Projectile wireless setting and Mechanical testing technology

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Abstract. This paper discusses the mechanical testing technology used in the wireless setting system of projectile, mainly including sensor, signal processing, system analysis, error analysis and data processing theory. The circuit simulation and system analysis are carried out by using Multisum, and the magnetic field simulation is carried out by using CST. The wireless setting scheme based on electromagnetic induction is designed, and the scheme is analyzed and improved. Finally, the data of range and firing angle of the projectile in high-speed motion can be set quickly.

1. Introduction
Mechanical testing technology is widely used in engineering testing, involving signal description, basic characteristics of measurement system, common sensor technology, signal conditioning and recording, signal analysis and processing, engineering application of testing technology, computer testing technology and virtual instrument[1]. Modern mechanical test technology is widely used in weapon test system. It systematically discusses various conventional process parameters in modern weapon test field, such as force, temperature, speed and power, flow and velocity, as well as relevant mechanical parameters, such as displacement or position, vibration and noise[2].

Wireless setting system is actually equivalent to a channel of information or energy transmission. At present, it is mainly used in two fields, one is wireless communication, the other is wireless power supply. Projectile setting refers to sending target data, such as projectile muzzle velocity, target distance, firing angle, temperature, humidity, air pressure and other information that affect projectile flight factors to electronic fuze before and after launch. The purpose of projectile setting is to control the ammunition to detonate at the best position, time and direction relative to the target, reduce the preparation time when firing shells, and increase the mobility of artillery. At present, there are electromagnetic induction setting, radio frequency setting, magnetic coupling resonance setting, laser setting and so on[4]. The whole process of wireless setting is shown in Figure 1.

2. Sensor technology in wireless setting
The traditional fuze setting is manual setting, and the explosion time is controlled by the knob. The purpose of wireless setting is to control the ammunition to detonate at the best position, time and direction relative to the target, reduce the preparation time when firing shells, and increase the mobility of artillery. At present, there are electromagnetic induction setting, radio frequency setting, magnetic coupling resonance setting, laser setting and so on[4]. The whole process of wireless setting is shown in Figure 1.
The setting information is converted into electricity by various sensors, and then collected and processed by the controller, sent to the setting device for data processing, such as amplification, modulation, and then transmitted to the wireless transceiver devices, such as coils, antennas, and the electronic devices on the fuze. After receiving the information, the signal processing, such as filtering, analog-to-digital conversion, is carried out, and then transmitted to the fuze controller. The controller synthesizes the input information to control the fuze.

In the wireless setting system, the information acquisition device needs to measure the physical quantities that affect the ballistic factors, such as wind speed, air pressure, temperature and humidity, and also needs to transmit the information of firing angle, target distance and so on. Wind speed measurement uses a wind sensor, which is composed of a small DC brush motor and a three cup rotating wind speed cup. The principle is that when there is horizontal flow wind in the environment, the rotating wind cup can rotate and drive the small motor to generate voltage. The generated voltage is proportional to the rotation speed, that is \( U = kv \), after the voltage signal is generated, the voltage signal is converted into a \( \text{a/d} \) signal. Generally, the range of voltage collected by the controller is 0V-3.3V, but the signal collected by the wind speed sensor is not in this range. Therefore, voltage stabilization and rectification should be carried out, either by adding an analog-to-digital conversion chip or by using an external voltage stabilization chip. After the voltage is converted to 0V-3.3V, the wind speed can be measured.

Air pressure sensors are often combined with temperature and humidity sensors to compensate and self-calibrate the altitude, humidity and air pressure. Inside the humidity sensor is a capacitive humidity sensor. The permittivity of dry air is very different from that of wet air. By comparing the permittivity of current air with that of standard air, the humidity of current air can be measured. The capacitance sensor is generally used to measure the dielectric constant. Firstly, the charge of the capacitor is measured when the vacuum is between two plates. The charge of the capacitor is measured by adding dielectric between plates with the same distance between plates. Then the relative dielectric constant can be calculated by formula.
\begin{equation}
\varepsilon_r = \frac{C_r}{C_0}
\end{equation}

When the humidity changes, the dielectric of the capacitive sensor changes, and the amount of charge at both ends of the capacitor will change. Detecting the amount of charge of the capacitor can detect the humidity in the air.

The temperature sensor generally has contact type and non-contact type. In the wireless setting system, the contact type is generally used, that is, the temperature sensor, such as thermistor, is used for temperature measurement. The calculation formula of resistance value of resistance strain gauge sensor is as follows.

\begin{equation}
R = \rho \frac{L}{A}
\end{equation}

It can be divided into two kinds: one is to use the nature of metal's thermal expansion and cold contraction to change the resistance after deformation, the other is to use the change characteristics of semiconductor's resistivity with temperature. Whether it is metal or semiconductor, the change is linear, so the temperature value can be measured by using the linear relationship.

![Fig. 3 air pressure sensor](image)

Acceleration sensors are used to measure the velocity of projectile. Modern acceleration sensors all use micro mechanical structure, as shown in Figure 4. There are two comb shaped electrodes in the accelerometer. When the acceleration changes, the acceleration can be detected by charging and discharging between the capacitors.

![Figure 4 acceleration sensor](image)

3. Signal processing in wireless setting

After data collection, the information needs to be processed and sent. Using the way of electromagnetic induction, the single information transmission is carried out first, the target distance is given to the fuze, the distance information is calibrated with the signal frequency, and the targets with different distances are converted into sinusoidal signals with different frequencies.

Firstly, the frequency of the AC signal is controlled by the controller, and the frequency component of the signal represents the explosion distance. After the AC signal is amplified by the voltage amplifier, after passing through the power amplifier, the function of the power amplifier is to output a large current and enhance the magnetic field strength of the coil. At this time, the receiving coil will generate the induced electromotive force.
According to the calculation, the induced signal should be the differential of the original signal, and the coil is a differential link in the circuit system. If you want to restore the original signal, you should add an integrator behind the coil, but because the transmission is sinusoidal signal, the signal after integration or differentiation is sinusoidal signal, so there is no need to add additional signal operation circuit. Because the induction signal is relatively weak, the signal is amplified before signal processing, and then filtered after the amplification circuit. Because high temperature will be generated when the projectile is launched, and the high temperature will ionize the air and produce complex electromagnetic field, the received signal not only emits the signal of the radiation circle, but also has the interference signal in the environment, so it needs to be filtered.

4. Improved wireless setting design
According to the calculation, the induced signal should be the differential of the original signal, and the coil is a differential link in the circuit system. If you want to restore the original signal, you should add an integrator behind the coil, but because the transmission is sinusoidal signal, the signal after integration or differentiation is sinusoidal signal, so there is no need to add additional signal operation circuit. Because the induction signal is relatively weak, the signal is amplified before signal processing, and then filtered after the amplification circuit. Because high temperature will be generated when the projectile is launched, and the high temperature will ionize the air and produce complex electromagnetic field, the received signal not only emits the signal of the radiation circle, but also has the interference signal in the environment, so it needs to be filtered. Because it only needs to check the frequency of the signal, and the requirement for amplitude is not high, the sinusoidal signal is converted into square wave signal through the comparator, and then transmitted to the fuze interrupt controller for frequency calculation, and the calibration results are written into the controller in advance, so as to complete the distance setting.
Finally, the restored signal is input to the controller, and the controller calculates the frequency and duty cycle of the signal. According to the calculated frequency and duty cycle, the corresponding firing angle and target distance are calculated.

5. Conclusions
The design of wireless installation system is closely related to mechanical testing technology, involving many fields of mechanical testing such as sensors, signal processing, etc. in order to make the wireless installation system more suitable for the modern war, its development trend can be considered from the following aspects, (1) Improve the efficiency of energy conversion. In addition to the location information of the fixed target, the wireless positioning system also needs to install information that affects the ballistic factors. The energy conversion efficiency is the main factor affecting the installation distance. The increase of the installation distance makes the system installation time longer and can transmit more information. (2) The coding algorithm is optimized. The coding technology mainly affects the wireless fixed information transmission rate. The coding algorithm not only requires fast encryption transmission, but also has high fault tolerance and stability. (3) Improve the installation mode with communication technology. The innovation of wireless installation technology is closely related to the development of communication technology. The innovation of wireless installation technology is closely related to the development of communication technology.

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