figure 3. Scicos model of cascade control circuit.

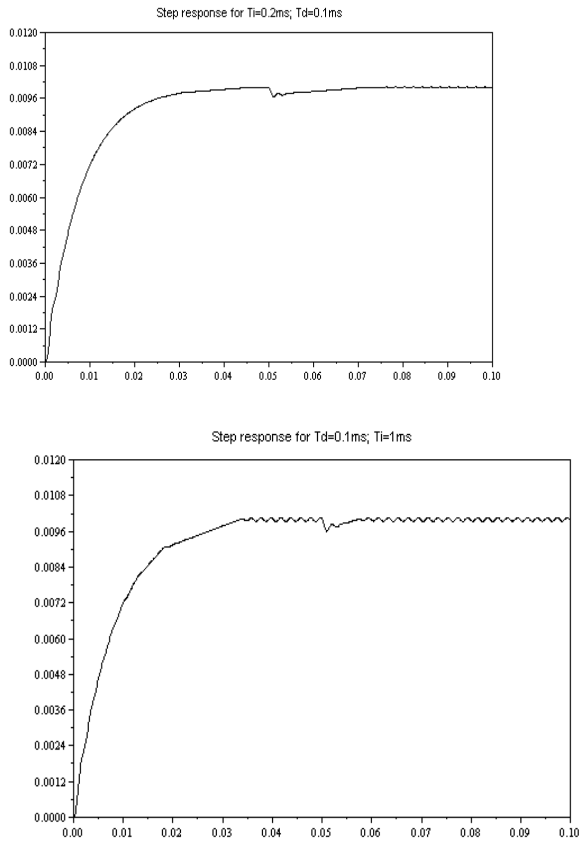

Figure 4. Step response for different values of the sample period for speed T_d and position T_i control circuit

4. Conclusion

For digital control systems, with different sample times, the fundamental sample time is considered the smallest common divider. For the analyzed case, the sample time for the position control were T_i = 0.2 and 1 ms, and for the speed control T_d = 0.1 ms; the smallest common divider is represent by the fundamental sample time, T = 0.1 ms. That's why, solution with constant samples time are often used.

References

[1] Chioncel, C.P. – *Limbaje de simulare. Aplicaţii de modelare şi simulare*, Ed. „Eftimie Murgu" Resita, 2004

[2] Gillich, G.R, Chioncel, C. -*Frame design and simulation using Analysis and SciCos*, 7th International Conference on Accomplishments of electrical and mechanical Industries, Banjaluka, 2005.

[3] Gillich, G.R. – *Dinamica maşinilor • Modelarea sistemelor tehnice,* Editura AGIR Bucureşti, 2003.

[4] Chioncel, C.P., Chioncel P. - *Probestand für automatische Regelungssysteme mit Mikrokontrollerr,* Robotica&Management, Vol. 10, Nr.2, 2005

[5] www.scilab.org

[6] www.scicos.org

Addresses:

- Assoc. Prof. Dr. Eng. Gilbert-Rainer Gillich., "Eftimie Murgu" University of Reşiţa, Piaţa Traian Vuia, nr. 1-4, 320085, Reşiţa, raini@uem.ro
- Assist. Eng. Cristian Paul Chioncel, "Eftimie Murgu" University of Reşiţa, Piaţa Traian Vuia, nr. 1-4, 320085, Reşiţa, c.chioncel@uem.ro
- Lect. Dr. Eng. Florin Constantin Berinde, "Eftimie Murgu" University of Reşiţa, Piaţa Traian Vuia, nr. 1-4, 320085, Reşiţa, f.berinde@uem.ro