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Automatic Control System of Speed of Synchronous Motor

*Azmer Dulevic1
1(Electrical Engineering/ Universitat Autònoma de Barcelona)
Corresponding Author: *Azmer Dulevic1

ABSTRACT: *This paper describes the automatic control system of the speed of the synchronous motor. Automatic regulation of acceleration in a system requires the device to detect frequency or speed in relation to the desired value. The automatic control system of the speed of synchronous motor regulates acceleration and the torque to attain fast and appropriate feedback. It consists of a double-locked current loops arrangement located on the q-axis and the d-axis.*
The system reacts to subsequent disturbance in the working environment like pressure and temperatures or fluctuating system requirements such as the condition of the load and power provision to ensure faster and precise response. The locked loop system assists in achieving the negative feedback requirements. Automatic control system swiftly executes error rectifications with minimum delays, before alteration of the system in to a different operating status.
Keywords: *Automatic Control, Synchronous Motor, Manual regulation, Negative response, Loop interruption, Closed or locked flux loop, jerk-in torque, modern speed regulators*

I. INTRODUCTION

1.1. Automatic Control System of Synchronous Motor Speed

The electromagnetic induction determines all operations of electric motors. Automatic regulation of acceleration in a system requires the device to detect frequency or speed in a distinct way in relation to the desired value. The frequency or speed detection establishes a signal of error, thereby forcing the system to respond through provision a corrective action. The automatic control system of the speed of synchronous motor controls the acceleration of the system and the torque to attain fast and good response.

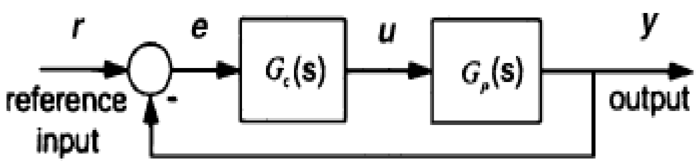

Fig.1 Feedback control configuration

The mechanical system consists of a double closed or locked current loops arrangement or system located on both the q-axis and the d-axis, locked torque loop and synchronous motor model with in a cascade structure. The current regulation loops form a subordination instruments to the acceleration or speed regulation loop. It is significant in high power devices because of its effectiveness at wide adjustable speed range. According to Gasiyarov, Maklakov,Voronin,&Maklakova(2015),the major significant of the automatic control system of the speed of the synchronous motor is its ability to guarantees high efficiency of energy. Besides high energy productivity, the automatic control system of the speed of the synchronous motor has reliable energy characterization. Its stator winding is normally supplied through the converter, back-to- back changer. Therefore, this paper seeks to describe the automatic control system of the speed of the synchronous motor.

1.1.1. General principles of regulation system

Manual regulation or open loop structure. The manual control system has fixed parameters or operator sets the parameters. This requires the system to attain self-equilibrium state. The angular situation or speed of the motor forms the operating equilibrium in the system. In some instances, the operator may not or may have control over parameters like the voltage supplied or a load of the motor (Gasiyarov, Maklakov, Voronin, &Maklakova, 2015). The alteration of the voltage supplied or load on the system's motor results in a new balance state. The establishment of a new balance or equilibrium state results in a new speed of the device. Therefore, the operator can alter the system's actual state of balance when the parameters are changeable.

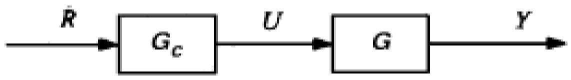

Fig.2 Connecting in Series-Open Loop

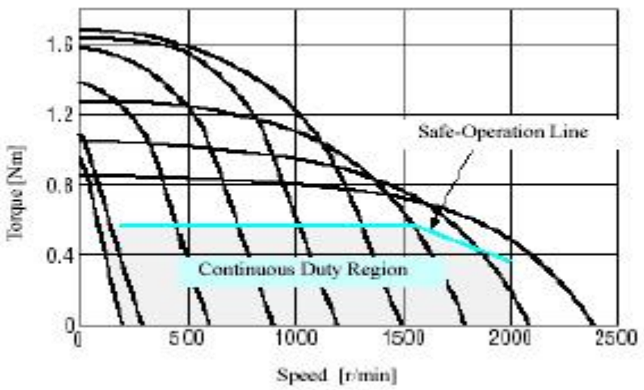

Fig. 24 Rotational Speed-Torque Characteristics for Open-Loop Control

1.1.2. Automatic control system or locked loop system

Un like the manual control system which does not react to subsequent disturbance or changes in the working environment of the system like pressure and temperatures or varying system requirements such as the condition of the load and power provision, the automatic control system ensures faster and preciseresponse(Gasiyarov,Maklakov,Voronin,&Maklakova,2015).Besides precise and faster response, the mechanical system does not require control and continuous monitoring of its operating condition, the system does not require the intervention of the operator.

1.1.3. Negative response

Negative feedback can refer to response control system. The feedback system permits operators to set the desired state of operation as reference or target. After setting the target, the system will mechanically achieve and maintain the desired point of operation. Monitoring of the original functioning state of the device requires the utilization of a sensor. Apart from sensor application, digital signal assist in illustrating output state of the system. The desired and actual state of reference is compared continually to determine any variation (Krause, Wasynczuk, Sudhoff, &Pekarek, 2013). The variation in the desired and actual state of reference or target represents a signal error which in turn assist the regulator to create control able parameters necessary in eliminating the signal error through back ward driving of the system to the desired operating state. Therefore, the locked loop system is essential in achieving the requirements of negative feedback.

Loop expansion or gain the signal error is normally very slight or insignificant. The detection of the error requires a high gain amplifier of error to assist the regulating signal to
Affect the change in the device, the loop expansion or gain(Voronin,Gasiyarov,&Radionov, 2016).

1.1.4. Loop interruption or delay

The error response in controlling systems in not instantaneous normally. The delays associated with error sensing or targeting new position, and error elimination or driving to favorite positions (Voronin, Gasiyarov, &Radionov, 2016). The delay in the automatic system may be related to inertia which is linked to lower possible speed in obtaining a mass to move when applying force to the system.

Automatic control system performances very swiftly to execute error rectification with minimum delays, prior to alteration of the system into a different operating status. The quick rectification ensures stable state of the automatic system. The system overshoots especially when there is enough time lag between error detection and accomplishment of the counteractive action with enough loop expansion or gain (Krause,Wasynczuk,Sudhoff, &Pekarek, 2013). The occurrence of this results in positioning of the error in the reverse direction making the regulating system to reverse its course of action to rectify the new error in the system. There versed course of action results in oscillation of the actual position to the desired point or position. The instability of the system makes it move towards the desired or aiming point. When there's pons aimed at correcting the delayed error at tense hundred and eighty degrees with the disturbance the system is attempting to eliminate, the system's direction will perform error reinforcement. Therefore, the delay has altered the response of the system from a negative feedback or response to a positive response, making the system to be unstable critically.

Generally, control systems with high automatic inertia have a long delay or slow response. Low magnitude results in slower correct if cation action characterized by low momentum (Leonhard, 2012). The minimal momentum makes the system to settle at the favorite operating point or state, particularly when the mechanical force is removed. However, the execution of corrective action majorly depends on the loop expansion or gain in the system. While, when the force of error correction is high, amplified or higher loop expansion, the control system will respond more swiftly resulting in a shorter delay in correcting action. The system will correspondingly have greater momentum or higher response speed.

1.1.5. Converter of the mechanical device

The back-to-back changer or converter consists of voltage source reverser or inverter (VSI) and the active front end (AFE). The operation of VSI and AFE is based on pulse-width modulation principle (PWM). The rotor twisting or winding is provided through an irreversible thyristor changer/converter. Thyristors are sequentially used jointly with the system's load to establish variable voltage through hindering current passage to the load or weight for the original portion of the series and changing the current through signal applied to the converter. Application of thyristors which are connected in reverse polarity and parallel generates both positive and negative flow of current with the control system (Gasiyarov, Maklakov, Voronin, &Maklakova, 2015). Both the locked-loop systems on the q-axis and d-axis require electromagnetic torque formation. Though the process might be subjected to delays resulting from lack of instantaneous motor winding inductance, it produces torque. Desired torque production in the system requires a well-maintained angle of flux amplitude in connection to the rotor. Besides flux magnitude, delivery of the desired torque relies on inductive constituents of current applied and this can be instantaneously altered for more effectiveness of the speed control system. The formation is necessary for the response of the doubled locked-loop system, the closed or locked flux loop and closed modern loop in the device.

1.1.6. Closed or locked flux loop and locked current loop

The rotating of closed or locked flux loop and a locked current loop is conducted through the transient progression. The automatic control system of the speed of synchronous motor rotation has compensation unit force caused by cross-connection during electromagnetic turning in the automatic device. The compensation unit energy is provided to counteract the effects of increased rotation speed on the system oscillation (Gasiyarov, Maklakov, Voronin, &Maklakova, 2015). The oscillation of the system reduces with increase in the rotation speed. The compensation unit results in isolation or separation achievement of the closed or locked flux loop and the locked current loops located in frame d-q of the automatic system.

$$W_{id}(p)=\frac{1+(x_{sd}/R_s)\cdot p}{2\cdot T_\mu \cdot p\cdot (K_{if}\cdot K_c/R_s)}; \quad (1)$$

$$W_{iq}(p)=\frac{1+(x_{sq}/R_s)\cdot p}{2\cdot T_\mu \cdot p\cdot (K_{if}\cdot K_c/R_s)}. \quad (2)$$

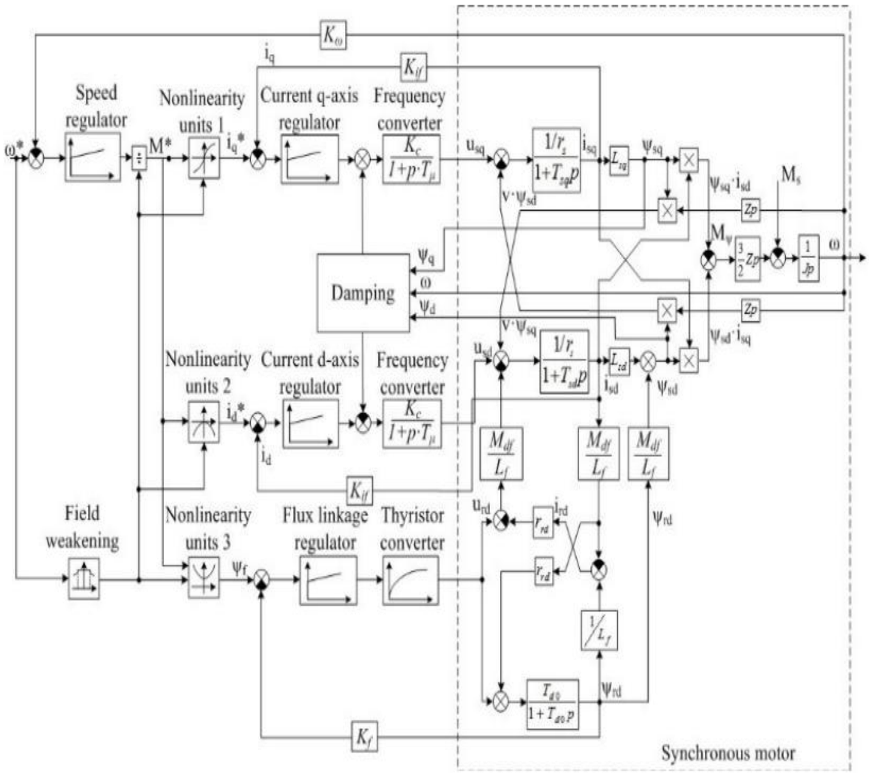

Fig.3 The block diagram of the automatic control system of synchronous motor

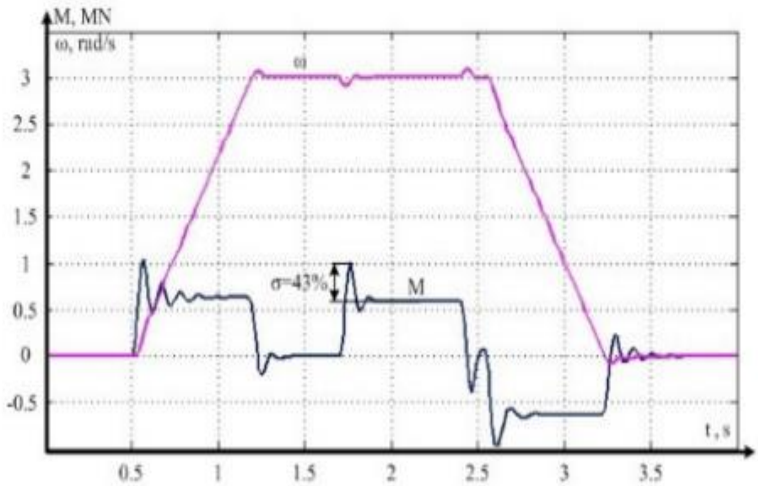

Fig. 4. The transient process of torque and speed of synchronous motor

1.1.7. Pull or jerk-in torque of the automatic system

The synchronous motor has a pull or jerk-in torque of approximately forty percent of the complete-load torque. The value of jerk-in torque is subjected to the power of stator flux. The more the voltage applied, the more the torque. Complete-voltage starting offers more torque as compared to a minimized-voltage starting. The torque is significant in creating a motor shaft of the automatic device or system. The created output shaft is important in approximating the actual acceleration of the system. The obtained actual speed is compared to the favorite speed to generate an acceleration error. The speed error is crucial in changing the amount of voltage used as input in the motor system to drive the device towards the desired acceleration (Krause, Wasynczuk, Sudhoff, &Pekarek, 2013). This way, the output voltage is compared to the reference voltage used as input in the device. The mechanical current regulation system has current regulation loop fixed within the current regulation loop. This permits the voltage regulation loop to distribute more current to the device. The current production cannot override the regulation system of current to ensure it is maintained within the current regulation loop limits. Therefore, the motor shaft is necessary for speed adjustment of the synchronous motor.

1.1.8. Non-linearity unit signals

The speed regulator of the device controls the produced voltage on non-linearity units, hence creating significant torque magnitude. The non-linearity unit signals operate on the modern or current regulators and the flux regulator (Gasiyarov, Maklakov, Voronin, &Maklakova, 2015). Decrease requirement of the device's automatic regulation dictates both the symmetrical optimum and magnitude optimum, therefore, affects the speed controller or regulator of the mechanical system.

1.1.9. Functions of the modern speed regulators

The current speed regulators incorporate microprocessors and power electronics to withstand multiple tasks with greater precision. Firstly, the automatic system offers electronic commutation. The commutator in an automatic device is significant in altering the direction/movement of the system's motor to energize the current as the alternate rotor pass or rotates beyond poles of the stator. The electronic switches on a mechanical speed control system perform commutation function. They reverse the current of the stator as poles of the alternate rotor pass through the poles of the stator. The detection of the reversed current is through the position sensors. The position sensors provide feedback to the angular position or spot of rotor shafts in the system. The response enables the speed regulator to alter the current direction when the poles of the rotor are within the appropriate position in respect to the poles of a stator (Voronin, Gasiyarov, &Radionov, 2016). Secondly, it regulates machine's dynamics in response to load applied. For example, torque, speed, and the machine efficiency or the position of machine's moving components. Thirdly, the automatic system facilitates self-starting of the motor. Fourthly, it matches the power or energy from the available source to meet the requirement of the motor. For instance, the number of phases, frequency, and voltage. Lastly, the automatic system provides motor protection from destruction.

II. CONCLUSION

The torque formation is essential for the response of the doubled locked- loop system, the locked flux loop and locked current loop in the device. Lastly, the automatic control system of the speed of synchronous motor rotation has compensation unit force to counteract the effect so increased rotation speed on the system oscillation there by mechanically regulating speed.

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