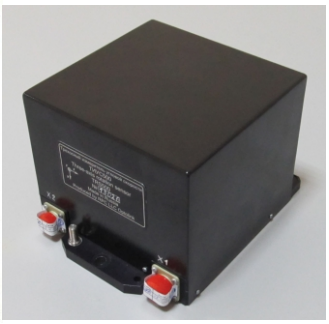
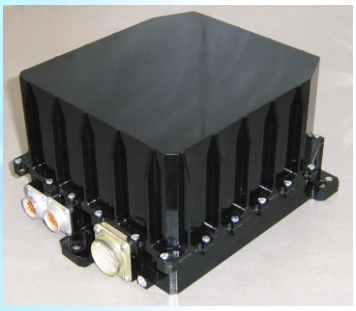
Fiber-Optic Gyroscopes

Closed loop fiber optic gyroscopes (FOGs) produced by LLC “Optolink” are solid-state devices that offer a combination of durability, high reliability, exceptional accuracy and low noise along with the potential of low serial production cost. The fundamental principle is based on Sagnac effect. Our FOGs have so-called minimum configuration that provides reciprocal optical paths for two beams counter-propagating in a fiber loop.

Three-axis FOG TRS500



Optolink's single- and three-axis FOGs consist of a single light source at 1550 nm wavelengths (SLD), depolarizer (DP), one or three photodetectors (PD), fiber splitters (FS), one or three sets of ring interferometers to sense orthogonal angular rate projections and signal processing circuits. In this design, multifunctional integrated optic chip (MIOC), fabricated via High Temperature Proton Exchange process technology, is used for splitting the light into clockwise and counterclockwise waves, light polarization and for the electro-optical phase modulation of lightwaves in the loop. Signal processing procedure is based on the conversion of photodetector signal into digital representation of the detected light intensity, followed by digital demodulation and integration. The loop is closed due to the use of integrated optical phase modulator with sawtooth modulated voltage. The voltage ramp slope is proportional to the rotation rate of a gyro (around definite axis).



OPTOLINK

Space grade three-axis FOG VOBIS

Radiation stability up to 1000 Krad

15 years lifetime at geostationary orbit

*** for export, marked gyro dynamic range is limited by ±495°/s**

Performance	SRS200 1-axis	SRS501 1-axis	SRS1000 1-axis	SRS2000 1-axis	SRS5000 1-axis	TRS500 3-axis	VOBIS 3-axis (space grade)
Range of measured angular rate, °/s	±550*	±250 (±1000*)	±550 (±90)	±40	±12	±400	±30
Bias drift at fixed temperature (1σ, 100s-averaging), °/h	0.3	0.03	0.005	0.002	0.0006	0.1	0.03
Bias drift in operational temperature range (1σ, 100s-averaging), °/h	0.7	0.1	0.03	0.05	-	0.3	0.07
Scale factor error, ppm	800	300	100	100	20	700	500
Angle Random walk, °/√h	0.01	0.005	0.0007	0.0003	0.0001	0.007	0.001
Bandwidth, Hz	>1000 (user defined)						
Weight, kg	0.22	0.35	0.8	1.5	2.5	1.2	2.6
Power supply, V / Consumption, W	5±0.25 / 6					27±5 / 8	27 / 20
Operational temperature range, °C	-40 ~ +60					-40 ~ +60	-30 ~ +40
Dimensions, mm	Ø70×28	Ø100×30	Ø150×40	Ø250×40	Ø250×45	110×110×90	172×176×110
Data output interface	RS-485					RS-422	MIL-STD-1553B

From optical components to navigation systems

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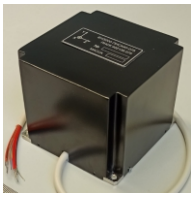
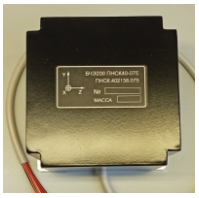
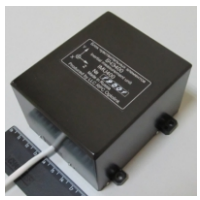
Inertial Measurement Units (IMU)

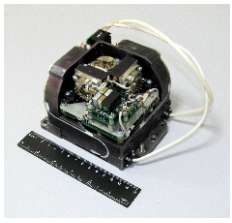
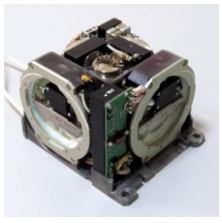
IMU200 & IMU400 (TRS200, TRS400)

IMU200 and IMU400 are state-of-art and *miniature* FOG IMU with low-noise *MEMS* accelerometers. TRS option without accelerometers is available.

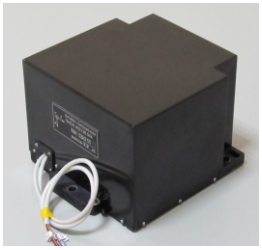

IMU500

IMU500 is based on Optolink's TRS500 gyro and three pendulum accelerometers

IMU501

IMU501 is based on three Optolink's SRS501 gyros and three pendulum accelerometers



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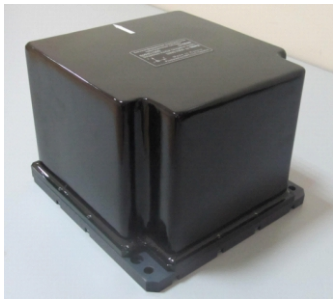
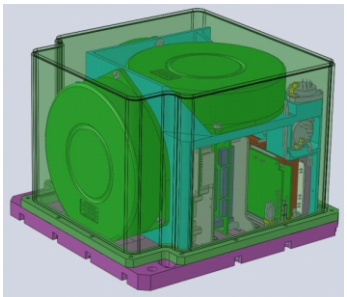
High-precision IMU1000

IMU1000 is based on three Optolink's SRS1000 gyros and three pendulum accelerometers

Performance	IMU200	IMU400	IMU500	IMU501	IMU1000
Gyro					
Angular rate range, °/s	±950 (±495)	±540 (±495)	±400	±250 (**±1000)	±550
Bias drift at constant temperature (1σ, 100s-averaging), °/h	0.2	0.1	0.1	0.03	0.005
Bias drift (1σ, 100s-averaging) in operational temperature range, °/h	0.5 (*0.2)	0.3 (*0.2)	0.3 (*0.1)	0.1 (*0.05)	0.05 (*0.02)
Angle random walk, °/√h	0.02	0.01	0.007	0.005	0.0007
Scale factor error, ppm	300 (*150)	200 (*150)	200 (*100)	200 (*100)	100 (*50)
Bandwidth, Hz	> 1000 (user defined)				
Accelerometers					
Range, g	±10	±10	±10 (**±40)	±10 (**±40)	±10 (**±40)
Bias drift at constant temperature, mg	1.0	1.0	0.5	0.1	0.05
Bias drift in operational temperature range, mg	2.0 (*0.3)	2.0 (*0.3)	1.0 (*0.15)	0.5 (*0.1)	0.1
Scale factor error, ppm	500 (*150)	500 (*150)	300 (*100)	300 (*100)	100
Noise power density, mg/√Hz	0.08	0.08	0.02	0.02	0.015
Bandwidth, Hz	> 300 (user defined)				
Physical Characteristics					
Misalignment, °	0.08 (*0.015)				
Output sample rate, Hz	up to 2000				
Power supply, V / Consumption, W	5, 27±5 / 7	5 / 7	5, 27±5 / 10	27±5 / 20	27±5 / 20
Digital output interface	RS-485	RS-422	RS-422 / 485	RS-422	RS-422
Operational temperature range, °C	-40°C ~ +60°C				
Dimensions, mm	75×75×60	80×95×62.5	110×110×90	155×140×110	171×224×252
Weight, kg	0.5	0.7	1.4	3	8.4

*** - improved calibration spec., ** - options of extended dynamic range, customizable (for export ±495°/s is a limit)**

From optical components to navigation systems

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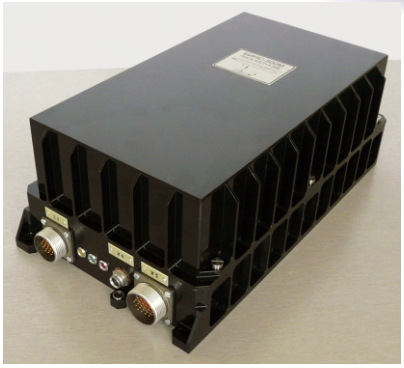
Strapdown Inertial Navigation Systems

Strapdown inertial navigation systems (SINS) produced by RPC “Optolink” are based on fiber-optic gyros, precise accelerometers and board computer. All SINS have satellite correction due to the installed latest-generation GPS/GLONASS receiver.

Optolink's SINS have completely solid-state design with no moving parts. Due to that, high values of mean time between failures (MTBF) are achieved, and in addition the units are totally maintenance-free. Oprolink’s SINS do not require recalibration during service life. Connection with data receiver is maintained via serial interface. In customized SINS we have realized the capability of being interconnected with different sensors (log, ADS) in a single complex to ensure better accuracy parameters.

Designed for autonomous navigation and guidance of aviation, land, marine and subsea vehicles, Optolink’s strapdown inertial navigation systems are compact, robust and maintenance-free, low-consumption units.

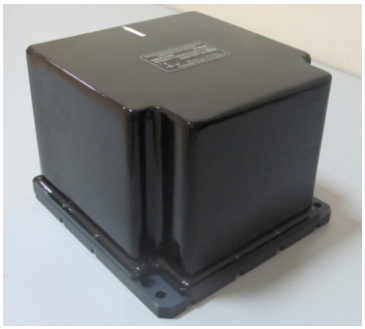


SINS500M

OPTOLINK

SINS500K

SINS501



SINS1000

SINS501M

Performance	SINS500K for land and air navigation (alignment in static conditions)	SINS500M for marine navigation (alignment in dynamics / tossing)	SINS501 for land and air navigation (alignment in static conditions)	SINS501M for marine navigation (alignment in dynamics / tossing)	SINS1000 for land and air navigation (alignment in static conditions)
Pure SINS performance (inertial mode), accuracy: - position (1-hour error), km - velocity, m/s - heading, ° - pitch and roll, °	 8 2 0.3 × sec(lat) 0.1	 8 2 0.3 × sec(lat) 0.1	 4 1 0.1 × sec(lat) 0.05	 4 1 0.1 × sec(lat) 0.05	 1.6 0.4 0.03 × sec(lat) 0.02
GPS/GLONASS mode, accuracy: - position, m - velocity, m/s	20 0.1				
Initialization time, min	10 (available options 15, 5 min)				
Gyro bias drift (1σ), °/h	0.04	0.04	0.02	0.02	0.005
Accelerometer bias drift (1σ), mg	0.5	0.5	0.1	0.1	0.05
Interfaces	RS-422 (MIL-STD-1553B as additionally available option)				
Power supply, V DC	27±5				
Power consumption, W	15	20	22	24	24
Dimensions, mm	240×160×110	343×185×120	286×163×124	338×185×150	171×224×252
Weight, kg	3.4	6.4	4.8	8.2	8.9
Operation ranges - angular rate, °/s - linear acceleration, g - vibration, Hz - temperature range, °C	 ±400 ±10 10-2000 -40 ~ +60	 ±400 ±10 10-2000 -40 ~ +60	 ±300 ±10 10-2000 -40 ~ +60	 ±300 ±10 10-2000 -40 ~ +60	 ±300 ±10 10-2000 -40 ~ +60

From optical components to navigation systems

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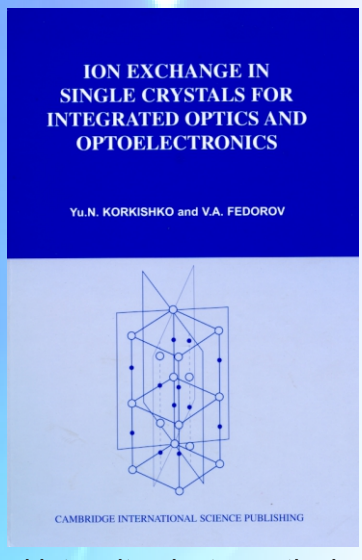
Integrated Optical Components on $LiNbO_3$

Optolink offers a wide range of Integrated Optical Devices based on state of the art HTPE (High Temperature Proton Exchanged) technology on $LiNbO_3$ substrates, in which Perspective Research Department at Optolink is among the world leaders. Integrated optical devices utilise electro-optical modulation and photorefractive Bragg gratings for the lightwave control in order to offer high performance devices for fiber optic communication systems, fiber sensors and scientific applications.

The technology developed by Optolink has allowed us to develop a wide range of custom devices in which numerous functions are integrated into the same optical circuit. Furthermore, we are prepared to collaborate with the customer in the design and optimization of the devices. We aim at satisfying every custom requirement by using our technological expertise.



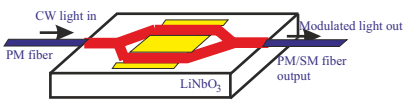
Processes

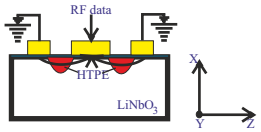
- High Temperature Proton Exchange (Soft Proton Exchange)
- Annealed Proton Exchange
- Fiber pigtailing
- High resolution Poling
- X, Y and Z cuts
- Dielectric and metal deposition
- Photolithography

Devices

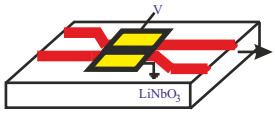
- Phase and intensity electro-optical modulators
- Multifunctional integrated optical chips for gyros
- High speed polarization insensitive switches
- PPLN devices

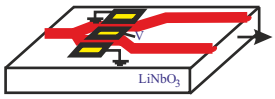
Amplitude modulators





Electro-optical Switches

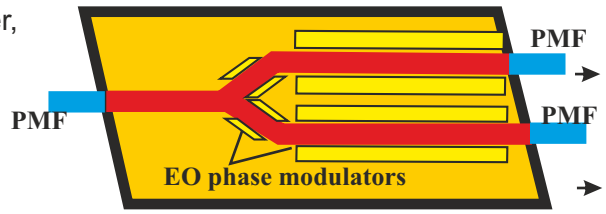


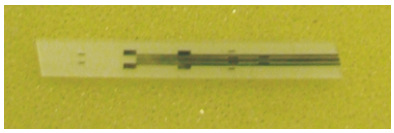


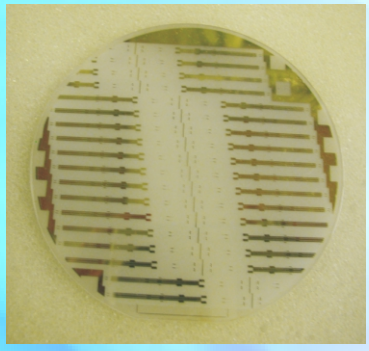
Multifunctional Integrated Optical Chip for Fiber-optic Gyroscope

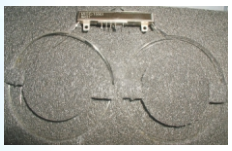
MIOC is a monoblock hermetic product. It includes a linear polarizer, Y-junction coupler and two electro-optical phase modulators.

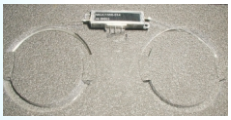
	λ = 830 nm	λ = 1550 nm
Half-wave voltage, V	< 2	< 3
Polarization extinction ratio (fiber-to-fiber), dB	> 25	> 25
Intensity modulation, %	< 0.1	< 0.1
Fiber-to-fiber losses (for depolarized light), dB	< 7	< 6

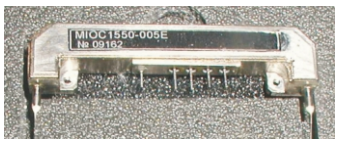


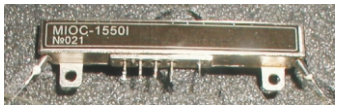


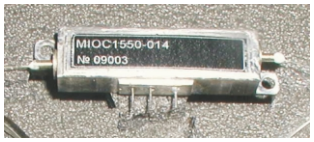


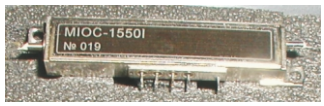












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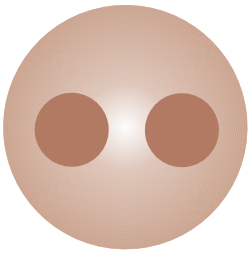
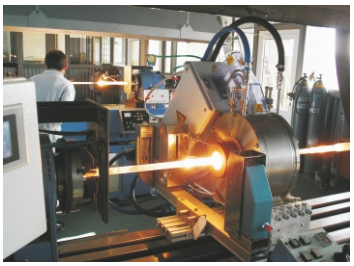
Polarization Maintaining Fiber for Gyro and Telecom Applications

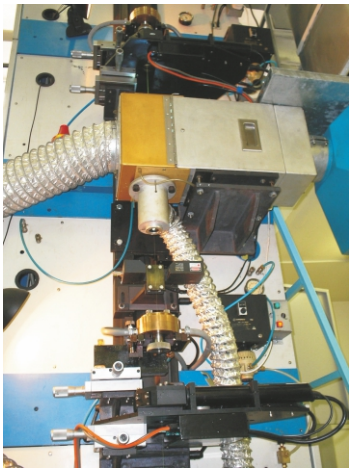
Optolink's PANDA-type polarization maintaining (PM) fiber design uses two stress-applying parts to create high birefringence, resulting in fibers with excellent polarization maintaining properties.



Optolink's PM fibers have high birefringence and exceptionally tight dimensional specifications, critical for manufacturing high precision high-performance gyro coils. The Panda-type configuration is preferred over bow-tie or elliptical clad designs because of its advantages in process scalability and product uniformity. These fibers are available for operation at 830, 1300 and 1550 nm wavelengths.

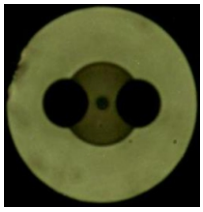
Operational wavelength, μm	0.83	1.55
Mode Field Diameter, μm	4.5	6.5
Cladding Diameter, μm	80	80-125
Coating Diameter, μm	160-175	160-175
Numerical Aperture	0.15	0.13
Polarization crosstalk (h-parameter), m^{-1}	$< 10^{-5}$	$< 10^{-5}$
Attenuation, dB/km	< 3	< 2
Cutoff Wavelength, nm	730–800	1300–1450
Beat Length, mm	< 3	< 3
Stress Type	PANDA	PANDA

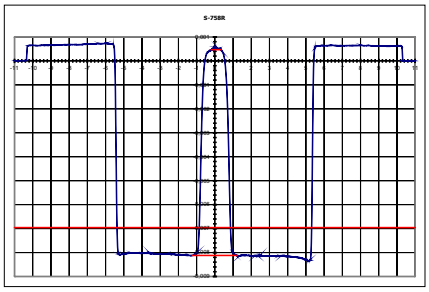




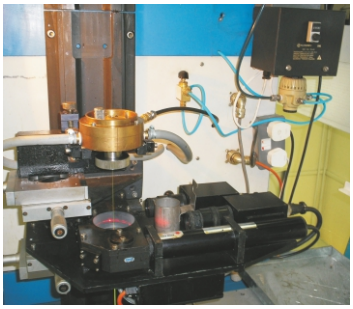
Radiation-hard SM and PM fibers

Pure silica core and depressed fluorine-doped silica cladding





Refractive index profile



Fiber components

Fiber depolarizer

Optical power loss, dB	< 0.5
Residual light polarization, %	< 0.1

Fiber splitters

Power splitting ratio	0.49 / 0.51
Insertion loss, dB	0.1

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