

Design And Verification Of Model Predictive Control For The PMDC Motor

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Abstract

In this paper using the system identification method a PMDC motor transfer function is derived. The transfer function is derived in digital as in continuous domain and it is verified with the parameter of PMDC motor. The model predictive control method is applied for the control of PMDC motor. The model of the system used here is the practical or the actual model of the system that is derived from the practical setup.

1. Introduction to PMDC motor

When high efficiency, high starting torque, and a linear speed/torque curve are required, PMDC motor is the best choice over other DC motor. The single design feature which distinguishes the permanent magnet DC motor from other DC motors is the replacement of the wound field with permanent magnets. The need for separate field excitation and attendant electrical losses in the field windings has been eliminated.

2. About Model Predictive Control

Originally developed to meet the specialized control needs of power plants and petroleum refineries, MPC technology can now be found in a wide variety of application areas including chemicals, food processing, automotive, and aerospace applications. Its reason for success is many, like it handles multivariable control problems naturally. But the most important reason for its success is its ability to handle constraints. Model predictive control (MPC) refers to a class of computer control algorithms that utilize an explicit process model to predict the future response of a plant. At each control interval an MPC algorithm attempts to optimize future plant behavior by computing a sequence of future manipulated variable adjustments.

The first input in the optimal sequence is then sent into the plant, and the entire calculation is repeated at subsequent control intervals. The basic MPC controller can be designed with proper restrictions on the prediction horizon and model length. The prediction horizon has to be kept sufficiently larger than control horizon. In this paper a constrained based SISO type MPC design is carried out based upon the practical model of the system.

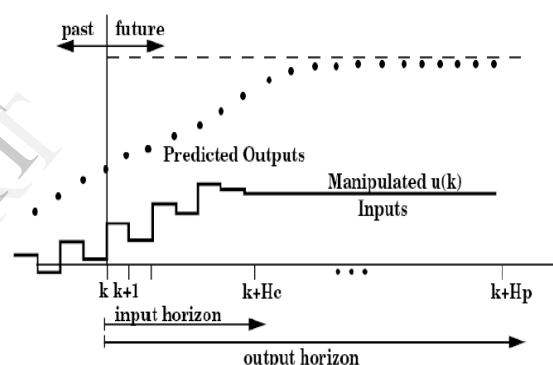


Fig.1 The receding horizon concept for the MPC

The figure 1 shows the basic idea of predictive control. In this presentation of the basics, we confine ourselves to discussing the control of a single-input, single-output (SISO) plant. We assume a discrete-time setting, and that the current time is labelled as time step k . At the current time the plant output is $y(k)$, and that the figure shows the previous history of the output trajectory. Also shown is a set point trajectory, which is the trajectory that the output should follow, ideally. The value of the set-point trajectory at any time t is denoted by $s(t)$.

2. Identification of the System

The first step is to calculate the transfer function of the PMDC motor[2]. This is done using data acquisition technique in MATLAB

Simulink. The block diagram and its initialization are as follows. Here the “Query instrument” facility is used to take the data serially from the PIC16F877A microcontroller. The Max 232 IC is used to transfer the signal from PIC microcontroller to the PC. The frequency to voltage converter circuitry is used take the data from proximity sensor in terms of pulses and converts it to voltage. The analog to digital converter of PIC16F877A is used to convert the data to the digital values and it transmit the data serially to the PC.

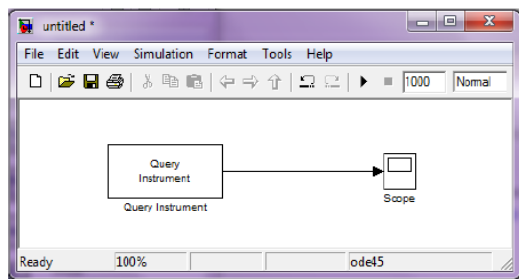


Fig 2 : Initialization of the query instrument

The hardware setup is used to get the PMDC motor speed data from PIC microcontroller PIC 16F877A to the PC and plot for the step input command is obtained as shown in the Figure 3.

The plot of the motor is obtained as follows. Here the scale is converted in appropriate unit:

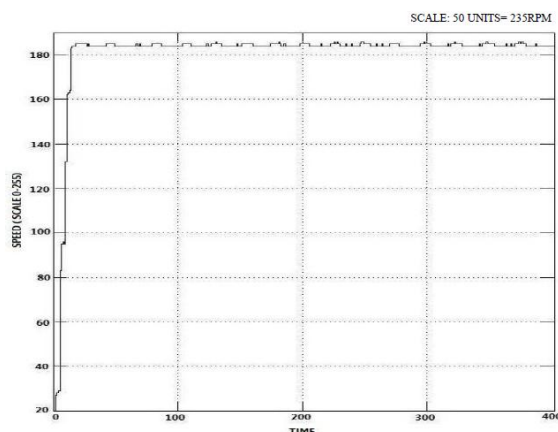


Figure 3 : Motor output

After that using the MATLAB Identification tool box the transfer function for the PMDC motor is obtained and the transfer function for the motor is

$$\frac{y(s)}{r(s)} = \frac{0.997e^{-0.097s}}{1 + 0.1657s}$$

The above transfer function is obtained without the motor load.

3. Model Predictive controller design

Here the MATLAB script is used to design the Model predictive controller in presence of noise. The noise is introduced into the system using the disturbance model and the disturbance transfer function used is

$$\frac{y(s)}{r(s)} = \frac{1.52e^{-0.5s}}{1 + 0.057s}$$

The MATLAB command used is `mpcsim` and `mpcon`, the output is as shown in figure

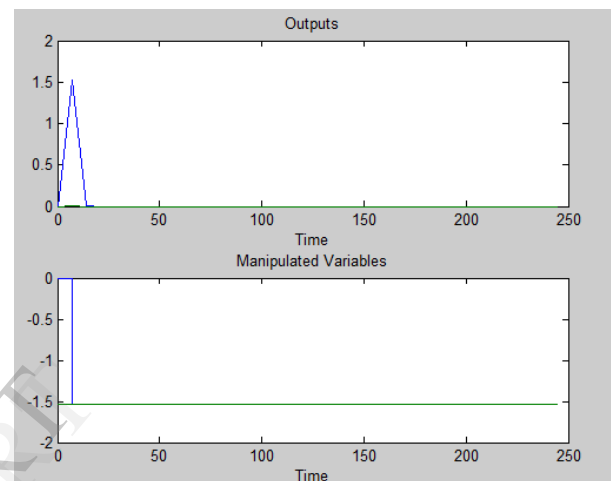


Figure 4 MPC output without the disturbance.

The MPC controller output for the unknown disturbance and manipulated is as shown in the figure 5. The input and output prediction horizon used here is 5 and 10 respectively. The gain matrix value used here is 10.

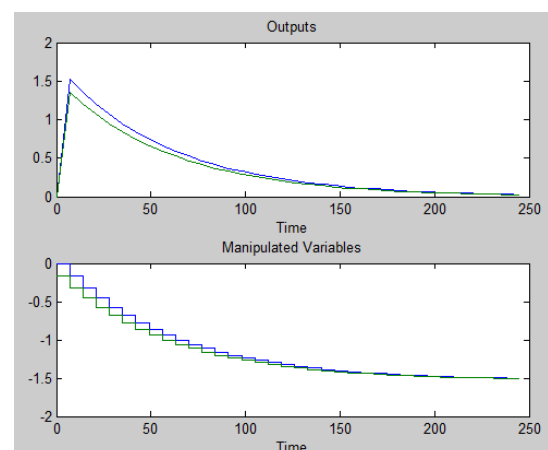


Fig.5 MPC output for the measured disturbance

The MPC output for the unmeasured disturbance is as shown in figure 6.

The sample code for the MPC is as below :

```

% Simulate and plot response for unmeasured
and measured
% step disturbance through dplant.
tend=245;
r=[ ]; usat=[ ]; tfilter=[ ];
dmodel=[ ];
dstep=1;
[y3,u3]=mpcsim(plant,model,Kmpc2,tend,r,us
at,tfilter,...
dplant,dmodel,dstep);
dmodel=dplant; % measured disturbance
[y4,u4]=mpcsim(plant,model,Kmpc2,tend,r,us
at,tfilter,...
dplant,dmodel,dstep);
plotall([y3,y4],[u3,u4],delt2);
pause;

```

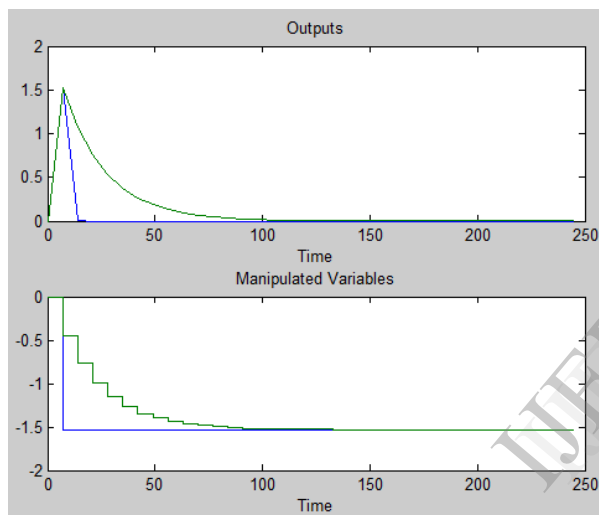


Figure 6 MPC output for the unmeasured disturbance.

4. Conclusion

We have designed the MPC controller using the actual plant model of the system. The MPC controller works well in presence of disturbances that is measurable. However for the unmeasured disturbances the MPC controller takes more time to reject the disturbance compare to the other controllers like PID or IMC tuned PID[3]. In future the online real time plant variation model can be incorporated into the present system to design the real time PC based MPC controller.

5. References

- [1]Kwon, W. H.; Bruckstein, Kailath (1983). "Stabilizing state feedback design via the moving horizon method". International Journal of Control **37** (3): pp.631–64
- [2]Prof Sandip Mehta, Prof Vishal Vaidya, "Design and comparative study of PID controller tuning method from IMC tuned 2-DOF pole placement parameter structure for the DC motor speed control application", IEEE international conference NUiCONE 2012.
- [3]H.A. Ghazzawi, I. Bate, and L.S. Indrusiak. MPC vs. PID Controllers in Multi-CPU Multi-Objective Real-Time Scheduling Systems. UKEF August 2012.