

Rights protection. Entirely VG941-3, its main components and production technique are under protection of RF Patents 2000543, 2000585, 2018159, 2018160, 2054391.

Background and status of VG941-3 This sensor is a modification of the VG941 which was developed and produced by the company since 1995. VG941 was a smallest fiber optic gyro worldwide. It comprised sensing optical assembly and primary electronics and was used with external processing electronics. VG941-3 is still smallest complete gyro rate sensor but it already comprises processing electronics implemented in SMT technique. Main optical sensing assembly is fabricated using Fizoptika exceptional “in line spliceless technology” from specially developed fiber. Recently made modifications of electronics module resulted in better bias temperature stability.

General VG941-3 is an analogue sensor of absolute rotation. It responds on angular rate by change of its output voltage. Output of the sensor is defined as voltage between contacts “Output” and “AGnd” (Analog ground). Sign of the output voltage depends on the direction of rotation around sensing axis. Output voltage is proportional to the angular rate with factor SF (scale factor in mV/ ° /s).

VG941-3 is produced in versions A and B. Sensing axis of A type is perpendicular to the sensor's body.

Sensing axis of B type is lengthwise the body.

TECHNICAL DATA

Physical	
Weight	40 grams
Size	27 mm diameter by 58 mm high
Power	
Total consumption	< 1 Watt
Power source	+ 5 V ± 5%
Activation time	< 0.1 s
Performance	
Bias repeatability	0.05 °/s, 1sigma
Bias variations (steady state)	0.01 °/s, 1sigma
Bias variation (OTR)	< 0.1 °/s
Scale factor nominal (SF)	4.5 mV/deg/s ± 20% (A), 3 mV/deg/s ± 20% (B)
SF repeatability (steady state)	0.2%, 1sigma
Scale factor variation (OTR)	< 5%
Random walk	PSD = 0.002°/s sqrt Hz
Frequency range	0 ... 1000 Hz
Operating range	± 500°/s
Environmental	
Temperature	30°C to +71°C

Vibration	6g, 20 Hz to 2,000 Hz
Shock, acceleration	90g

OTR = operating temperature range

STRUCTURE VG941-3 contains two main modules:

- Sensing optical assembly - ring interferometer comprising fiber sensing coil, two fused fiber optic couplers, fiber optic polarizer, piezoceramic phase modulator (PZT), SLD module. Output fiber lead goes to the photo diode which is mounted on the processing electronics OE141.

OPERATION Underlying phenomenon is a "Sagnac effect" - light transmit time through a circular way in a rotating system depends on direction of circulation. In a ring fiber optic interferometer light is divided in two beams traversing fiber loop (coil) in opposite directions. After traveling beams are combined (interfere) in the coupler to give signal $[1+\cos(F)]$, F -"Sagnac phase"- phase difference proportional to rotation rate. The factor between rate and Sagnac phase is an optical scale factor (OSF). Its value roughly determines input range. To enhance sensitivity PZT adds AC phase to the Sagnac phase. Electronics OE141 excites PZT oscillation at optimal frequency and amplitude and controls SLD to normalize optical output. "Normalized" signal contains AC and DC components of predetermined values. Signal component at PZT oscillation frequency depends on angular rate. This component is detected by OE141 and converted into output voltage in the frequency range (0 ... 1000 Hz). This voltage is a function of angular rate \mathbf{W} and ambient temperature (t°). Within the input range ($-W_{\max} \dots +W_{\max}$) a good approximation is given by the expression

$$U(W,t^\circ)=SF_n \cdot [1 + s(t^\circ)] \cdot [W + W_n + W_N + w(t^\circ)] \cdot [1 - (W / p \cdot W_{\max})^2]$$

where W_b - bias nominal; W_n - equivalent input noise, $w(t^\circ)$ - bias temperature variation; SF_n - scale factor nominal, $sf(t^\circ)$ - its temperature variation;
 $p > 2$ - linearity parameter (better than 1% approximation is given by higher order polynomial).
 After overrating VG941-3 returns to normal mode in parts of second. Scale factor variation $s(t^\circ)$ is a reproducible function of temperature with a scale 2..5% over temperature range. It belongs to thermal behavior of electronic components and SLD wavelength temperature dependence. The irregular bias drift results from imperfect optical filtering and amplitude noise arising due to interference of secondary optical waves. This last determines the limit of gyro accuracy (bias repeatability and variation). Output noise U_n is caused by natural quantum properties of light and thermal noise of preamplifier. Noise spectrum is uniform within the output frequency range. It results in some variance of measured angular rate. Variance (RMS) depends on measurement period. When gyro is exposed to a harsh environments such as shocks, vibrations and strong magnetic fields some additional errors appear. Magnetic sensitivity occurs due to "Faraday effect". Vector of this sensitivity is stable during exploitation and lies in fiber coil plane. Its value may be estimated 3°/h per Gauss. Mechanical vibration gives additional output signal due to micro deformations of the fiber coil. This signal is proportional to variation (derivative) of gyro acceleration as 3°/h per g/s, bias components g and g^2 are

negligible. VG941-3 output is uncompensated. To achieve specified performance its data should be corrected (modeled). Bias and scale factor temperature dependence to be taken into account.

MAIN COMPONENTS 100m of polarization preserving fiber is wound to form a sensing coil. Phase modulator - PZT is a piezoceramic cylinder on which surface a part of the fiber is wound. PZT fundamental radial resonance frequency is about 80 kHz. Fiber optic couplers 2x2 are made by fusion technique and mounted on quartz substrates to stabilize performance over vibration and temperature. Fiber polarizer (polarization filter) is a key component reducing bias drift. It is fabricated by surrounding the tapered fiber by highly birefringent optical crystal. SLD light module is made by soldering technique after SLD to fiber precise alignment. All optical components are mounted inside a sealed aluminum case. .

DESCRIPTION OF VG941-3 I/O PINS FUNCTIONS

TYPES	PIN NUMBER	PIN NAME	DESCRIPTION
POWER INPUTS	1	+ 5VDC	+5 Volts DC regulated. Ripple 50mV max. Current temperature dependent
	4	DC return Gnd	DC return line for +5VDC, Ground, Case is connected
SIGNAL OUTPUTS	3	OUTPUT	Output signal - voltage Differential input recommended.
	2	DC return AGnd	Signal DC return or Analog ground. Differential input recommended.
OTHERS		-	Spare