Free-space RF Transfer between Buildings Using Single-mode-fiber-coupled Optical Communication Terminal

Miho Fujieda[1], Kohta Kido[1,2], Nobuyasu Shiga[1,2], Yoshinori Arimoto[1]

[1]National Institute of Information and Communications Technology, Koganei, Tokyo, Japan
[2]Japan Science and Technology Agency, Kawaguchi, Saitama, Japan

Email: miho@nict.go.jp

Accurate and stable frequency distribution is demanded in many fields including particle accelerators, radio astronomy and metrology. Frequency transfer through optical fibers has been established and well-known as its accuracy and stability. However, installing the optical fibers between two sites is often difficult or costly. This problem motivated us to start a study on free-space optical transfer aiming to establish a compact, easy-to-install and stable frequency distribution system. As a first step, we performed a free-space RF signal transfer experiment between two buildings using a pair of free-space optical terminals[1] and 1-GHz transfer system to investigate the stability against wireless link environment. The terminal has been originally developed for multi-Gigabit wireless links and provides a true replacement of a single-mode-fiber. A 1.5-μm light amplitude-modulated by a 1-GHz reference signal was emitted from one terminal and then received by another terminal installed at a 100-m distant building. The transmitted light, amplified by an Erbium-doped-fiber amplifier, was sent back to the original terminal through the same wireless link. The phase variation of the 1-GHz signal was measured during the transmission over a round-trip distance of 200 m. We first observed that an optical signal loss caused by rainfalls induced a phase variation by the AM-PM conversion of the transfer system. Second, we also observed a daily pattern of the phase variation influenced by the room-temperature variation. We consider that this was caused by the optical-path length change in the free-space and optical-fiber. Finally, the 1-GHz transfer continued for one week without any disconnection. We achieved the instabilities of 3 x 10^{-13} and 7 x 10^{-17} at 1 second and 100,000 seconds, respectively, and confirmed that they were stable enough for a hydrogen-maser signal transfer. This shows that short-range free-space optical transfer is a promising alternative to the fiber transfer. The experimental setup and result will be presented in this report.

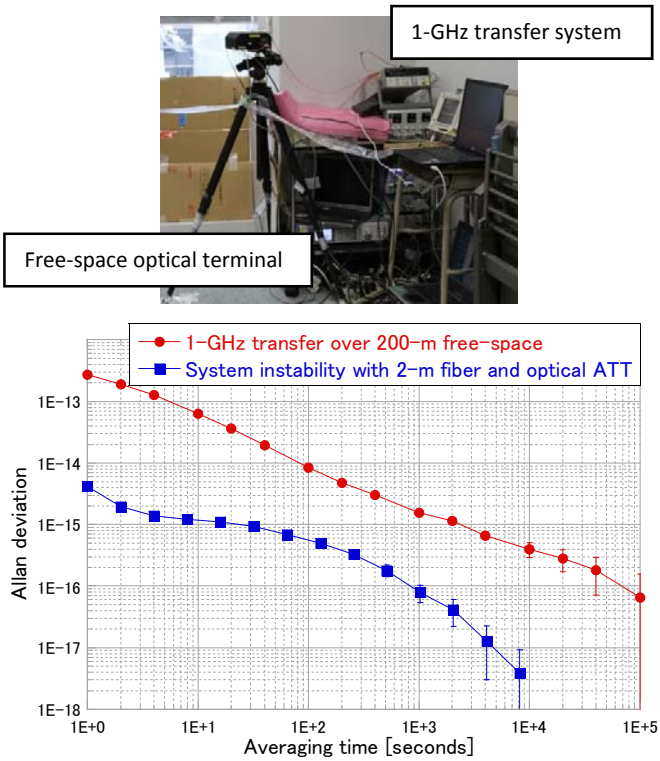

Fig.: (Upper side) free-space optical terminal and 1-GHz transfer system, (Lower side) instability comparison of free-space and fiber transfer.

[1] Y. Arimoto, Optical Engineering, 51, 3, 031203, 2012.