New Generation Free Space Optical Communication System (prototype)

FSO-2601

FSO-2601 system design concept is far different from those of the conventional fee-space optics. The novel system deployed to FS-2601 is the direct transmission scheme of the optical signal received from the optical fiber to the air without any O-E-O signal conversion. Two transmitter and receiver nodes provide the full duplex bi-directional free space communication. Automatic beam axis acquisition and tracking function is equipped in the transmitter and receiver system for the full-time communication link. The tracking function assures the high atmospheric fluctuation tolerance and quick recovery from the signal flicker.

FSO-2601 system provides the high-speed seamless optical communication link to the fields where fiber optic physical connections are impractical due to restrictions (e.g. Building-to-building, over rivers, railways and roads).

Further development is on the way to provide mobile links utilizing free-space optical communication technology.

◆ SYSTEM ENGINEERS` Co., Ltd. ◆ E-LambdaNet Corporation

What's new in FSO-2601?

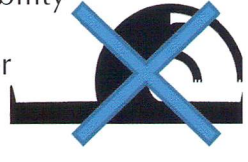
Conventional free-space optical communication system has technical issues as shown below:

Low transmission speed

Typical free-space optical transmission system's transmission speed is around 100 Mbps and 1.5 Gbps at the highest speed. They are not high enough to support trunk lines and high-resolution video transmission systems which require up to 10 Gbps.

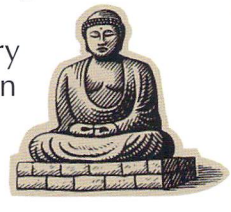
Low flexibility on transmission speed and signal format

Conventional transmission system makes optical-electronic signal conversion in the transmitter, thus modifying transmission speed and signal format is not possible. Also, system compatibility to the optical cable transmission is another issue.



Communication between two fixed points

Transmission system is equipped for two fixed-point link, thus the equipment location cannot be changed and the system has no mobility. Skilled operator is necessary to change the node location for the precise system re-alignment.



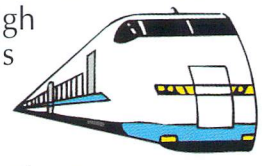
Low tolerance for rough weather

Transmission quality depends on the atmospheric fluctuation, such as rain, snow, fog and heat haze as well as background light of sunrise and sunset.

FSO-2601 System features

High transmission speed

FSO-2601 system directly transmits the received signal from the optical fiber. No optical-electronic signal conversion features bit-rate-free transmission links. In our laboratory, as high as one Tbps operation is confirmed.



Highly flexible system configuration

Direct transmission scheme can deploy to wide signal formats. FSO-2601 can transmit Ethernet traffics and video signals such as high-resolution video materials.

High mobility system

Automatic beam axis acquisition and tracking function suppresses minute vibration to the equipment and provides stable communication between two nodes. Moreover, the function assures the automatic link recovery operation after the node location change. Mobile application such as a node mounted on a mobile object tracked by another node is under development.

Highly tolerant operation under rough weather condition

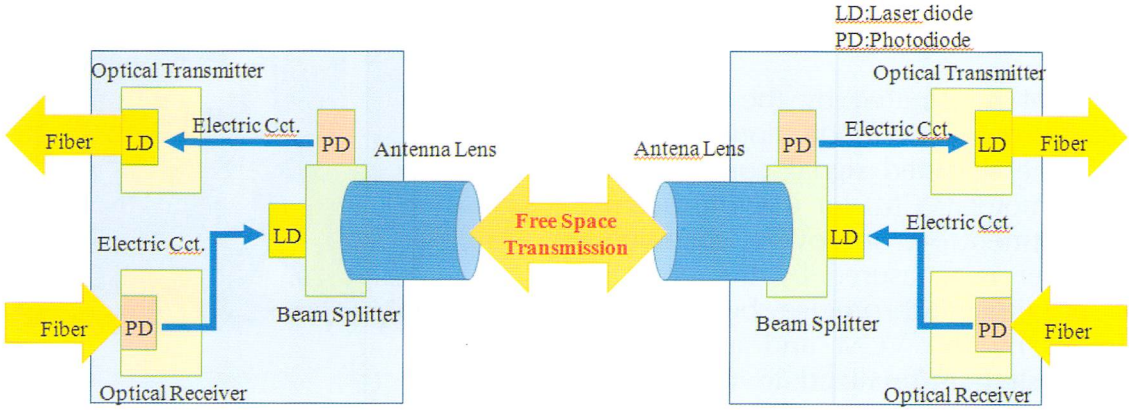
Transmission beam diameter is small and sharp to minimize the link degradation due to the atmospheric fluctuation and background light.

Comparison between FSO-2601 and conventional free-space optical communication systems

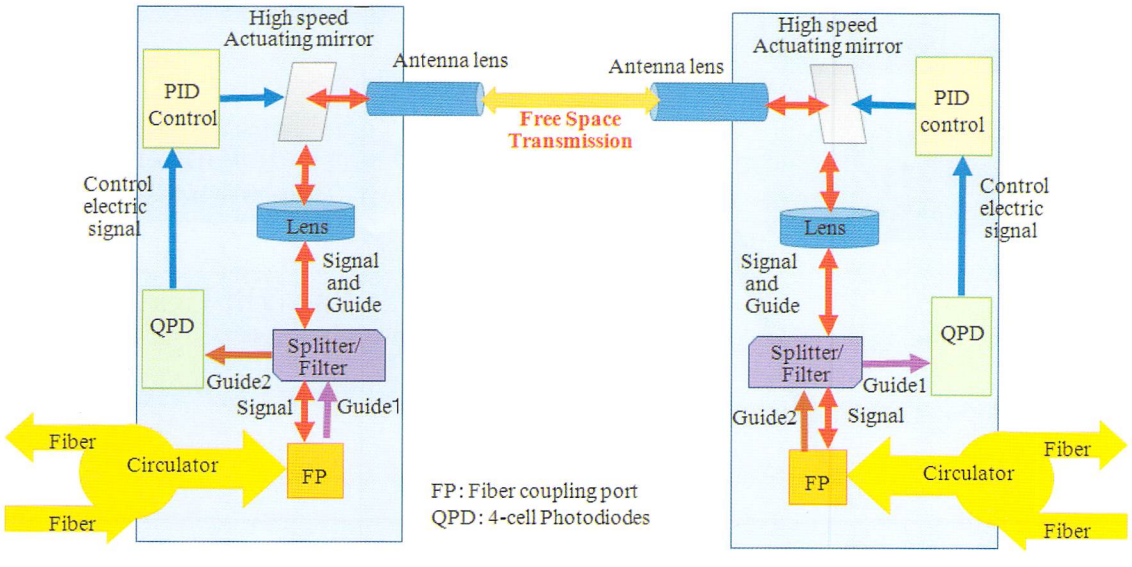
Conventional free-space optical communication system deploys the OEO conversions in the transmitter and receiver. Transmitter converts the received optical signal from the optical fiber to electronic signal and again makes the electronics to optical signal conversion to get the free-space transmission signal. The receiver converts the optical signal from the space to the electrical signal and makes the electrical signal to optical signal conversion so that the optical signal transmits over the optical fiber.

FS-2601 system receives the optical signal transmitted over optical fiber and directly transmits the signal to free-space. The receiver simply receives the optical signal and guides the signal to the optical fiber. There are no OEO conversions in the FS-2601 system.

Conventional FSO System



All Optical FSO System



How to operate the FSO-2601 system

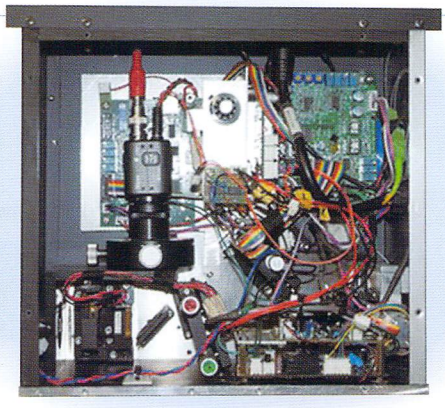
1. Controller PC automatically measures the position, altitude and azimuth of the transmitter/receiver node. Measured data are shared by two nodes through wireless network such as WiFi systems. Based on the shared data, the nodes calculate relative position and adjust the automatic head position to face the antenna together.

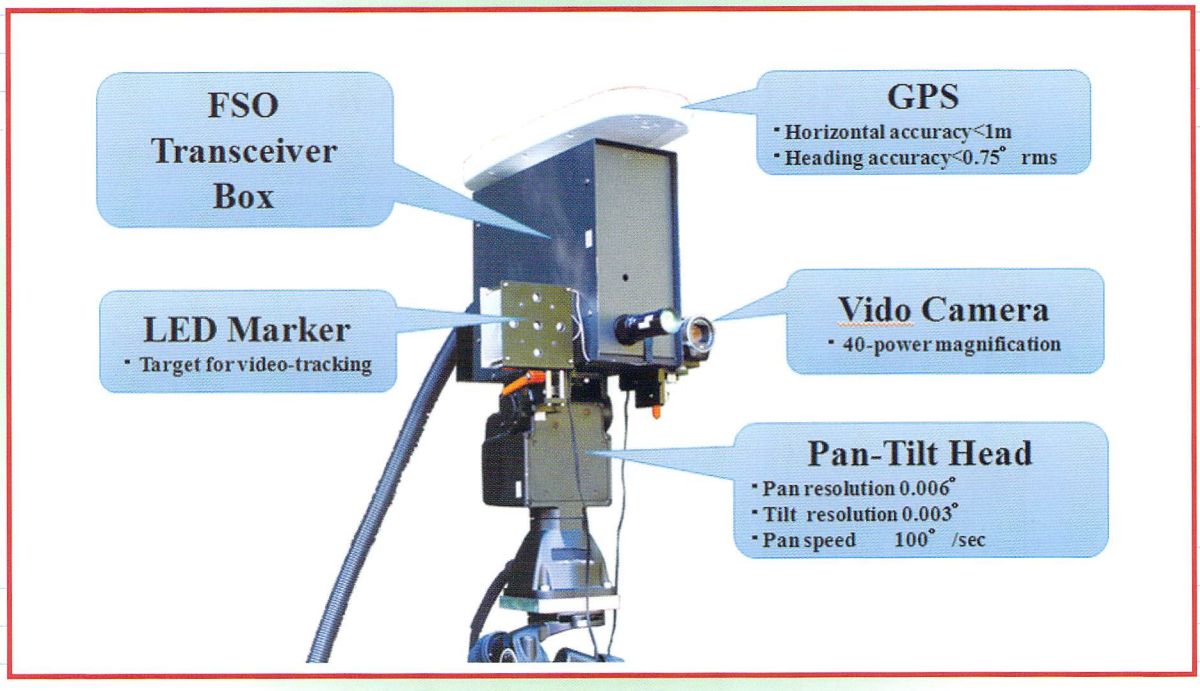
2. High power LEDs mounted on the side of the nodes start blinking. The LED light is shot by the high-sensitivity video cameras equipped for image recognition to adjust the pan-tilt heads. This step completes the course beam axis adjustment process.

3. Beacon light transmitted by the nodes is detected by quad cell photodiodes in the receiver. The detected signal controls the voice coil motor (VCM) for the fine beam axis adjustment.Å@Moreover, received signal power is measured by the optical power monitor and precise beam axis adjustment by the VCM and automatic focusing system is finalized to maximize the received power.

4. Automatic beam axis adjustment is continued by quad cell photodiodes and the optical power monitor during the communication.

5. When the signal flicker occurs, the system maintains the current positioning and waits for the link recovery. If the link does not recover, the system starts beam axis acquisition and tracking operation.





What's going on in FSO-2601 system development?

Original tracking system

Conventional system used galvano mirrors in the tracking unit. New FSO-2601 introduces voice coil motors (VCMs) to actuate two lenses (each for x-axis and y-axis). VCM can quickly acquire and track the beam axis against the vibration and atmospheric fluctuation. The VCM technology is widely used in the optical pickups for the CD players.

Better optical system for the beacon light

Conventional system used beacon light sources with narrow spectral width. FSO-2601 installs wide spectral width light sources which simplify the beacon optical system and are cost-effective.

Beam separation optics

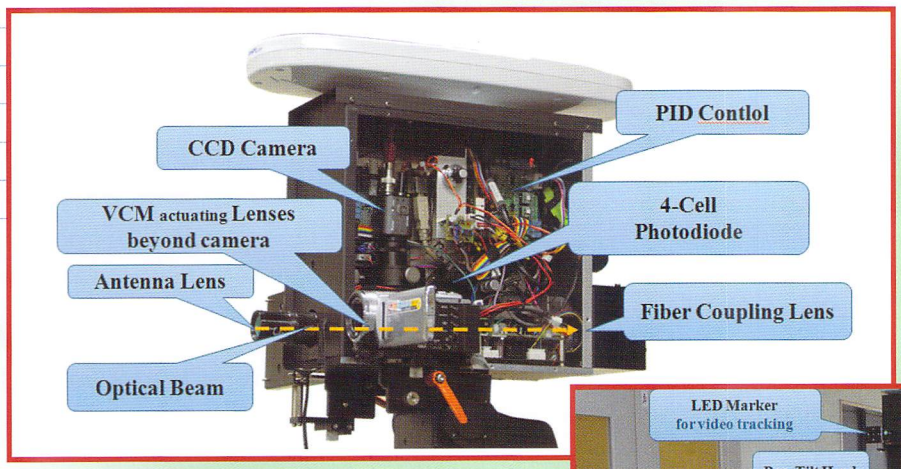
Conventional system used complicated optical systems to separate the signal and beacon light. New beam separation unit is developed and deployed in FSO-2601 system. The new unit is simple configuration and easy to manufacture as well as has better separation performance.

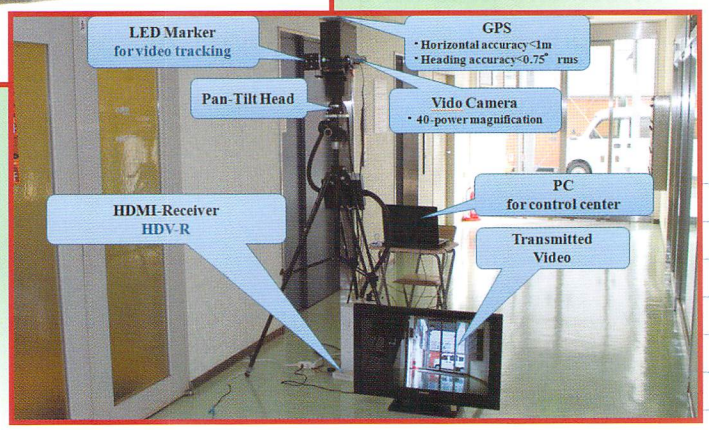
Automatic focusing system

FSO-2601 has a new feature to adjust the gap between the optical fiber facet and the lens so that the free-space signal focuses on the fiber facet.Å@The z-axis automatic adjustment function assures the stable system operation together with x and y-axes adjustment by VCM units.

Original acquisition and tracking technology

Easy operation supported by the automated acquisition and tracking process from position and azimuth measurement by GPS compass to beam axis adjustment with pan-tilt heads as well as the beacon light acquisition and tracking.



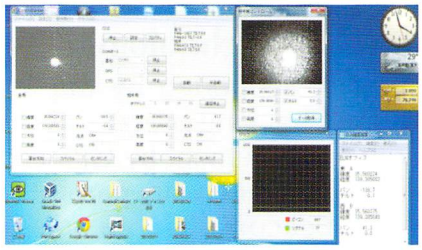


FSO-2601 standard hardware setup

A. Operation center

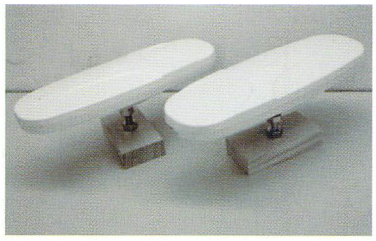
A personal computer with dedicated control software operates and monitors the whole system.

- CCD image monitor of the facing node beacon light
- Automatic pan-tilt head control
- Optical power monitor for the beacon light and the received signal light



B. Accurate GPS compass

Marine GPS compass to measure node position, altitude and azimuth with high accuracy.



C. Automatic pan-tilt heads

High precision pan-tilt heads by SUSTAINAble Robotics for stable optical axis adjustment.

D. Micro-motion heads

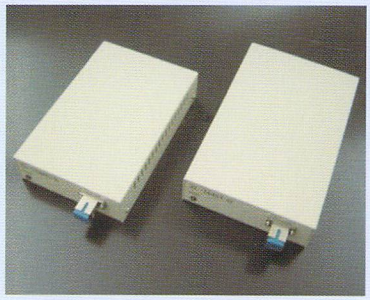
Manual operation micro-motion head and tripod by Manfrotto. Stable support and positioning the system.

E. Optical antenna for mid-range transmission

Optical antenna optimized for 500 to 2,000 m transmission.

FSO-2601 options

High-resolution TV optical transmission system: Real time video transmission from the high-resolution TV camera. HDMI signal is divided to four wavelength and transmitted by CWDM (course wavelength division multiplexing) technology.



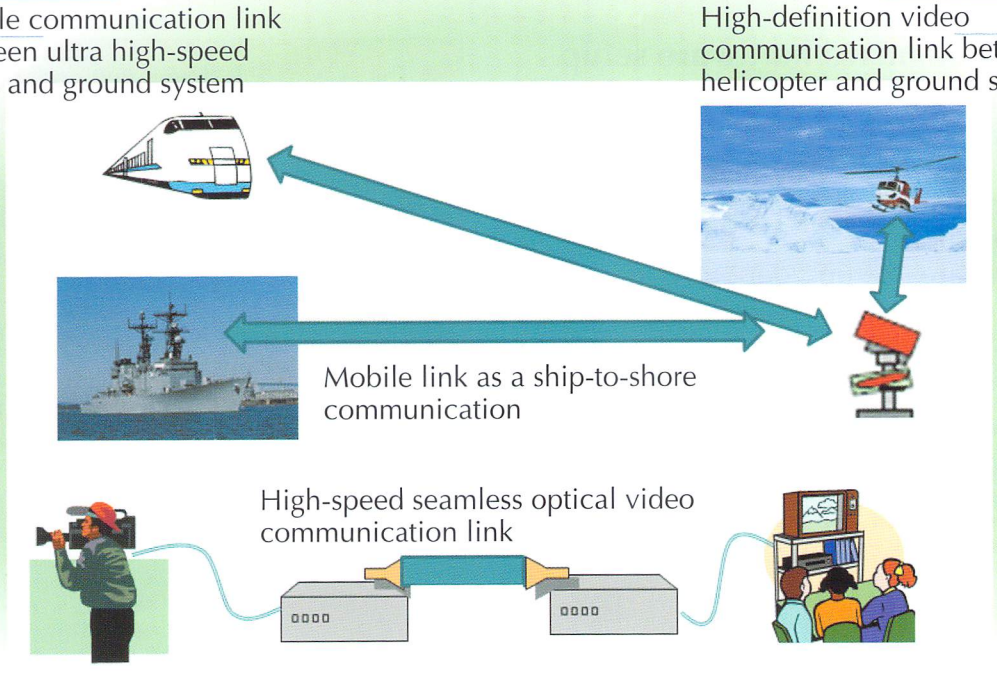
FSO-2601 Free-space optical transmission system development progress

Indoor transmission experiments

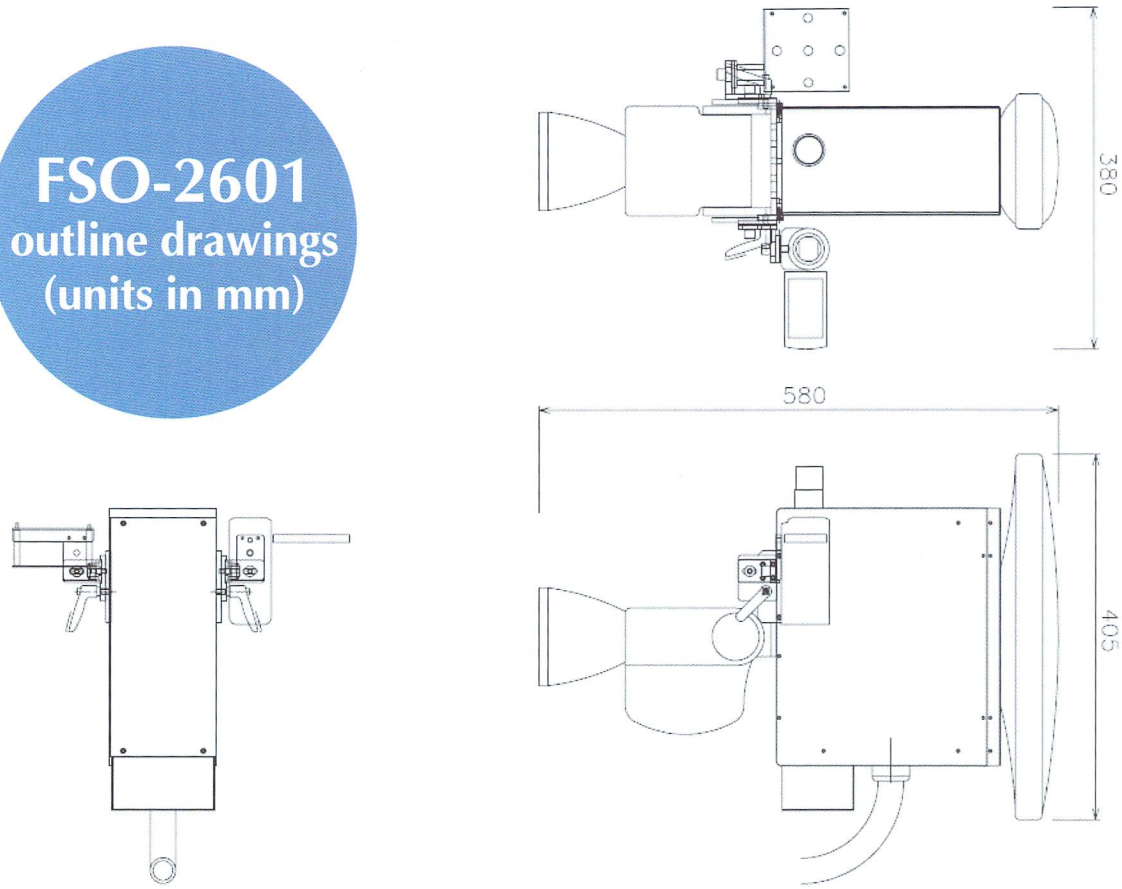
Outdoor mobile transmission experiments

New possibilities for the free-space optical transmission systems

The free-space optical transmission system is now applied for fixed two-point communication. In future, the node can be installed on vehicles and acquisition/ tracking between the mobile node and the fixed node would be possible. The mobile function is expected to start a new era for the free-space optical communication.



FSO-2601
outline drawings (units in mm)



FSO-2601 system major parameters

Body dimensions : Width 380mm x Depth 580mm x Height 405mm
Body weight : 5 kg
Antenna diameter : from 10 to 48mm
Power supply : DC 12V +/- 20%

FSO-2601 standard hardware setup

Body equipment, Control center (Personal computer and control software), 6.5 magnify antenna (for beam axis adjustment), GPS compass, Automatic pan-tilt head and Tripod with manual platform.

Note : Hardware setup depends on the applications.

FSO-2601 options

Micro-motion head, Tripod, 10 magnify antenna, optical transmitter/receiver, 1.3 um optical circulator, etc.

- The system was developed under the patent license by the National Institute of Information and Communications Technology.
- The system development was supported by the Strategic Basic Technology Upgrading Support Program of the Ministry of Economy, Trade and Industry.
- The system specifications may be changed without previous notice.
- The system performance is not guaranteed by the manufacturer due to the system is a prototype during its development.

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