

Anti-Gravity System Based on Magnetic Levitation Technology

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Abstract. This paper presents a design of an anti-gravity system based on magnetic levitation technology. The system utilizes the force generated by magnetic principles to counteract gravity and achieve object suspension and control. The design objective is to achieve portable maglev technology for everyday use. Specific requirements include adjustable speed range, endurance time, effective suspension range, mass, control mode, safety, magnetic field strength, suspension stability, altitude control precision, resistance to strong magnetic field interference, and portability. The system structure includes suspension device, magnetic field generator, sensor, and control system. Control strategies such as PID control, fuzzy control, and sliding mode control can be employed, and signal communication can be achieved through Bluetooth, Wi-Fi, or fiber optic communication. By selecting and designing appropriate control strategies and integrating suspension, magnetic field generator, and sensor components, the anti-gravity system based on magnetic levitation technology can achieve height control and suspension stability.

Keywords: Anti-gravity system, maglev technology, control system, speed range.

1. Introduction

At present, some progress has been made in the research of maglev technology and anti-gravity system at home and abroad. In the field of transportation, some countries have successfully developed maglev trains and other means of transportation to achieve high-speed, smooth, and low-noise transportation. In the field of scientific research experiments and industrial manufacturing, maglev technology is widely used in microgravity environment simulation, precision machining and precision positioning. With the continuous development of science and technology, maglev technology has gained significant attention as a new levitation technology. It utilizes magnetic fields to suspend and support objects, offering advantages such as stable suspension, low friction, and no contact [1]. Maglev technology finds applications in transportation, scientific research experiments, and industrial manufacturing.

The aim of this paper is to study the feasibility and potential application of an anti-gravity system based on magnetic levitation technology. Specifically, the goal is to develop portable magnetic levitation technology for everyday use. This suspension program has wide-ranging applications in transportation, aerospace, and commercial fields, requiring significant energy, which could be driven by nuclear energy. Additionally, the development of new materials (alloys, etc.) is crucial to reduce costs. The term "anti-gravity technology" in this paper refers to a technical approach to achieve high-speed or light-speed flight by canceling or reducing the inertial mass effect, thus mitigating the impact of gravity on the aircraft. Progress has been made in the research of maglev technology and anti-gravity systems both domestically and internationally. Countries have successfully developed maglev trains and other transportation means for high-speed, smooth, and low-noise travel. Maglev technology is widely used in microgravity environment simulation, precision machining, and precision positioning in scientific research experiments and industrial manufacturing.

This paper will be divided into seven parts. The first part introduces the research background, the purpose and significance of the research and the research status at home and abroad. The second part will focus on the principle and system composition of maglev technology, as well as the third is design and control strategy of anti-gravity system. Fourth and Fifth parts perform evaluation will be carried out and the feasibility and performance of the system will be verified through theoretical model simulation and result analysis. Sixth, the research results of this paper are summarized, and the future research direction is prospected. And the reference at last. Through this research, it will provide

theoretical basis and technical support for the development and application of portable magnetic levitation technology and promote the wide application of magnetic levitation technology in daily life and industrial fields.

2. Overview of Maglev Technology

2.1. Magnetic Levitation Principle

Maglev technology is a technology based on the principle of magnetic force to achieve the suspension of objects. It uses the forces generated by the interaction of magnetic fields to support and levitate objects, thereby lifting them off the ground or other supports. The principle of magnetic levitation is based on two main forces: magnetic force and gravity.

Maglev systems usually consist of a suspension and a magnetic field generator. A suspension is usually an object with a magnetic material, such as a magnet or permanent magnet. A field generator, on the other hand, is a device that creates a magnetic field by passing an electric current through a coil, such as an electromagnet or permanent magnet. By adjusting the strength and direction of the magnetic field, the position and movement of the suspension can be controlled, the suspension gap is $\delta(t)$ and the suspension current is $I(t)$, then the nominal suspension force $F_n(t)$ provided by the suspension magnet is:

$$F_n(t) = \frac{\mu_0 S N_{turns}^2 I^2(t)}{4\delta^2(t)} \quad (1)$$

Formula (1) constructs the mathematical expression of the suspension force, which is a nonlinear formula, and it is difficult to analyze it directly. In general, the suspension force $F_n(t)$ is linearized by Taylor expansion at the equilibrium point, and its higher order terms are ignored. This derivation is quoted in "Formula Optimization of the suspension Force of Maglev Train and Modeling and Experiment of Suspension System" [2]. And finally, the $P(s)$ formula of the suspension system model with uncertainty is obtained:

$$P(s) = \frac{N(s) + W_N \Delta \Gamma}{M(s) + W_M \Delta \Gamma} \quad (2)$$

$$\begin{cases} W_N = -k_0 k_1 \Gamma_w \\ W_M = -k_\delta \bar{R} \Gamma_w \end{cases} \quad (3)$$

$$\begin{cases} N(s) = \frac{-k_0 k_1 \Gamma}{(s+\theta)^k} \\ M(s) = \frac{m L_0 s^3 + m \bar{R} s^2 - k_\delta \bar{R} \Gamma_0}{(s+\theta)^k} \end{cases} \quad (4)$$

And when the uncertainty is zero, the nominal suspension system model $P_0(s)$ can be obtained:

$$P_0(s) = \frac{N(s)}{M(s)} \quad (5)$$

2.2. Composition of the maglev system and application

Maglev system components: Suspension (magnet or permanent magnet), Magnetic field generator (electromagnet or permanent magnet), Sensor (displacement, acceleration, angle), Control system (feedback signal, control algorithm).

Maglev technology has diverse applications in transportation, scientific research, industrial manufacturing, and medical equipment. Maglev trains enable high-speed, smooth, and noiseless transportation. In scientific research, it creates microgravity environments for precise experiments. In industrial manufacturing, it enhances precision machining, measurement, and positioning. Medical devices, like MRI systems, benefit from stable suspension support. The development of portable maglev technology, such as footwear-like vehicles and heavy object lifting equipment, holds

promising applications in daily life. Real-time direction and angle adjustments, level detection, and a maximum deflection angle of 60 degrees are essential for safe and efficient operation.

3. Design of anti-gravity system based on maglev technology

3.1. Overview of Class antigravity system

Class anti-gravity system is a system based on magnetic levitation technology, designed to achieve the suspension and control of objects, so that it has an effect similar to anti-gravity. The system uses the force generated by the principle of magnetic force to offset gravity, so that the object can be suspended in the air, and by controlling the strength and direction of the magnetic field to achieve height control, while the need to compensate for the Earth's magnetic field deflection. Maglev as the basis of the magnetic levitation track unit, the track will not be oriented, such as each board is composed of 3*3 groups of electromagnetic coils, the magnetic field between each two coils synthesis repulsive force, composed of the track, and the driving force considering the speed reasons, need to reduce the magnetic, to maintain at 2-5km/h, of course, if for the purpose of transportation or the pursuit of speed, Can be improved by the electromagnetic coil NS pole exchange frequency, as well as the basic magnetism in the permanent magnet itself will also affect the speed. The application of these control algorithms in magnetic levitation systems can be determined according to specific control requirements, system characteristics and performance requirements. They can be used to adjust the suspension height, stability, anti-interference ability and control performance of the maglev system to meet the requirements in practical applications. In the control direction, there can also be air or particle propulsion assistance [3]. The design structure is shown in figure 1.

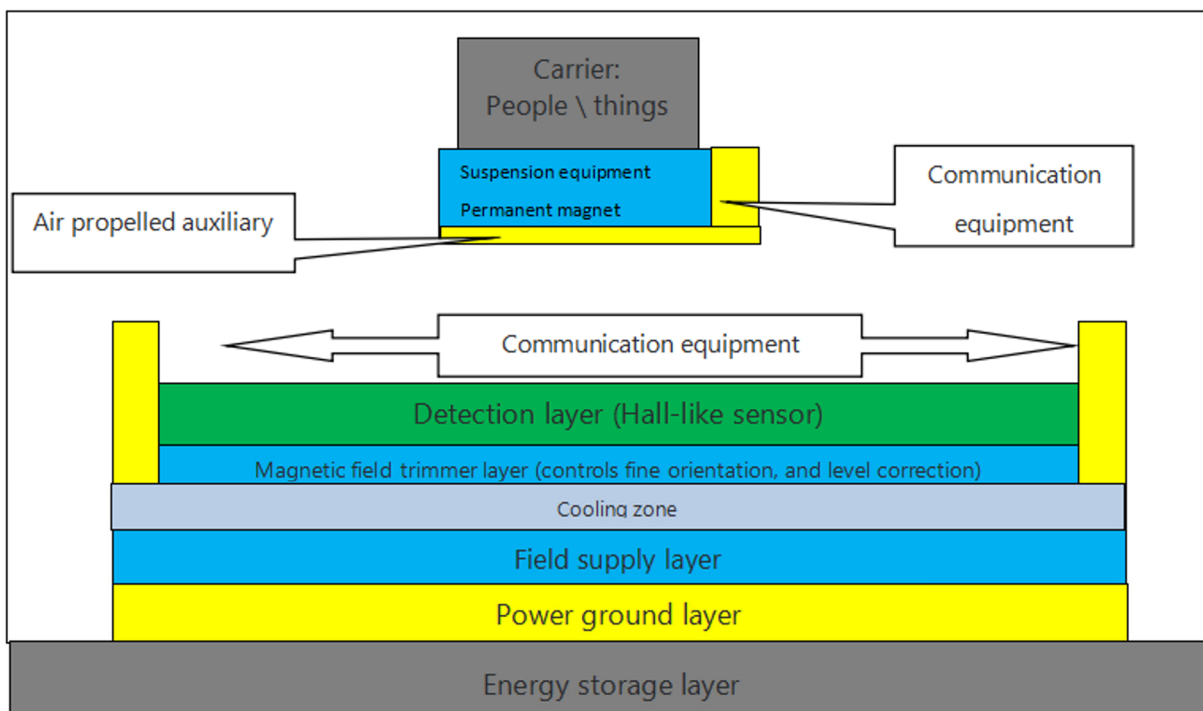


Fig.1 Designed structure (Photo/Picture credit: Original)

3.2. Design objectives and requirements

The goal of the Design Class anti-gravity system is to achieve portable maglev technology so that it can be used in everyday life. The specific requirements are as follows in table 1.

Table 1. Specific requirement

Argument	Description	Data value interval
Velocity interval	Adjustable speed range for controlling the movement speed of the suspension device	0.1 m/s - 10 m/s
Endurance time	The time that the suspension device can continue to work, that is, the use time that can be supported with a single charge	1 hour - 4 hours
Effective range	The height range of the suspension equipment can be suspended and controlled, that is, the effective suspension range	0.5 mile - 5 miles
Mass	The mass of the suspension equipment itself, including the weight of the shoes and the suspension system	0.5 kg - 2 kg
Control mode	A way to control the motion and levitation of the levitation device	Buttons, remote controls, mobile apps, etc
Safety	The safety performance of suspension equipment, including the prevention of accidental injury and the protection of user safety	Prevent accidental injury and protect user safety
Magnetic field strength	The strength of the magnetic field generated by the floor that provides the suspension force	0.1 T - 1 T
Suspension stability	The stability of the suspension equipment at different heights, that is, whether it can maintain stable suspension at different heights	Maintain smooth suspension
Altitude control	The precision and stability of height control can be achieved by the suspension equipment, that is, whether the suspension height can be accurately controlled	1 cm - 10 cm
Resistance to strong magnetic fields	The resistance of suspension equipment to strong magnetic field interference, that is, whether it can work normally in a strong magnetic field environment	Works well in strong magnetic field environment
Portability	The size, weight, and portability of the suspension device, that is, whether it is easy to carry and use	Easy to carry and use

3.3. System structure design

The structural design of class anti-gravity system includes suspension, magnetic field generator, sensor and control system and other components. Suspension: A suspension is an object with a magnetic material, such as a magnet or permanent magnet. It is suspended and controlled by its interaction with a magnetic field.

Magnetic field generator: A magnetic field generator creates a magnetic field by passing an electric current through a coil. It can be an electromagnet or a permanent magnet. By adjusting the strength and direction of the current or magnetic field, the position and movement of the suspension can be controlled.

Sensor: The sensor is used to detect the position and motion state of the suspension. Commonly used sensors include displacement sensors, acceleration sensors and Angle sensors, etc. Through the feedback signal of the sensor, the position and stability of the suspension can be controlled.

Control system: According to the feedback signal of the sensor and the preset control algorithm, the control system applies the appropriate control signal to the magnetic field generator to realize the control of the height and stability of the suspension. For special magnetic field generation, part of the derivation is based on the "Acquisition of High Energy Controlled Pulsed Magnetic Field" [4].

3.4. Control strategy design and signal communication

The control strategy design of class anti-gravity system is the key to achieve altitude control and suspension stability. The control strategy can be based on PID control, fuzzy control, sliding mode control and other methods.

PID control: PID control is a classical control algorithm that adjusts the output of the controller through the combination of three parts: proportion, integral and differential. In the class anti-gravity system, PID control can adjust the control signal of the magnetic field generator according to the position error, speed, and acceleration information of the suspension, so as to achieve height control and suspension stability.

Next is about the controller, in the class anti-gravity system, due to the need to transmit signals in real time and resist strong magnetic field interference, wireless communication technology can be considered to achieve signal transmission between the maglev equipment and the floor. The following are some possible methods of signal sending and receiving system and resistance to strong magnetic field interference: **Bluetooth:** Short-range wireless communication technology with low power consumption and high reliability. Modules in shoes and on the floor enable real-time signal transmission. Bluetooth 4.0 or above is used to resist magnetic field interference. **Wi-Fi:** Wide area wireless local area network technology with large coverage and high-speed data transmission. Modules in shoes and on the floor enable real-time signal transmission. Dual-band Wi-Fi reduces interference from strong magnetic fields. **Fiber optic:** Communication technology with high speed and strong anti-interference ability. Sensors and receivers in shoes and on the floor enable real-time signal transmission. Attention is needed for installation and protection to avoid damage from strong magnetic fields.

In order to further improve the security of the system and its ability to resist strong magnetic field interference, the following measures can be taken: **Magnetic shield design:** In the design of shoes and floors, magnetic shield materials or structures can be used to reduce the interference of external magnetic fields on the system. **Signal encryption and verification:** In the process of signal transmission, encryption and verification mechanisms can be adopted to ensure the safety and integrity of the signal and prevent interference or tampering by unauthorized equipment is shown in figure 2.

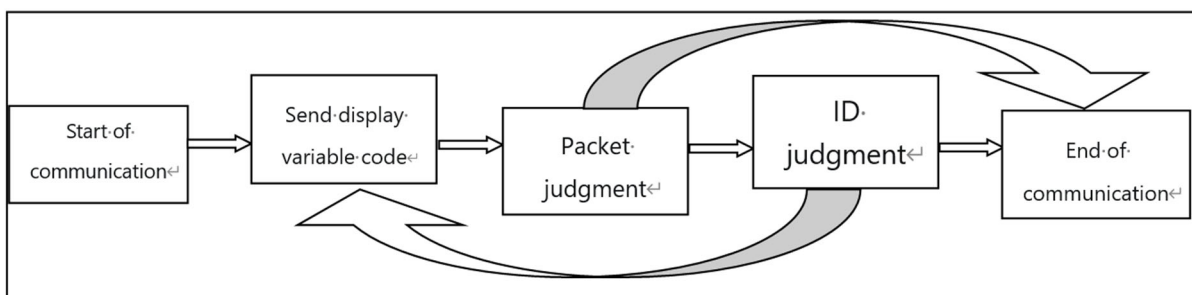


Fig. 2 Signal communication mode (Photo/Picture credit: Original)

4. The theoretical model of anti-gravity system based on maglev system

4.1. System modeling method

In order to study and analyze the performance and control strategy of the anti-gravity system, it is necessary to establish the theoretical model of the system. Modeling is to describe and derive the physical characteristics and dynamic behavior of the system and express the motion laws and mutual relations of the system in the form of mathematical models.

Anti-gravity systems need to meet the conditions from ‘On the essential relation of particle energy, mass and charge and its extended significance: A preliminary study on the theory of all things [5].

A class antigravity system can be modeled through the following steps: Determine the input and output of the system: In a class antigravity system, the input is a control signal, such as the current of a magnetic field generator or the strength of the magnetic field; The outputs are the position and speed of the suspension. Establish the dynamic equation of the system: According to the physical characteristics and motion laws of the system, the dynamic equation of the system can be established. Determine the state variables and control variables of the system: Determine the state variables and control variables of the system based on the dynamics equations of the system. State variables are variables that describe the state of the system, such as the position and speed of the suspension; Control variables are variables that control the behavior of the system, such as the control signal of a magnetic field generator. Establish the state space equation of the system: Based on the dynamics equation and state variables of the system, the state space equation of the system can be established. State space equations are mathematical models that describe the relationship between the state of the system and the control variables. Among them, the power supply and energy storage implementation plan is quoted in the "Research on Capacitive Coupling wireless power supply Technology of Medium and low speed Maglev Train", wherein, because the energy storage is lightweight and high-speed moving, flywheel energy storage can be used at the same time, and the wind energy generated when moving can be stored by spiral fans [6, 7].

4.2. System Parameter setting

When establishing the system model, the parameters of the system need to be determined. The system parameters include the mass of the suspension, the characteristics of the magnetic field generator, and the sensitivity of the sensor. These parameters can be determined by experimental measurement, simulation, or literature research.

The following is an example of some parameters of a maglev based antigravity system model, along with their roles and data intervals. This table is only used as an example, and the parameters may need to be adjusted according to the actual system requirements which is shown in table 2 [8].

Table 2. Parameters based antigravity system model

Parameter	Effect	Data interval
The mass of the suspension	Determine the static stability and dynamic characteristics of the system	1-1000kg
Characteristics of magnetic field generator	It directly affects the suspension height and stability of the suspension	

For a magnetic field generator, its characteristics can include the following in table 3.

Table 3. Parameters of magnetic field generator

Parameter	Effect	Data interval
Magnetic field intensity	The suspension height and stability of the suspension are affected	0.1-10 Tesla
Frequency	It affects the dynamic characteristics of the suspension	1-1000Hz
Waveform	The stability and efficiency of the suspension are affected	Sine wave, square wave, etc

When establishing the system model, it is necessary to determine the parameters of the system. System parameters include the mass of the suspension, the characteristics of the magnetic field generator, the sensitivity of the sensor, etc. These parameters can be determined by experimental measurement, simulation, or literature research. By establishing the theoretical model of the system, the system performance analysis and control strategy design can be carried out. This includes system stability analysis, response characteristic analysis, controller design and parameter adjustment, etc.

It should be noted that the specific theoretical model analysis and derivation process needs to be carried out according to the specific system and control strategy, involving specific mathematical derivation and calculation. In the paper, the analysis and derivation process of the theoretical model can be explained through the way of text description and formula derivation to show the performance of the system and the effectiveness of the control strategy.

4.3. Theoretical Model Analysis and derivation

By establishing the theoretical model of the system, the system performance analysis and control strategy design can be carried out. This includes system stability analysis, response characteristic analysis, controller design and parameter adjustment. Through the analysis and derivation of the mathematical model, the performance of the system can be evaluated, and the control strategy can be optimized to meet the design requirements. As for anti-interference and its electromagnetic compatibility issues, the following figure 3 shows the detailed.

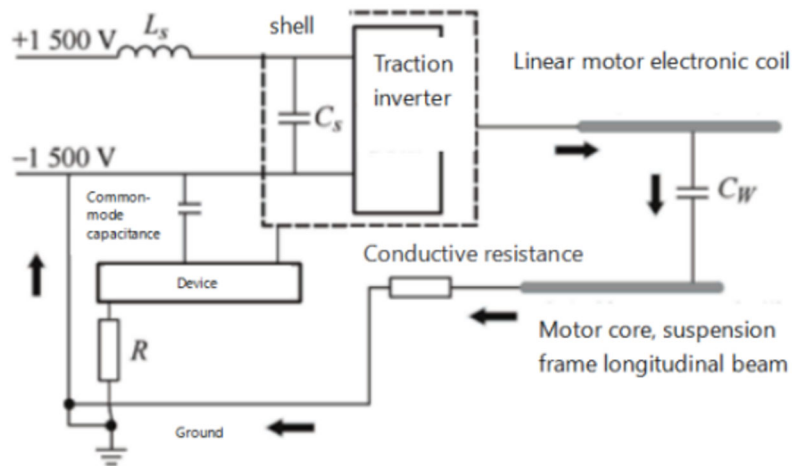


Fig. 3 Optimized linear motor electromagnetic interference flow path of maglev train [9]

5. The performance evaluation of class anti-gravity system

For a Class anti-gravity system, the following indicators can be used to evaluate its performance:

Suspension stability: The stability of the suspension at different heights is an important indicator to evaluate the performance of the system. The suspension stability can be evaluated by parameters such as the position error of the suspension, the amplitude of vibration and the stability time which is shown in table 4.

Table 4. Experimental parameters of four control methods [10]

Controller	Parameter	Value	Controller	Parameter	Value
PID	K_p	3 000	PID	K_i	6 000
	K_d	90		—	—
SMC	c_1	300	SMC	c_2	0
	k	300		ε	70
ISMC	c_1	300	ISMC	c_2	200
	k	300		ε	70
	Δ	0.02		—	—
ESO-ISMC	c_1	300	ESO-ISMC	c_2	200
	k	300		ε	70
	Δ	0.02		β_{01}	300
	β_{02}	30 000		β_{03}	1000 000

Height control accuracy: Height control accuracy refers to the accuracy with which the system achieves a preset height. Altitude control accuracy can be evaluated by parameters such as altitude error, speed of ascent and descent.

Energy efficiency: Energy efficiency refers to the relationship between the energy consumed by the system in the process of achieving suspension and altitude control and the lift force provided. Higher energy efficiency means that the system is able to use energy resources more efficiently when achieving suspension and altitude control.

6. Conclusion

This paper only describes the possibility of a maglev system in the field that has not been developed at present, and some of the pure theoretical solutions for the whole operation logic, grounding protection, communication logic, direction control, level adjustment and so on. And based on one time, if the actual application of the required parameters, as well as the overall design of the basic model.

However, there are still many shortcomings in the practical application, such as the earth magnetic field, operating power, and stable altitude control. And according to the actual environment also need to make quite a lot of adjustments, in the high temperature, low temperature, weightless environment and other aspects still need to make different adjustments.

Permanent magnet suspension technology has evolved from passive to active systems, offering intelligent features based on sensing, feedback, control, and energy efficiency. However, industrial application requires addressing three key challenges: magnetic circuit design and material characteristics, precise modeling of magnetic behavior and hysteresis, and system performance and controller design. These aspects are interconnected and require systematic research tailored to specific application scenarios. By overcoming these challenges, permanent magnet suspension technology can transition from laboratory prototypes to industrial products. The future development of this technology lies in its realization mechanism and ongoing advancements in its development status: (1) PMST has wide applications in light load, low frequency scenarios, e.g., micro-PMS bearings, low frequency PMS vibration isolation, and PMS gravity compensators. (2) Precise magnetic circuit design is crucial for PMST, optimizing the utilization of magnetic energy and considering factors like structure, size, and material characteristics. (3) Intelligent control methods for PMST include variable air gap, reluctance, and magnetic source systems. Classic PID and state feedback have limitations, while fuzzy PID, H_∞ robust control, fractional PID, and nonlinear state feedback show promise.

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