INTRODUCTION

The Maglev train at the Yamanashi Test Line is driven by the LSM (Linear Synchronous Motor). In such a system, accurate information of the train position is essential for stable and efficient train operation. Moreover, the information of the train position is also important from the viewpoint of safety. The system calculates the speed of the train with the information of position, and checks if the train is not violating the current speed limit. Thus the train position detecting system plays one of the very important parts in assuring the operation safety. Figure 1 shows some parts of the former train position detecting system currently in use.

In the former system, the train position is detected using the inductive radio system which performs with high reliability and accuracy. But the cost of construction and maintenance is expensive, because the system needs cross-inductive wire to be laid all along the test line precisely, and also needs the local transmission equipments to be installed along the test line at intervals of 2 km approximately. That is the reason we started the development of the new method to detect the train position without cross-inductive wire.

The new system we developed does not contain the inductive radio system. Instead, it contains the EMF (Electromotive Force) observer, wheels tachometer, wayside coils counter, and millimeter wave radio. The information collected by these subsystems are combined or selected according to the train condition so that the system decides the train position. This new method made it possible to cut down the cost of construction and maintenance.

So far, we have installed the new train position detecting system and confirmed its basic performance. Hereafter, the outline of the new system is explained and the result of train running test with the new system is reported.

OUTLINE OF THE NEW TRAIN POSITION DETECTING SYSTEM

Figure 2 shows the structure of the new train position detecting system. The main system combines or selects the information collected at the subsystems such as wheel rotation pulse counter, wayside coil counter, EMF observer, and millimeter wave radio. Then it decides the current train position and speed, and outputs them for systems of drive control, traffic control and operation safety.
The position and speed information for driving control must be calculated every 5ms precisely. For the calculation of the position and speed, the main system uses the information from EMF observer, wheel rotation pulse counter, and wayside coil counter.

The EMF observer information is collected at the driving inverter and processed through the PLL (Phase locked loop), statistical process, and selection process. The wheel rotation pulse generated 500 times per rotation is counted on the train. That counted pulse number is transmitted every 5ms through the train radio, and put into the statistical process with the information of wheel diameter. The wayside coil count subsystem includes one transmitting antenna attached on one side of the vehicle and two receiving antenna attached on the other side. The radio wave is transformed through the wayside coil arrangement, transmitted through the null flux cable which connects each wayside coils, and received by the two receiving antennas at different timings. The receiving equipment counts the number of crossings made by two radio waves from the different receiving antennas. Then the counted number is transmitted every 5ms through the train radio.

At low speed stage, the information from EMF observer is not as precise as that at high speed stage. On the other hand, the information from wheel rotation pulse counter is precise at low speed stage when the train is not levitated. Therefore, in calculation of the train position, the information from EMF observer is used at high speed stage, and the information from wheel rotation pulse counter is used at low speed stage. Although the train position detecting system usually uses the information from these two subsystems, the information from the wayside coil counter is used as backup when the EMF observer fails, and also used for revising the measurement error caused by wear of the rubber wheels.

2.2 Position and speed information for traffic control and operation safety

The position and speed information is also essential for the traffic control and the operation safety. The position and speed information for driving control is calculated precisely using the EMF, wheel rotation pulse counter, and the wayside coil counter. However, these counting methods are kinds of relative measurement. For the traffic control and the operation safety, the absolute position and speed need to be measured. For this purpose, the detection system uses the information from the millimeter wave radio measurement system.

For the limitation in the radio propagation, the error range of the position and speed measured by the millimeter wave system can be larger than that measured by the EMF and wheel rotation pulse counter. But the advantage of the millimeter wave radio measurement system is that it can measure the absolute train position using the radio propagation time between the mobile station and the fixed base station.

3 TEST RESULT OF TRAIN DRIVING CONTROL WITH THE NEW SYSTEM

For train driving control, the new system was tested step by step according to the following process. First, the system was tested in the factory. Second, the system was installed in the Yamanashi Test Line and calculated the train position and speed, although they were not used for actual driving control. And third, the train was actually driven using the position and speed information generated by the new system. In the driving test, the train running speed was gradually increased. And at last we succeeded in the running test of 500 kmph in August 2004.

The phase difference of the measured position values between the former system and the new system was approximately 5 degrees, showing that the new system measures the train position precisely enough to be used for the LSM drive control. Figure 3 shows the result of train running test.
The train is driven with the drive synchronous control, so that the measurement error of the train position can affect the passenger comfortableness. Figure 4 shows that there is no significant difference of the acceleration of back and forth vibration in driving between the former system and the new system.

4 TEST RESULT OF MILLIMETER WAVE RADIO MEASUREMENT SYSTEM

The millimeter wave radio measurement system outputs the absolute train position information used for the traffic control and the operation safety. Figure 5 shows the configuration of the three millimeter wave radio antennas as the base station. The system selects the well performing base station and calculates the train position through the statistical process.

We confirmed that the system can detect the train position continuously when the train passes through the wayside antenna at high speed. And as the average detection error was approximately within 3 meters, it is confirmed that the performance of the detection system is enough to be used for the traffic control and the operation safety. The train position information output from this system can be used to decide the block section for signaling and interlocking.

5 CONCLUSION

We developed the new train position detecting system without cross-inductive wire. With the new system, we can reduce the cost of construction and
maintenance of the whole train control system. We will continue to accumulate the test data for the verification of the system reliability.

6 REFERENCES

