High-Bandwidth Frequency Servo Loop for Resonant Micro Optic Gyroscope with a Reduced Sampling Rate Proportional-Derivative Controller

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Introduction

As a promising candidate for autonomous navigation applications, the resonant micro-optic gyroscope (RMOG) based on the Sagnac effect is receiving high attention from many institutions for its advantages of small size, high theoretical sensitivity and anti-vibration[1-3].

To suppress the high frequency noise in resonant micro optic gyroscope, this paper develops a high-bandwidth feedback loop with a reduced sampling rate proportional-derivative controller applying to a phase modulator. Simulations are carried out to show the characteristics of the new loop.

Principles and System Design

Figure 1 shows the schematic diagram of the RMOG with the proposed high-bandwidth frequency servo loop. Light from a narrow-linewidth laser after passing through an isolator (ISO) is split into two equivalent beams by a Y-branch phase modulator (PM). Two sinusoidal waveforms at frequencies f1 and f2 are applied to the Y-branch PM which are used to signal modulation and demodulation. Two triangular waveforms at frequencies f3 and f4 are applied to phase modulators PM1 and PM2, which are added for improving the total carrier suppression level against the backscattering noise [4]. After modulation, the two beams are coupled into the WRR through circulators CIR1 and CIR2 in CCW and CW directions. Photodetectors D1 and D2 receive the optical signals from the WRR and convert them into electrical signals.

The CW signal is demodulated by the demodulation module DM2 with the reference phase of θ2. Then, the output from DM2 is divided into two parts. One of which is filtered by the low-pass filter LPF2 and then input to the Servo which is based on Proportional-Integral Control, to suppress the low-frequency noise, adjusting the laser frequency to track the resonance frequency of the WRR in the CW direction. The other part is input to the PD controller as shown in the green frame and then fed back to the Y-Branch PM to suppress the high-frequency noise. The CCW signal is demodulated by DM1 with the reference phase of θ1 and then filtered by LPF1, regarding as the final output of RMOG. All the signal processing is implemented on a single FPGA.

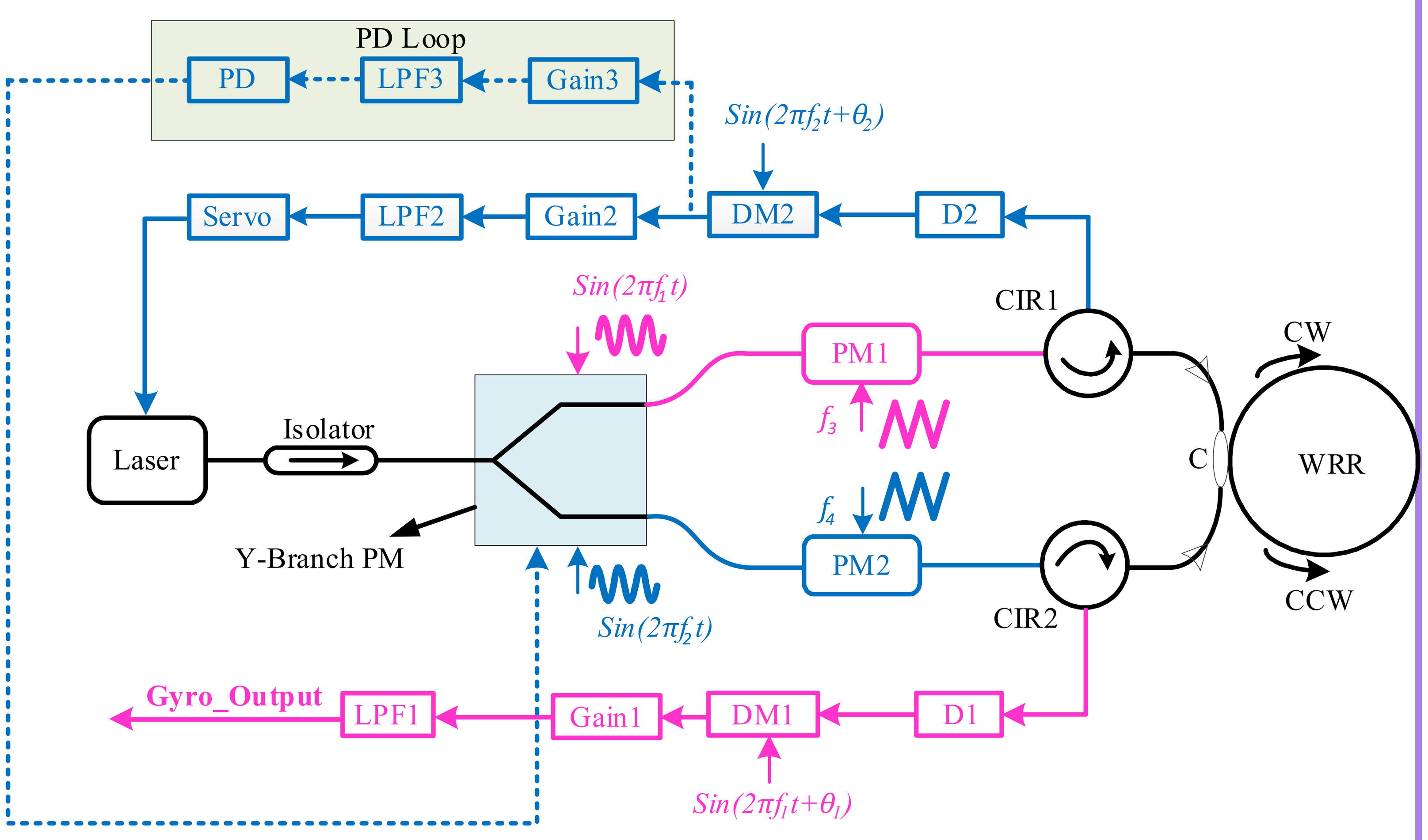

Figure 1. RMOG with the proposed scheme.

Simulation and Discussion

Figure 2 shows the frequency characteristics of the original servo control loop, which can be seen that the bandwidth is only 230 Hz.

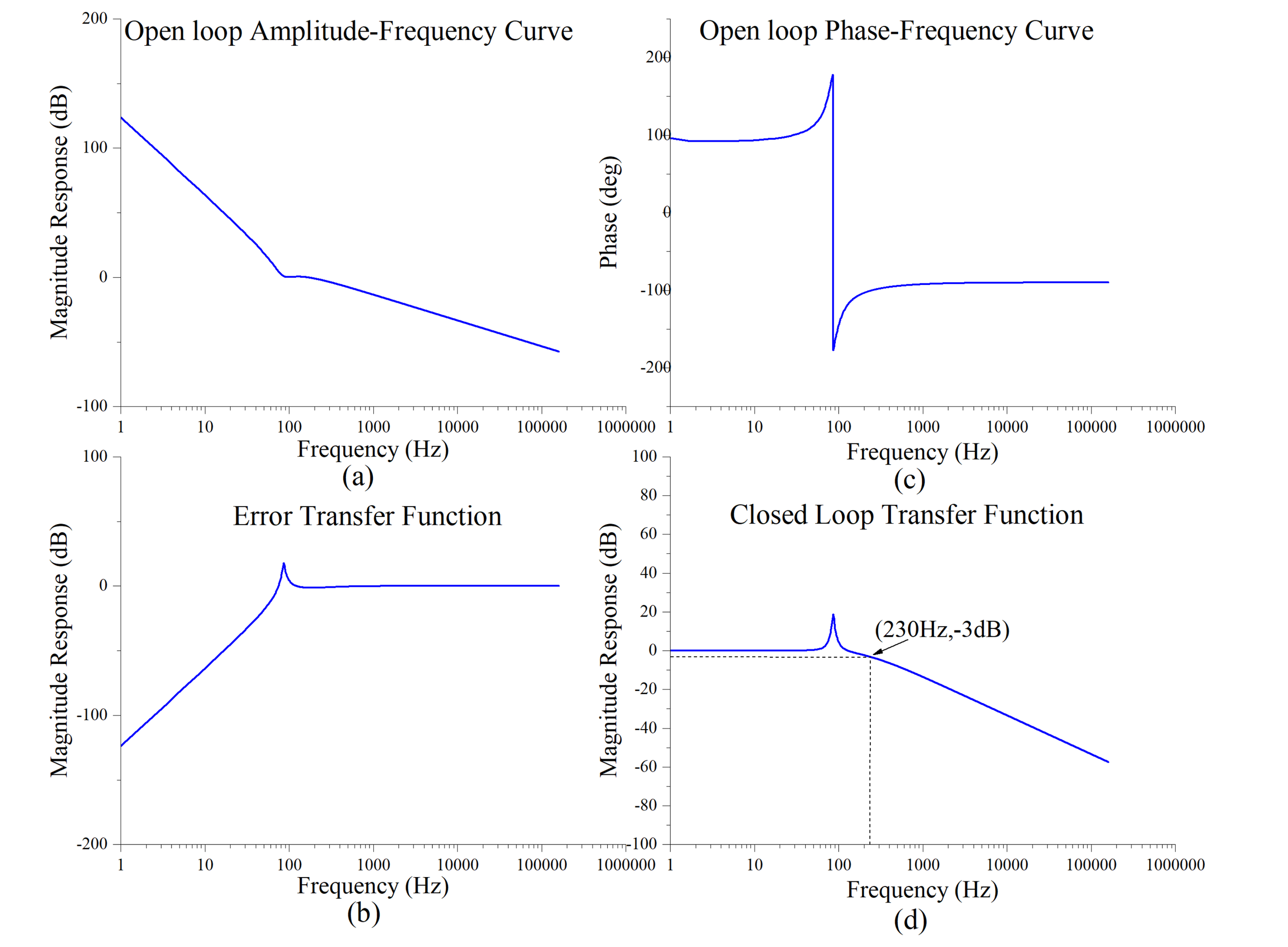

Figure 2. Frequency characteristics of the original servo control loop.

Figure 3 shows the frequency characteristics of the servo control loop with the proposed PD controller at different sampling rates of 5 MHz, 500 kHz and 50 kHz, respectively. It can be seen that the passing band of the PD loop gradually increases as the decrease of the sampling rate.

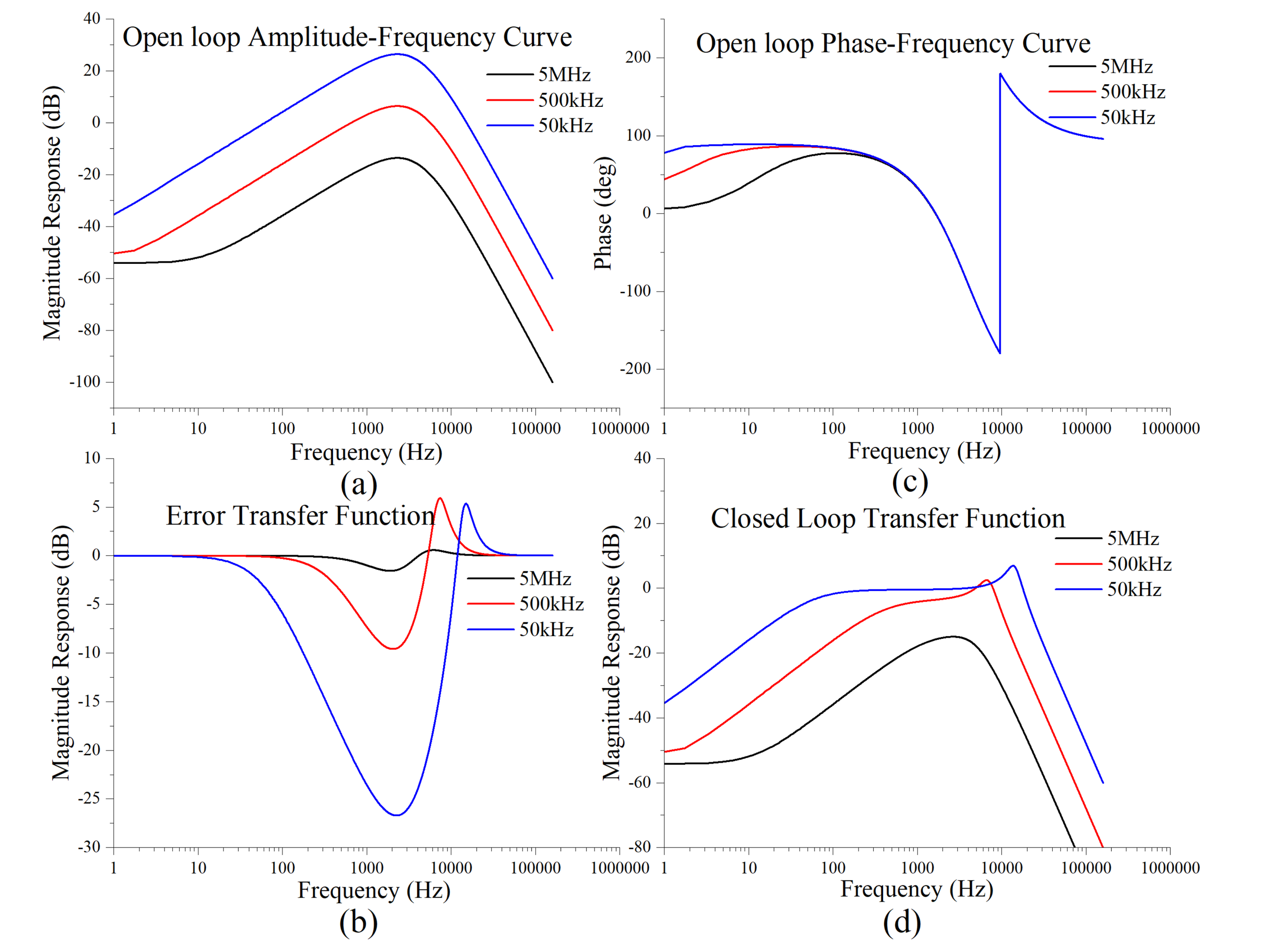

Figure 3. Frequency characteristics of the servo control loop after applying the proposed loop.

With the proposed PD controller, the bandwidth of servo control loop is shown in Fig. 4. It can be seen that the high-frequency response improves as the decrease of the sampling rate. When the sampling rate is reduced to 50 kHz, the bandwidth improves from 230 Hz to 19.3 kHz.

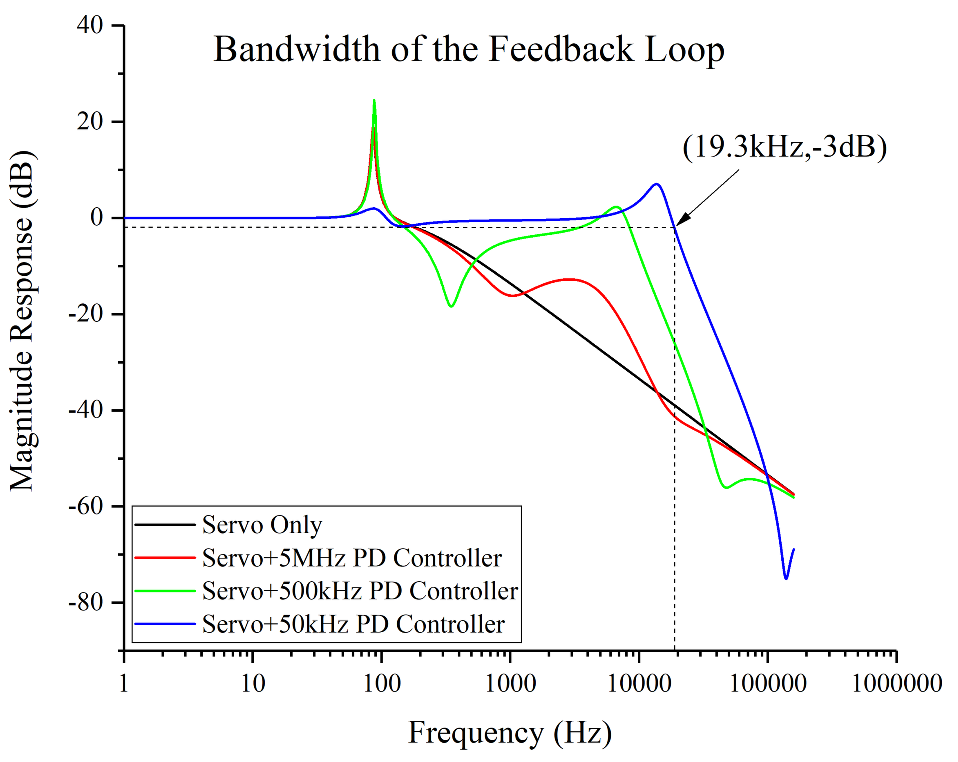

Figure 4. Bandwidth of the servo control loop .

Reference

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Conclusion

A novel control loop is proposed to suppress the high frequency noise in RMOG. Relevant simulation shows that when the sampling rate is 50 kHz, the bandwidth of the loop improves from 230 Hz to 19.3 kHz, a nearly 8 times increase.