Small Size Simple Configuration Fiberoptic Gyro

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ABSTRACT

Simple and potentially low cost fiberoptic gyro with low performance was demonstrated. It contains only one fused coupler [2x2]. Dependence of gyro bias on properties of light sourse and fused coupler was investigated. Fusing coupler elongation was found to make the gyro bias oscillaiting and diminishing in the case of low coherent light source and high birefringent fiber. Simple optical architecture results in reducing of gyro size and weight.

2. INTRODUCTION

The practical realization of FOG potential advantages is restrained partially due to economical reasons, i.e. the optical scheme of FOG [1] which makes it possible to achieve high performance contains many precision and complex for the production elements. It is worth while to look for simpler ways of FOG construction. Besides the FOG's construction using the "minimum configuration" scheme we also investigated the possibilities of the improvement of the FOG performance characteristics on the bases of a ring interferometer containing single fused coupler.

3. CONFIGURATION

The sensor configuration is the ring fiber interferometer containing single fused coupler and a superluminescent diod (Fig.1). PZT which is controled by a sinusoidal signal biasing the interferometer. A hybrid circuit formes the PZT signal and the sensor output signal. All FOG's elements are in the same envelope that improves the FOG's miniaturisation.

3.1. Coupler

The sensing coil, the modulator and the coupler are produced from the one unbroken length of the fiber (IN - LINE TECHNOLOGY). The fiber is a single-mode polarization -maintaining one with the following parameters: H=0.001 1/m, the beating length is 3mm, NA = 0.25, Cladding diam.is 50 μ.

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The fused coupler was produced using automatic setup with the simultaneous control of the FOG output signal. The setup makes it possible to vary the coupler length in a wide (~50 mm) range and to produce "overcoupled" couplers. The level of optical losses and the amplitude of the first harmonics of the PZT modulation frequency (it corresponds to the shift of the FOG zero) are controlled during the fabrication process.

3.2. Light source

We used the universal light source [2] which has three contact sections. The source operates in the regime of a superluminescent diode with the following parameters: the power of the radiation is not less than 500 μW (in the fiber), the width of the spectrum is not less than 15 nm, the depth of the spectrum modulation by the Fabri-Perrot modes is less than 3%, the degree of the radiation polarization is less than 10%. The SLD-pigtail is fabricated by fixing of the fiber and the SLD-crystall with the help of the soldering.

3.3. Electronics circuit

The circuit forms the signal of the excitation of the phase modulator, detects the first harmonics of the modulation frequency and stabilizes the FOG's scale factor. The accuracy of the stabilization is 1-3%. The scheme is made in the hybrid form (D=50 mm) and consumes the voltage and current ±15 V and 45 mA, respectively

4. CONCEPT

The interferometer with one coupler has two bias components. First component may be effectively suppressed using mutually oriented birefringent fiber and low coherent light source[3]. The second one is the coupler bias. If there are no losses in the coupler then the interferometer bias at the nonsymmetrical output exactly equals π. This bias does not prevent FOG's normal operation but in fact there are some losses in the coupler, i.e. the bias differs from π and this difference is not a constant. That is why the FOG which is constructed according to the simplest scheme is not usually used. As it is known optical losses of the fused single-mode coupler are determined by the adiabaticity of the transformation of the main fiber mode.[4] A part of the power is transformed in the modes of a higher order which excite a high order modes of the fused coupler taper.[5] Due to the phase shifts of these modes in the coupler are different the reverse transformation into the main mode of the fiber is accompanied by the interferometric power loss. Besides the coupler high order modes create the additional way of the interference of the ring FOG interferometer waves and hence change its initial bias. Suppose that besides the main mode an additional one with the amplitude r<<1 is excited at the coupler taper. The main modes of the coupler taper are excited by the corresponding combinations of main modes of the fiber ones. The additional modes of the taper excite the higher order coupler's modes of approximately the same amplitude. At these conditions the expressions for the useful signal amplitude (A2) and for the interferometer bias (A1) assume the following form (the polarization effects are ignored):

$$A1 \sim \langle 2r^2 (\cos\Phi_{13} + \cos\Phi_{24})[r^2 (\sin\Phi_{14} + \sin\Phi_{23}) + \sin\Phi_{12} + r^4 \sin\Phi_{34})] \rangle \quad (1)$$

$$A2 \sim \langle \sin^2\Phi_{12} \rangle \quad (2)$$

where Φ_{ij} are the phase difference of the coupler taper modes i and j, symbols <> mean the light source spectrum averaging. Φ_{ij} are proportional to the taper length. Taper "overcoupling" makes $\Phi_{ij} \gg 1$. In this case broad spectrum diminishes bias ($A1 \ll r^2$) and avereges FOG's scale factor to the constant value (A2=1/2). Hence, coupler's low optical loss (in this model $\approx r^2$), wide light source spectrum and appropriate elongation ensure initial interferometer bias to be smaller.

5.EXPERIMENTAL RESULTS

We produced FOG's samples with fiber length 100m. Coil diameter was 30 mm. SLD- crystal was oriented with respect to fiber so, that output light was fully depolarized. Then the coupler was fabricated while FOG's signals (1-st and 2-nd harmonics of modulation frequency) were controlled. The dependence of 1-st harmonic's signal upon coupler's elongation is shown on Fig.2. It's seen that initial bias of FOG abruptly falls from 0.1 rad to the level 0.01 - 0.001 rad. This level corresponds to the residual polarization bias and depends on quality .of the used fiber. Short term stability of bias was found to be some better (3-10 times) in all cases. Thus, we've experimentally shown that "overcoupling" makes the FOG's bias substantially smaller. Samples made in such a manner had next performance characteristics:

- random walk drift	0.001 deg/sec$\sqrt{Hz}$
- short-term(1 min) bias drift	0.03 - 0.05 deg/sec
- max input rate	300 deg/sec
- output analogue signal	30 mV/deg/sec
- size (with electronics circuit)	diam 55mm x h.22mm
- weight	0.05 kg
- power consuption	< 1.5 W

6. CONCLUSIONS

New simple configuration low cost prototype FOG has been developed. This FOG is based on fiber ring interferometer with only one "overcoupled" coupler. All FOG's elements are produced from one unbroken length of fiber (IN-LINE TECHNOLOGY) Having high sensitivity it may be used in the measurements of angular vibration and solving short-term angular stabilization problems.

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8. REFERENCES

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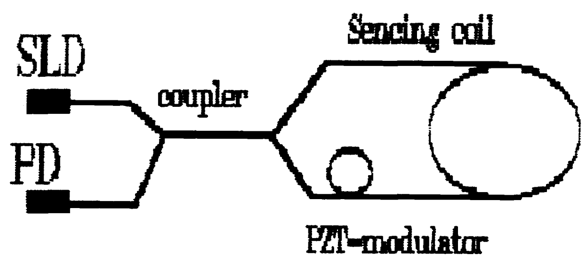

FIG.1. FOG's configuration

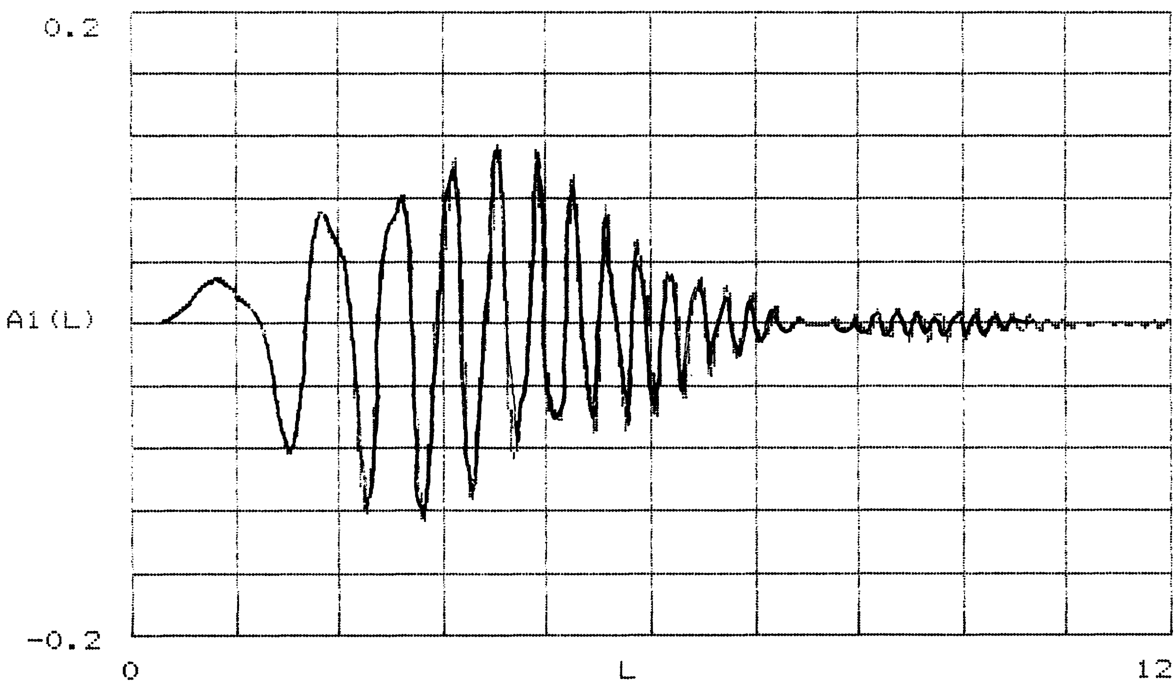

FIG.2. Dependence of FOG's bias upon coupler's elongation