A study on the individual control method comparing the lateral displacement control of front wheel and rear wheel of IRWs system

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Introduction

This paper proposes an algorithm to obtain better results in the integrated control by reflecting the characteristics of the individual control of the front wheel and the rear wheel of shallow-depth subway systems In the case of the surface transportation, which has recently been introduced, severly curved driving performance is required for the downtown. It is possible to decrease the curve radius and to improve the performance of the straight running with the individual torque control. Therefore, the individual torque control performance of the motor is the most important point of the surface transportation. The front and rear wheels have different torque characteristics, and the length of the bogie during curve travel also affects these results.

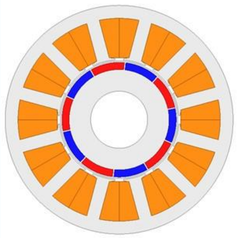
This system is more controllable than the system with 1C4M(1Controller 4Motor) in the form of 2C4M with the front and rear wheels being individually controlled, allowing more precise control because of its higher degree of freedom. Because of this individually controlled characteristic, it is possible to control more precisely in the integrated control considering the characteristics of the front wheel and the characteristics of the rear wheel. The validity and usefulness of the proposed control algorithm is verified by experimental results using a small-scale bogie system

Conclusion

- For the permanent magnetic synchronous motor, the torque ripple is smaller compared to the induction motor. Also, with the advantage of high torque density, it is receiving spotlight as the future traction motor. and also applied 1/5 scale for the small-scale bogie to verify the later recovering control algorism.
- When disturbance occurs in the small-scale bogie, centering can be maintained, which demonstrated the superiority of algorism.
- Based on the lateral recovering algorism proposed through the small-scale bogie, it is considered that the algorism can be applied to the actual train system.
- When a disturbance occurs, the recovery time of the front wheels takes longer than the rear wheels.
- The recovery time of using improved control method becomes shorter than using conventional restoring control method.

Motor of IRWs

The Characteristics of Independent-wheel Motors



The model of the motor of independently rotating wheelsets

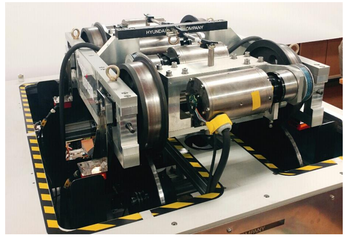
The size of the motor for the small-scale bogie is 1/5 scale of the actual urban low-depth train. Thus, the load torque is decided according to (1) in the base speed of small-scale motor. For the small-scale motor, the length of each side is reduced by 1/5 where the total volume becomes 1/125. The output by (1) becomes 1/125, thus 360W. This paper considered the output margin to design 500W motor. Thus, when 15 [km/h] base speed is selected as sharp curve drive speed for the test of small-scale bogie, the load torque value in base speed in 2[Nm].

SPMSM

The motor of independently rotating wheelsets selected model in accordance to performance of control to independently control 4 motors. Magnetic torque and reluctance torque are the two torques that exist in the motor. In the case of reluctance torque, it occurs due to interaction of d-axis and q-axis currents. The controllability reduces compared to the magnetic torque that only uses d-axis current. Thus, the motor was designed with SPMSM(Surface Permanent Magnet Synchronous Motor)using only the magnetic torque.

Experiment

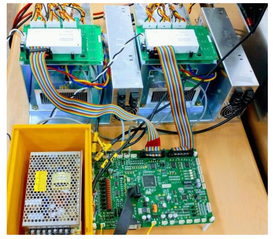
Hardware



Small-scale bogie

The small-scale bogie was made as shown in Fig. by using 4 independent wheel motors. Each motor was in charge of the each bogie's wheel, and it was connected through the reducer.

The rotor position of the motor used encoder for measurement.
To recognize the lateral displacement of small-scale bogie, 4 laser sensors were fixed on the center part of the wheel.

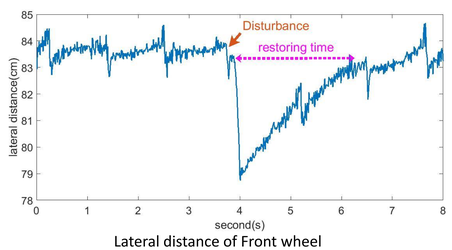


DSP and inverters

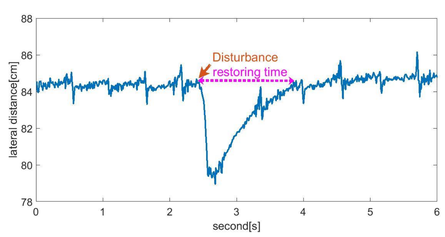
Fig. used independent wheel motor to show the later recovering control test inverter and controller.

Because of the 1C2M system, there are 4 motors. DSP used TI28335, and because 12 switching signals can be created per 1 DSP, a total of 2 DSPs were used.

Results



Lateral distance of Front wheel

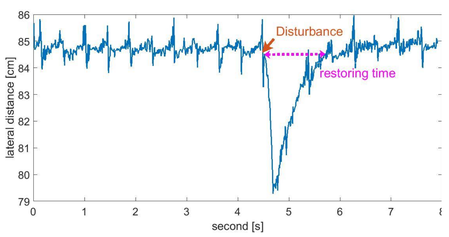


Lateral distance of rear wheel

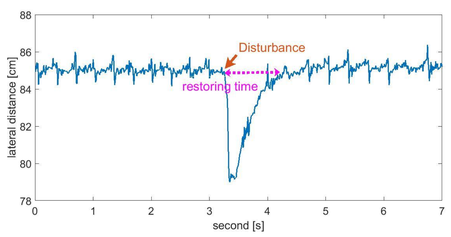
When a disturbance occurs, the recovery time of the front wheels takes longer than the rear wheels.

Because it is mechanically susceptible to disturbance, the weight that the front wheel should tow in the direction of travel is less than the weight that the rear wheel should tow

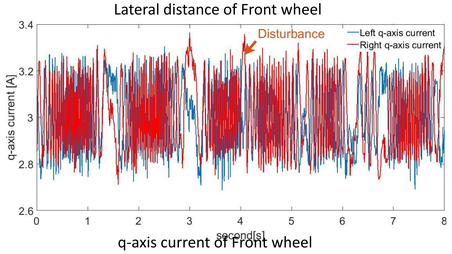
The characteristics of the whole vehicle, which combines the characteristics of the front wheel and the characteristics of the rear wheel, are shown in the graph on the right.



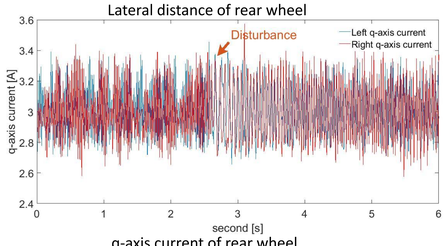
Lateral distance of whole wheel



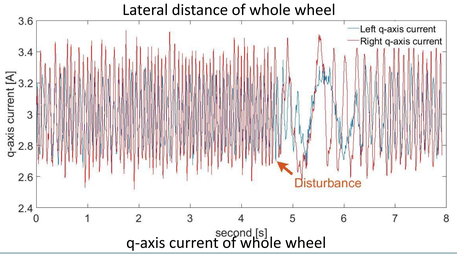
Lateral distance of using advanced method



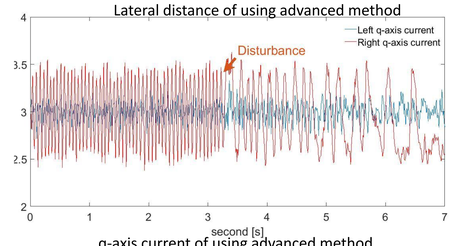
q-axis current of Front wheel



q-axis current of rear wheel



q-axis current of whole wheel



q-axis current of using advanced method

Since the characteristics of the front wheels and the rear wheels that are driven independently are checked, the recovery time for the disturbance becomes shorter by using the improved control method.

As shown in the figure on the left, a recovery time of about one second was required when restoring to the original state, but a recovery time of about 0.8 seconds was required for improved restoration control using front wheel and rear wheel characteristics.