Journal of Physics: Conference Series **1449** (2020) 012129 doi:10.1088/1742-6596/1449/1/012129

Design of a testing system for dynamic arming time of clock mechanism in fuze safety system

WEI Yawei[1], LI Haojie

[1]School of Mechanical Engineering, Nanjing University of Science and Technology, Nanjing, 210094, China

Abstract: In view of the fact that the specific time of arming can not be obtained when testing the arming of fuze safety system at home and abroad at present, and there are some problems such as cost and repeatability, a testing system based on the dynamic arming time of fuze safety system is proposed. In this system, the mechanical signal is transformed into electrical signal by micro switch, laser and photodiode, and the millisecond level accurate timing of dynamic arming time of fuze safety system is realized. Through the design of start, timing, stop modules and display modules, the calculation and display functions of the actual arming time of fuse components after dynamic simulation are completed. The test and data analysis show that the measurement accuracy of the test system is high and the error is small, which meets the accuracy requirements.

1.Introduction

Fuze is the terminal damage control system of ammunition. The dynamic arming time of fuze safety system has a very important influence on the safety distance of fuze [1,2]. In the fuse safety mechanism, the clock mechanism is a very important typical mechanism widely used in the rotating projectile. There are two main methods of arming test. 1. Dynamic test: install the fuze on the shell, use the gun to aim at the target plate for launching, and judge whether the arming has been cancelled at a predetermined distance by whether the shell has exploded or not. The disadvantage of this method is obvious, because one experiment can only determine whether the insurance is released at a specific distance, so the cost is high, and the specific time and distance of the insurance can not be obtained. [3] 2. Simulation test method: the main instrument used in the simulation test method is the centrifugal test machine. The fuze safety system is installed on the test bench of the centrifugal test machine, and the safety mechanism rotates with the test bench, so as to simulate the centrifugal force of the shell after it is discharged. After the test, disassemble and observe whether the fuse has been disarmed. The advantage of this method is that the specific projectile speed corresponding to the arming can be obtained, and because there is no need for live ammunition, the cost is low. However, this method also has some disadvantages. It can't get the exact time of detonator alignment and the specific time of releasing the insurance. Based on the above problems, this paper proposes a laboratory test system based on the dynamic arming time of centrifuge fuze safety system.

2.Working principle of test system

2.1. Working principle of delay arming mechanism of clock and watch in fuze safety system

The safety system of the fuze measured by the test system adopts a clock delay arming mechanism. Its structure is shown in Figure 1:

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

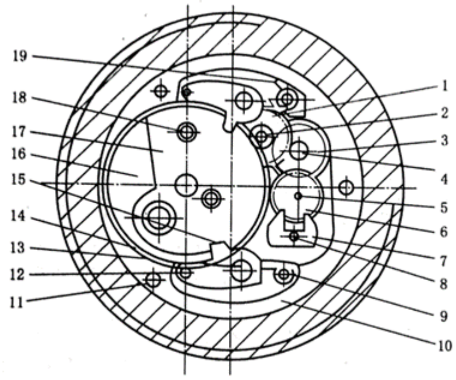


Fig. 1 delay arming mechanism of fuse clock

As shown in the figure above, its working principle is as follows: before the projectile is launched, the rotor equipped with detonator is constrained by both centrifugal claw and recoil pin and cannot rotate. At this time, the detonator and explosion sequence are staggered, and the projectile is in safe state. After the projectile is launched, the linear inertial force acts on the recoil safety pin, and the recoil safety is released first. Under the action of centrifugal moment, the centrifugal claw overcomes the resistance of its own torsion spring to rotate and release the rotor. The rotor equipped with detonator starts to rotate under the action of torsion spring. Due to the action of slip pendulum and riding wheel in the clock mechanism, the rotation is relatively slow, which can ensure that the safety of the projectile will be released after flying out a certain distance. After a certain period of time, the rotor turns to be normal, the detonator in the rotor is aligned with the explosion sequence under the rotor, and the fuse is disarmed. [4 ~ 6]

2.2 timing principle of test system

As shown in Figure 2, the timing system of the test system mainly sends the start signal to the single-chip microcomputer through the starting device, and the timer in the single-chip microcomputer starts timing, and displays in real time through the display device. When the MCU receives the stop signal sent by the stop device, the timing stops and the test ends. The key part is to design start device and stop device.

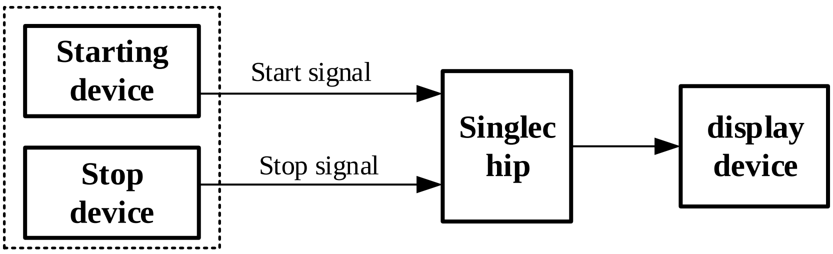


Figure 2 timing principle of test system

The starting signal of the starting device can be as follows: the release of the centrifugal claw is used as the start of the timing system and the removal of the recoil pin is converted into a level change and transmitted to the single chip microcomputer as the signal of timing start. After analysis, the centrifugal claw can be opened when the rotating speed of the centrifugal testing machine is low, and there is still a large gap between the rotating speed at this time and the rotating speed when the shell is launched, which will cause the timing junction If there is a big error. So choose the latter as the start signal source.

When the stop device sends out a signal, it means that the detonator is aligned with the explosion sequence, that is to say, the round hole filled with the detonator on the revolving body is turned to the designated position, so the light emitting device and the photosensitive element can be respectively installed on the top and bottom of the designated position, so as to achieve the purpose of transforming the safety release into an electrical signal and sending it to the single chip microcomputer. The specific installation and working principle are shown in Figure 3 below. When the laser beam irradiates the middle test piece, a small hole is left on the test piece and the detonator to ensure that the laser source can pass through. The detonator can rotate around the rotation axis on the central wheel. In the initial state, there is an included angle between the hole diameter of the detonator and the hole diameter of the test piece, that is, when the center of the detonator and the test piece is not coincident, the laser beam cannot pass the detonator on the central test piece, and there is no induction on the photosensitive device. When the detonator turns to the center of the middle test piece, the laser beam passes through smoothly, irradiates the photosensitive device below, transmits a level signal, and causes the single chip microcomputer to stop timing.

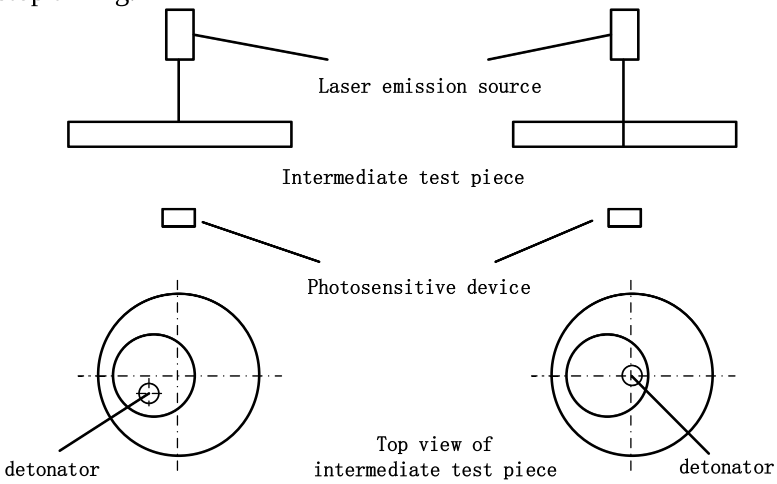


Fig. 3 Schematic diagram of working principle of installing light emitting device and photosensitive device

3.Test system design

According to the above working principle, the designed test system mainly includes: the overall design of the system, the design of each module of timing circuit and so on. The workflow of the test system is shown in Figure 4:

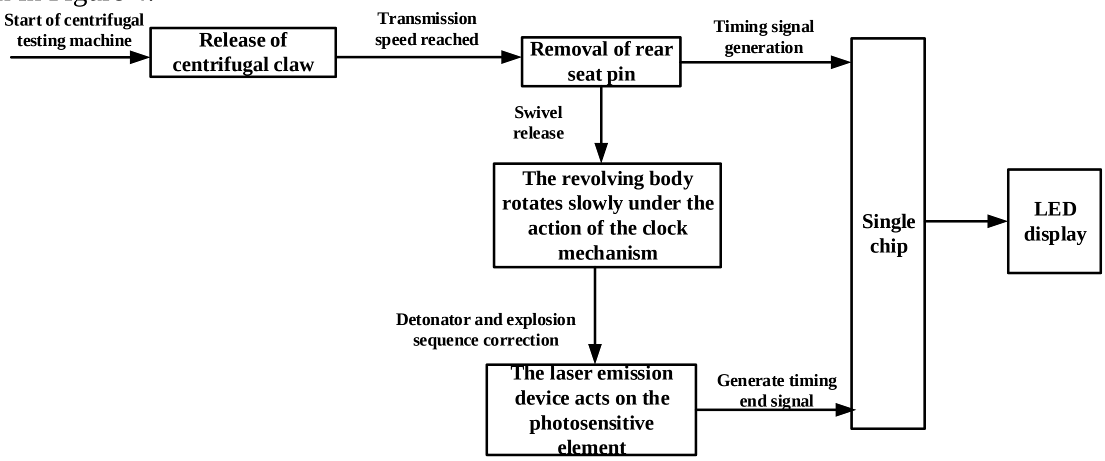
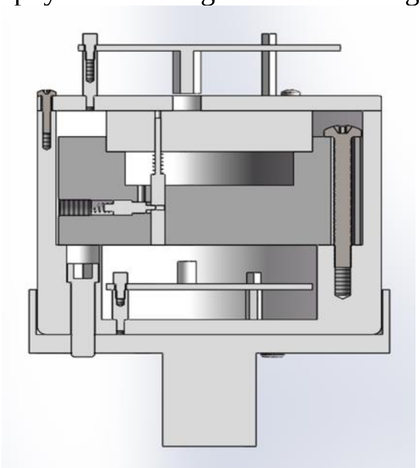


Figure 4 workflow of test system

3.1. System overall design

According to the principle of the timing system in the above process and the workflow of the test system, the overall structure of the system is designed, mainly including the design of various parts and components, as well as the determination of the relative position of each module. The overall assembly drawing and physical drawing are shown in Figure 5 and Figure 6.



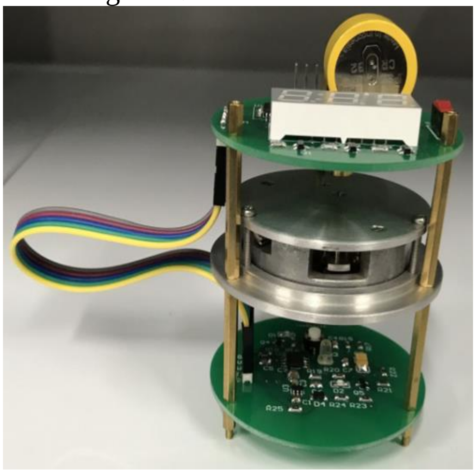


Figure 5 overall assembly diagram of test system   Figure 6 assembly diagram of test system

3.2 module design of timing circuit

The timing circuit is composed of 7 modules, including power module, voltage reducing and stabilizing module, laser driver module, photodiode amplifier circuit module, backseat switch module, MCU module and nixie tube display module. The structure of the circuit is shown in Figure 7. The power supply module is 12V power supply, which supplies power for the whole circuit; the step-down voltage stabilizing module is used to reduce 12V voltage of the power supply to 3V low voltage, which is used to drive the laser driver module, photodiode amplifier circuit module, recoil switch module, single chip microcomputer module and nixie tube display module; the laser driver module can provide stable input voltage and current for the laser, so as to prevent the laser from being flushed The function of the photodiode amplifying circuit module is to realize the conversion of the mechanical node of the safety system to the electrical signal; the function of the backseat switch module is to convert the mechanical node of the safety system to the electrical signal; the single-chip microcomputer module is used to accurately record the time between the two electrical signals; the digital tube display module is used to display the timing results in real time Show.

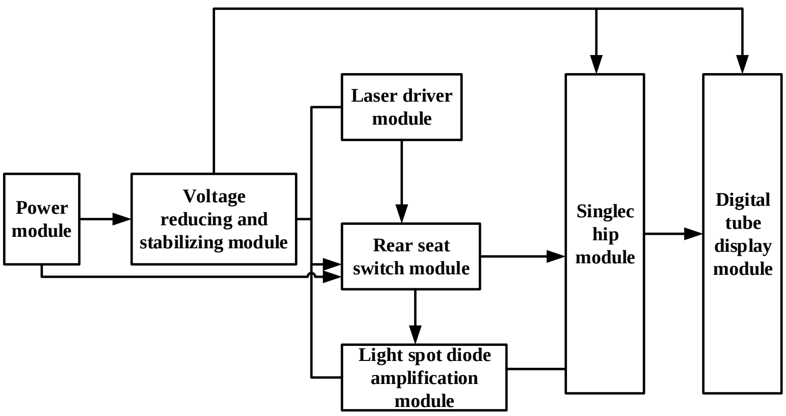


Figure 7 circuit structure of time test system

The physical figure of the circuit diagram is shown in Figure 8 and Figure 9.

Figure 8 front view of upper circuit board Figure 9 schematic diagram of lower circuit board

4. Test test and data analysis

In order to verify whether the measurement accuracy of the test system meets the requirements of milliseconds, as shown in Figure 10: connect the start device terminal and stop device terminal of the circuit part with the 1 and 2 interfaces of the oscilloscope. Use an oscilloscope to measure the time difference between the falling edge generated at the start device end and the rising edge generated at the stop device terminal, and compare with the result measured by the timing system. In this experiment, the timing system test device is used instead of the timing system. The button switch is used to simulate the impact of the rear seat pin, and the light source is shielded manually to simulate the stop switch state.

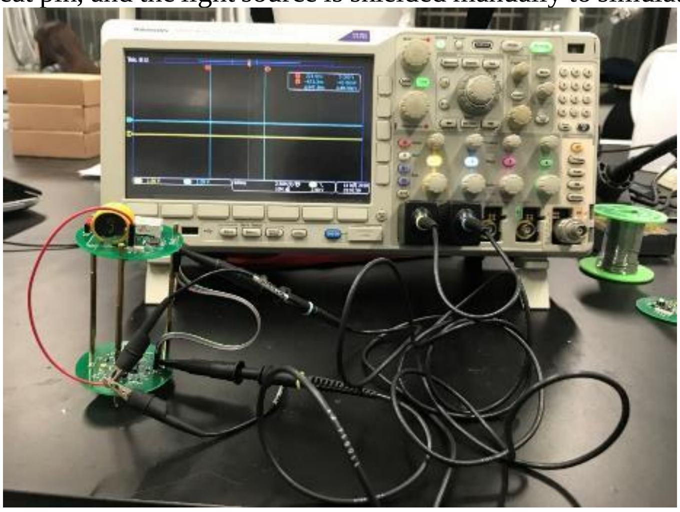


Figure 10 test experiment wiring diagram

Since the arming time of fuze safety system is generally 50-80ms, and in order to ensure the universality of time test system for other time periods, the number of measurement groups in each time period is arranged as follows:

1) 1-50ms 3 groups;
2) 10 groups of 50-100ms;
3) 100-500ms 5 groups;

The results are shown in Table 1;

Table 1. measurement results and errors of test experiment

Test measurement results (ms)	Oscilloscope results (ms)	Absolute error (ms)
21	21.800	0.8
32	32.400	0.4

49	48.600	0.4
57	56.800	0.2
62	61.400	0.6
68	68.000	0.0
71	71.200	0.2
77	76.600	0.4
80	80.800	0.8
83	83.400	0.4
94	94.200	0.2
97	97.000	0
99	98.200	0.2
127	127.40	0.4
239	238.60	0.4
315	315.80	0.8
392	392.20	0.2
481	481.80	0.8

Compared with the real result read by the oscilloscope, the absolute error is shown in Figure 11:

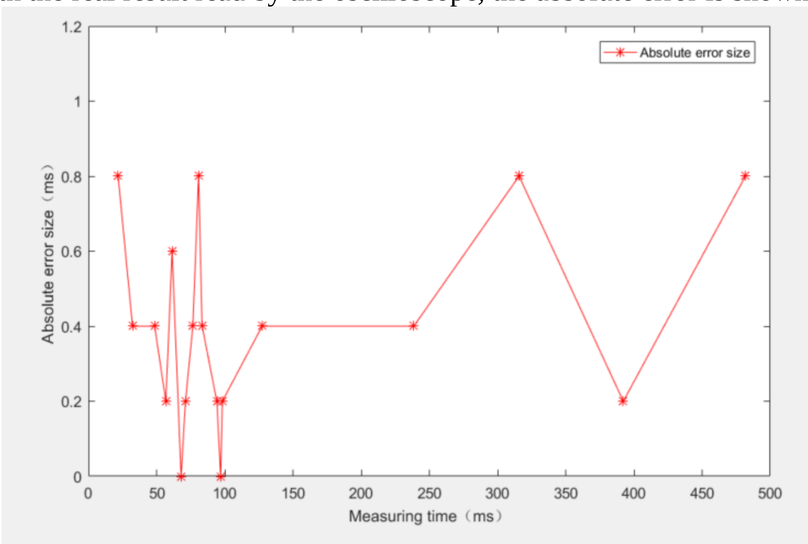


Figure 11 absolute error diagram of measurement results of test system

It can be seen from the figure that in the measurement time range of 500ms, the absolute error of the measurement result is 0.8ms at most, less than 1ms. Within the allowable error range, the measurement value of the test system meets the test function and performance requirements.

5. Conclusion

In this paper, a test system based on the dynamic arming time of fuze safety system is proposed. The system overcomes the problems of high cost in the test method of general fuze arming and can not get the specific arming time. It has the advantages of low timing cost, high timing accuracy and strong universality. Through the design of start device and stop device, the overall structure of the test system is determined. The design of each module of the circuit and the software programming realize the precise timing of the single chip microcomputer and the real-time display of the display module. The experimental test and data analysis show that the system realizes the millisecond level accurate timing of the dynamic arming time of the fuze safety system, and the system is easy to operate, easy to realize and has high practical value.

References

[1] GJB / Z135-2002 fuze engineering design manual [S]. Beijing: Military Standard Publishing and Distribution Department of general equipment department, 2002
[2] Qi Xiaohong. Test method of muzzle safety distance when the fuse is released or detonated [J], Journal of detection and control, 2010,32 (3): 6-9
[3] Wu Xiaoying, Zhang Wanjun, Yang Yuying. Optimization design of the dynamic test method for the safe distance of programmable electronic time fuze [J], guidance and fuze, 2009,30 (1): 1-5
[4] Zhang He, Li Haojie. Fuze mechanism [M]. Beijing: Beijing University of Technology Press, 2007. 114-126; 131-133
[5] Zhao Mingyu. Simulation of the time of Delayed Arming of clock mechanism [J], Journal of Sichuan industry and technology, 2013.34 (8): 64-65
[6] Chen Dongbo. Design of safety and arming mechanism and control circuit of rocket penetration fuze [D]. Nanjing University of technology, 2009.21-47