ANALELE UNIVERSITĂȚII
"EFTIMIE MURGU" REȘIȚA
ANUL XXIII, NR. 1, 2016, ISSN 1453 - 7397

Digital Speed Cascade Control, using Scilab / Xcos Environment

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This paper presents an application of digital cascade control implemented in Scilab / Xcos environment, using a P type regulator for the position adjustment circuit, a PI controller for the speed circuit adjustment; the current respectively moments control circuits are rendered by elements of PT1 type. On this basis the program is done in Scilab and the related signal block diagram implemented in Xcos; through simulation, the step response of the system is analyzed for different sampling times.

Keywords: *digital cascade control, sampling time, Scilab/Xcos environment*

1. Introduction

Digitization is a megatrend that has significantly changed the manner and the way we live and work. The 4.0 industry, the interconnected production has the character of the technical industrial revolutions of the last two centuries. The transition to a digital future will significantly affect most companies, regardless the industry they belong. It returns to the education system to develop the needed skills, so that the adaptation to the changed environment should be made possible and the potential of the digital context to be used. The work illustrates the transition from analog, in continuously time, to the digital, in discrete-time, for an application in the field of electric drive.

2. Digital cascade control, with different sampling times, in Scilab / Xcos environment

The position control of the machine is often a cascade structure, with subordinate speed and torque controls. The position control is implemented by digital P controller, and in the speed control circuit, by PI digital regulators. We will use a simulation model which includes the couple or current circuit by a PT1 element with the time constant T_{EM}, and a PT_1 element with mechanical time constant T_M, figure 1.

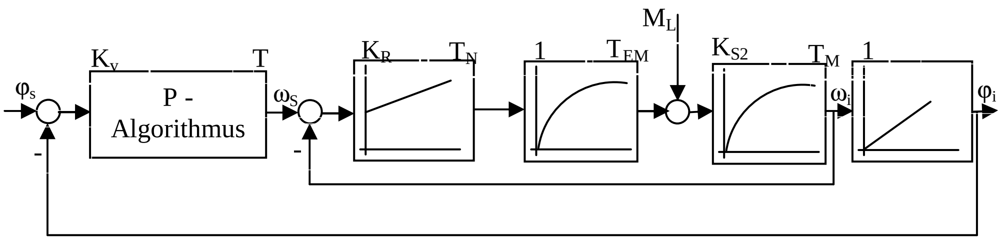

Figure 1. Continuous time signal diagram, with digital position control and subordinate speed and torque control

The PI speed controller is designed with the PID standard algorithm:

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

With adopted time constants K_R=, T_N=T_M=20ms, T_{EM}=1ms and Td=0.1ms we obtain the Z- transfer function.

$$H_{R,v}(z) = \frac{y_v(z)}{x_{dv}(z)} = \frac{K_R\left[\left(1+\frac{T_d}{T_N}\right)z-1\right]}{z-1} \tag{2}$$

For the P controller, the obtained speed gain, K_R:

$$v_{ref,k} = K_R x_{dp,k} = \frac{1}{8T_{EM}} = 125 \cdot x_{dp,k} \tag{3}$$

The figure 2 presents the Xcos model of the position control circuit, with cascade structure. The time variation of the simulated control size is considered for a leading measure reference of $0.001\cdot\sigma(t)$ from the step unit signal; the interfering function is defined through a delay function $M = 2\sigma(t\text{-}0.04\cdot s)$.

The symbolic parameters which can be found in the implemented Xcos simulation cascade control block diagram use the Xcos *SetContext* option, to define symbolic parameters used in block definitions, figure 2. The used blocks are part of the *Commonly Used Blocks*, *Continuous time systems*, *Signal Processing*, *Discrete time systems*, *Sources* and *Sinks* palettes of the Xcos libraries, figure 3 [11].

Based on the relations (1), (2) and (3), the implemented cascade control diagram, figure 4, offers opportunity to analyze the system behavior through modifying the two sampling times in the loop cascade responsible for position and speed control. The obtained results are highlighted in figure 5 [6].

Based on the existing speed and position control of the DC motor controlled system [10], the influence of the sampling period [5], [8] is highlighted using modeling and simulations methods, implemented in the Scilab / Xcos environment [2] ,[7], [4]. The literature [1], [3] reveals also other algorithms that manifest a better independence towards perturbations (noise) or sampling times. Based on the implementations areas, the constrains that results from here and the requests of the final user, the automation together with the electric machine designer chose the proper control strategy that has to be implemented.

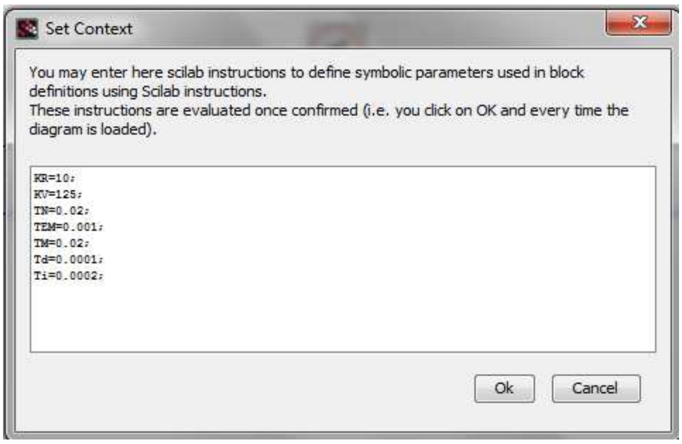

Figure 2. *SetContext* window in Xcos to define symbolic parameters

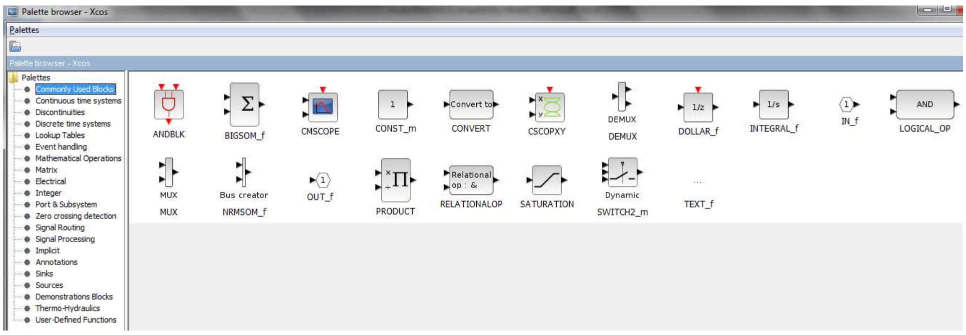

Figure 3. Used Xcos libraries – accessed via Palette browser

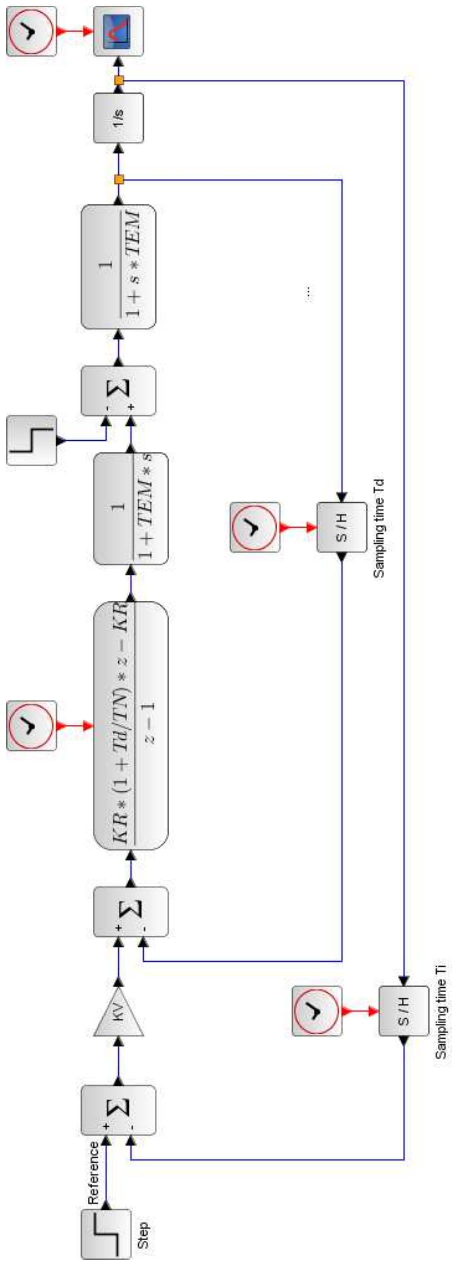

Figure 4. Control cascade structure, with different sampling time, for speed and position circuit, implemented in Xcos

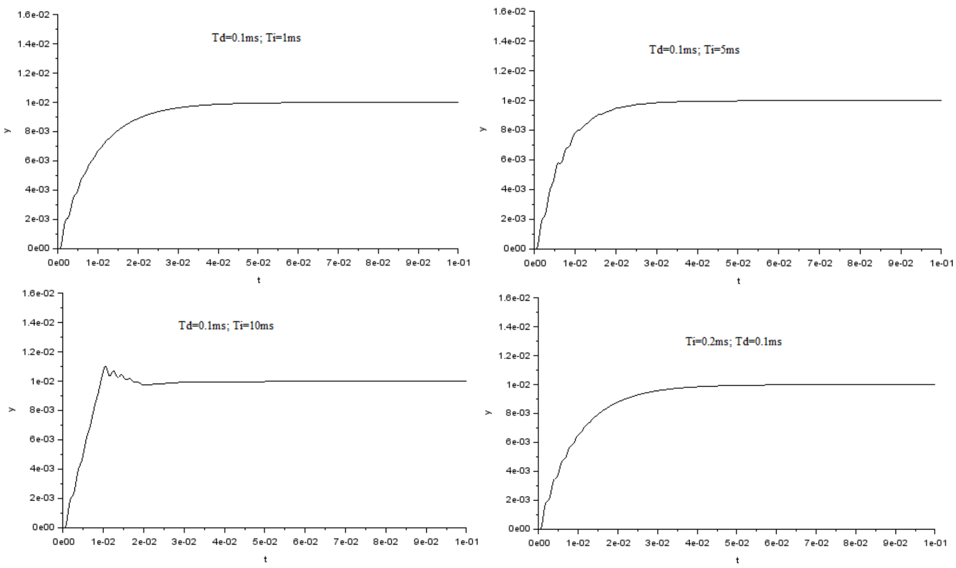

Figure 5. System response by variation of the sampling time Td of the speed control and the variation of the Ti sampling time of the position control loop

3. Conclusion

The digital control cascade, commonly found in DC motors where high speeds and accuracy control is required, are approached with linear and invariant differential equations that can be solved in Z transform. For digital control simulation, they are available programming environments such as Scilab / Xcos with libraries of discrete blocks (Signal Processing), blocks operating in discrete time. They have at the output retaining elements (Hold Block) typically of the order of 1, and the sampling time can be individually selected for each transmission block. The control path may be in continuous time, as the example of this paper, or discrete time, existing the possibility of simulation and optimization of the chosen variant.

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