A Study on the Practical Application of High Capacity Laser Communication Technology to Railways

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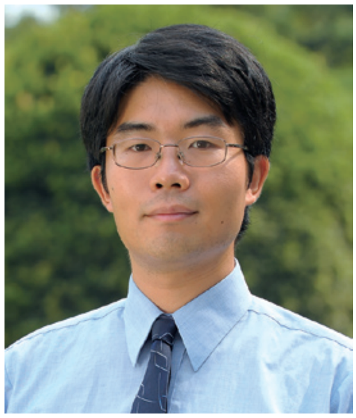

1. Introduction

Recent years have seen remarkable progress in mobile communication technologies. On Japanese railways, in-train internet connection service has begun. In such circumstances, having an eye to the laser communication technology that is already proven in the field of fixed section-to-section communications, we have carried out research and development work for a high capacity optical communication system offering practical application of this technology as a means of ground-to-train communication.

2. Developed system

The system we have developed, as shown in Fig.1, is a so-called laser scan communication system. Both the on-train communication device (mobile station) and its ground counterparts (base stations) emit beacon infrared lights as their identifying signals and transmit data between them by sending out a laser beam to each other with their beacon signals as the targets. Even in a situation where the relative positions of the ground and the on-train communication units change rapidly, they can keep track of each other through adjustment of their internal movable mirrors. Also, the system contains a handover function to switch rapidly and dynamically from one base station to another in response to the running speed of the train, which enables continuous communication.

Shown in Fig.2 is an external view of the device. The communication devices were designed so that they could be easily installed on the train and at the trackside. The design parameters also include a transmission distance of approximately 300m and a transmission rate of approximately 1Gbps as the theoretical values. A communications test was conducted with two settled communications devices. This achieved a data transmission rate of 923Mbps using TCP at a transmission distance of 320m.

3. Field test on a railway line

To investigate the feasibility of applying laser communication technology to railways, we tested the system we had developed with the co-operation of JR-West (West Japan Railway Company) using a commercial train on a conventional line. As shown in Fig.3, with three devices set up on the ground and one device in the conductor's cabin of the last car of the train, continuous communication was tested while a handover was being implemented from one base station to another. As a result, we could obtain a transmission rate ranging from approximately 500 to 700Mbps at a train speed of approximately 130km/h. (Fig.4) The handover took approximately 0.4 seconds due to vibrations of the train as shown in Fig.5. In a bidirectional transmission test with high-definition video, however, little disturbance was observed in the pictures. It was particularly evident, in the test using TCP, that we could see the video without observing any effect caused by the handover.

Furthermore, similar communication tests were conducted on a Shinkansen line. Since there was only one base station, we did not evaluate the performance of the system during a handover. Although in all of our six tests no communication could be established and data transmission was not possible, the two devices could track each other for a maximum of approximately 0.7 seconds at train speeds up to 270km/h.

By conducting these tests, we were able to verify the applicability of the system we had developed to railway environments. At the same time, problems that will need to be solved in the future were identified, such as the handover time and the influence of glass in train windows. We intend to continue our efforts to bring the system to perfection in pursuit of its practical application.

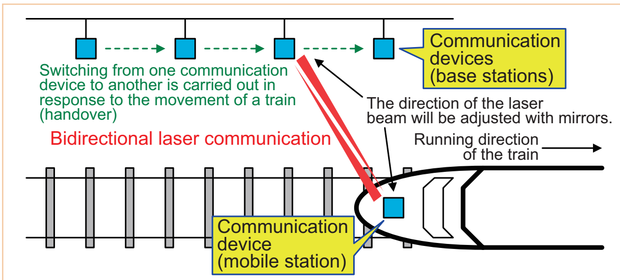

Fig.1 Optical communication using laser scan communication system on a railway line

Fig.2 Appearance of the communication device

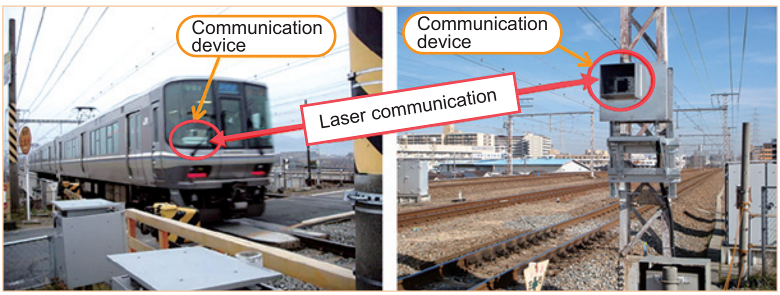

Fig.3 View of the field test on a railway line

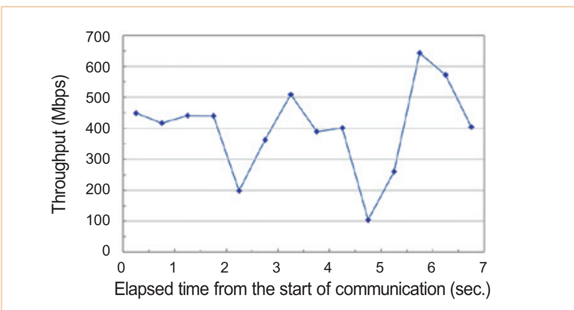

Fig.4 Result of throughput measurement test

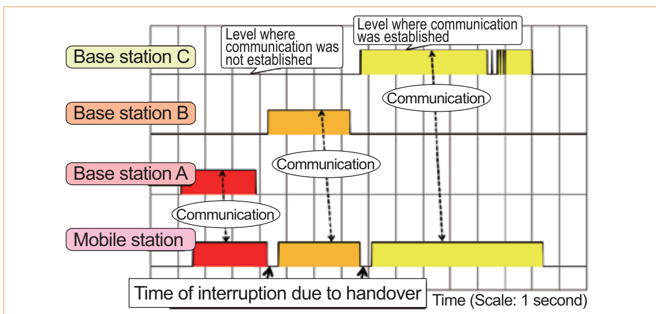

Fig.5 Result of handover performance test