# Actuator for Non-contact Elevation Using Linear Induction Motor

# (Analytical Consideration on Effect of Tether Diameter on Thrust Characteristics)


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**Abstract**

In conventional elevators, vibration and cable twisting are major problems when the cable is long. Therefore, we are considering an elevator that omits the counterweight and uses a single cable with fixed ends to move the actuator. However, there are problems such as reduced efficiency due to cable contact and damage. Therefore, we propose a vertical transfer system that uses a cylindrical linear induction motor (LIM) as an actuator to move the actuator in a non-contact manner over a long uniform conductor cable. By placing the cylindrical LIM on top of a reaction plate, which is a cylindrical shell-shaped conductor, the advantage is that the magnetic force acts uniformly on the reaction plate and vibration in the gap direction is suppressed. So, we built an analytical model in which the cylindrical LIM is driven vertically and analyzed the electromagnetic field using the finite element method.


## 1 Foreword

In conventional elevators, one load is attached to one tether, and the elevator occupies a large area on a certain floor in a high-rise building. The most common method of elevators and other elevators that does not use counterweight and are raised and lowered by actuators on a single tether fixed at both ends, is to use pulleys or tires to raise and lower the elevator using the frictional force generated by the contact with the cable [1]. However, this method is less efficient and causes damage to the cable due to entrapment of foreign matter. Therefore, the authors studied an actuator that raises and lowers a uniformly conducting cable (reaction plate) vertically using a cylindrical linear induction motor because of its advantage of applying a uniform magnetic force from the actuator to the cable [2]. In this report, an electromagnetic field analysis using the finite element method is performed to study the effect of the cable geometry on the thrust characteristics exerted.

## 2 Climber analysis model

To investigate the effect of tether diameter on thrust characteristics, a cylindrical LIM for vertical movement was created as shown in Fig. 2. Coils are installed at six locations inside the core of the climber, each connected to a three-phase AC power supply. The tether material is copper, and the frequency output from the power supply is varied from 10 Hz to 100 Hz to calculate the thrust characteristics acting on the climber. The analysis was performed by changing the tether diameter to 30mm, 50mm, 100mm, and 150mm, and the changes in thrust were compared with the existing data. The 3D model is shown in Fig. 3. In the previous paper [2], a hollow tether was

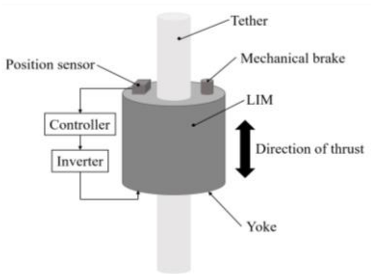


Figure 2: Schematic diagram of the actuator

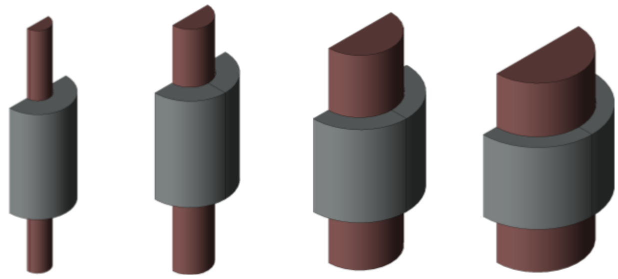


Figure 3: Each 3D model diagram

used for the study, but in this paper, the analytical model is constructed using a solid tether as the basic study, because the effect of thickness is excluded to study the effect of tether diameter, and the magnetic field from the opposing coil may affect the thrust characteristics.

## 3 Conclusion

In this report, a vertical transfer system that uses a cylindrical LIM as an actuator to move contactless over a uniform conductor cable is investigated. Models with tether diameters of 30 mm, 50 mm, 100 mm, and 150 mm were analyzed, and it was found that the thrust force increased as the diameter of the tether increased. However, the tether could not reach its own weight and could not levitate. In the future, in addition to changing the diameter of the tether, we plan to change the circuit used in the analysis, changing from a current source to a voltage source, and changing the number of coils and wire diameter.

## References


[1] Matsuno, *Recent Elevator Control Technology, Measurement and Control*, **21 (1892)** 686-689.

[2] K. Ikeda, D. Uchino, K. Ogawa, A. Endo, T. Kato, T. Narita and H. Kato, Cylindrical Linear Induction Motor for Vertical Transfer: Fundamental Consideration on Vertical Vibration during Transportation, *IFAC -PapersOnLine*, **55** (2022) 393-398.