Remote Control and Monitoring System for the Scaled Active Steering Railway Vehicle

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Abstract: - This paper describes the remote control and monitoring system of the scaled railway test-bed for development of the active steering control using the 2.4G wireless LAN system and the wireless camera sets. Generally active steering system of railway vehicles has proven its ability to bridge the gap between stability and curve friendliness. The scaled test-bed consists of two steering actuators, a steering controller, various sensor systems, and control station to control the active steering controller and monitor the various sensor signals. To communicate control station to the scaled vehicle, we used the 2.4G wireless LAN system with Netmeeting software. Running test results of 1/5 scaled active steering vehicle on the curved track show that the proposed remote control and monitoring system (control station) has good performance.

Key-Words: - Remote Control, Monitoring, Wireless Camera, Active Steering, Railway Vehicle, Scaled Test-bed

1 Introduction
In urban transit systems, rail passenger vehicles are often required to construct tight curves. Therefore running the curve section, the wheelsets of conventional vehicles generally misalign radically with the track increasing wheel/rail contact forces and resulting in increased wheel and rail wear, outbreak of squeal noise, fuel consumption, and risk of derailment. To alleviate these problems, modified suspension system designs, application for alternate wheel profiles, active and semi-active steering techniques have been proposed. Over the past few decades, a considerable number of studies have been accomplished on the effects of the active steering system of railway vehicles. And the active steering system has verified its ability to solve the mutual relationship problem between stability and curve friendliness [1]–[8].

Generally scaled railway vehicles were developed to research the basic dynamic characteristic of the full size railway vehicle in laboratory level. In this paper, a 1/5 scaled railway vehicle is carried out for the development and testing of prototype bogie design, and the investigation of fundamental railway vehicle running behavior.

In this paper, we design an experimental test-bed with a control station for the purpose of monitoring the sensor signals from test-bed and controlling the active steering controller.

This paper is organized as the followings. Section 2 describes an active steering control system for 1/5 scale model. Section 3 deals with the remote control and monitoring systems. Section 4 contains the experiment results. The main conclusions are then summarized in section 5.

Fig.1 Block diagram of active steering control system

2 Active Steering Control Systems

2.1 Control Strategy for the Active Steering
The basic concept of steering control strategy is to apply a controlled torque to the wheelsets in the yaw direction. This can be achieved through longitudinal actuators as shown in Fig.2. This strategy is founded on the coupling of the lateral and yawing motions of the wheelsets by using the laser sensor signals represented in the wheel/rail displacement.

2.2 Scaled Active Steering Railway Vehicle

The scaled test-bed is designed based on the dynamic similarity laws behind the full scale model. The object of the scaled test-bed is aimed at designing the active steering strategies and at testing the active steering bogie of the railway vehicle. A block diagram of test-bed for the active steering control system is given in Fig.3.

2.2.1 Curved Track of Steering Test

For running test, 27.11 [m] and R=20 curved track is used. This track has not a cant, and consists of the straight track (6.41m), curve track (14.30m) and straight line track (6.41m).

2.2.2 The Scaled Research Vehicle

The scaled research vehicle is consisted of the diving bogie module, the steering bogie module, the controller module, the sensor system module, and car-body module.

First, driving bogie module consists of a BLDC motor of DC48V 39.1A, a 5:1 reduction gear, a driving motor driver, and a braking system. Two encoders which are mounted two wheel side of the driving motor axle are used for calculating the vehicle speed.
as the core part including A/D and D/A input/output terminals, a control station module having function of remote command and data acquisition, actuator module for driving the steering bogie corresponding to the controller output signals, and various sensors system module.

As the feedback signals, the relative movement between the wheels and the rail are considered in the development of controllers using the measured distance of the laser sensor from axle box to rail head.

![Fig.6 Realization of the active steering control module with MATLAB/SIMULINK](image1)

Fig.6 shows a realization of the active steering control module with MATLAB/ SIMULINK for scale model.

Third, the steering bogie of F-link type which consists of two steering actuators and several links is depicted in Fig.7.

![Fig.7 Active steering bogie module](image2)

The actuator force is proportional to the input voltage values. That is, the actuator force increases from 0 [N] to 200 [N] approximately proportionally to the actuator command voltage (0 [V] to 4 [V]).

Finally, the sensor system of the test-bed mainly consists of four components:
- Wheel/rail relative displacement measurement using laser sensor
- Car-body vibration characteristic measurement using accelerometer sensor
- Yaw angle measurement of the steering bogie using gyro sensor
- Detection of the start/end point of the curve track using magnetic sensor
- Wheel/rail dynamics monitoring using wireless camera systems

![Fig.8 The scaled vehicle with various sensor systems](image3)

**3 Remote control and monitoring system**

For active steering control of the test-bed, it is vital to control the active steering controller and to monitor the various sensor signals by using the control station.

![Fig.9 The active steering controller (DS1103 PPC Controller Board and desktop PC)](image4)

![Fig.10 The experimental results: the dSPACE control desk screen on the desktop PC](image5)
The control signals from the control station are delivered with the laptop computer with Matlab/Simulink and dSPACE through wireless network.

Fig. 10 shows a dSPACE control desk screen on the desktop PC to control the active steering controller which is composed of velocity command, moving direction, control strategy selection, and so on, and to monitor the various sensor signals which is made up of moving velocity, moving distance, lateral displacement, lateral force, yaw rate, and so on.

Fig. 11 shows the wireless camera, battery pack, and transmitter in the steering bogie to monitor the lateral movement of wheel, and Fig. 12 illustrates the wireless camera receiver with two channels for monitoring the wheel dynamics.

Fig. 13 The experimental results: the remote control screen and the wheel dynamic monitoring screen

4 Experiments of Test-bed

In the running test of the research vehicle, the test-bed for the active steering control system can be tried and validated under real-time condition.

Control station offers a controlling the active steering controller (velocity command, moving direction, control strategy selection, and so on), a monitoring the signals (moving velocity, moving distance, lateral displacement, lateral force, yaw rate, and so on), and an observing the wheel dynamics behavior.

(a) 8 seconds, moving distance = 5.94m

(b) 11 seconds, moving distance = 11.89m
The experimental results of the lateral movement of the right trailing wheel for comparison with the conventional system and the active steering control system to produce the pure rolling are shown in Fig. 15.

5 Conclusion
In this paper, we present the remote control and monitoring system for the scaled railway test-bed which is aimed at the development of the active steering control strategies of the railway vehicle. Control strategy to the active steering system based on two axle vehicle attached to actuator of the yaw torque considering the riding quality has been applied. Experiment results show that the proposed control station yields good performance through comparing with the passive system and the active control system.

References: