12th Optoelectronics and Communications Conference/16th International Conference on Integrated Optics and Optical Fiber Communication (OECC/IOOC2007)
Technical Digest, July 2007, Pacifico Yokohama

11D2-4

Anti-Shake Mechanism for Mobile Optical Wireless Communication

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Abstract
We implement and demonstrate an anti-shake mechanism to suppress the involuntary hand movements for mobile optical wireless communication. The demonstration suggests that the effectiveness of the anti-shake mechanism to usual use.

Introduction

The memory volume of mobile devices such as mobile phones and digital cameras has been increasing rapidly in recent years. Some users want to exchange large data between mobile devices and fixed devices such as personal computers and information appliances by using high-speed interfaces. Optical wireless interfaces are very attractive among the various wireless interfaces because of high potential for high-speed communication and high security. The standard of an infrared light communication at a speed of 100 Mbit/s with a transmission distance of 100 cm have been defined [1]. Furthermore, demonstration of the 1 Gbit/s data transfer between mobile devices with the transmission distance of 10 cm by using infrared light has been reported [2]. The transmission speed increase results in decreases of transmission distance and/or receivable area because the minimum sensitivity decreases as the transmission speed increases. In order to enhance the usability, it is desirable to extend the transmission distance, but more reduction of receivable area is inevitable. The involuntary hand movements may result in frequent “link down” states due to misalignment in case of high-speed communication. In order to expand the receivable area, an automatic optical axis alignment system was reported so far [3]. The posture of the receiver was adjusted by monitoring the direction of the data beam. However, the technology was suitable for communication between fixed or semi-fixed devices, but wasn’t seemed to be considered for compensation of the involuntary hand movements. We have already proposed an anti-shake mechanism for mobile optical wireless communication [4]. Beam fluctuation can be compensated by a monitor of beam position and an adjustment of the photodiode position.

In this paper, we described the implementation of the anti-shake mechanism for mobile optical wireless communication in detail. We have also demonstrated the anti-shake mechanism.

System Configuration

In the transmitter, two laser diodes at wavelengths of 850 nm and 658 nm are utilized for data and guide respectively. The data and guide beams are collimated and radiated along the same axis.

In the receiver, the guide beam is eliminated by an optical filter in front of the front lens as shown in Fig. 1. After that, the data beam is split into two beams for a communication and a position sensing with the ratio of 9:1 by a beam splitter. A position sensing beam is focused on a position sensitive detector (PSD) with an active area of 45 mm x 45 mm square. A communication beam is injected to a multimode fiber with a core diameter of 1 mm and is guided to a 200 μm - diameter photodiode through the multimode fiber. The PSD and one of the ends of the multimode fiber are fixed on the 2-dimentional motorized stage in order to avoid the mount of RF circuits with the photodiode on the motorized stage. The stage is controlled by monitoring the PSD signals so that the communication beam is coupled into the multimode fiber.

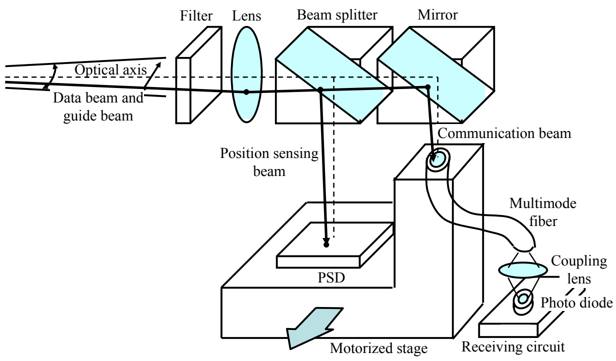

Fig. 1 Configuration of the proposed receiver

Evaluation of anti-shake mechanism

Firstly roughly estimation of the involuntary hand movements was carried out. A beam position fluctuation on the optical filter due to the involuntary hand movements was measured by the PSD which was set behind the optical filter. A distance between a transmitter and a receiver was set to 2 m. Note that the transmitter was handheld with a stand and the beams were aimed to the center of the optical filter. Typical fluctuation of examples which were one-dimensionally measured was shown in Fig. 2 (a). The position was measured every 0.02 seconds for 5 seconds. The maximum position fluctuation was within 20 mm. Figure 2 (c) shows the frequency distribution calculated

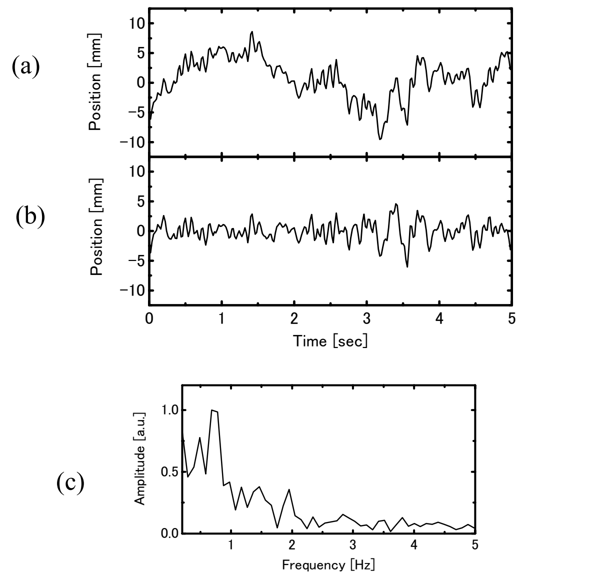

Fig.2 Experimental results of (a) beam position, (b) beam position after filtering and (c) Fourier transformation.

from Fig. 2 (a) by Fourier transformation. It was found that relatively large spectral components were distributed at frequency of less than 2 Hz. The time-domain data calculated by the extraction of spectral components lower than 2 Hz from the experimental data is shown in Fig. 2 (b). The peak-to-peak amplitude was reduced to 10.6 mm. By passed through the front lens, the amplitude, which was measured at the end of the multimode fiber on the motorized stage, would be decreased to 0.61mm, considering of optics. This value was smaller than the core diameter of the multimode fiber. This result indicates that the effect of the involuntary hand movement can be suppressed by the movement reduction with the spectral components less than 2 Hz.

Next, the performance of the anti-shake mechanism was evaluated as shown in Fig. 3. Although the anti-shake mechanism was designed to provide effectiveness to two-dimensional beam fluctuation, the evaluation was carried out in one-dimension for the purpose of simplification. The transmitter was set on the motorized rotary stage to emulate the involuntary hand movements. The distance between the transmitter and the receiver was also set to 2 m. The radiated power and the diameter of data beam were set to 1.26 mW (+1 dBm) and 1.4 mm, respectively. The communication beam diameter measured at the end of the multimode fiber on the motorized stage was estimated to be approximately 0.1 mm. Considering of the result of the analysis of the involuntary hand movements, the applied amplitude and frequency were set to 20 mm and 2 Hz, respectively. As for the amplitude, it was measured under the same condition for the evaluation of the involuntary hand movements. Figure 4 shows the received power fluctuation calculated by the photodiode current. The dot-and-dash line shows a minimum receiver sensitivity of -17 dBm (20 μW) which is defined in the standardized specification of Gigabit Ethernet at the wavelength of 850 nm. The received power was drastically fluctuated in ranging between 0 and 40 μW without anti-shake mechanism. The link state was seemed to be changed alternately between the “link up” and “link down” states. On the contrary, the received power was stable with a variation of 5 μW with anti-shake mechanism. As the power was kept higher than the minimum receiver sensitivity, it was expected that the link was always established.

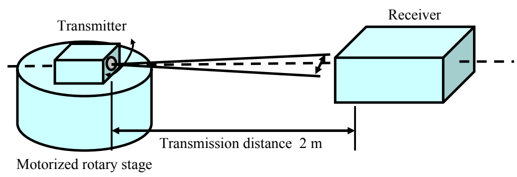

Fig.3 Experiment setup for demonstration of the anti-shake mechanism

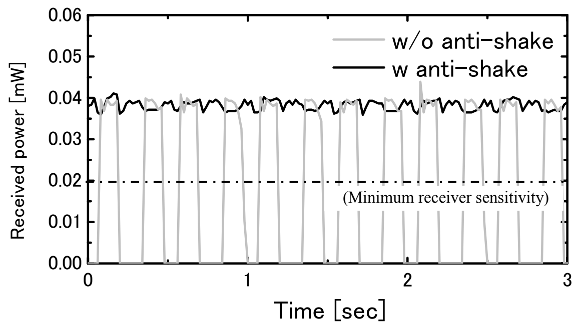

Fig.4 Power received by the photodiode

Conclusions

The anti-shake mechanism against the involuntary hand movements has been implemented and demonstrated for mobile optical wireless communication. We have successfully confirmed the effectiveness of the anti-shake mechanism to suppress the involuntary hand movements.

Ackknowledgement

The authors wish to thank Dr. S. Akiba, Dr. M. Suzuki and Dr. M. Usami for their continuous encouragement.

References

1 http://www.irda.org/
2 T. Yazaki et al., LEOS Annual Meeting 2006, MH-4 (2006)
3 K. Nonaka et al., 30th ECOC, We4.P.127, Stockholm, (2004)
4 M. Hattori et al., IEICE Society Conf. 2006, C-14-9 (2006)