

Model Predictive Control Of Dc Motor Model In Matlab

Aakriti Khanna, Tamanna Gaur

Abstract— The Growing need of industry for higher productivity is placing new demands on mechanisms connected with electrical motors. This is leading to different problems in work operation due to fast dynamics and instability. The stability of the system is essential to work at desired set targets. The nonlinear effects caused by a motor frequently reduce stability which reduces the controller's ability to maintain speed or position at set points. Hence number of the industrial process applications requires position control of DC motor. DC motors have traditionally been modeled as second order linear systems, which ignores the dead nonlinear zone of the motor. The paper gives insight into Model Predictive Control and run MATLAB simulations to show some of the theory for linear systems using a generalized system. The importance of MPC, components of MPC is mentioned and some of its practical applications on DC Motor are presented. This paper gives basics of MPC, use of MPC TOOLBOX for DC Motor modeling and Control.

Index Terms— DC Motor, model predictive control – MPC, MATLAB modeling, MPC Toolbox, simulink.

1 INTRODUCTION

A DC motor is a class of electrical machines that converts direct current electrical power into mechanical power.

The most common types rely on the forces produced by magnetic fields. The DC motor works on the principle of passing a current in a conductor inside a magnetic field. A force is developed on the conductor. When a group of these conductors are fixed on a rotating armature, a resultant torque is produced from all the forces on the individual conductors. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line.

In predictive control of DC Motor, pair of low-cost brushed DC motors is used to control the elevation and azimuth angles of a solar concentrator used for electrical power generation. Motion control systems takes input voltage as actuator input, and outputs linear or rotational position/speed/ acceleration/ torque, the most used actuator for motion control systems is DC motor. A single joint robot arm is an application example of an electromechanical system used in industrial automation. One technique of position control of DC Motor is implemented in this paper using MPC Controller toolbox in MATAB. The term Model Predictive control does not designate a specific control strategy but a very ample range of control methods which make an explicit use of a model of the process to obtain the control signal by minimizing an objective function. These design methods lead to linear controllers which have practically the same structure and present adequate degrees of freedom.

2. DC MOTOR-SYSTEM MODEL DEVELOPMENT

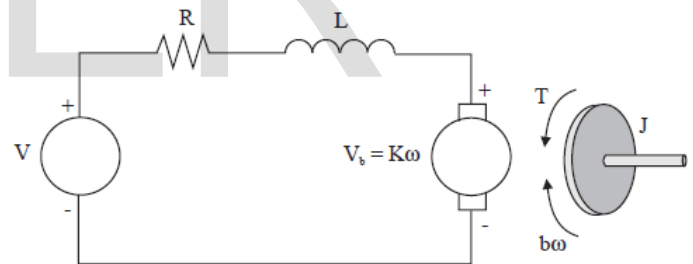
The simplest model has a first-order plus integrator structure:

$$G_p = \frac{K_p}{s(T_p s + 1)}$$

Where the output is angular position, K_p is the gain and T_p is the time constant related to the mechanical part of the motor.

2.1 Electrical Equivalent of DcMotor

Fig 1. Electrical Equivalent of Dc Motor



The input is the armature voltage V in Volts (driven by a voltage source). Measured variables are the angular velocity of the shaft ω in radian per second, and the shaft angle θ in radian.

Where:

V = Armature Voltage (volts)

R = Armature Resistance (Ω)

L = Armature Inductance (H)

I = Armature current (amp)

b = damping (friction) coefficient

V_b = Back emf (volts)

T = Torque (Nm)

θ = angular position of the rotor shaft (rad)

2.2 Equations

The motor torque, T , is related to the armature current, i , by a constant factor K

$$T = Ki \tag{1}$$

The back electromotive force (emf), V_b , is related to the angular velocity by:

$$V_b = Kw \tag{2}$$

2.3 Transfer Function with Block Diagram

$$J \frac{d^2\theta}{dt^2} + b \frac{d\theta}{dt} = Ki, \tag{3}$$

$$L \frac{di}{dt} + Ri = V - K \frac{d\theta}{dt}. \tag{4}$$

The transfer function from the input voltage, $V(s)$, to the put angle, θ ,

$$\frac{\theta(s)}{V(s)} = \frac{K}{s[(R + Ls)(Js + b) + K^2]}.$$

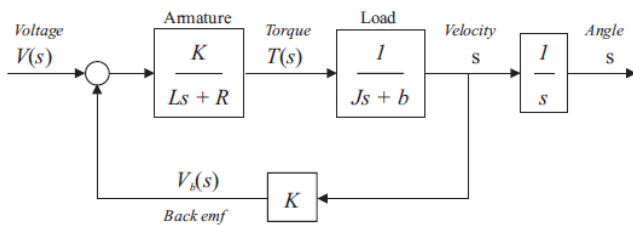


Fig 2. Block Diagram of DC Motor

3. MODEL PREDICTIVE CONTROL-CONTROLLER DEVELOPMENT

The paper uses Model Predictive Controller (MPC) for the control of DC motor. Predictive Control Technique is widely implemented in industry. Predictive Control describes an ‘approach’ to control design, not a specific algorithm.

Many effective control strategies have their origins in human behavior. Humans make good use of predictions. For example: Driving a car, Racquet Sports.

Prediction underpins practical human control strategies and thus seems a logical concept to incorporate into automated strategies.

Prediction Control is Easy to understand, implement for variety of systems, handles constraints systematically, Handles MIMO systems and dead time without any modification, is Feed Forward and Handles challenging dynamics (unlike PID).

MPC is a type of control in which the current control signal is determined such that desirable output behaviour results in the future. Thus we need the ability to efficiently predict the future output behaviour of the system. This future behaviour is a function of past inputs to the process as well as the inputs that we are considering to take in the future. In MPC structure there is a feedback or feed forward path to compute the process measurements. There are mainly three components are available in MPC structure:

- The process model
- The cost function
- The optimizer

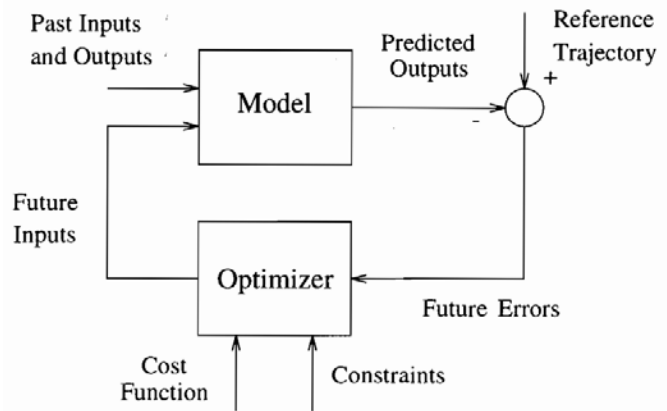


FIG 3 BASIC STRUCTURE OF MPC

4 .MATLAB SIMULATION

Dc Motor system model can be made using the differential equations (3) and (4) ; Considering no friction i.e. $b=0$

The simulated model is as shown in fig 4. :

The parameters considered are : moment of inertia =0.005 kgm², inductance = 0.2 H , Resistance =1ohm , $K(\text{torque}) = 0.02 \text{ N-m/A}$, $K(\text{backemf}) = 0.22 \text{ V/(rad/s)}$

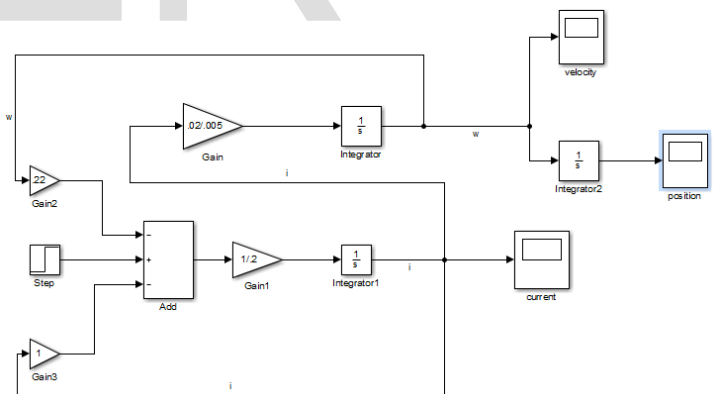
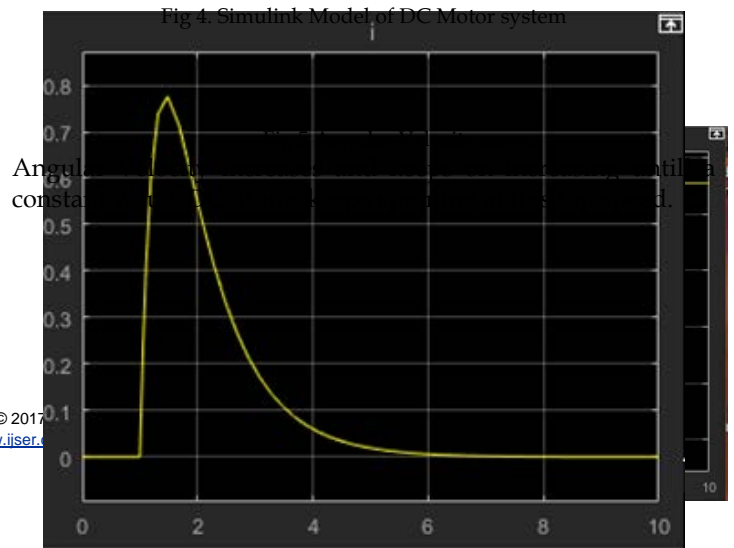


Fig 4. Simulink Model of DC Motor system



• Aakriti Khanna is currently pursuing masters degree program in electronics and instrumentation engineering in YMCA University OF Science and Technology, India, PH-9718873339. E-mail:aaki.0502@gmail.com
• Tamanna Gaur is currently pursuing masters degree program in electronics and instrumentation engineering in YMCA University OF Science and Technology, India, PH-9711225827. E-mail: tamanna_tg@gmail.com

Fig 6 Current curve

Current goes up when step function of voltage increases because it is applying torque to load and load starts to spin then current decreases

The simulink diagram for the DC Motor position control using MPC is as shown in the Fig 7.

Fig 7. Simulink Model for DC Motor using MPC

The DC Motor plant model is simulated using MPC Controller and the results after simulation are shown below in Fig 8-11.

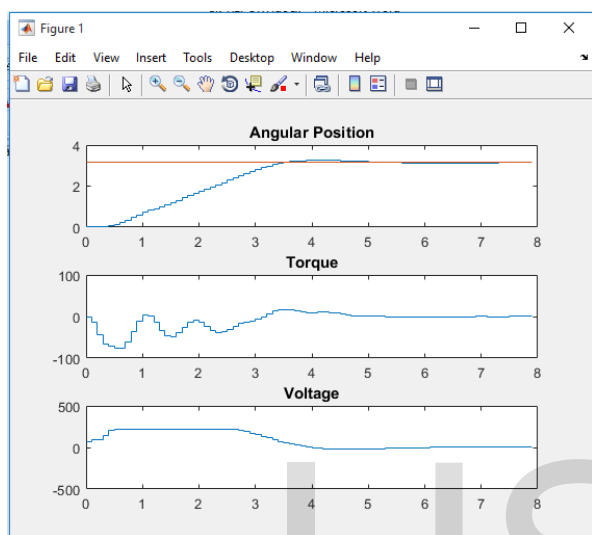


Fig 8.Theoretical result

Fig 10 Torque Wavefrom from Simulink

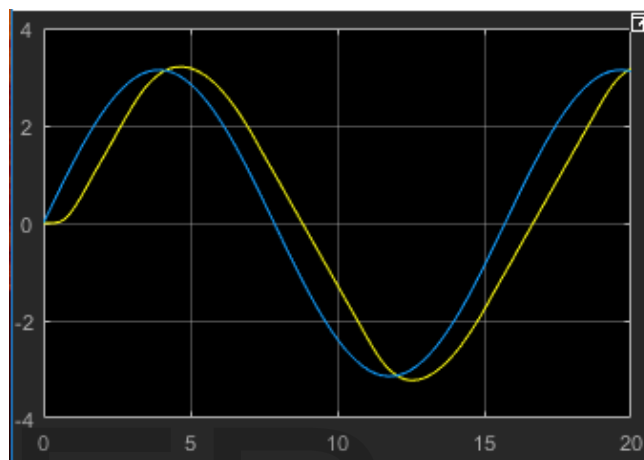


Fig 11 Angle Waveform From Simulink

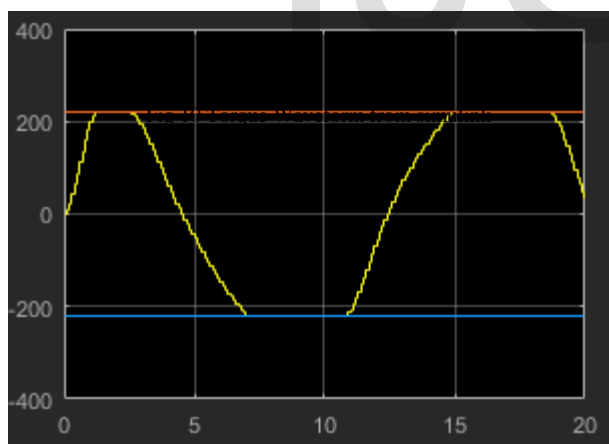


Fig 9 Voltage Waveform from simulink

The key features of the diagram are as follows:

The MPC Controller output is the plant input.

The Voltage Scope block plots it (yellow curve). Minimum and maximum voltage values are shown as blue and red curves respectively.

The plant output is a vector signal. The first element is the measured angular position. The second is the unmeasured torque. A Demux block separates them. The angular position feeds back to the controller and plots on the Angle scope (yellow curve). The torque plots on the Torque scope (with its lower and upper bounds).

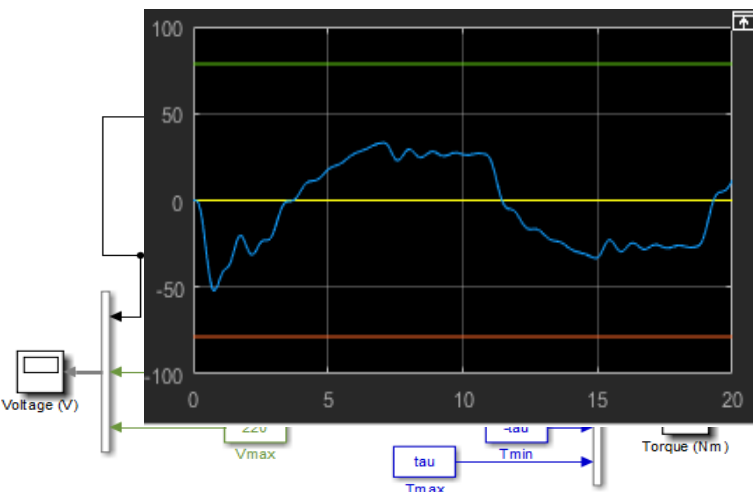
The position set point varies sinusoidally with amplitude π radians and frequency 0.4 rad/s. It also appears on the Angle scope (blue curve).

The scope displays for a 20-second simulation. The angular position tracks the sinusoidal set point variations quite well, despite saturation of the applied voltage. The set point variations are more gradual than the step changes used previously, so the torque stays well within its bounds.

5. CONCLUSION AND FUTURE SCOPE

The paper gives insight into model predictive control and run MATLAB simulations to show some of the theory for linear systems using a generalized system. MPC is popular due to its ability to yield high performance control systems capable of operating without expert involvement for longer periods of time and also its ability to handle constraints.

The importance of MPC, components of MPC is mentioned



and some of its practical applications on DC Motor is presented. It can be concluded that using MPC TOOLBOX in MATLAB is beneficiary in designing of the controller. It is less time consuming. Input and Output constraints are taken care of.

The future Scope of this can be:

- The comparison of MPC with different type of controllers so that the best controller can be chosen.
- Robust and Adaptive multiloop controllers may be developed and implemented for the same process.
- Control strategies may be developed for other similar nonlinear MIMO processes

ACKNOWLEDGMENT

I would like to take this opportunity to express my profound gratitude and deep regard to my guide Mr. Lalit Rai for his exemplary guidance, valuable feedback and constant encouragement throughout the work. The valuable suggestions were of immense help in completing the work.

I would also like to give my sincere gratitude to all my friends and colleagues especially Ms.Tamanna Gaur who filled in the survey, without this the research work would be incomplete.

REFERENCES

- [1] Ms.Manjusha Patil,Modelling and simulation of dc drive using PI and PID controller
- [2] K.Hari kishore kumar and K.Rohith , performance comparison of different controllers for brushless dc motor,2013
- [3] Dinesh L.Mute, Khushak Chaudhari, Ramesh Khamari, Abhijit Singare,System Identification using neural network model for speed control of DC Motor.
- [4] M.S.RUSU and L.Grama,The design of a DC motor speed controller,Fascicle of Management and Tech Eng. Vol VII(XVII),2008,pp1055-1060
- [5] Chun Htoo Aung , Khin Thandar Lwin and Yin Mon Myint,Modelling motion control system for motorized robot arm using MATLAB, World Academy of Science,Engineering and Technology.
- [6] N.N.P.Mahalik and K.K.Kim, "A prototype for hardware in the loop simulation of a distributed control architecture,"IEEE Trans. Syst., vol.38, no.2, pp.189- 200, Mar. 2008.
- [7] Paul I-Hai Lin, Santai Hwang and John Chou "Comparison on Fuzzy Logic and PID controls for a DC Motor Position Controller" National Taipei Institute of Technology, Taipei, Taiwan,Republik of china, 1994 IEEE.
- [8] Model Predictive Control Design and Implementation using MATLAB,Springer
- [9] Model Predictive Control, Eduardo F.Camacho and Carlos Bordons.