

Response of 2-input 3-state MIMO Model of an Instrument Control Motor

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Abstract: The paper deals with behavior of Multi Input Multi Output (MIMO) state space models for different types of inputs. To achieve a satisfactory response the study of plant control is necessary. The standard input signals are analyzed by taking a state space industrial D.C servo motor model. The model is built using control and simulation loop present in Lab VIEW software. The responses depend on the values of state-space matrices, magnitude of the gain provided in the feedback mechanism and also on the behavior of the continuous linear systems like Integrator and Derivative functions.

Keywords: MIMO, Lab VIEW, State space, Model Predictive Control (MPC).

I. INTRODUCTION

A plant is a combination of various machine parts that function together to perform a particular operation. A system is a combination of different components acting together for performing a particular task. The plant parameters can be analyzed by SISO, SIMO, MISO and MIMO dynamic system models. SISO systems are linear and time invariant whereas MIMO systems are nonlinear and time variant. PID comes under the category of SISO whereas advanced controllers like MPC are categorized under MIMO. MIMO systems are popular in all process industries which deals with multiple inputs like inlet temperature, input pressure built in any particular section and multi outputs like level of a tank, flow of liquid from one section to other, output temperature so on. The state space equations for continuous time-invariant systems are given by:

$$x' = A x(t) + B u(t) \quad (1)$$

$$y = C x(t) + D u(t) \quad (2)$$

where u is the input vector, y is the output vector, x is the state vector. A , B , C , D are called the state-space matrices where A is state matrix, B is input matrix, C is output matrix, D is direct transmission matrix. Servo motors are used to yield best means of speed control in terms of reliability and instrument performance. There are two types of servo motors A.C and D.C.D.C servo motors are suitable for small control processes like machine tool handling, smooth operations like conveyor belts which carry raw as well as finished materials and parts from one section to other section for further processing.

II. SIMULATION

Lab VIEW (Laboratory Virtual Instrumentation Engineering Workbench) is used as simulation software for MIMO modeling. Lab VIEW is used as software for Virtual Instruments. It is a graphical user interfacing with built-in functionality for simulation analysis and presentation of data.

The main components in VI are front panel and block diagram. Front panel contains controls and indicators. Controls are inputs used to simulate the instrument input devices to supply data to the block diagram. Indicators are outputs that are used to simulate instrument output devices and display data the block diagram acquires or generates. Block diagram include terminals, sub VIs, functions and constants. Control design is a process that involves development of mathematical models for describing a plant, analyzing the models to learn about their dynamic characteristics, creating a controller to achieve the required characteristics. The model based control design involves four stages which include developing and analyzing a given model, designing and analyzing a controller for the dynamic system defined.

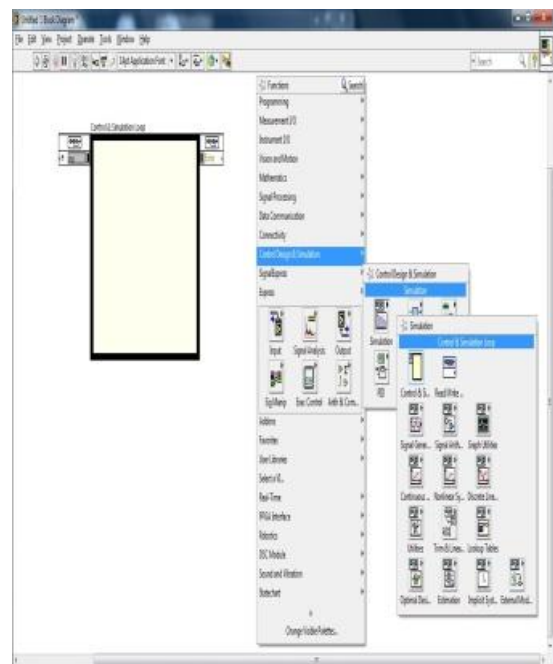


Fig.1. Block diagram representing control and simulation loop.

Simulation of the dynamic system and final stage includes deploying the designed controller. The control and simulation loop is used to simulate the given linear systems and also to determine the responses. There are two nodes known as error input and error output.

Error input is used to detect the error and the simulation diagram sends the information to the error output and simulation is not executed. It is present in the functions palette of block diagram as shown in figure 1.

Transfer function is the ratio of numerator polynomials having zeroes and denominator polynomials having poles. A transfer function is constructed with the help of the CD construct transfer function model tool present in Lab VIEW software.

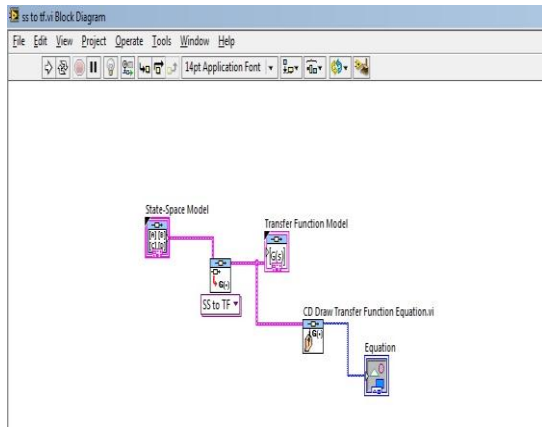


Fig.2. Block diagram representing conversion of state space model to transfer function.

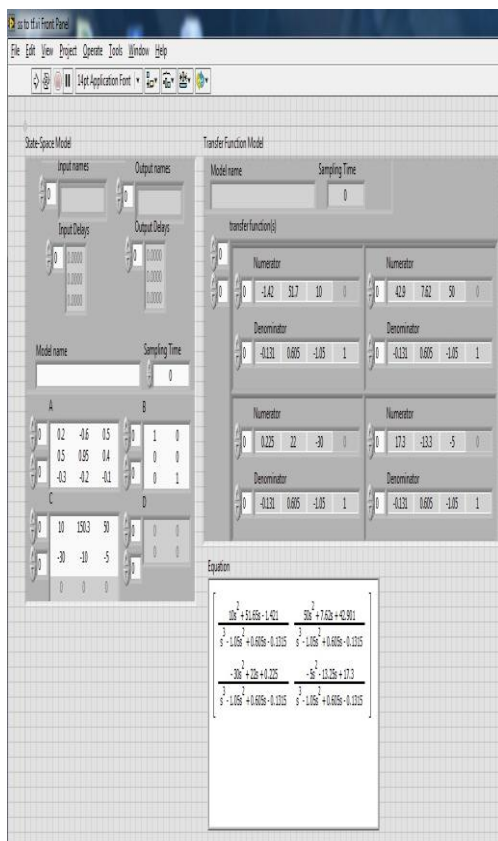


Fig.3. Transfer functions for the given state space matrices.

The MIMO transfer function is converted into either a continuous or discrete state space model. It is shown in figure 2. For obtaining discrete model, sampling time should be provided.

III. MODELLING

Mathematical modeling is a description of the system in terms of equations. The MIMO system must have several inputs each of which is a function of time and several outputs that are variables to be calculated. The input is taken from signal generator block as shown in figure 4. The advantage of this model is that the model dimensions can be specified internally along with the elements of A,B,C and D matrices as shown in figure 5. The values present in the matrices (state, input and output) are obtained from the transfer function equation of a D.C servomotor. The collector block is used to connect the intermediate blocks to the XY graphs in order to represent the responses of the state space models. Collector is used to collect a signal at each time step of the simulation and returns a history of the signal value. It comes under the category of utilities.

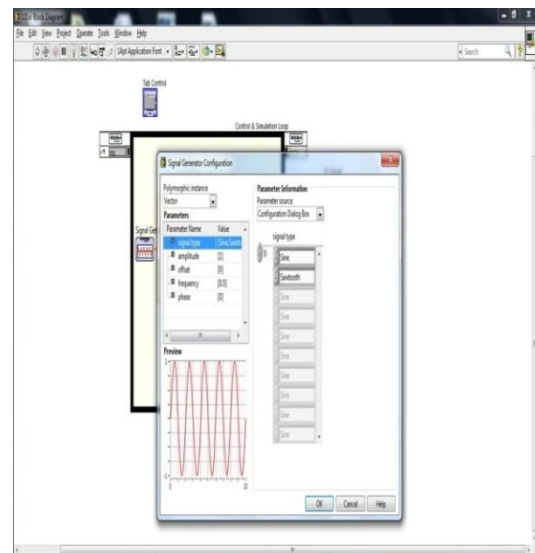


Fig.4. Selection of signal generator parameters.

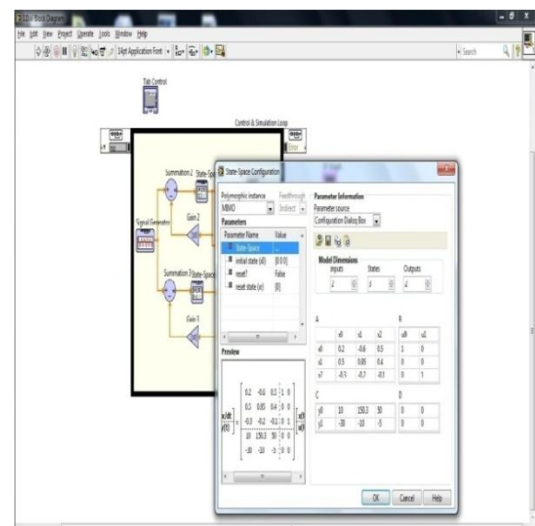


Fig.5. Defining the state variable model values.

The output $y(t)$ of state space matrices corresponding to the industrial motor are connected to integrator and derivative functions as shown in figure 6. A summation is used to introduce gain in the feedback. The gain is adjusted to a value until a clear response is obtained.

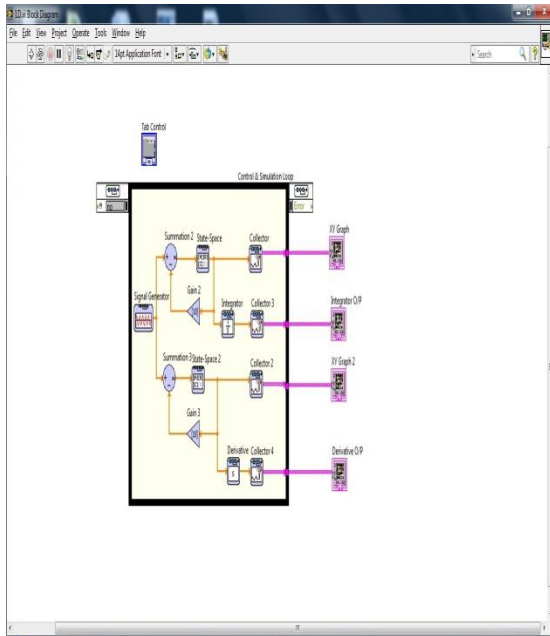


Fig.6. Block diagram showing input and output blocks.

IV. RESULTS

Figure 7 shows the responses of both the output of steady state model $y(k)$ and integrator function. The amplitude values change based on the given values and also on the feedback gain. Figure 8 displays the responses of both the output of steady state $y(k)$ and derivative function.

As the values taken in the matrices are having decimal terms the resultant graphs of integrator and derivative are not clear and it resembles that there is some disturbance. So, selection of parameters in the matrices will affect the response curves.

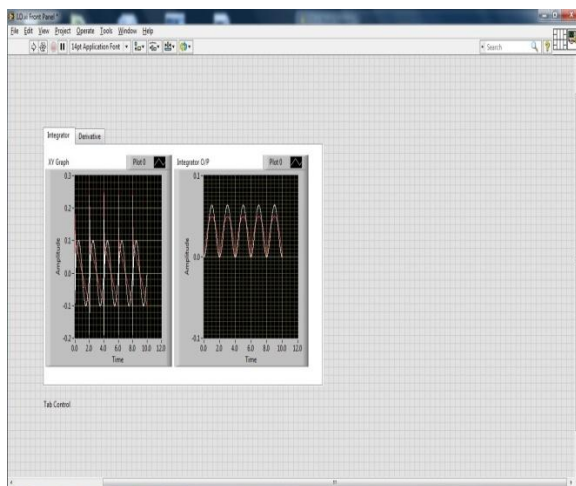


Fig.7. System responses for $y(k)$ and integrator function.

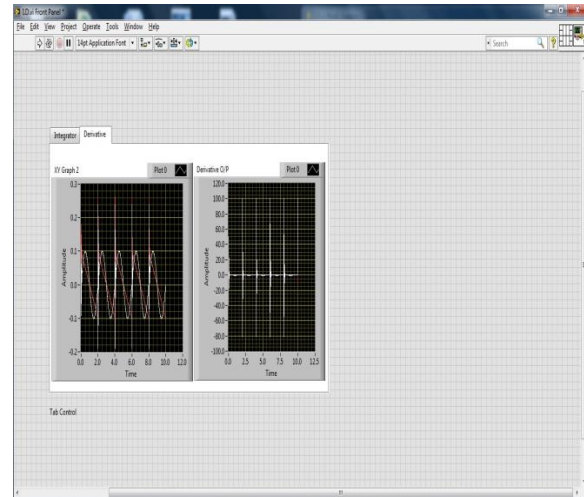


Fig.8. System responses for $y(k)$ and derivative function.

V. CONCLUSION

In this paper the state space models are analyzed for multiple inputs with linear functions and results are displayed graphically. This method is simple as the number of inputs can be varied according to the transfer function model of any particular system like a DC servo motor which is used for speed control of actuators in an instrumentation field.

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