Form 2

Dissertation Abstract

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Dissertation title	AC Magnetic Suspension Using Magnetic Resonant Coupling （磁界共振結合を利用した交流磁気浮上）		

Abstract

※ The abstract should be in keeping with the structure of the dissertation (objective, statement of problem, investigation, conclusion) and should convey the substance of the dissertation.

The fundamental characteristics and performances of alternating current (AC) magnetic suspension using magnetic resonant coupling have been studied analytically and experimentally. Wireless power transfer to the suspended object is required during non-contact suspension in some applications. Therefore, magnetic resonant coupling has been introduced for AC magnetic suspension to achieve self-stabilizing magnetic suspension and energy transfer to the floator simultaneously. The magnetic suspension is investigated in the differential operation in this research. An AC magnetic suspension system using magnetic resonance coupling is designed and fabricated to investigate the performances. A floator is placed between the upper and lower stator electromagnets, and this device is operated differentially to keep the floator at a constant position even when several parameters of the circuit of the stator electromagnets are changed.

The effect of circuit parameters for developing an experimental apparatus and performances are predicted from the solution of the equivalent circuits analytically. At first, an equivalent *magnetic* circuit is derived and analyzed to characterize the self-inductance and mutual inductance with the gap. An equivalent *electrical* circuit is analyzed to derive the current and force equations including *magnetic* parameters of the circuit. The derivation of these equations is numerically solved to study the characteristics of the primary current, the secondary current, and the force with respect to the gap and the applied frequency. A finite element analysis is conducted to investigate the physical parameters of the apparatus. After confirming a sufficient attractive force can be generated by the upper electromagnets, the device has been fabricated. A set of permanent magnets is used in this system to reduce the required supply of electrical energy to the upper stator electromagnets.

The individual force, current and phase for variable frequencies and gaps between primary and secondary electromagnet are measured to examine the basic characteristics and performances. The comparison between theoretical and experimental results is depicted, and the reason for the differences is explained. The experimental and theoretical results show that positive stiffness is possible, which is essential for achieving self-stabilization. The self-stability is confirmed by the frequency response of the suspension system to disturbance experimentally. Indirect damping is applied to achieve a maximum gap of 3.4 mm and a minimum gap of 2.0 mm during differential operation. Indirect damping is applied using voice coil motor (VCM) between the base and the upper stator to make the system dynamically stable. The derivative (D) control is applied to adjust the effect of the damping for stable suspension. The frequency response analyses the relation between the stiffness and the floating position and the effects of indirect damping on the suspension characteristics. The effects of the amplitude of the applied voltage and the applied frequency are estimated experimentally during the stable suspension in the differential operation. Wireless power transfer efficiency has been measured during the floating mode.