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Analysis of vibration error in digital closed-loop fiber optic gyroscope

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Abstract: Vibration error of fiber optic gyro affect its application performance directly. In order to solve the problem, the main causes of vibration error were analyzed. The expression between the closed-loop gyro output and optical power was conducted, The conclusion is that The inner stress of the fiber coil and the device pigtail caused by vibration leads to the variation of the polarization mode and optical power of propagating light. The vibration status of gyro mechanical structure, especially the resonance feature was analyzed with the method of finite element analysis (FEA) and verified by tests. So from the view of design and technique, some effective measures to improve the dynamic performance are put forward, included disposal of fiber coil and optical device pigtail, resonance free with reasonable structure design and improvement of closed-loop control. The result shows that the methods are valid. In vibration condition, the dynamic precision of fiber optic gyro is near static performance and satisfied application need.

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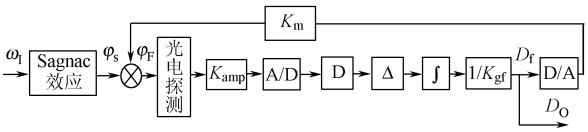
+°[u f #, l *] º uC ð*K À Ç ö " " 4f K£(7 +°LŠ¾?,$/' , 0¬• \ 0u t f T Î "w" 6 ù L f u f +° B.

• u 3ÐKl<æ ^ T, (Û å ; ", u Ë(³ ù À [*] º ÷D˜Ó*K Sagnac ,$/' φ_s +°) œ, Ÿ

$$P(\varphi_s) = P_0[1 + \cos(\varphi_s + \varphi_b)] \quad (1)$$

; Y φ_b f ,$ y { 4š. ú 6 ; ,7 &, u Ë(³ P_0 +° B 2, Ñ(7 Î "w" # $P(\varphi_s)$+° B.

%º K (Û ^ å ; , ¢ # r * ®* 1 l .f.



K_{amp}— j S(Û7®;A/D— M œD˜Ž;D— œ ƒ ? A/;

∫—/ 2(Û7®;K_{gf}— ù N´2' œ;K_m—A/ " A/ b 2' œ

* 1 œ ƒ K (Û u 3ÐKl<æ "w*aC å r *

u 3ÐKl<æ°ž "µ # *] ; (2) ûE [1]:

$$\varphi_s = \frac{2\pi LD}{\lambda C} \cdot \omega_I \quad (2)$$

Î "w" D¿&*a · # f

$$V = P_0[1 + \cos(\varphi_s + \varphi_b)] = P_0[1 + \sin\varphi_s] \quad (3)$$

; (3) Y+°0X1 F 2 [, "m2 Fû, T y 4š j S " YFó*TKÀ, *aC =× ç µ, 58 ñ ì "w+°0X2 F 2 $P_0 \sin\varphi_s$, TK (Û ^ å ; 7, A ' +°=' «, $/' φ_F *T á"´ Sagnac ,$/' , E Î "w" D¿& f

$$V = P_0 \sin(\varphi_s - \varphi_F) \quad (4)$$

*] * 1 Ã &:

$$\Delta = P_0 \sin(\varphi_s - \varphi_F) \cdot K_{amp} \cdot K_{AD} \quad (5)$$

@ê (Û Ê+ö f

$$A = K_{amf} \cdot K_{AD}$$

$$D_O = \Delta \cdot K_{gf} = P_0 \cdot A \cdot \sin(\varphi_s - \varphi_F) \cdot K_{gf} \approx P_0 \cdot A \cdot (\varphi_s - \varphi_F) \cdot K_{gf} \quad (6)$$

*] * 1 D/A D˜Ž, @ê/ b *a · :

$$V_m = \frac{V_{2\pi}}{2^N} \cdot D_f$$

$$\varphi_F = K_m \cdot V_m = K_m \cdot \frac{V_{2\pi}}{2^N} \cdot D_f \quad (8)$$

ô $$D_o = D_f \quad (9)$$

$$D_f = \left(\frac{2\pi LD}{\lambda C} \cdot \omega_I - K_m \cdot \frac{V_{2\pi}}{2^N} \cdot D_f\right) \cdot P_G \cdot A \cdot K_{gf} \quad (10)$$

$$\left(\frac{1}{AP_0 \cdot K_{gf}} + K_m \cdot \frac{V_{2\pi}}{2^N}\right) \cdot D_f = \frac{2\pi LD}{\lambda C}\omega_I \quad (11)$$

@ê $$K_1 = \frac{1}{AP_0 \cdot K_{gf}} + K_m \cdot \frac{V_{2\pi}}{2^N} \quad (12)$$

f $$D_f = \frac{\frac{2\pi LD}{\lambda C}}{K_1} \cdot \omega_I \quad (13)$$

I $$D_O = \frac{\lambda C}{K_1} \cdot \omega_I = K_2 \cdot \omega_I \quad (14)$$

; Y K_{AD} f M œD˜Ž A/D +° Ê+ö; D_O [K (Û u 3ÐKl<æ°"wFûD¿& #; K_m f ,$ y A/ b " +°A/ b 2' œ; K_{gf} f ù N´2' œ; $V_{2\pi}$ f ,$ y KbÛ" +° h; ω_I f D¿' >þEKÒ. *] K_1 ,7 &, • A BßK S,

$$K_1 = \frac{1}{AP_0 \cdot K_{gf}} + K_m \cdot \frac{V_{2\pi}}{2^N} \approx K_m \cdot \frac{V_{2\pi}}{2^N} \quad (15)$$

I $$D_O = \frac{2^{N+1}\pi LD}{\lambda C V_{2\pi} \cdot K_m} \cdot \omega_I \quad (16)$$

‹] [A, u Ë(³ +° B %D¿& 9 EL< • ù. r • ÊKq(ÛC +° Ê+ö 9 K ", K_1 2 \ DêÎ "w" +° u f P_0 +°" Ô58" Ô, E 2, Ñ(7 D¿&+° B.

1.2 Kl<æ "w3ð 4 3ÿ ° A<[%å(7 A Ê S A<[^ f [Ô+°'¥ ¶'â - , „ T º ' • 3ÿ ° • Y. TA<[%å6, E [Ô Ì " . *] º u 3Ð(1 u *a " " +° j 3Ð) F) [Kp,l B & ÆT u 3ÐKl<æ (Û+° [½OÔâ ±+°, • 3ÿ ° Ó*KA<[", ñ &b F'¡ E \ u 3Ð,*] 6 LŽ+° 2 ¼Ã- , u 3Ð+° [Ô F AB£ { [- +° B, « D¿& ý *K B. K• • B、u ' " " ö ì "w*aC +° µ=ñ & ÆÐu ‹ F)>-"µ ö \ FýŠ 3ÿ ° +°@ê@Í, • 3ÿ ° @ê@Í、=ñFy 7¦ ö µ=ñ 9 ¸ ° ", F) F (7 u 3ÐKl<æ• =" ö "w3ð 4 X • +° A<[, A<[« Ã u C +°4f K£=× j S, ù L T Kl<æ° D¿& # 6,] [EL< Kl<æT [Ô • " 7 – Ê S, L" y ý *K B.

1.3 [Ô(7 K (Û 2' 4 L" y A B)2 @ê u 3ÐKl<æ° ù À R é g >- u T u 3Ð Y+° L D¿" " +° • ù, 8 u 3Ð+° J« Ò f 1 km, Kl <æ° - K| R é f 100 kHz[2]. &b58, Ê Kq « *T Y, u 3ÐKl<æ K (Û ì "w*aC +° " " 、(ÛC Ê+ö 0uF) 2 K| b Kl<æ° R é. Ÿ « E c, u 3ÐKl<æ° R é ù [f ÜKl<æ° 9 6. œ ƒ K (Û u 3ÐKl<ææ t, « Ã 2' 4 ÷3ô ^ T L" y KpDý, • 5 >þEKÒD¿' ", 2' 4 6) T ¢ ù À " K ±, 4 & ù N´, $/' , =' « Sagnac ,$/' . T [Ô • " 7, y P V 2L T u C Y A ' +° LŠ¾?, $/' , ù L T Kl<æ # 6, , $ • º A ' ² , VD¿' >þEKÒ, 8 2' 4 9 6) T ù À " K ±, 4 & ù N´, $/' ,] F EL< Î "w" D¿& # 9 6) K 4 T L"%å, EL< Kl<æ L" y A ý *KD¯S B, QFù " *F7 « 2' 4] Ó.

2 e E u 3ÐKl<æ[Ô S 6) +° Ö é