Design of laser detection instrument of a certain type of missile

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Abstract. This paper introduces a laser detection instrument for calibration the optical axis parallelism between laser transmitter with small field of periscope optical aiming mirror, and also it can measure laser transmitter power and view spot diameter of the main,minor zoom field and fixed foci small field to determine whether the optical performance is good .

1. Introduction

With the missile weapon system troops and equipment in large quantities, coupled with the troops chronicle live fire exercises intensity increased year by year, so maintenance detection of weapons is imminent. Due to operations of the laser detection equipment is complex, and intelligent level is not high, can not adapt to the increasingly frequent maintenance testing needs. In this paper, designing a set of detection instrument which detection laser power, axis parallelism and laser spot diameter in one of the laser detector [1]. The technical index and working environment are: test range 50m, infrared CCD size 8.8m*6.6m, working wavelength: 0.908um, minimum illumination 0.02Lux, optical system focal length 75mm, camera distance 6m, laser target 750mm*600mm, working temperature: -20—+50. Working field: field.

2. Instrument system design and testing principle

As shown in Figure 1, the laser detector consists of a continuous video capture module, a AC/DCpower supply module, a laser camera and a special computer, a lens and an electronic box.

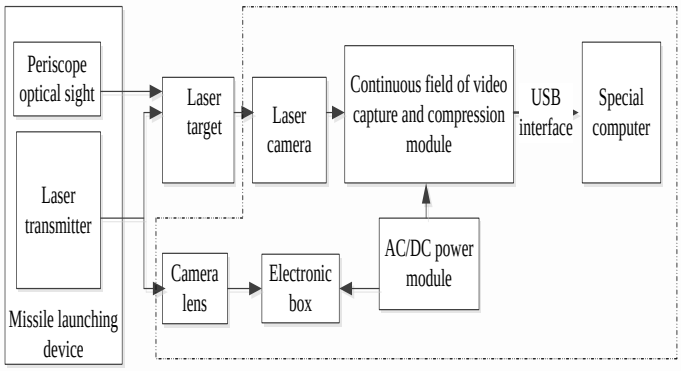


Fig. 1 working principle diagram of laser detector

The laser transmitter is mainly used to convert the encoding control instruction of the guidance electronic box into the laser pulse, while the laser target is responsible for receiving the laser pulse emitted by the laser transmitter. The video capture and compression module is based on FPGA [2] technology and USB technology to complete the digital acquisition, compression and buffer transmission function of the analog signal generated by the laser camera. The special computer completes the function of digital image acquisition, image processing, target recognition, coordinate calibration, optical axis calculation and spot diameter calculation.

The lens includes a front optical system and a photoelectric detector, which is used to focus all the laser light on the detector, and the optical signal is converted to an electrical signal by the detector. The electronic box is the electrical signal which is converted by the photoelectric detector

in the lens to signal processing. The single chip microcomputer system with high integration degree is used to measure the average power.

According to the test standard, the optical axis deviation is not more than 5% qualified, due to the 0.09mm of the standard laser pointer, the spot is uniform and no astigmatism, and the ellipse is no more than 1:0.7 (ellipse = spot standard diameter / length of the measured light spot). If the error exceeds the allowable range, the adjustment mechanism is set up by the laser transmitter, and the mechanical adjustment is performed.

2.1 Detection principle

(1) Analysis of the object: the laser measuring instrument detection is divided in three parts of the laser axis and laser spot diameter and laser power detection. The laser transmitter consists of four field, each field is detected, the same principle, the laser power by the laser power meter detection.

(2) parallel to the optical axis of the and laser spot diameter detection principle: laser transmitter and a periscope optical aiming mirror in the relative position of the vehicle mounted missile system as shown in Figure 2, the laser transmitter with respect to the periscope optical aiming mirror in the distance of horizontal axis X and the vertical distance y. So the design of the special laser target plate as shown in Figure 3, "aimed at the cross" and "Grand Cross", "aim at the cross" corresponding periscope optical sighting telescope, test the Grand Cross of the corresponding laser transmitter and make two cross relative position and periscopic aiming mirror and laser transmitter locations are the same.

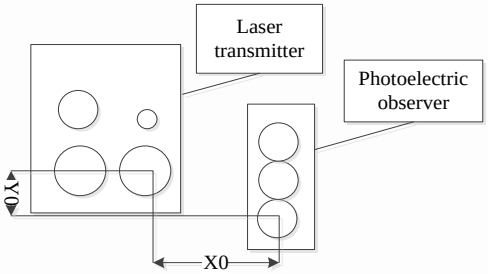


Fig. 2 the relative position of the laser transmitter and the photoelectric observer

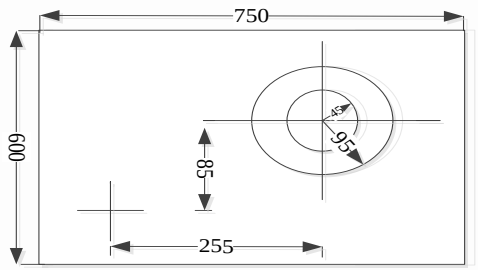


Fig. 3 the laser target board

Manipulating emissive guidance device, emitted by the laser transmitter and geometric center of laser spot should coincide with the Grand Cross of the detection. Corresponding to laser transmitter with respect to periscope optical aiming mirror field of view position, the coordinate (X0, Y0), assumed optical axis is not parallel, spot center location (x, y), according to the principle of projection, parallel to the optical axis deviation is

$$\Delta\theta x = (x - x_0) / L \quad (1)$$

$$\Delta\theta y = (\mathrm{y} - y_0) / L \quad (2)$$

By computer processing contour point set of spot image, it can obtain the spot inscribed circle radius r, corresponding missile flight distance of the spot diameter D; laser transmitter and the laser target distance h, missile flight distance L, R for laser transmitter with laser target between distance. Calculating formula of laser spot diameter by detecting principle:

$$D = d / R*L \quad (3)$$

3. The major hardware design

The hardware design of the system mainly includes the design of the firmware configuration of the continuous field video capture and compression module, which is the hardware circuit design of the A/D module, the hardware circuit design of AC/DC power module and the electronic circuit design.

3.1 The continuous video capture and compression module

After the system is reset, CPLD reads the configuration program section of FLASH, completes the FPGA configuration, FPGA soft core starts work, according to the requirements of SAA7113, and SDRAM SAA7113 two image data buffer, CY7C68013 two image data buffer (and FPGA image buffer sharing), the FPGA soft core waiting state and monitor USB interface control commands, such as receiving the command, the I2C total line to write SAA7113 register, digital image acquisition and write buffer. When an image is collected, the soft core of the FPGA reads the image data from the buffer zone of the SAA7113, and the image is compressed, and the buffer is written to the CY7C68013, then the FPGA will be filled with an image data sent to the FIFO CY7C68013, and CY7C68013 will be transmitted to the special computer.

①FPGA firmware configuration design:

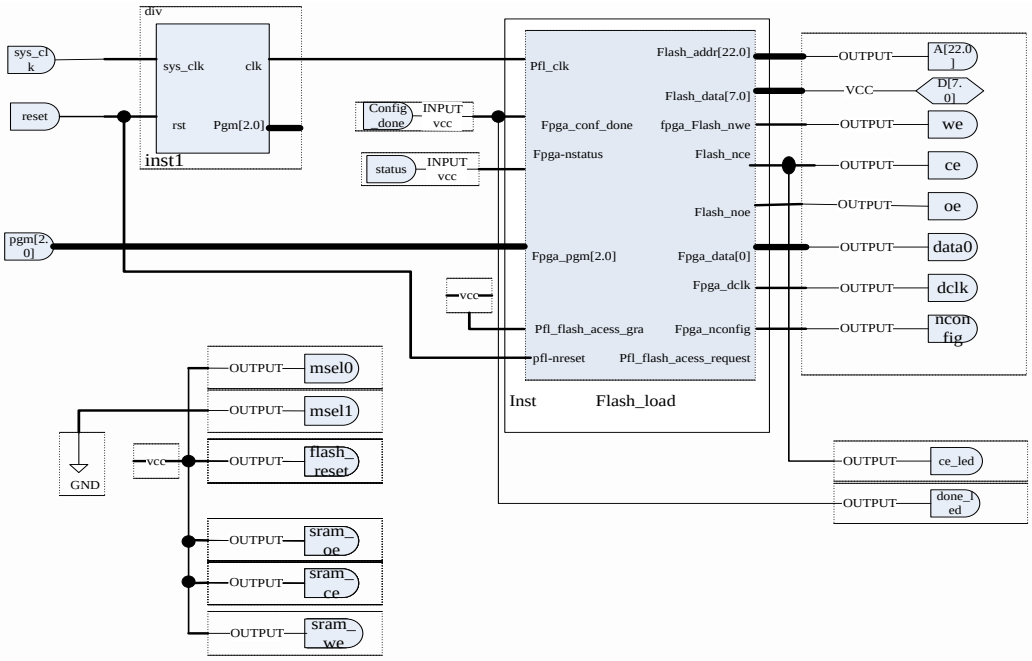


Fig. 4 FLASH program loading configuration

②for the video A / D unit SAA7113 provides clock is an active clock, the frequency of the output 24.576mhz; provide for the USB output transmission unit CY7C68013 clock is a passive crystal, the frequency is 24.000MHZ. The principle diagram is as follows:

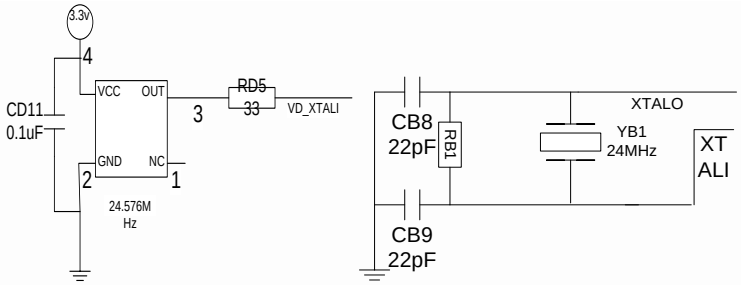


Fig. 5 active clock circuit Fig. 6 passive clock circuit

3.2 The AC/DC power module

The electric control box of the electric control box of the missile photoelectric device is introduced into 220V/50HZ alternating current, which is converted to 30V AC voltage by the transformer, and the KBJ606/6A bridge type rectifier [3] is changed into DC voltage. KBJ606/6A plastic silicon rectifier bridge circuit working principle as shown in Figure 7: E2 for positive half cycle, D1, D3 and direction of voltage, D1 and D3 conduction; of D2 and D4 with reverse voltage, D2, D4 cutoff. The circuit is composed of E2, Rfz, D3 and. The Rfz is formed on the positive and negative half wave voltage. E42 is negative half cycle. The D2, and D4 are positive, D4, D2, D3, D1, D1, D3, D1. The circuit is composed of E2, D4, D2Rfz power circuit, and the other half wave of the positive and negative [4] is formed on the Rfz.

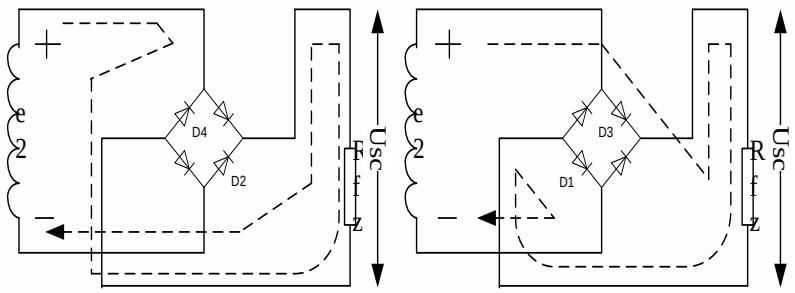
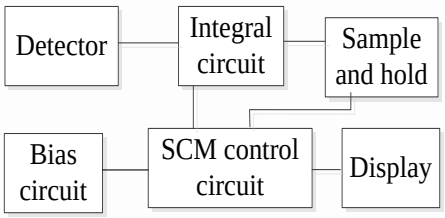


Fig. 7 Schematic diagram of KBJ606/6A plastic silicon rectifier

3.4 The electronic box module

The electronic box is the pulse signal which is converted into the detector, in order to obtain the average power of the laser, and the whole processing circuit is composed of a bias circuit, an integrated circuit, a single chip acquisition control circuit, a display circuit and so on. Schematic circuit diagram as shown in Figure 8, key part of integral circuit and MCU control circuit, laser power meter measurement accuracy, the integral circuit with integrated operational amplifier circuit [6], a resistor, a capacitor composed of circuit principle diagram as shown in Figure9.



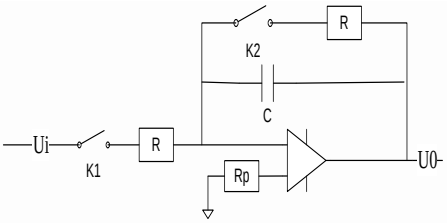
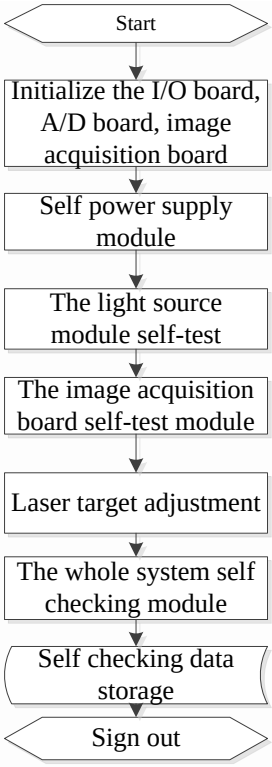


Fig. 8 block diagram of electronic boxFig. 9 schematic diagram of integrated circuit

4. The main software design

Thesoftware system of laser detection system has designed an unified communication and control interface, which provides a transparent and convenient implementation for the data acquisition transmission, processing, analysis and other functions. The system is composed of a self checking program and a detection procedure. The self-test program is composed of a power self test module, a light source, an image acquisition board and a full system self-test module, which is shown in Figure 10. The testing program is composed of a reference processing module, a main field of view processing module, a sub field processing module, and a small field of view processing module, and the software flow of the laser axis calibration device is shown in Figure 11.



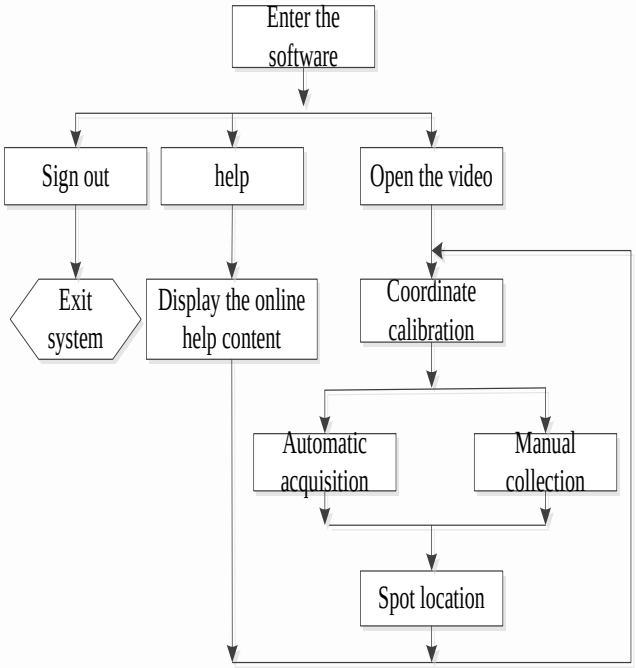


Fig.10 self-test program flow chart Fig. 11 software process of laser axis calibration device

The software design the coordinate calibration module, using the image tool to generate the coordinates X, Y axis. Automatic acquisition module can collect the laser spot image in time sequence. Manual sampling is a single collection of current real time laser spot image. After the completion of coordinate calibration and image acquisition, the software of the three positioning operation results of the statistical average, calculate the coordinates of the laser spot center, the error value [8-10], if the error value exceeds the technical requirements, it is necessary to adjust the installation of laser transmitter.

5. Summary

The design of the laser detector consists of consecutive video capture technology, bridge rectifier method, integrated operational amplifier circuit design and software and self detection module design. The overall design of the system's modular, intelligent, simple, improve the efficiency of the equipment detection. The laser measuring instrument is full, practical and reliable, and the system is safe and reliable. It has good guidance for the detection and maintenance of large scale equipments such as missile and so on.

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