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Design and Control Three Half Leg Phase Converter for Active Magnetic Bearing Drive

Paddam Babu Rao[1], Dr.Prabodh Khampariya[2],

[1]*Research Scholar, Dept. of Electrical Engineering, Sri Satya Sai University of Technology and Medical Sciences, Sehore Bhopal-Indore Road, Madhya Pradesh, India.*

[2]*Research Guide, Dept. of Electrical Engineering, Sri Satya Sai University of Technology and Medical Sciences, Sehore Bhopal-Indore Road, Madhya Pradesh, India.*

Abstract

Active Magnetic Bearing technology is getting attractive for a few reasons, for example, high-speed tasks, high dependability, and vibrations exclusion. The power conversion framework depends on three half-spans, one to polarize the bearing and two to control the pivotal powers freely on the x and y tomahawks. So as to accomplish Design and Control Three Half Leg Phase Converter For Active Magnetic Bearing Drive alongside high bandwidth current control ready to create the ideal orthogonal powers, a prescient control methodology has been proposed, for the few points of interest, it can give, for example, quick unique reaction, no need of regulation, a simple consideration of non-linearities and limitations of the framework, the chance of consolidating settled control circles in just one circle and the adaptability to remember other framework prerequisites for the controller. Also, AMB can act as active vibration dampers and give constant control of the pole. For every one of these points of interest, AMBs are especially attractive for highpower - high-speed applications. These alluring highlights come at the expense of the expanded intricacy of the framework, which presently incorporates a power electronic converter and a control framework committed to the AMBs. This paper focus on the control framework that has been approved in MATLAB simulation, including the impact of parameter mismatches in the coils.

INTRODUCTION

Bearings are basic parts of all rotating machinery. By definition, the bearing is the static piece of the machine (frequently called the stator) that bolsters the moving part (regularly called the rotor). While air and liquid bearings might be found in multi- level of-opportunity ball and attachment joint machines, ball bearings, which take into account unadulterated revolution, are by a long shot the most well known. They are generally accessible, modest, and can deal with exceptionally huge static burdens. Notwithstanding, the most widely recognized disappointments in rotating machinery are ball bearing disappointments. For instance, such a disappointment might be expected to over- worry from unevenness loads, grease warm breakdown, or oil sullying. Magnetic bearings are an option in contrast to the ball, air, or liquid bearings. Magnetic bearings are built from permanent magnets (PM), electromagnets (EM), or blends of both. Active magnetic bearings (AMB) use stator mounted electromagnets and criticism control to produce powers on the rotor so it turns without contacting the stator. That is, the magnetic bearing is frictionless! Furthermore, criticism control may actively change the framework's solidness and damping qualities to d iminish vibrations brought about by rotor awkwardness. The end of grease, activity in a vacuum, and the non-reaching nature take into account low-support, long life expectancy, high-speed bearings. Moreover, propels in power electronics have brought about AMB's built- in smaller bundles with minimal outer equipment. Regardless of the considerable rundown of advantages, magnetic bearings do have a few constraints that customary bearings don't. The most key impediments are the electromagnet power immersion and the power slew-rate limits.

High-speed applications and direct drive frameworks are picking up significance in industry and they are dependent upon broad research. The greatest speed is fundamentally restricted by the mechanical properties of materials, warm issues, and bearings confinements. Active Magnetic Bearings (AMB) technology has been accessible since the late seventies, mostly for high-end aviation applications. The enthusiasm for the utilization of AMBs to a more extensive scope of mechanical items has as of late expanded because of the higher accessibility and lower cost of empowering advances, for example, power electronics and control equipment. Truth be told, AMBs are turning into a legitimate option in contrast to standard move bearing for rotating machines, lessening misfortunes, and accomplishing a full active rotor-dynamic control of the framework. AMB technology presents a few favourable circumstances: they can work at high speed with least misfortune and no mechanical wear and, because of the nonappearance of erosion, they are highly solid and absolved from vibrations. Notwithstanding these general highlights, they can go about as dampers of different wellsprings of vibration, and the propeller position control framework can give full constant control of the pole working conditions. For every one of these favourable circumstances, AMBs are especially attractive for high power just as high-speed applications.

Diverse magnetic bearing topologies in the mix with their control procedure have been proposed in the writing to decrease the position's solidness, to improve the power thickness, diminish misfortunes, and improve dynamic exhibitions. The employable guideline of AMBs depends on the transition thickness unbalance in the fundamental air- hole, which prompts power following up on the rotor component. This transition thickness unbalances, consequently, powers, are produced by actively controlling the current provided to the AMBs power coils. The loop game plan and control framework embraced is continually understudied as they assume a major job in the exhibitions of the framework. An assortment of curl numbers and courses of action can be found in writing misusing the capacities of three half leg stage frameworks regarding the single-stage ones. In this work, the Wheatstone Bridge (WB) design for the AMB's power curl is thought of. A wide scope of control procedures has been proposed and researched with the mean to limit power dispersal, improve dynamic reaction, or increment strength against obscure parameters or aggravations.

So as to control the coils currents, a power conversion framework is required. In this work such a framework is acknowledged utilizing a six- leg voltage source converter. The converter is equipped for controlling the biasing charging motion thickness in the AMB through a DC current, indistinguishable in each loop, and control the rotor position over the x and y tomahawks, by methods for a current unbalance in the single AMB coils. Be that as it may, since the six converter legs are associated with a similar DC-Link and not detached from the AMB coils, undesired coursing current is available and must be smothered by the current control.

The ability of controlling the coils current with wide bandwidth is a pivotal prerequisite, as it legitimately impacts the dynamic exhibitions of the AMB. For such framework, Model Predictive Control (MPC) speaks to an attractive arrangement, because of its inalienably quick unique reaction, no need of balance, simple consideration of non- linearities and imperatives of the framework, the chance of fusing settled control circles in just one circle and the adaptability to remember other framework prerequisites for the controller. MPC considers a model of the framework so as to anticipate its future conduct over a particular time sk yline. Based on this model, MPC tackles an improvement issue where a grouping of future activities is acquired by limiting a cost work which speaks to the ideal conduct of the framework. The best performing activation is then applied and all the estimations are rehashed each example period. Since exchanging power converters are frameworks with a limited number of states, given by the potential blends of the condition of the exchanging gadgets, the MPC advancement issue can beimproved and diminished to the expectation of the conduct of the framework for every one of the potential states.

MAGNETIC BEARING TERMINOLOGY

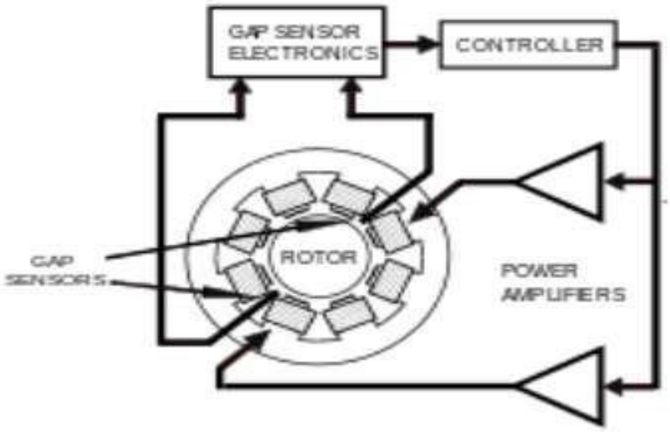


Figure 1.Magnetic bearing terminology

Magnetic Bearing: A type of bearing, especially for rotating shafts, that utilizes electromagnetic powers to help the pole with no mechanical contact.

Active Magnetic Bearing (AMB): A type of magnetic bearing wherein non-contact support of a shaft is accomplished by utilizing shut circle control. Such bearings utilize attractive magnetic powers wherein any event some portion of the magnetic power is created by actively controlled electromagnets. The AMB incorporates a magnetic actuator, position sensor, and magnetic bearing controller (MBC) with a control gadget, power intensifiers, and power flexibly. Generally mechanical and business magnetic bearings are of this sort.

LITERATURE REVIEW

Hongbo Sun [1] proposed on FEB 2020 that in his assessment magnetic bearing is a center technology for high-speed rotational machines. Power electronics converter as the active magnetic bearing drive is the incitation unit and its topology highly impacts the presentation of the bearing framework. This paper presents the advancement of the topology of the active magnetic bearing drive. The underlying topology of an H-connect doesn't adequately use the power electronics gadgets. The topology with half-connect and shared stage leg has been proposed as the fundamentaltopology. In this paper, two methodologies of novel magnetic bearing drive topology adjustment have been created based on the fundamental topology. In the primary methodology, focal stage leg for a multiaxis magnetic bearing drive can be additionally shared and the power electronic gadgets can be globally streamlined in the entire framework. Further, a topology with the c urrent in the converse heading can decrease the focal stage leg current rating and power misfortunes. In the subsequent methodology, deficiency open- minded magnetic bearing drive topology has been created based on the fundamental topology, as well. It can ride-through the open-circuit shortcoming of power electronics switch-in activity and save levitation for the magnetic bearing. The arrangement work of novel topologies can improve the exhibition of an active magnetic bearingframework in the application.

Parag Kshirsagar[2] on March 2016 introduced a diminished switch converter for the active magnetic bearing framework is investigated and its presentation is tentatively approved at 24,000 rpm on a 4-pivot magnetic bearing test-rig. In view of the coupled curl course of action and unidirectional current activity, the decreased switch converter is inferred and its methods of activity are expounded. In contrast with ordinary topologies, this converter lessens the necessity on the number of switches, entryway drives, and heartbeat width balance signals coming from the controller. The investigation and exploratory outcomes effectively approve the activity of diminished change converter to meet the magnetic bearing activity necessities.

Dong Jiang [3] in January 2017 proposed a paper on Magnetic bearing that has been created for high-speed rotational machinery and its power electronics drive is its key technology. In this paper,a novel converter with diminished switches for the magnetic bearing drive is portrayed. The guideline of the magnetic bearing and its test rig was presented and graphically delineated from the outset. At that point, in view of the current unidirectional and stage leg sharing standards, the novel converter topology for a magnetic bearing drive along with the current control capacities is presented, including the consistent state and dynamic execution. Fewer power electronics gadgets are required for this converter in examination with regular magnetic bearing drives. Simulation and trial results have effectively approved the current control ability of a magnetic bearing with the proposed converter. With the novel converter and the controller, the magnetic bearing can convey prevalent levitation and dynamic control execution. In the rotational test, the magnetic bearing has been controlled with position blunder under 20% of the air hole up to 24 000 r/min on the test rig.

Simon E. Mushi[4] distributed a paper on July 2011 that expresses that a fruitful mechanical utilization of adaptable rotors bolstered on active magnetic bearings (AMBs) requires cautious consideration not exclusively to rotodynamic plan perspectives yet in addition to electromagnetic and input control structure angles. Model-based control configuration gives the system to guarantee productive, dependable, and safe activity of turbomachinery on AMBs. This paper portrays in detail the structure, development, and demonstrating the process for a high-execution AMB test rig which exemplifies a little modern super-basic divergent blower. A one of a kind part of the structure are the two extra spiral AMBs to permit the use of recreated destabilizing liquid or electromagnetic powers to the rotor. These powers are hard to anticipate and can prompt rotodynamic precariousness

of modern machinery if not appropriately represented. This test rig gives a sensible stage to assess settling control algorithms for high-execution turbomachinery. A total model of rotor, AMB actuators and going with electronics, is built from separately checked part models. Model approval is affirmed through the fruitful structure and execution of a μ-synthesis controller.

PROPOSED METHODOLOGY

The Active Magnetic Bearing schematic considered in this examination is appeared in Figure. 2, where the power coils are highlighted in red and in blue for the x-axis and the y-axis control separately. A 2 axis control, 4 post field active magnetic bearing is thought of. In this setup the power coils around every tooth are partitioned into two indistinguishable parts. These windings, along with the one on the contrary tooth are orchestrated to shape a Wheatstone connect setup. The plan is completed to permit a power age of 2kN for every axis. A DC-predisposition field is created by forcing a DC current in the power twisting so as to store magnetic vitality in the bearing. An unsettling influence causing a rotor position removal from the focused condition produces an unbalance in the air gap magnetic field that can be compensated by unbalancing the DC current in the power coils and, along these lines, creating the necessary adjusting power.

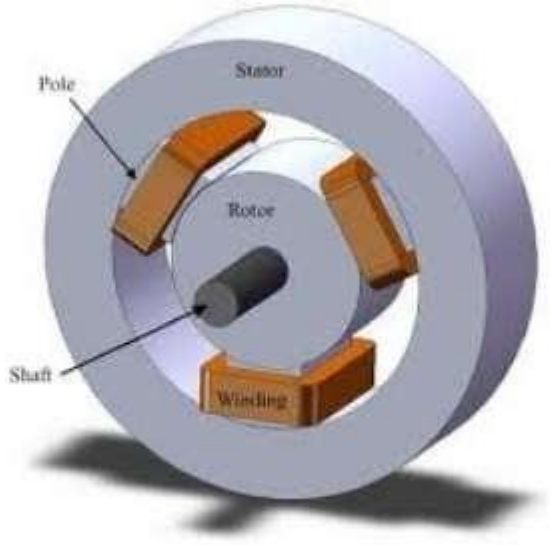


Figure. 2. AMB x-axis view

This winding setup permits to produce of the DC-bias field by taking care of the Wheatstone bridge with a controlled DC current, appeared in the base of Figure. 2 permits to create the necessary unbalance supply by presenting a current source in the middle of the extension itself as appeared in the top. Moreover, a self-detecting bearing plan can likewise be accomplished by putting windings, by methods for detecting coils, on the non-wounded teeth. In such sensing, coils can connect the motion created by the power winding structure and, in this way, decide the situation from the unbalance in the voltage across them.

The design of the AMB is done with Finite Element analysis combined with a first logical structure stage. From the framework vitality balance equation, a rearranged detailing has been considered for the power age where x and y speak to the rotor position along the AMB's geometrical axis, ix and iy are the currents infused over the arms of the Wheatstone connect, ki, = ki, are the current firmness constants and km,x = km,y are the mechanical solidness constants, separately for the x and y-axis. AMBs are portrayed by negative mechanical firmness which should be remunerated when the rotor structure in not focused. The even structure of the gadget prompts an indistinguishable trademark along the two geometrical axis. The currents ix and iy are the differential currents that should be forced to balance the DC inclination current and empower the tweak of the magnetic field required to create the powers. The geometrical structure, the DC inclination current, and the differential current level have been resolved so as to guarantee the necessary yield power without happening in the immersion level that debases the presentation of the AMBs. FEA has been performed to approve the plan and portray the conduct of the AMBs considered in this work. Figure. 3 presents the motion circulation in the AMBs highlighting focused rotor position and forcing the greatest differential current along the x-axis.

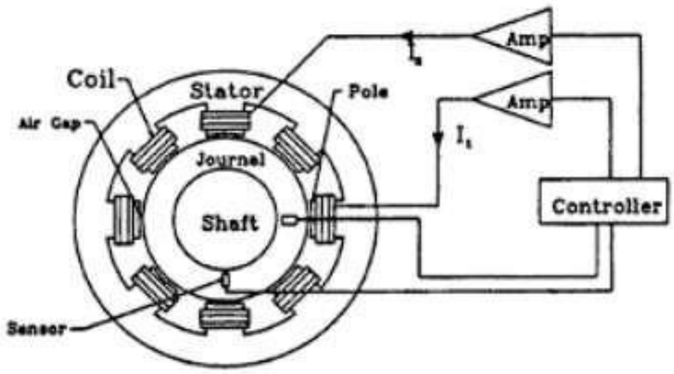


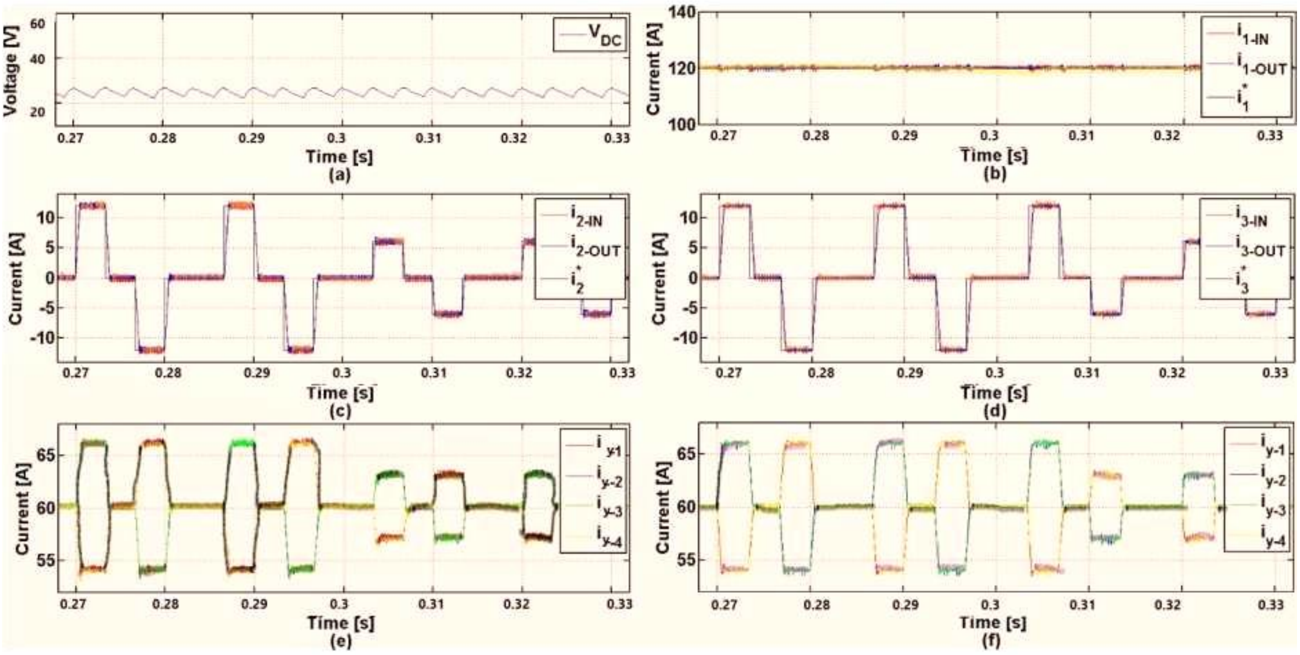
Figure 3.Rotor Position and its Flux density of AMB

Because of the solid connection of the coils with the magnetic circuit, the inductances of the coils are appropriate to change in various operational states of the framework. This is displayed and approved by methods for FEA analysis, where additionally the immersion impact is represented. In the accompanying analysis a variety of ±19% of the inductance with deference its ostensible worth is thought of.

SIMULATION RESULTS

Simulations of the proposed framework are completed for two investigation cases utilizing MATLAB/PLECS. The primary simulation considers the perfect instance of adjusted inductances on the WB arms. In this figure it tends to be noticed that the DC-Link is kept up consistent true to form and the three half leg stage HBs create, separately, the essential DC current coursing through the HB 1 and a variable square wave current with a fundamental recurrence of 300Hz on the HB 2 and 3. The square wave can be viewed for instance of a potential reaction of the external position loop to outside unsettling influences on the fundamental shaft. It is imperative to highlight that, since the requirement in (3) is fulfilled the WB leg currents follow the normal example, satisfying the limitation in (2).

Figure.4 shows the simulation results for uneven inductances on the WB arms. This experiment is especially significant since the curl inductance differ with the rotor position. For this situation the control is as yet ready to follow the info and yield currents of the three HBs satisfying the limitationin (3).



***Mx-1* = *My-1* = 5mH, *Mx-2* = *My-2* = 5.2mH, *Mx-3* = *My-3* = 5.5mH, *Mx-4* = *My-4* = 5.7mH**

Figure. 4. Experimental results with Induction: (a) DC-Link voltage; (b) Current HB 1; (c)Current HB 2; (d) Current HB 3; (e) X-axis leg currents; (f) Y-axis leg currents

Notwithstanding, the unbalance in the arm inductance esteems create an unbalance in the WB leg currents of roughly 1A in the most pessimistic scenario, for a greatest inductance variety of 20% the ostensible worth. This case speaks to an extraordinary circumstance since a variety of about 15%

the ostensible worth are normal in the genuine framework. In addition, this impact can be decreased by actively mapping the estimation of inductance at various rotor position in the control framework by utilizing Finite Element simulation results or depending on the external position control loop. Then again, this test shows the steadiness of the proposed Predictive current control regarding model parameter vulnerabilities.

CONCLUSIONS

Predictive current control is applied to the power e lectronic converter control for an active magnetic bearing framework, d isp layed as two Wheatstone Bridges. The converter is made out of three half leg stage H- Bridges, which work freely and control the DC current moving through the WBs and the current unbalances in the two WBs leg currents separately. Truth be to ld the DC current is important to magnetically s tack the AMBs and by unbalancing the WBs leg currents is conceivable to move the ro tor on x or y machine axis so as to actively react to mechanical vibration and d ifferent unsettling influences. As these vibrations, for the particular application, are in the request for many Hz, the current control must have the opt ion to fo llow current varieties a t a s imilar recurrence. S imulation results show a quick current fo llowing reaction even on account of unequal WB inductance esteems. Be that as it may, for this situation a balance between the WB leg currents is available. This impact can be diminished by including the information on the variety of the inductance esteems with the rotor position.

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