Design and Implementation of Gyro Off-line Test Platform

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Abstract. The off-line test platform of gyroscope is designed, and the functions of the platform are realized by designing the modules such as biaxial electric rotating platform, rotation controller, turntable control software, data acquisition and recording system. It is of great significance for the off-line test and preventive maintenance of gyroscope.

1. Introduction
Ships are constantly moving at sea under the influence of wind and waves, and ship-borne radar is also constantly moving with the movement of the carrier[1]. Since the range of the radar antenna beam is generally much smaller than that of the ship, it is difficult for the servo system to ensure that the antenna is stably pointing towards the target, if no action is taken to eliminate the effect of the vessel roll in the servo tracking loop. Gyroscope is the important equipment for ship-borne antenna isolation of ship rolling[2]. By superimposing fiber optic gyroscope tracking, the ship rolling can be effectively isolated and the antenna stable tracking target can be achieved.

Under the condition of severe sea conditions, the number of failures of gyroscope increases with the extension of service time. The gyro malfunction could cause the antenna to follow the wobble, and even cause target loss and mission failure[3]. So the research on the off-line testing platform of gyroscope is very important to ensure the antenna safety.

2. The Design of test platform
The design of the off-line gyro testing platform is divided into five parts, which are: dual-axis rotating platform, rotating controller, turntable control software, signal acquisition module and data processing module[4-5]. The platform of the test system is designed as a two-axis rotating platform. The tested gyroscope is mounted on the loading platform. The test platform makes the rotating platform rotate in the sine and cosine by using motor, rotation controller and rotation controller. Through the data acquisition device, the output signal of the tested gyro is collected and transmitted to the computer. By comparing and analyzing the output signal of the gyroscope and the attitude information of the platform, we can judge whether the gyroscope signal is normal or not[6].
2.1. Biaxial electric rotating platform

Biaxial rotating platform is designed as u-shaped aluminum alloy frame structure[7]. As shown in FIG. 2, the dual-axis rotation platform is designed with two rings, the inner ring is the azimuth axis frame, the outer ring is the pitch axis frame, and the inner and outer rings are vertically rotating each other. DC motor is used to drive the inner and outer rings to rotate and rotate, and the attitude measurement of three-dimensional space position and angle is realized at the same time.

![Design drawing of two-axis rotating platform.](image)

The technical indexes of the two-axis rotating platform are as follows:

| Project                                | Index                        |
|----------------------------------------|------------------------------|
| Size and weight of load                | 50mm×50mm×50mm / 0.7kg       |
| Installation space for loads           | 120 mm×120mm×120mm           |
| Angle range of spindle and pitch axis | No limit                     |
| Rate range                             | 0.1º/s~300 º/s               |
| Slip Ring                              | 12 rings / rings 2A          |
| The weight of the platform             | 15Kg~20 Kg                   |
Dimensions of measuring and controlling electric box: 300mmW×320mmW×88mmH
Series rate: 115200 bps

2.2. Attitude measurement module
The design chooses the 3D sensor as the attitude measurement module, which is a miniature all-attitude measurement sensor device. The attitude measurement module consists of three sensors, such as three axis MEMS gyroscope, accelerometer and magneto resistive magnetometer. Three-axis gyroscope is used to measure absolute angular velocity, three-axis accelerometer is used to measure the acceleration of the tested gyroscope, and three-axis gyroscope and accelerometer provide the azimuth pitch rotation of the platform when it works. The three axis magneto resistive magnetometer is used to measure the three-dimensional geomagnetic intensity and to calibrate the initial azimuth.

Table 2. Performance Indicators of Full Attitude Measurement Sensors

| Performance index                         | Parameter       |
|-----------------------------------------|-----------------|
| Static Angle Error (Pitch, Roll)        | ± 0.1 degree    |
| Dynamic Angle Error (Pitch, Roll)       | ± 1.0 degree    |
| Static angle error (heading)            | ± 0.5 degree    |
| Heading angle resolution                | <0.1 degree     |
| Accelerometer measurement range         | ± 2 g           |
| Measurement range of rate gyroscope     | ± 300 °/sec     |

2.3. Formatting author affiliations
The 3DM-2E controller is selected, and the acquisition controller is connected to the computer through USB or serial interface to realize the signal acquisition of the attitude module and the measurement control of the electric turntable.

Table 3. The Index of Rotary platform controller

| Performance index                     | Parameter       |
|--------------------------------------|-----------------|
| Frequency of Angle measurement data acquisition | 20Hz            |
| Shape size                           | 260mmW×230mmW×88mmH |
| Series rate                          | 115200 bps      |
| Working power supply                 | 220VAC/200W     |

2.4. The control software
The control software is rich in functions, including location mode, rate mode, and wobble mode. It can control the two axes of the turntable to move separately. The turntable can be set to rotate an angle at a certain angular rate. The turntable can be controlled to rotate continuously at a certain angular rate. The turntable can also be set to swing at a certain angle.

At the same time, considering the need of testing and the accuracy of debugging, the operation of "position horizontally" and "position homing" are added, which can make the turntable rotate to the initial 0 degree position and the position perpendicular to the horizontal plane respectively.
3. Data acquisition and recording system

3.1. Data fetch
1. Read and write data operation steps:
   - FT_ListDevices->FT_OpenEx>FT_ResetDevice>FT_Write>FT_GetQueueStatus->FT_Read>
     FT_Close
   - In FT_Write - > FT_GetQueue - > FT. Read is the main body of data collection, put it in the While
     loop and close the USB device directly with FT_Close.
2. Write data function:
   uint32_t FT_Write(uint32_t Handle, const uint8_t *Buffer, uint32_t BytesToWrite, uint32_t *
     BytesWritten)
   - The Handle is the USB device number, default is 0; *buff is an array to write to the acquisition card,
     BytesToWrite is the length of the array to write to the collection card, *BytesReturned is the number
     of bytes actually written to the collection card.
3. Reading function:
   uint32_t FT_Read(uint32_t Handle, uint8_t *Buffer, uint32_t BytesToRead, uint32_t *
     BytesReturned)
   - Read the array, including N times of acquisition results, each time the data structure is: header + data
     + suffix, which is 216 (0xD8), suffix 218 (0xDA), the middle is a useful data acquisition. To read the
     data, is not necessarily a prefix byte 0 bytes, but a byte 0-5, that is to say, every time to read the data,
     there are several bytes is the last time before the end of the data, the last few bytes, is also a part of
     the last 1 acquisition rather than the entire department.
   - The method of data parsing is to discard the first few bytes before 0xD8 and the last few bytes after
     0xDA; the form after data parsing is: N bytes beginning with 0xD8 and ending with 0xDA. These bytes
     are sequentially emitted in the format:
     0XD8 AIN0_H AIN0_L AIN0_L AINN_H AIN2_H AIN2_L AIN3_L AIN4_L AIN5_H AIN5_L AIN6_H AIN6_L AIN7_H
     AIN7_L DIO0xDA

3.2. Voltage calculation
The calculation method of the 16 bit AD is:
   - AD value= (AIN_H*128+AIN_L)*4
   - (1)
   - If the AD value is greater than 32767, the corresponding voltage value is negative, and if the AD
     value is less than or equal to 32767, the corresponding voltage value is positive.
   - Positive voltage formula:
     Voltage = AD value /32767*10
     (2)
   - Negative voltage calculation formula:
     Voltage = -(65536- AD value) /32767*5
     (3)

4. Conclusions
In this paper, the off-line testing platform for gyroscope is designed and realized, and the corresponding
control software is developed. The dual-axis rotating platform is designed to test under dynamic
conditions. The data recording and analysis software is developed, which makes it possible to trace
the original data and compare the results online. The influence of ship rolling is effectively overcome by
superimposing the platform attitude measurement module. It breaks through the limitation of testing in
laboratory static condition and realizes the testing in offshore dynamic condition.

References
[1] Lefevre H C. OFS2012(2012) .The fiber-optic gyroscope:actually better than the ring-laser
    gyroscope.
[2] Li Hongwei, Yitongsheng, Wang Yang. Radio Engineering. 2013 (07) Design of Ship Rolling Stabilization Loop for Shipborne Surveying Radar [J].

[3] Qu Yuanxin, National Defense Industry Press. (2008) Ship Rocking Stabilization Technology for Telemetry and Control Communication Equipment of Space Surveying Vessels [M].

[4] Jwo D J, Shih J H, Hsu C S, et al. Journal of Marine Science and Technology. (2014) Development of a strapdown inertial navigation system simulation platform.

[5] Dong Liang, Zeng Qinghua, Deng Xiaoyi, Li Yan. Aeronautical Computing Technology. 2012 (06) Design and Implementation of Multifunctional Strapdown Inertial Navigation Simulation Platform Software [J].

[6] Zhang Haifeng, Sun Xuecheng, Wang Dandan, Wang Dongsheng. Computer Simulation. 2016 (01) Design and Research of Strapdown Inertial Navigation Virtual Test System [J].

[7] Feng Zhiyong, Zeng Han, Tension, Zhao Yixin, Huang Wei. Journal of Southwest Normal University (Natural Science Edition). 2011 (04) Attitude angle measurement based on signal fusion of gyroscope and accelerometer [J].

[8] Fan Chuntao, Xu Chengfeng, Jiang Yonghua, Li Rongqiang, Zhang Yanni, Yang Juming. Modern Electronic Technology. 2015 (07) Development of Motor Speed Measurement and Control System Based on LabVIEW [J].

[9] Xu Xiaojie, Huang Kesheng, Lin Feng, Xu Qingfen. Data Acquisition and Processing. 2012 (S2) Design and Implementation of Massive Data Acquisition System Based on CPCI Interface [J].

[10] Ye Jian, Li Binhua, Cheng Xiangming, Yang Lei, Zhang Yigong. Optical technology. 2015 (02) Design of motion control system for a new type of contour turntable [J].

[11] PLX Technology, Inc. 2000. PCI 9054 Data Book, Version 2.1.