Vibration Reduction Methods for Superconducting Maglev Vehicles

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A study was conducted on the effectiveness of applying vibration control methods to the primary and secondary suspension components in a three-car model of the vertical and pitching motions of a superconducting Maglev train.

A linear generator device has previously been demonstrated in full-scale vehicle running experiments to generate on-board power. This device was also able to effectively apply additional electromagnetic forces to the primary suspension and reduce vibrations of relatively higher frequencies that are otherwise difficult to reduce by controlling only the secondary suspension.

The Maglev train set has an articulated bogie arrangement, in which all bogies are evenly spaced along the train set. Utilizing these properties, techniques for preview control of the secondary suspension are examined that measure external disturbances at the front of the Maglev train set and feed the data to the rear of the train set, to enhance the ability of the vehicle to efficiently minimize the impact of irregularities in the guideway ground coil alignment.

The figure shows an example of the results of simulations for a Maglev vehicle traveling at a constant speed of 500 km/h. Case A represents a frequency-shaped optimal preview control of the secondary suspension, and Case B represents the combination of Case A and maximum force control of the primary suspension. Case A, which controls only the secondary suspension, has significantly reduced the middle car body vertical acceleration power spectral density (PSD) peak at around 1 to 2 Hz, while only slightly reducing the peak at around 4 to 5 Hz. Case B, which controls both the primary and secondary suspension components, has significantly reduced both PSD peaks.

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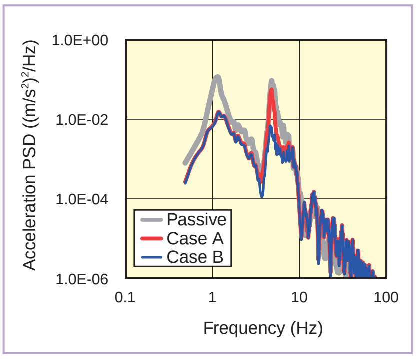

Fig. 1 Middle car body vertical acceleration power spectral densities

Effects of Current Collection Noise and Lineside Obstructions on GPS Signal Reception

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In the future we would like to integrate the onboard location detection function of GPS/GNSS with CBTC (Communications-Based Train Control). However, GPS signals are often obstructed by topography and structures, and this is a common problem for land transport. This especially affects railways, where various structures such as road bridges and truss bridges, and concrete electrification masts, exist adjacent to the tracks, making the receiving environment unfavorable. Moreover, on electric railways there is concern that radio noise generated from the contact wire and the pantograph affect the frequency bandwidth (GHz band) which is used by GPS. Therefore, we commenced research to investigate the GPS signal receiving environment on railways and the effects on GPS positioning.

In on-track tests, GPS antennas were temporarily installed at two locations on the roof of an electric railcar, which runs on a line electrified at 1,500 V DC. One antenna was installed as close as possible to a pantograph to measure adverse effects due to the current collection noise, and other equipment was temporarily installed in the cabin. The outputs of the GPS receivers were recorded, and the intensity of radio noise in the central frequency (1.57542GHz) of the GPS usage band was measured at the receiver input edge. Furthermore, video recordings were made from the front and rear driver's cabs to record obstructions such as bridges along the line that might shield the GPS antennas. The test train made two round trips of approximately 43km over an existing line (partly single track) at less than 95km/h.

The following observations emerged from the tests.

Since GPS is performing data transmission by spread spectrum, it is conceivable that the adverse effects of radio noise generated from the contact wire and the pantograph have little direct effect on the accuracy of the positioning. However, it is preferable to position a GPS antenna on a roof away from the pantograph if possible.

In addition, it became evident that GPS signals may be obstructed when the train is running by structures and installations adjacent to the track; this not only causes the positioning rate to degrade but also leads to errors in the navigation messages (Fig. 1). If such irregularities in navigation messages are ignored, it is possible that there will be a serious effect on the positioning which could be of critical importance. In applying GPS to safety systems such as train control, adequate measures are essential to eliminate this type of hazard by ensuring that the navigation messages are received in duplicate.

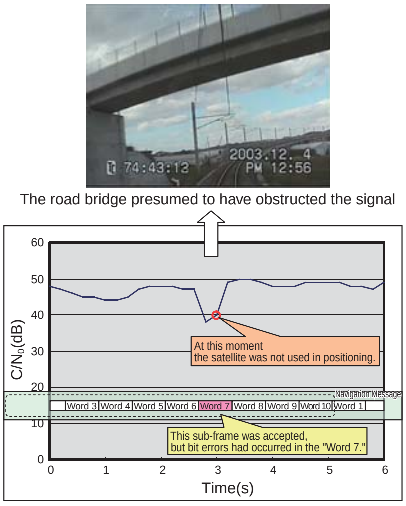

Fig. 1 C/N$_0$ deterioration and navigation message error at passing under an overbridge