COMPARISON OF SLIDING MODE AND PROPORTIONAL INTEGRAL CONTROL FOR BRUSHLESS DC MOTOR

Igor Karaskakovski[1], Goce Shutinoski[2]

[1]OKTA – RAFINERY Skopje, e-mail: ikaraskakovski@yahoo.com,

[2]Faculty of Electrical Engineering, Skopje, e-mail: sugo@etf.ukim.edu.mk

The aim of the work is to compare properties of Sliding Mode Controlled (SMC) versus classical Proportional Integral (PI) controlled brushless DC motor (BLDC) in applications where the speed constancy is demanded. The micromotors mostly used in the past were brush-type DC motors (BDC), induced by their low market price and appropriateness for mass production. However, they exhibit limitations both in the rotating speed and in the torque as a consequence of the sparking brushes and because the driving windings are located at the rotating part. BLDC micromotors are working at higher speeds, accelerate faster, dissipate lower heat power supporting higher torque and are much lighter, [1]. In dental applications speed constancy and low vibrations are the must, thus BLDC completely suppress BDC, [2], [3].

Keywords: Sliding Mode Control (SMC), Proportional Integral Differential (PID) control, Brushless DC motor (BIDC)

I. INTRODUCTION

There are several approaches in variable speed drive control of BLDC micromotors such as PID, FUZZY, neural network, genetic programming and hybrid algorithms, [1], [5], [6]. In this paper we make comparison between SMC and PID control of BLDC drives applicable to dental equipment. The "matlab/simulink" simulations were made on a model very similar to the one used in the contemporary dentistry [7], yet results presented are not supported by laboratory examinations. A sliding dynamics, existence and stability of the equilibrium point of SMC controlled BLDC micromotor are given in [8]. Schematic diagram of the simulation is shown in fig.1.

II. A PID CONTROLLED BLDC MICROMOTOR

The BLDC model utilized for simulation by Proportional Integral (PI) controller is taken from [7] as Matlab simulation example No.6. It is a 3-phase motor model with trapezoidal emf distribution and parameters specific to the dental micro-motors that are given in table 1. (It appears that the Differential part is unnecessary). The referent values of the speed and the load used for simulations are typical for dental micromotors and are shown in fig.3. The speed and the load change their sign during the simulation process. Fig.2 presents a control scheme for driving current prediction implemented by PI controller with a saturation module. A discrete PI algorithm obeys equation (1). Further details can be found in [4]. Simulation results for the rotational speed are presented in fig. 4.

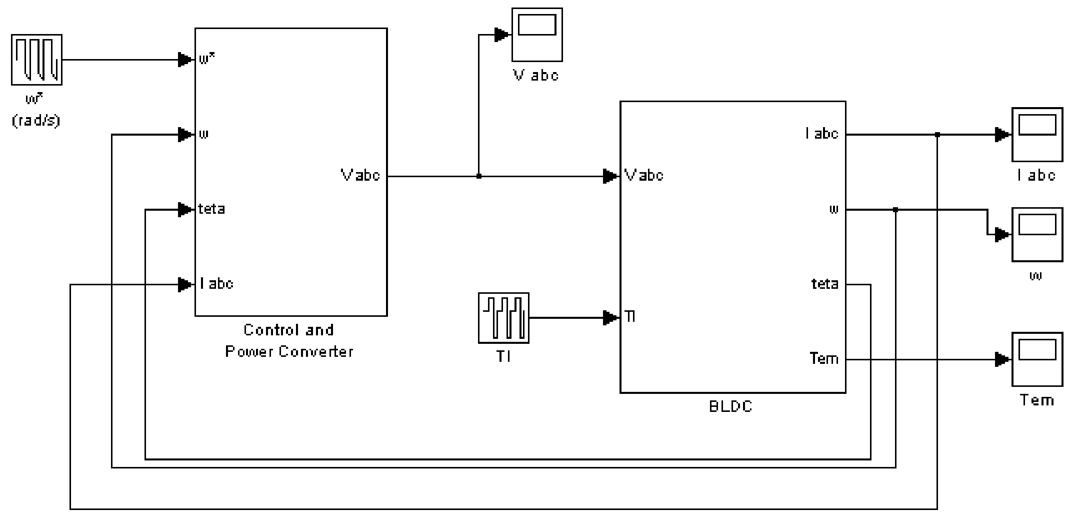

Fig. 1 Schematic representation of simulation

Table 1 BLDC model parameters

Number of poles,	p1 = 2
Stator resistance,	Rs = 0.1 Ω
Stator inductance,	Ls = 0.5 mH
Mutual phase inductance,	M = 0.1 μ H
Rotor length,	lpm = 10 mm
Total rotor inertia,	J = 5 Nm x10-6
Friction constant,	B = 2 Nm x10-9
Maximal current,	Imax = 12 A
Sampling Period,	Ts = 0.5x10-6 s

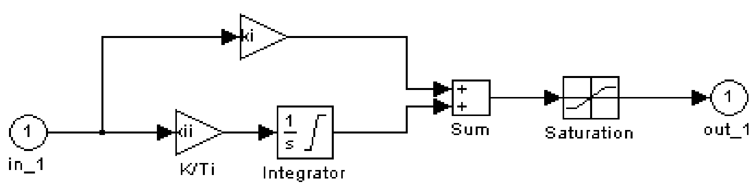

Fig. 2 Block diagram of PI controller
(time constant = 0.01s; gain = 1; overload factor kl = 2)

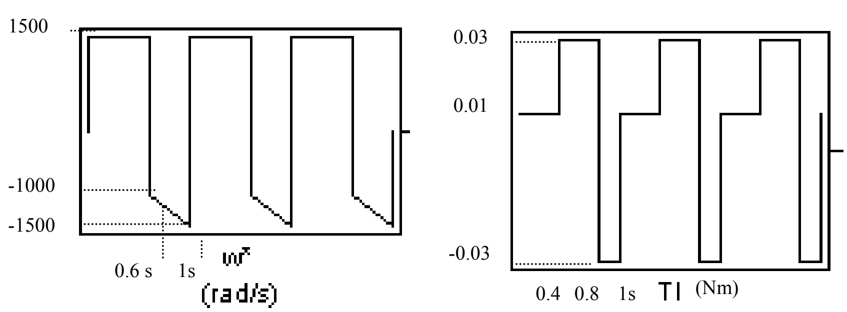

Fig. 3 Referent values of rotational speed w^* and load torque T_l.

$$i(t,t+T_s)=k_i\Delta w(t)+k_{ii}T_s\sum_{j=0}^{n}\Delta w(jT_s)$$ (1)

$$\Delta w(t)=w(t)-w^*(t); \qquad t=nT_s\,. \quad n=0,1,2,..$$

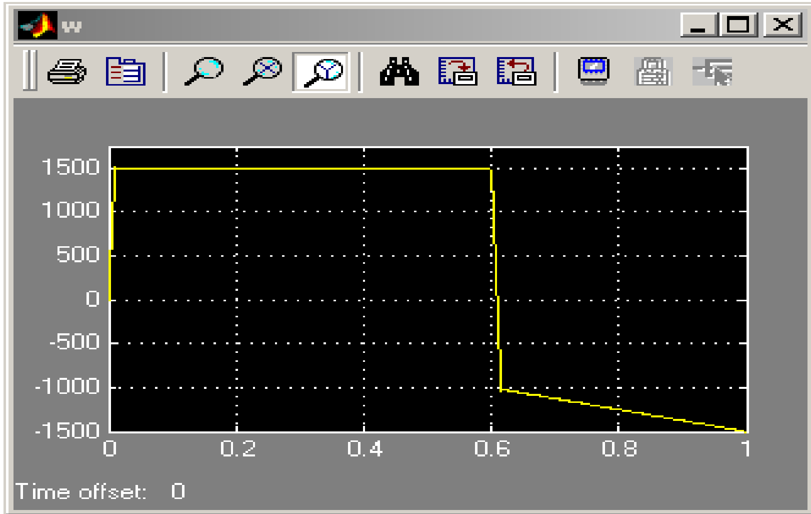

Fig. 4 Time dependence of a speed with PI controller

III. SMC CONTROLLED BLDC

The same motor model is used in sliding mode control (SMC) simulation, but instead of a PI block we introduce a signum function for the current with two values: I_max and I_min, fig. 5. SMC algorithm is given in equation (2). The simulation result for the speed is given in the fig.6.

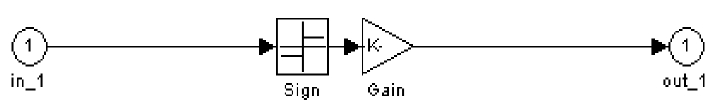

Fig. 5. SMC controller block diagram

$$i(t,\,t+T_s)=\begin{cases} I_{min}\;, \Delta w(t)>0 \\ I_{max}\;, \Delta w(t)<0 \end{cases}$$

$$\Delta w(t)=w(t)-w^*(t); \qquad t=nT_s, \quad n=0,1,2...$$
(2)

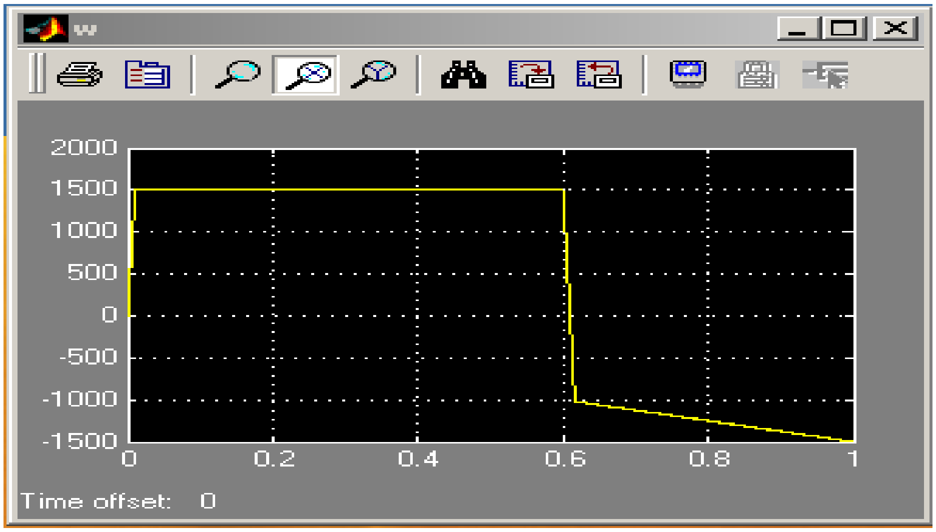

Fig. 6. Time dependence of a speed with SMC controller

IV. Conclusion

Simulation shows that both PID and SMC techniques give almost identical results regarding the time response of the rotational speed control. Nevertheless, SMC algorithm is simpler for digital (or analogue) implementation thus it can be considered as preferred in practical cases especially in dental micromotor applications.

V. References

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