Fizoptika

VG091 SERIES

MINIATURE FIBER OPTIC GYROSCOPES

Information Guide

Output	***Model Name***		***Key Features***
	Main	***Extension***	
differential	***VG091A***		***Smallest ever fiber optic gyro***
		1	***Vibration proof***
		2LN	***North seeking capability***
		2LN (shielded)	***Ultimate magnetic immunity***
	VG091B		***Orthogonal (to VG091A) sensing axis***
		2LN	***Low noise performance***
		2LN (shielded)	***Magnetically immune***

Table of Contents

1. Introduction ... 3

1.1. Scope of this Information Guide ... 3
1.2. Product Description ... 3
1.3. Outline Dimensions ... 3
1.4. Product Specifications ... 4
1.5. Essential ... 5
1.6. Electrical Characteristics ... 5

2. Mounting Guidelines ... 6

2.1. Adhesive Mounting Guidelines ... 6
2.2. Clamping Guidelines ... 6
2.3. Mating Surface ... 6
2.4. Cable Routing ... 7

3. Open-loop Fiber Optic Gyroscope ... 7

3.1. Principle of Operation ... 7
3.2. Embedded Design ... 7
3.3. Analog Electronics Board ... 8
3.4. Analog Output $U_{\Omega} = SF \cdot \Omega$ ... 8

4. Typical Test Data ... 9

4.1. Test Data for VG091A ... 9
4.2. Test Data for VG091B ... 10

5. Other Models in the Series ... 11

5.1. Vibration proof VG091A1 ... 11
5.2. North seeking VG091A-2LN ... 12
5.3. Low Noise VG091B-2LN ... 13
5.4. Magnetically Shielded VG091A-2LN and VG091B-2LN ... 14

6. Precautions and Recommendations ... 14

7. Product Page Quick Links ... 14

Annex. VG091 Series Specifications ... 15

1. Introduction

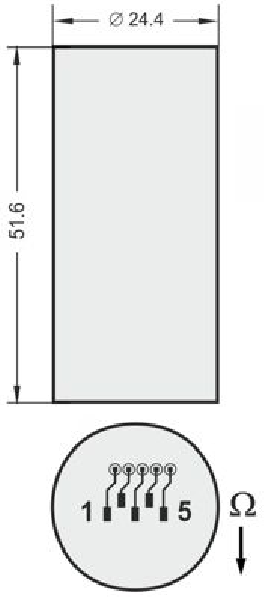
1.1. Scope of this Information Guide[1]

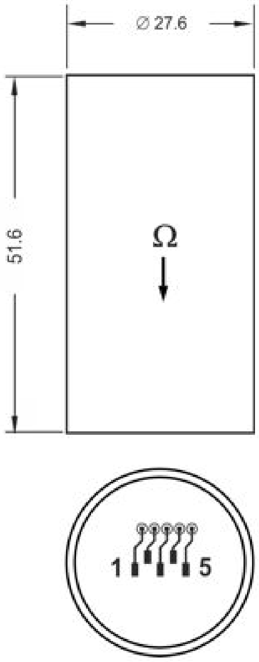
This guide provides readers with an understanding of the product's main features and advantages. The sensing technology used in the construction of the fiber optic gyroscopes (FOGs) is described along with suggestions regarding their use and installation. Advice is also given regarding practices to avoid when handling these devices.

1.2. Product Description

The basic model of the series is VG091A – the smallest and lightest ever fiber optic gyro. The series features thumb-sized design combined with instant start-up and low power consumption. There are models with north seeking capability, magnetic immunity and supressed vibration response. The model VG091B has orthogonal (to A) sensing axis orientation along its cylindrical body.

1.3. Outline Dimensions





Ω - sensing axis

VG091A Outline Drawing

VG091B Outline Drawing

[1] *The information contained in this document is believed to be correct. Fizoptika accepts no liability for any errors it might contain and reserves the right to alter specifications without prior notice. All pictures shown are for illustration purpose only. The actual product may vary due to the ongoing product enhancement.*

1.4. Product Specifications

The VG091A specifications are listed in the table below. A summary table with the specifications of all the models in the series may be found in the Annex.

Parameter	Value
MAIN PARAMETERS	
Input range*	300 deg/s
Scale Factor (SF)**	7 mV/deg/s
Frequency range	0…1 kHz
Angle random walk (ARW)	0.04 deg/√h (4μV/√Hz)
Bias stability, RMS Bias repeatability, RMS***	3 deg/h
SF stability, RMS SF repeatability, RMS***	0.01% 0.02%
Readiness time	20 ms
PHYSICAL PARAMETERS	
Dimensions	⌀24.4x51.6 mm
Dissipation (typical)	0.5 W
Weight	30 gram
Volume	3 cl
Housing material	aluminum alloy
ENVIRONMENT	
Temperature (operating)	-40°C…+70°C
Temperature (endurance, 2 h)	-55°C…+85°C
Vibration, RMS	12 g, 20 Hz… 2000 Hz
Shocks	350 g, 1 ms
RELIABILITY	
MTBF (20°C)	60000 hours
Lifetime	15 years

*** Terms definitions see in Glossary**
**** Approx. -0.05% /°C, individually calibrated**
***** Day-to-day repeatability at fixed temperature**

1.5. Essential

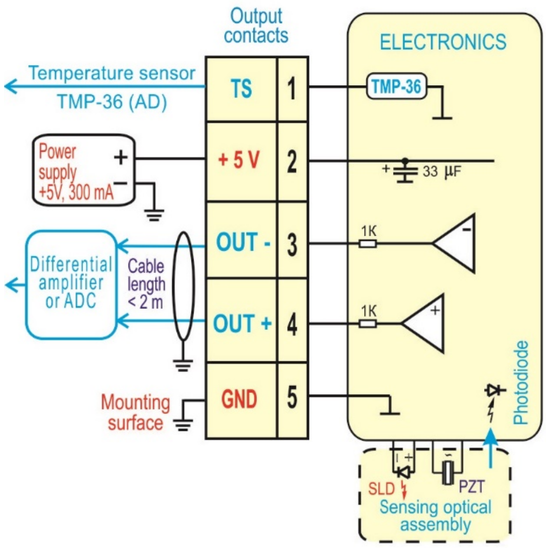
The VG091 aluminum housing is silicone sealed and provides short term (about 120 hours) humidity protection. Condensed moisture is a major cause of lifetime shortening. It is recommended to treat the VG091 as a delicate device sensitive to electrostatic discharge and to high humidity. Wet FOG conditions must be avoided at all times during storage and use.

To realize the device's exceptional potential, it should be properly mounted and its data transmission should be correctly arranged. If there are any doubts on the mounting method or application environments, please, contact info@fizoptika.com to avoid any erroneous action.

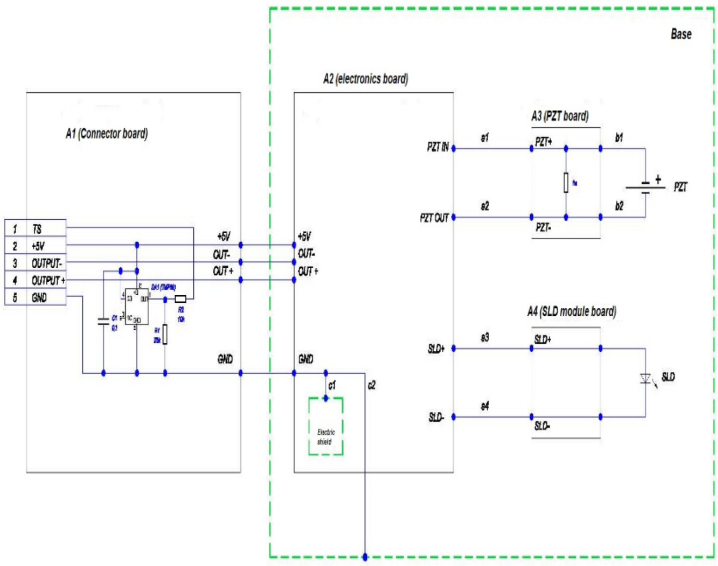
1.6. Electrical Characteristics

The VG091 measures rotation using precise optical filtering and synchronous detection at 75kHz modulation frequency. It requires a clean and stable, low noise 5Vdc power source or battery supply. Excitation voltages greater than 5.5 volts (or reversing polarity) can cause some components to heat and eventually fail.

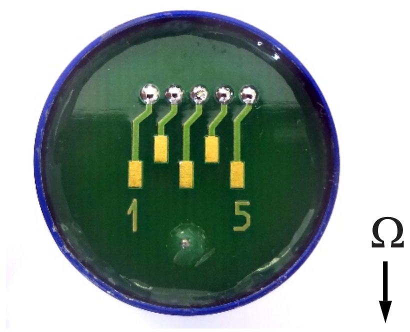
Short (ns-scale) pulses from power transients or from accidental shorting to grounds or to the objects under potential may cause irreversible damage to the super luminescent diode (SLD). Voltage pulses may reach the SLD via capacitive bridges existing for spatially separated objects. It is recommended to ensure smooth voltage transient at power-on (1-5 ms).



Connection Diagram



Electrical Diagram



Ω - sensing axis

VG091A face with output contacts

Output Voltage

The gyro provides output voltages via two leads (OUT+, OUT-) biased at **U0=1V** to Common lead (GND). Both have 1kOhm impedance formed by serial resistors (shown in the Connection diagram).

From $\mathbf{U_{(+)} = U0 + ½\ SF \cdot \Omega}$ and $\mathbf{U_{(-)} = U0 - ½\ SF \cdot \Omega}$ the returns are:

1) Output differential voltage $\mathbf{U_{\Omega}} = \mathbf{U_{(+)}} - \mathbf{U_{(-)}} = \mathbf{SF \cdot \Omega}$ (**SF**=7 mV/deg/s, full scale ±2V)
2) Bias voltage $\mathbf{U_{(+)}} + \mathbf{U_{(-)}} = 2\mathbf{U0}$

The positive and negative outputs of the unit should be connected to differential input amplifiers with an input impedance of at least 500kOhm referred to ground. The amplifier should also have a good common mode rejection and a suitable bandwidth for the application. The gyro bandwidth 1 kHz is formed by 2nd order LPF.

Diagnostics. Gyro failure (abnormal response to rotation) may be detected by the monitoring of **U0** or **+5V** current ($\mathbf{I_{+5}}$)

*- criteria (1): **U0** change >0.1V (>99% confidence)*

- criteria (2): $\mathbf{I_{+5}}$ *change > 20mA (70% confidence est.)*

2. Mounting Guidelines

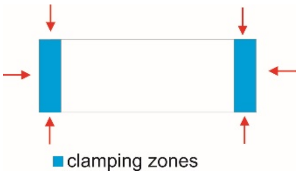
The VG091 is typically adhesively mounted, but also may be clamped.

2.1. Adhesive Mounting Guidelines

- The mounting surface should be clean and free of any residue or foreign material.
- The mounting surface should be smooth and fit the gyro curvature.
- For best performance silicone adhesive is recommended. Apply to both surfaces using activator according to manufacturer's recommendations.

2.2. Clamping Guidelines

- The gyro may be clamped as shown in the picture below.



- The clamping should be gentle enough to avoid deforming of the housing.

2.3. Mating Surface

Special consideration is required when there is high frequency vibration. Eigen-frequencies (resonances) of the mating frame should exceed vibration frequencies. Otherwise a noisy signal is possible as a result of gyro mechanical distortion.

2.4. Cable Routing

Use high flexibility cables with a low weight per length. It is strongly recommended that the cable be secured by fastening it at some point in the vicinity of the output pads. This may be accomplished in a variety of ways such as by the use of a cable clamp, tie wrap, tape, etc. The initial attachment should be within 1-3 cm of the contacts. The gyro top cover may be used for gentle fixing near output pads. Make sure that cable bending does not result in contacts stress. Avoid routing cables near high-voltage wires and also ground the shield at the signal conditioner to minimize ground loops.

3. Open-loop Fiber Optic Gyroscope

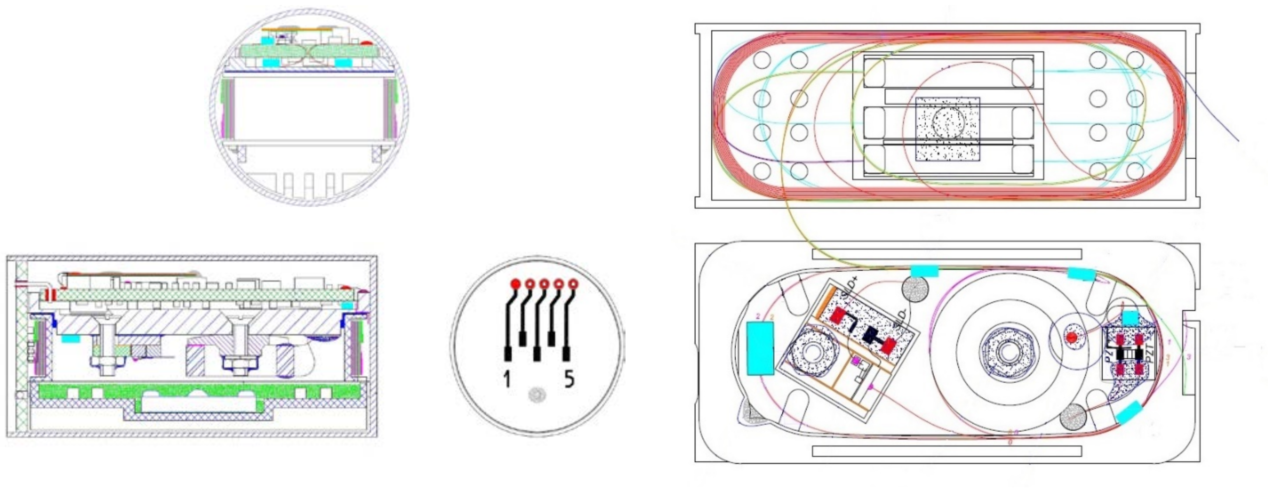
3.1. Principle of Operation

An FOG is a gyroscope that uses the interference of light to detect mechanical rotation. The sensor is a coil of 100 m of optical fiber. Two light beams travel along the fiber in opposite directions. Due to the Sagnac effect, the beam travelling against the rotation experiences a slightly shorter path than another beam. The resulting phase shift affects how the beams interfere with each other when they are combined. The intensity of the combined beam then depends on the angular rate of the device. The broadband SLD together with beam splitting components launch the light so that the light travels simultaneously in clockwise and counterclockwise directions through the fiber. The FOG provides extremely precise rotational rate information, in part because of its lack of sensitivity to vibration, acceleration, and shock. Unlike the classic spinning-mass gyroscope, the FOG has virtually no moving parts and no inertial resistance to movement. Hence, FOG technology is one of the most reliable gyroscope technologies.

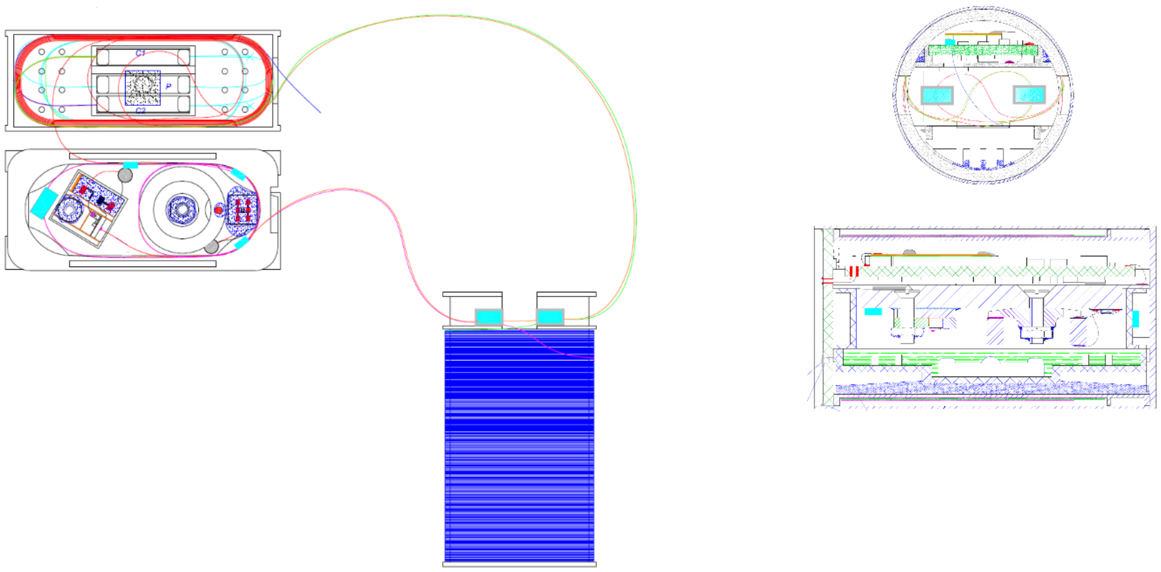
3.2. Embedded Design

The Fizoptika FOG is a complete gyro system which comprises a fiber optic sensing assembly and analog processing electronics. The sensing assembly (open-loop minimum configuration) is fabricated from a single length of optical fiber by a fusion-tapering technique. Industrial silicone compounds are used to mount optical components on quartz substrates. The substrates are placed into a miniature plastic container filled with soft silicone gel for protection and mechanical stabilization. The processing PCB is mounted on the opposite (to optics) side of the inner frame. A connecting board is used to connect the processing PCB to external power source and instrumentation. The connecting board includes a temperature sensor and works as a gyro cover (refer to Assembly drawings below). When the gyro experiences mechanical, thermal or electrical shock that exceeds its specifications, the resultant failure is most often traced to SLD electrical damage or to fiber and wire breakage. To ensure the gyros are in good working order prior to leaving the factory, each gyro runs at an elevated temperature while scale factor, bias and current consumption are measured. Every unit is shipped with a certificate specifying major parameters.

For demanding applications additional specific ATP (burn-in test, vibration mapping, screening, etc) may be conducted with correspondent certificates provided.



VG091A Assembly Drawing



VG091B Assembly Drawing

3.3. Analog Electronics Board

The open-loop gyro requires electronics to drive the SLD and phase modulator (PZT) for signal conditioning and for precise demodulation of the optical signal. For more information regarding the processing board, refer to Analog Electronics OE141-55 Info Notes.

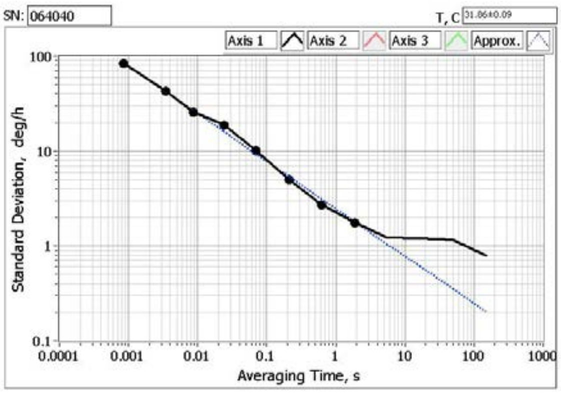
3.4. Analog Output $U_{\Omega} = SF \cdot \Omega$

Due to its open-loop configuration the FOG responds to rotation instantly (<0.2 ms). Furthermore, it does not have "weak points" (bias jumps, day to day change, cross-axis errors, dead zones, g, g^2components, transients, etc) inherent in other gyroscopes. Noise, bias variation (drift) and SF variation should be mentioned to complete the output description. The main source of the noise is light quantum fluctuations. Bias variations are traced to electronics temperature sensitivity and to light scattering on fiber defects. There is also magnetically induced bias caused by nonreciprocal magneto-optical phenomena. SF variation is due to SLD spectrum temperature dependence. The typical values of the noise contributors are demonstrated by Allan variance plots in the ***Typical test data*** section or in the descriptions of the specific models. For more information regarding the analog output, refer to [Open-loop Fiber Optic Gyroscope](#).

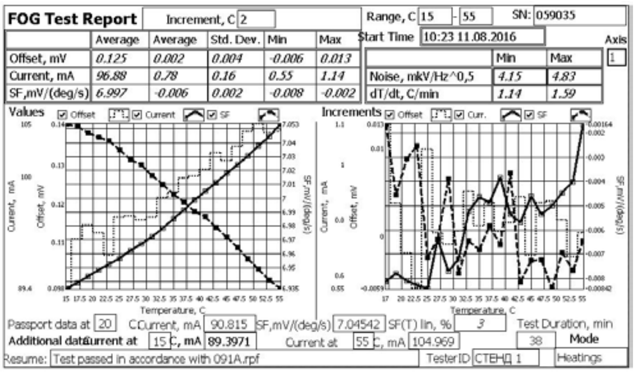
4. Typical Test Data

Typical test data belong to the basic model VG091A and to all other models of the series unless specific model data are provided.

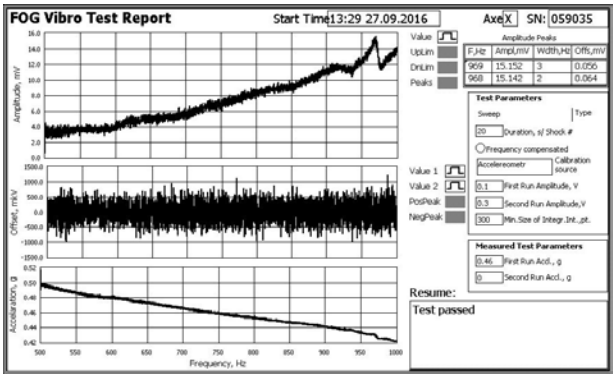
4.1. Test Data for VG091A



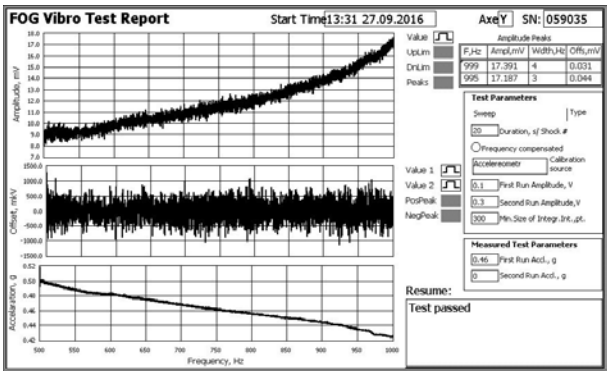
VG091A (B). Allan Variance Plot



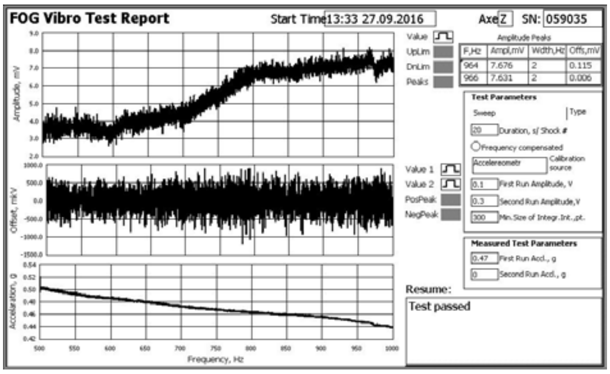
Main Parameters (Bias, SF, Current) vs Temperature



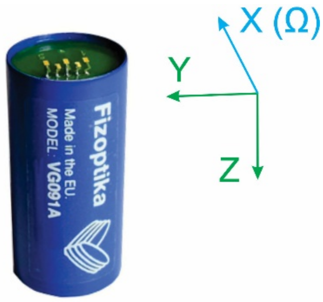
Output Components (AC, DC) vs SINE Vibration
(2 g, sweep from 200Hz to 1kHz)
X axis (sensitivity axis)



Output Components (AC, DC) vs SINE Vibration
(2 g, sweep from 200Hz to 1kHz)
Y axis (additional axis)



Output Components (AC, DC) vs SINE Vibration
(2 g, sweep from 200Hz to 1kHz)
Z axis (the gyro cylinder body main axis)

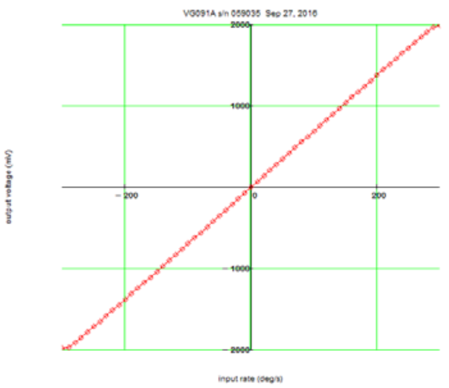


Axes Definition

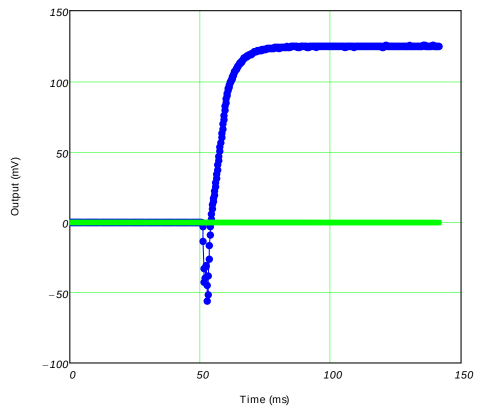
Magnetic Test Report		Average	Std.Dev.	Min	Max
SN: 059035	Gx, mkV/G	4.62	0.10	4.50	4.77
Axis 1	Gy, mkV/G	-29.69	0.12	-29.87	-29.54
	Gz, mkV/G	50.88	0.20	50.63	51.23
	Current, mA	91.5	0.3	91.0	92.0

Start Time 12:41 28.09.2016	Min	Max
Range, C 29.5 - 29.5		
Noise, mkV/Hz^0,5	4.04	4.08
dT/dt, C/min	0.00	0.00

Magnetic Sensitivity (μV/ Gauss)
Gx – along the gyro sensitivity axis (non-Faraday component)
Gy, Gz – directions in fiber optic coil plane (Faraday component)

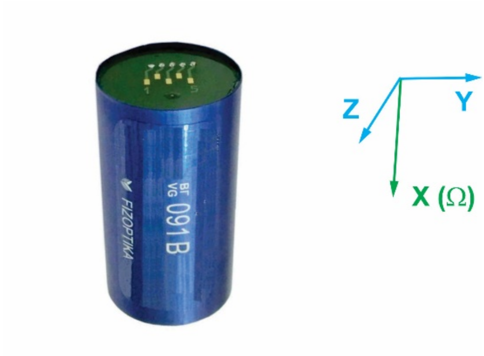


Output Voltage vs Angular Rate

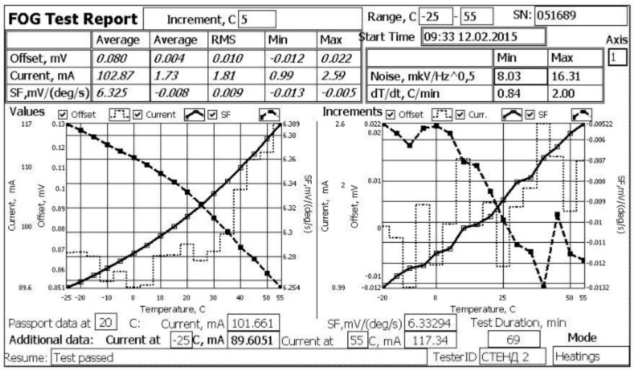


Power-on Transient (ms) as Gyro Rotates 20 deg/s, time resolution 0.2ms

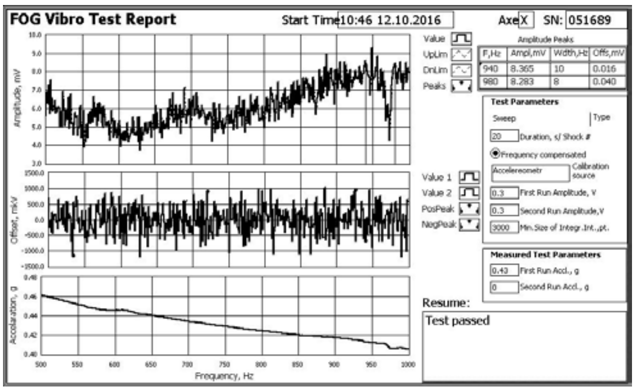
4.2. Test Data for VG091B



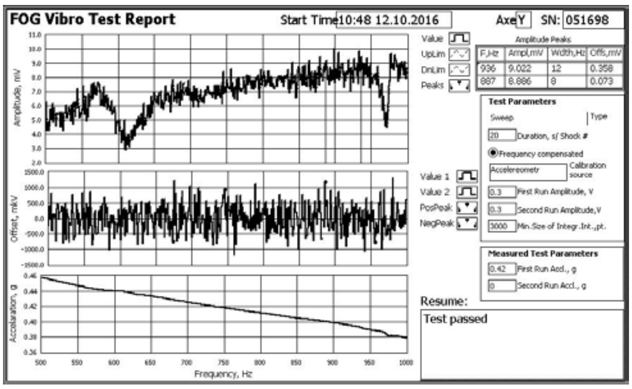
Axes Definition



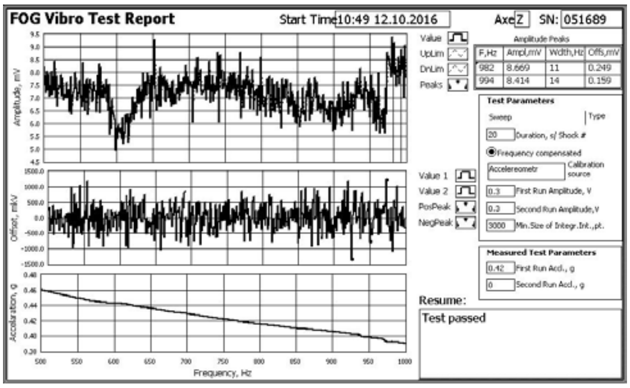
Main Parameters (Bias, SF, Current) vs Temperature



Output Components (AC, DC) vs SINE Vibration
(2 g, sweep from 200Hz to 1kHz), X axis



Output Components (AC, DC) vs SINE Vibration
(2 g, sweep from 200Hz to 1kHz), Y axis



Output components (AC, DC) vs SINE vibration
(2 g, sweep from 200Hz to 1kHz), Z axis

Magnetic Test Report

SN: 051689

Axis 1

	Average	Std.Dev.	Min	Max
Gx, mkV/G	**8.70**	0.56	8.22	9.57
Gy, mkV/G	0.48	0.55	-0.28	1.27
Gz, mkV/G	**-2.66**	0.52	-3.30	-2.03
Current, mA	103.8	0.1	103.7	103.9

Magnetic sensitivity (μV/ Gauss)
Gx – along the gyro sensitivity axis (non-Faraday component)
Gy, Gz – directions in fiber optic coil plane (Faraday component)

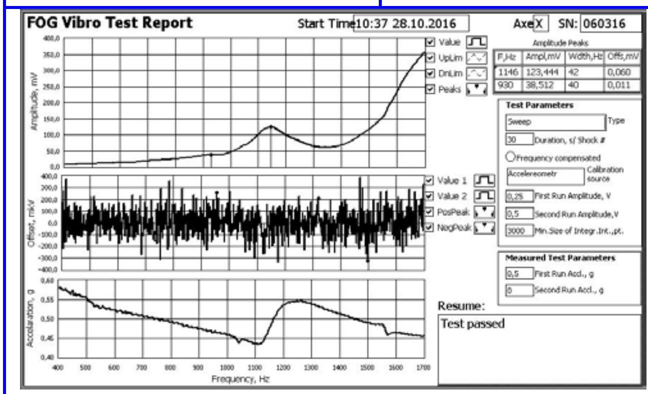
5. Other Models in the Series

5.1. Vibration proof VG091A1

Its reinforced inner frame (eigen frequency ≥1.5kHz) gives VG091A1 lower sensitivity to vibrations compared to the standard model.

Specific product features:

Vibration endurance	**18g RMS, 20Hz – 2kHz**
Vibration immunity factor	**~0.1 μV /m/s^3**
Weight	**33 gram**



Output Components (AC, DC) vs SINE Vibration
(2 g, sweep from 400 Hz to 1.7 kHz)

5.2. North seeking VG091A-2LN

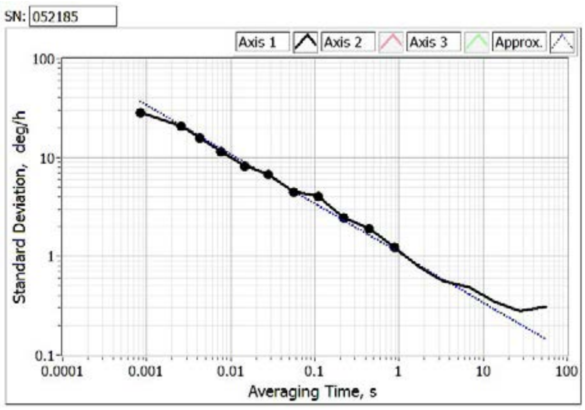
The VG091A-2LN possesses north seeking capability. Based on VG091A it has reduced noise due to significantly increased length of the sensing fiber coil.

Moreover, VG091A-2LN has optically suppressed Faraday component of magnetic sensitivity (along Y and Z axes) with typical suppression factor of 30.

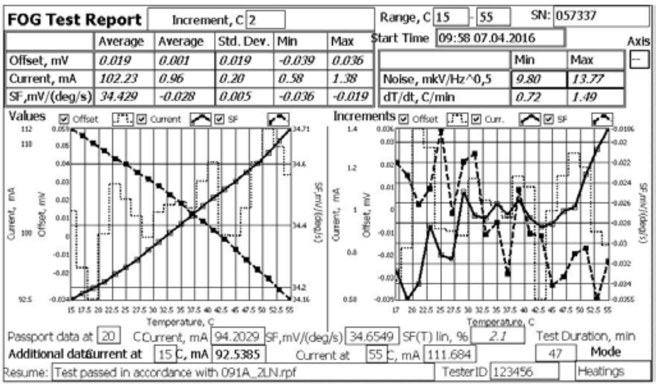
Specific product features:

Input range 60 deg/s
SF 30 mV/deg/s
ARW 0.02 deg/√h
Bias stability, RMS 2 deg/h
Magnetic sensitivity:

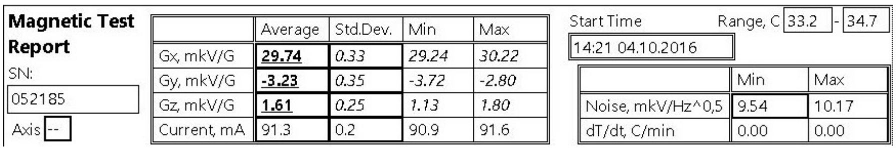
- **Faraday component** < 5 µV/Gauss;
- **Non-Faraday component** 30 µV/Gauss.



Allan Variance Plot



Main Parameters (Bias, SF, Current) vs Temperature



Magnetic Test Report
SN: 052185
Axis --

	Average	Std.Dev.	Min	Max
Gx, mkV/G	**29.74**	0.33	29.24	30.22
Gy, mkV/G	**-3.23**	0.35	-3.72	-2.80
Gz, mkV/G	**1.61**	0.25	1.13	1.80
Current, mA	91.3	0.2	90.9	91.6

Start Time 14:21 04.10.2016
Range, C 33.2 - 34.7

	Min	Max
Noise, mkV/Hz^0,5	9.54	10.17
dT/dt, C/min	0.00	0.00

Magnetic Sensitivity (µV/ Gauss)
Gx – along gyro sensitivity axis (non-Faraday component)
Gy, Gz – directions in fiber optic coil plane (Faraday component)

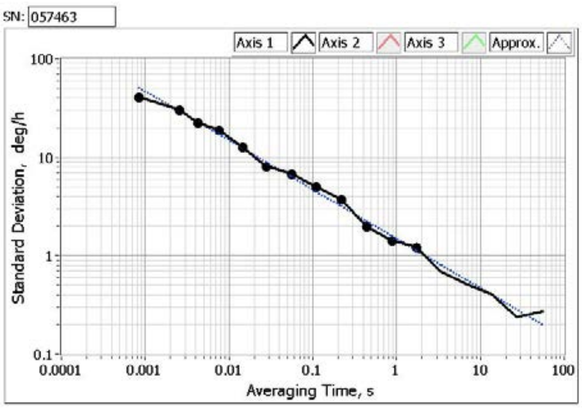
5.3. Low Noise VG091B-2LN

The fiber optic gyroscope VG091B-2LN is based on the VG091B and has reduced noise due to significantly increased length of the sensing fiber coil.

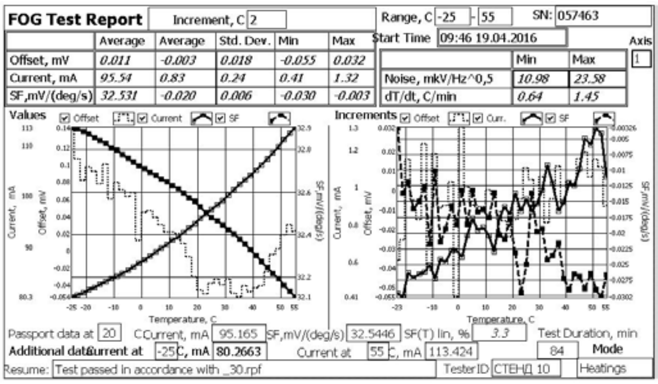
Moreover, VG091B-2LN has optically suppressed Faraday component of magnetic sensitivity (along Y and Z axes) with typical suppression factor of 30.

Specific product features:

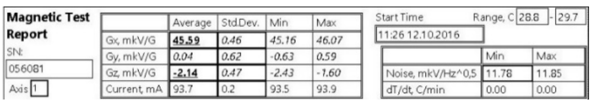
Input range 60 deg/s
SF 30 mV/deg/s
ARW 0.02 deg/√h
Bias stability, RMS 2 deg/h
Magnetic sensitivity:
- **Faraday component** < 5 µV/Gauss;
- **Non-Faraday component** 50 µV/Gauss.



Allan Variance Plot



Main Parameters (Bias, SF, Current) vs Temperature

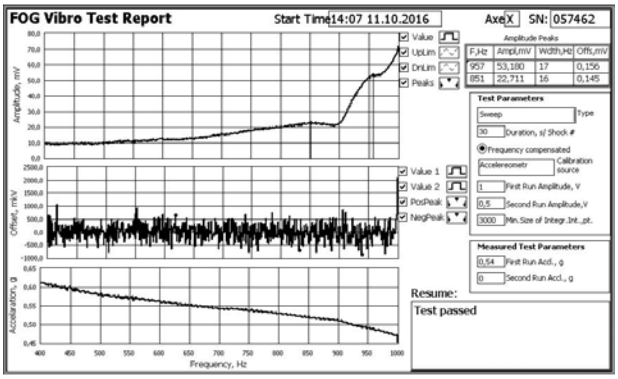


Magnetic Test Report		Average	Std.Dev.	Min	Max
SN: 056081	Gx, mkV/G	45.59	0.46	45.16	46.07
Axis 1	Gy, mkV/G	0.04	0.62	-0.63	0.59
	Gz, mkV/G	-2.14	0.47	-2.43	-1.60
	Current, mA	93.7	0.2	93.5	93.9

Start Time 11:26 12.10.2016 Range, C 28.8 - 29.7

	Min	Max
Noise, mkV/Hz^0,5	11.78	11.85
dT/dt, C/min	0.00	0.00

Magnetic Sensitivity (µV/ Gauss)
Gx – along gyro sensitivity axis (non-Faraday component)
Gy, Gz – directions in fiber optic coil plane (Faraday component)



Output Components (AC, DC) vs SINE Vibration
(2 g, sweep from 200Hz to 1kHz)

5.4. Magnetically Shielded VG091A-2LN and VG091B-2LN

<table>
<tr>
<td>
In magnetically aggressive environments an additional suppression of magnetic sensitivity can be provided by µ-metal housing (instead of standard aluminium one). Full shielding is realized when a µ-metal cap (supplied with the gyro) is mounted. With no cap the magnetic sensitivity is still very low.

Specific product features:
Magnetic sensitivity < 0.01 deg/h/G (VG091A-2LN MS)
< 0.1 deg/h/G (VG091B-2LN MS)
Weight 50 gram (VG091A-2LN MS)
60 gram (VG091B-2LN MS)
</td>
<td>

VG091A-2LN and VG091B-2LN shields
</td>
</tr>
</table>

6. Precautions and Recommendations

- Do not deform housing
- Fragile components inside – no shocks, no drop
- Treat as electrostatic sensitive unit
- To be mounted inside moisture-proof compartment
- Power must be off during connecting
- Soldering to contacts – by low temperature solder

7. Product Page Quick Links

<table>
<tr>
<td>
Documentation
• Data Sheets
o VG091A
o VG091A1
o VG091A-2LN
o VG091A-2LN (shielded)
o VG091B
o VG091B-2LN
o VG091B-2LN (shielded)

• Info Notes
o Fiber Optic Sensing Assembly
o Electronics Board OE141-55
</td>
<td>
Publications
• Non-Faraday magnetically induced nonreciprocity in a fiber optic gyro
• Taper twisting for higher FOGs production yield
• Fiber Optic Gyro in-line Technology

Request for Quotation & Technical Support
</td>
</tr>
</table>

Annex. VG091 Series Specifications

Specific Values

PARAMETER	VG091						
	A1	A	A-2LN	A-2LN (shielded)	B	B-2LN	B-2LN (shielded)
Input range (deg/s):							
60			●	●		●	●
300	●	●			●		
SF (mV/deg/s):*							
7	●	●			●		
30			●	●		●	●
ARW (deg/√h):							
0.02			●	●		●	●
0.04	●	●			●		
Bias stability /Bias repeatability**, RMS (deg/h):							
2			●	●		●	●
3	●	●			●		
Dimensions (mm):							
ø24.4x51.6	**ø24.4x52.2**	●	●	●			
ø27.6x51.6					●	●	●
Weight (gram):							
30	●	●	●	**50**			
35					●	●	**60**
Housing material:							
aluminum alloy	●	●	●		●	●	
μ-metal				●			●

Common and Extended Values

PARAMETER	ALL MODELS	MODEL WITH EXTENDED RANGE
Frequency range (kHz)	0-1	
SF stability, RMS (%) SF repeatability, RMS (%)**	0.01 0.02	
Readiness time (ms)	20	
Temperature (operating, °C)	-40 …+70	
Temperature (endurance, 2 h, °C)	-55…+85	**VG910A1**
Vibration, RMS	12 g, 0.02 - 2kHz	18 g, 0.02 - 2kHz
Shocks	350 g, 1 ms	
Volume (cl)	3	
Dissipation (typical, W)	0.5	
MTBF (20°C)	60000 hours	
Lifetime	15 years	

*** Approx. -0.05% /°C, individually calibrated**
**** Day-to-day repeatability at fixed temperature**