Compact Optoelectronic System for Velocimetry Using Vitual Instrument

Mengyao Li , Fengchun Sun, Hongwen He

School of Mechanical Engineering, Beijing Institute of Technology, Beijing 100081, China

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Abstract: We have built a optoelectronic velocimeter that has proven to compact, easy to operate, and fairly inexpensive. The main components are off-the-shelf Optocoupler and High-sample-rate digitizers, The maximum velocity of this system is up to 1000m/s and is limited by the Response frequency of optocoupler. The system measures the Time of Flight with resolution of 1usec. For most application, the data of two-channel voltage is analyzed using correlation method, which determine the final velocity time history. The system allows multiple velocities to be observed simultaneously. We have obtained high-quality data on many experiments.

1 Introduction

In recent years, instruments and equipment for measuring the velocity of high-speed objects have developed rapidly. There are mainly two methods to measure the velocity of high-speed objects: time interval device measuring method and radar velocity measuring method. The currently used velocity measuring radar generally adopts the continuous wave reflection Doppler velocity measuring system, however, the radar velocity measurement structure is complex, the equipment is huge, the price is expensive, and it is not suitable for the measurement of the velocity of objects in the fixed track. In addition, there are photometric method, extrapolation method, missile load sensor, geomagnetic meter revolution method.

The principle of measuring the muzzle velocity of a projectile with a zone cutting device is to measure the time (t) when the projectile flies over a known distance (s).By the formula $v = s / t$, The average velocity of a given distance can be obtained. Zone cutting device is the key equipment in the average velocity measurement system. It is set on the object after the fixed channel period, when objects through it, you can generate the beginning and end of the tunnel section signal (the length of the object itself can be used as the distance between the start and end point), with the starting point and end point signal timing control device, can get the object in the passage of time.

Since this system is used to measure the velocity of multi-channel high-speed running objects, the distance between the multi-channel track velocimeter tubes is very small. Therefore, the method of measuring the velocity of projectile mentioned above, when used for the measurement of multi-channel high-speed objects, has several disadvantages that are difficult to overcome: high cost; Large volume, not conducive to installation; The accuracy is not high, and easy to damage, can be replaced poor; Complex system, manual operation is not easy.

Optoelectronic technology is a new and high technology that combines traditional optical technology with modern microelectronic technology and computer technology. It is an important means to obtain optical information or extract other information, such as speed and displacement, with the help of light. At present, optoelectronic technology has penetrated into many scientific fields and developed rapidly. Optoelectronic sensor is a kind of device which converts optical signal into electrical signal. Its physical basis is the optoelectronic effect. It is widely used in modern measurement and control system. Optoelectronic switch, as a basic optoelectronic device, It has been widely used in military and civil fields due to its advantages of quick response, simple structure and high reliability. In this paper, optoelectronic switch is used to measure the velocity of opaque objects passing through fixed orbit at high speed. This paper mainly introduces the system design of using optoelectronic switch as detection source to measure the velocity of high-speed

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objects and the selection and test of main parameters of the optoelectronic switch. The design is practical and anti-interference, and the whole system is easy to operate and can be popularized.

2 System Design

2.1 Scheme Introduction.

In this test system, each orbit (a total of 4) is composed of a diffuse reflection optoelectronic switch. When an object flies over the orbit, the light emitted by the transmitter shines on the surface of the object and reflects on the surface. Part of the reflected light is detected and received by the receiver in the optoelectronic coupler, which converts the optical signal into an electrical signal and generates a optoelectronic current. Because its intensity is related to the detection distance and the surface reflectance of the detected object, it produces a changing electrical signal. The moment when the projectile flies past the optoelectronic couplers in the barrel can be measured, and The time difference (t) between the signal change (i.e. from high level back to high level) of the object flying over each optocoupler can be calculated, Given the length l of each object in each orbit, we can use the formula $v = l/t$ to calculate the velocity v.The overall structure of the designed system is shown in figure 1:

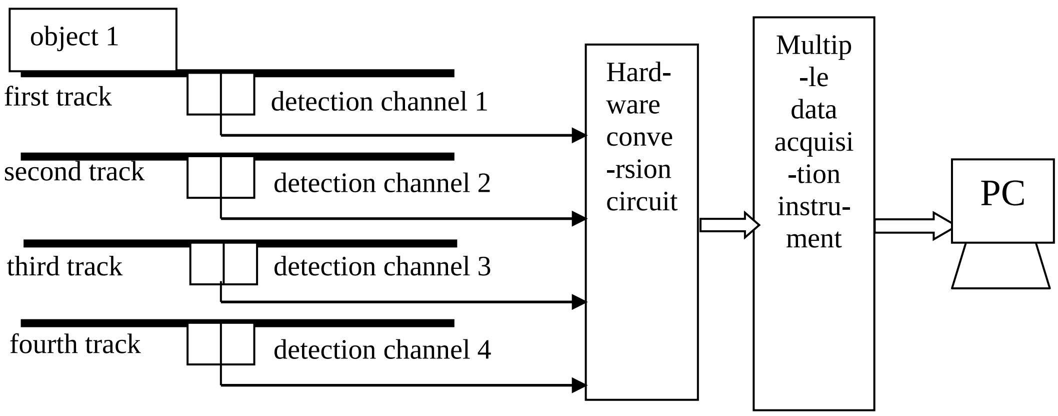

Figure1 system overall structure diagram

In the illustration, when the measured object passes from the track (ie, from left to right), it passes through an optocoupler in each track, because the receiving end of the optocoupler can receive the surface reflection from the emitting end The light coming back turns on the Darlington tube, so the electrical signal output from the output changes (from high to low). The data acquisition instrument collects the signal and transmits it to the computer, records the sampling timing and the sample value, so that the object speed can be calculated.

2.2 Detector Selection.

The main component of photodetection is optocoupler, optocoupler is optical coupler (abbreviated as OC), also known as opto-isolator. It is a semiconductor optoelectronic device developed in recent years. The optocoupler generally consists of three parts: light emission, light reception and signal amplification. The input electrical signal drives a light-emitting diode (LED) to emit a certain wavelength of light, which is received by the photodetector to generate a photocurrent, which is further amplified and output. This completes the electro-optical-electrical conversion, thereby functioning as input, output, and isolation. The main structure of the photocoupler is to assemble the light-emitting device and the light-receiving device in a closed casing, and then use the pin of the light-emitting device as an input terminal and the pin of the light-receiving device as an output terminal. The light emitting device emits light when a signal is applied to the input. Thus, the light-receiving device generates a photocurrent after illumination due to the photosensitivity effect and is outputted from the output terminal. There by, the electrical signal transmission with "light" as the medium is realized, and the input and output ends of the device are electrically insulated. This constitutes a novel semiconductor electronic device that transmits signals in the middle through the light.

According to the design requirements of the system, the optocoupler is a triode output optocoupler SPI-315-05. The internal structure is shown in Figure 2. SPI-315-05 is a diffuse reflective optocoupler that is a sensor that can be used for contactless measurement. It places a light-emitting diode and a Darlington tube on the same end face and is isolated from each other by a transparent insulator with no reflectors in front. Under normal circumstances, the light emitted by the LED is not received by the phototransistor; when an object approaches the probe, the beam emitted by the LED is reflected to the light receiving surface of the triode, the optocoupler is responded, and the output signal is logically inverted. For example, the output transitions from low to high. The optocoupler is characterized by high input and output insulation performance and high response speed. The main performance parameters of SPI-315-05 are: LED forward voltage drop is 1V; forward current is 50mA; collector-emitter reverse breakdown voltage is 20V; collector-emitter saturation voltage drop is 1.2V; The response speed is 100μs. Its volt-ampere characteristic curve is shown in Figure 3.

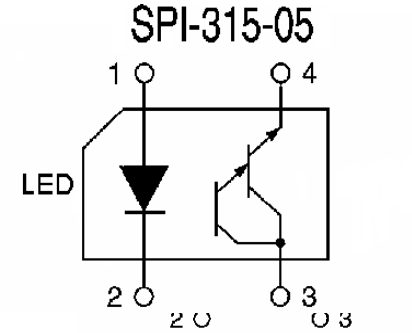

Figure 2 SPI-315-05 internal structure diagram

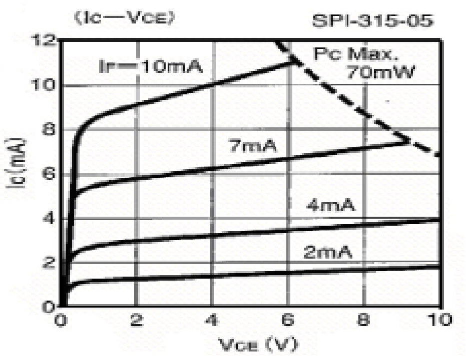

Figure 3 SPI-315-05 volt-ampere characteristic curve

Throughout the measurement process, the Darlington tube functions to discover optical signals, receive optical signals, generate electrical signals, and amplify them to provide data for subsequent data acquisition. Therefore, when verifying whether an optocoupler meets the requirements of the system, the response speed of the Darlington tube becomes a crucial parameter. In addition, the distance between the surface of the optocoupler and the reflecting surface of the projectile is also an important factor affecting the size of the output signal. Therefore, the optocoupler must be screened for the response speed and position characteristics of the optocoupler.

Fix the optoelectronic conversion circuit on the wall, use the laser range finder to give the optical switch receiver an optical signal, and see if the response of the optoelectronic switch reaches the required value under the oscilloscope. The test result is shown in Figure 4. The theoretical response time is 7 microseconds, which can meet the system requirements. As can be seen from Figure 5, the optimal reflection distance is 0.8mm, because it is better to design the device to have a distance of 0.8mm from the surface of the object. The resulting signal works best.

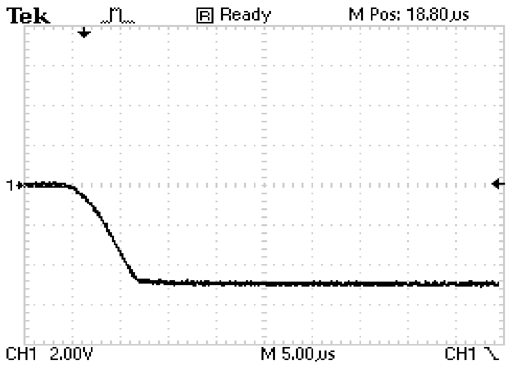

Figure 4 Response waveform of the optocoupler

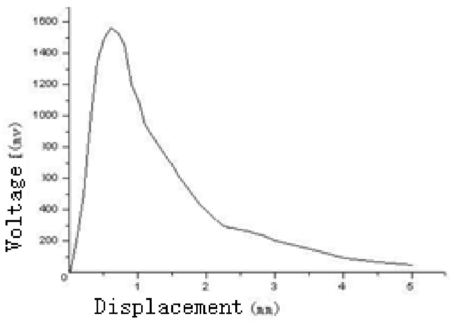

Figure 5 Position characteristic screening experiment curve

2.3 Design of Data Acquisition System.

In this design, a four-channel data acquisition card is used to form a data acquisition system. Because the designed detection system consists of four optoelectronic switches, each photoelectric switch occupies one output signal, so the data acquisition card requires at least four channels. The length of the rough object is 200mm, and the maximum speed does not exceed 100m/s, so the length of time passing through the detector is t=15 microseconds, so the theoretical sampling rate required is 100k. Therefore, to ensure the acquisition rate, the acquisition rate needs at least 200K.

The data system collection works as shown in Figure 6.

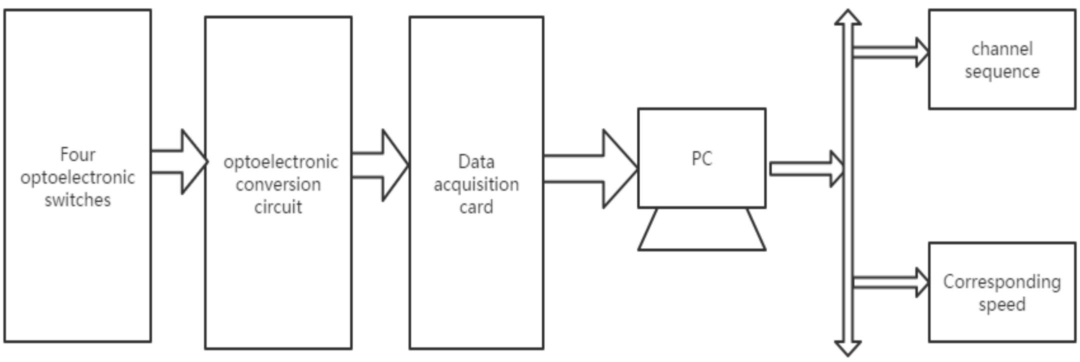

Figure 6 data acquisition system working principle diagram

2.4 Software Design.

Build a virtual instrument system, after the basic hardware is determined, you can implement different functions through different software. Software is the key to virtual instrumentation systems. In the development and promotion of virtual instrument programming technology, the first national instrument company (NI), LabWindows / CVI. This programming language is a virtual instrument programming technique based on C language.

The data acquisition process of the test system under LabWindows/CVI programming software is shown in Figure 7.

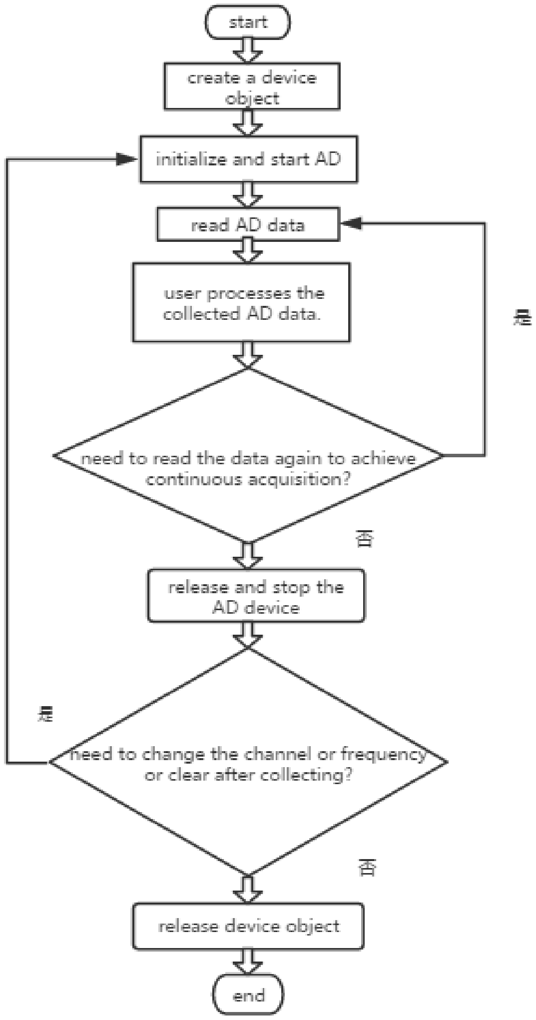

Figure 7 data collection flow chart

By reading data from the data acquisition instrument, the data can be rendered, processed, and calculated. Find the point at which the voltage changes (from the high-level falling moment and back to the high level). Because the object may be irregular, the voltage change is not as flat as a rectangular wave. Find two points, and then measure the length l of the object, you can calculate the velocity of the object motion in the track $v = l / t$.

3 Test Results

The following is a channel waveform diagram of the simulation test，The waveform is shown in Figure 8.

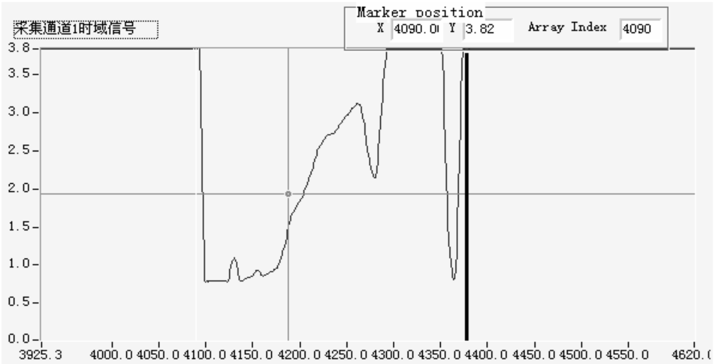

Figure 8 waveform diagram

As can be seen from the time domain diagram, the total number of points collected is: $4380-4090=290$, and the set sampling rate is 2k, so the time taken for the object to completely pass the detector is: $t=209/2000=0.1045\,s$,The length of the object used for simulation is $l=20cm$ .Therefore, the average velocity of the object in the fixed orbit can be calculated as: $v=l/t=1.9m/s$.

4 Conclusion

In recent years, instruments and equipment for measuring the velocity of high-speed objects have developed rapidly. But there are all kinds of shortcomings, such as complex structure, huge equipment, high price, and poor replacement. At present, optoelectronic technology has stepped into many scientific fields. The above system defects can be overcome by using photoelectric switch as the detection source for non-contact velocity measurement of high-speed objects in a fixed orbit. The design is practical, low in cost, strong in anti-interference. the velocimeter is easy to operate and can be popularized.

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