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Cascade PI Observer with Stabilization Lock

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Abstract: **— This paper presents a new practical control structure to achieve the stable condition of electric motor drives. PI observers are incorporated with predesigned PI controllers in order to enhance the robust performance of current and speed controllers. The proposed method uses an adaptive final control by taking the magnitude of processed difference in error to accure faster steady state.**

***Keywords*-cascade control; electric motor drive; cascade control method; proportional integral(PI) observer; pulse width modulation.**

I. INTRODUCTION

The cascade control system is used to reduces disturbances and improve closed loop system performances. The cascade structure which is composed of two nested loops with two pi controllers, consists of primary (outer) and secondary (inner) loops [1]. Due to the effect of model uncertainties and external disturbances, the design of efficient controllers has been a central problem in control society. Adaptive, sliding mode control [5], mode predictive control and observer-based control, are some of the control strategies used in existing system. These methods have improved the robust performance of the control system in different aspects. Cascade configuration adopted as a basic scheme for demanding control problems, because of its practical advantage such as it accounts for external disturbances and simple**.**

In previous studies there were two classes of observer design methods. One method related with state estimation. The kalman filter also known as linear quadratic estimation is an algorithm that uses a series of measurements observed over time, containing statstical noise and other inaccuracies, and produces estimates of unknown variables that tend to be precise than those based on single measurement alone. Its extensions are based on plant model, assumed or use the knowledge about the measurement noise. They are able to work with disturbance model-based observers or disturbance descriptions. This method can be used for robust estimation of states in case of modeling uncertainities or additive non linear effects. The second type of observer based on luenberger observer approach is called disturbance approach. Even if an accurate model of system is available, in reality the system may affected by unknown inputs, which may be disturbances or unmodelled dynamics. Luenberger observer is widely used, because of its capability to estimates the system states. The proportional observer is the most basic of all luenberger observers. An observer with integrators, modified integral observers, proportional integral observers and function observers are other types of observer equipped with complex feedbacks. The pi observer is characterized by stronger attenuation of reconstruction errors and provide better reconstruction quality than p observer. In some cases the non proportional observers that mentioned above can remain unstable, independent of its gain selection. Dob scheme [6], [7] and load torque observer method is set to improve the robustness property. Pio has two loops a proportional loop and integral loop of an output error estimation. It is used to estimate the states and unknown inputs**.**

II. CASCADE CONTROL METHOD

Proportional integral (pi) is the most used algorithm to regulate armature and speed of cascade control system in dc motor drives. The controller uses two pi controllers. One pi controller is for speed control and second pi controller for current control in cascaded structure. Inner loop is for current control and outer loop is for speed control. The outer loop is called primary loop and inner loop is called secondary loop.

The purpose of secondary loop is to compensate quickly for the uncertainties so that its response in the primary output variable of the process is small. Cascade control can give improved tracking of varying a set point. Pio control algorithm is implemented on pic 18fmicrocontroller [4].

III. PI OBSERVER

The high-gain pi-observer as a state and disturbance observer can be applied to design an observer-based nonlinear robust control. Due to the simple linear structure of the pi-observer, the best complementary method for the pi-observer in nonlinear control design is the exact feedback linearization approach. The pi-observer can offer the estimations of the states and unknown inputs for the exact feedback linearization. The linearized model generated by the feedback linearization is appropriate for the pi-observer design. The state and disturbance observers have advantages in reconstructing the state and disturbance simultaneously and are therefore appropriate for disturbance attenuation, disturbance rejection, and fault diagnosis in control systems.

Among the state and disturbance observers, the high-gain pi-observer is the one with almost the simplest structure and design process. The high gain pi-observer has a simple linear structure in contrast to nonlinear observers. It is robust against disturbances and noise compared with luenberger observer [8] or observers without the integral part in the feedback of estimation errors. It estimates the states and unknown inputs simultaneously in comparison with state or disturbance observers, requires no special limitations on the type of disturbances compared with other kinds of state and disturbance observers [3].

The proposed structure includes two simple reduced-order PI observers (PIOs) in a cascade structure. Additional feed forward compensation done using the dual observers enhances robust performance against parameter uncertainties as well as the slowly varying load torque. In fact, the novelty of the proposed method is not in the use of PIO (or DOB) but in the cascade use of the reduced-order PIOs and the theoretical analysis of the structure. General properties of PIOs are discussed in [9],[10].

The proposed controller design process can be divided into two stages. In stage one, nominal cascade PI controllers are designed using a technical optimum scheme to achieve the control objectives in the absence of uncertainties. In stage two, the reduced-order PIOs are constructed to preserve the nominal performance of the cascade control approach. Since the design processes of the dual observers are decoupled from each other, the PIO for the current control loop does not use any information from the mechanical part of the system. The observer for the speed control loop uses neither electrical parameters nor the unknown load torque disturbance.

IV. COMPUTER SIMULATION

The development of accurate performance of motor drives is very important in industrial as well as other applications. for high performance motor drives should have good dynamic speed, command tracking and load regulating response dc motors are used in various applications such as defence, industries and robotics.

A. Simulation Algorithm

The flowchart of the proposed algorithm is depicted in fig.1. Speed of the dc motor connected is set with the help of a variable resistor which is connected to pin which works as a ADC port in microcontroller. When the controller gets the speed set from user, it start counting the pulse from sensors and from that, it measures the current speed of motor. after that entered and current speed of the motor gets compared and difference is calculated as error. if there is positive error, generate the negative magnitude p value. if there is no positive error, generate the positive magnitude p values. get the load value analyze it with p values for a specific time interval in order to degenerate the control signal. if the control signal is in stable zone, calculates the limited control signal to remove fluctuations. if the control signal is not in stable zone, provide original control signal.

B. New Methods

- ❖ Here we use an adaptive final control by taking the magnitude of processed difference in error to accure faster steady state.
- ❖ For higher load control observer, based on maximum point triggering get faster stability or high load cutoff.
- ❖ Third method is stability tuning to nullify small fluctuations in stability zone to adapt stable running in set speed with least tolerance.

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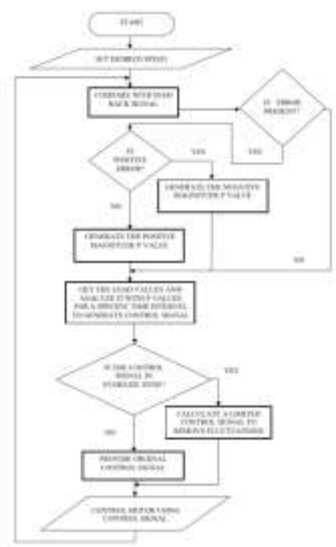

Fig. 1 . Flowchart

V. ANALYSIS RESULT

Fig. 3 shows the performance of three different systems under a constant 50% Load and set speed of 304 RPM. The simple PI cascade attains steady state much later than the other two types. The cascade system with PI observer provides much controlled output and attain the state early and the later system with stabilization loop have same properties like cascade system with PI but have an advantage of reaching stability 5 to 10 second faster than previous. The load and back emf response of simple cascade is very poor while comparing with other two systems and the cascade PI observer system is lagging some seconds against the system having stabilization loop.

The performance of new system under different test parameters like load variations, speed levels are shown in Fig. 2. For 20%, 50% and 75% the system starts differently but attains the steady state almost at the same time. So this proves that the system have the same response for different load levels. The other parameter considered here is the response to over load; Fig. 2. shows that the motor can't run at reference speed when it is loaded at 95% so the system shuts off the motor.

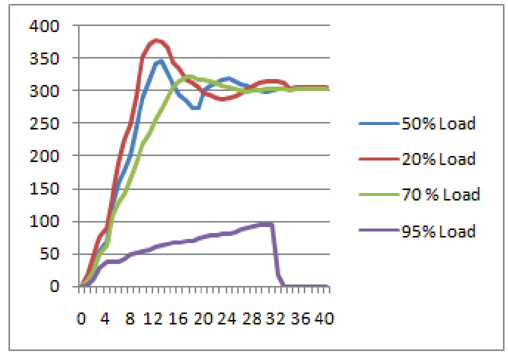

Fig. 2. Performance under Different Load Levels

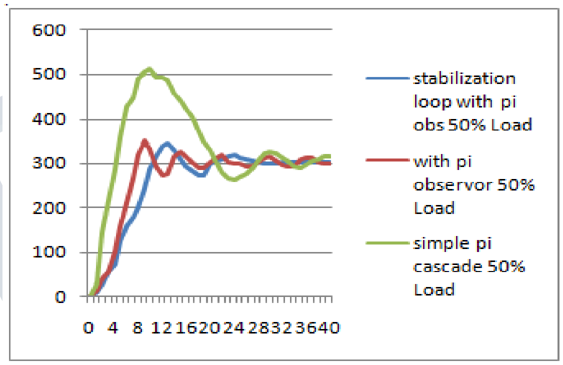

Fig. 3. This Gives the Comparison Chart of Three Different Types of The System

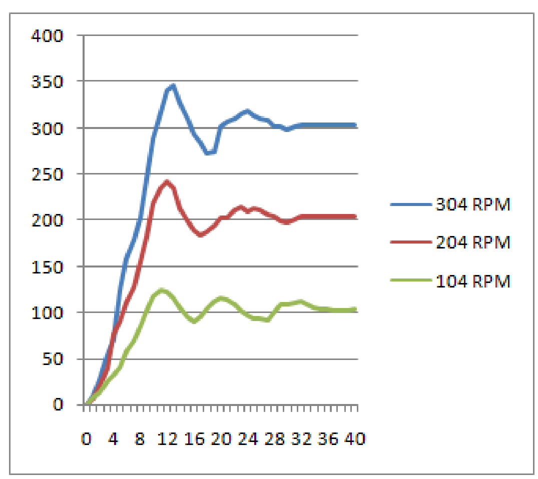

Fig. 4. Speed Level Performance.

The response graph of the system at 104, 204, 304 RPM where the load is constant at 50% is shown in Fig. 4. The stability perfomance of the system in different speed levels is almost the same.

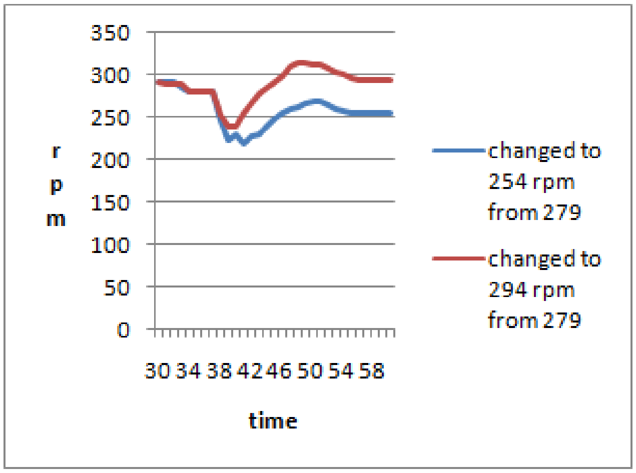

Fig. 5. Response when the reference speed is varied while operating.

The performance of the system by varying the reference speed positively or negatively is shown in Fig.5. The response graph of the system whose reference speed is varied 25 RPM positively at first and 25 RPM negatively, the system stabilizes at the same period of time.

V. CONCLUSION

A new practical control structure using dual first-order observers has been proposed in order to improve the performance of conventional cascade control method for electric motor drives. The single full-order PIO-based load torque observer has been widely employed. The cascade approach using the proposed observer has been subsequently applied to current and speed control that it may not affected due to disturbances or external uncertainities. Verification of the performance of the proposed approach is done using computer simulation. The analysis shows that the system attains stable condition using the proposed system faster than the existing methods.

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