Infrared Target Generator Development Technology

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Abstract. The integration of air and space and information warfare has become the main development trend of future military battlefields. Infrared target simulation technology is the key supporting technology for space-based infrared early warning system and photoelectric imaging precision guidance system research, which can provide basis for its research and development and upgrade. Technical Support. This paper introduces the domestic and international development of the infrared target scene generator of the core component of infrared target simulation technology.

1. Introduction

In recent years, air and space integration and informationized operations have become the main development direction of military battlefields. Through space-based early warning systems, airspace targets can be detected, identified and tracked, and aerospace strategic defense systems can be constructed to make navigation more accurate and more effective. Accurate and thus more effective in acquiring the battlefield situation. At present, the United States and other countries have used a large number of advanced military reconnaissance satellites to conduct reconnaissance of important military facilities and military mobilizations of hostile countries in an effort to gain an active position in the war.

The infrared target scene generator is the core technology of infrared target simulation technology. Firstly, the simulation computer provides various parameters of the target and background to the image generation computer, and the infrared target scene generator generates infrared signals, which are converted into corresponding frequency bands by the projection system. The infrared dynamic image is then supplied to the optical and sensor sections of the infrared seeker for detection and identification.

2. Infrared target scene generator

The infrared target scene generator is the core component of the infrared target simulation. The image generated by the computer image generator is converted into an infrared physical radiation signal by the infrared target scene generator, and then projected into the test system through the optical system to simulate the infrared scene for testing. The system performs detection and identification.

![Figure 1. Infrared target simulation technology](image-url)
infrared target scene generator can simulate the real target and the background with the characteristics of infrared radiation variation. The real simulation target characteristics can effectively evaluate the performance of the infrared imaging system, and can capture the tracking ability and the anti-interference ability test.

The infrared target scene generator is mainly divided into direct infrared radiation and radiation modulation. The direct radiation type refers to the image generator of the control generator generating radiation itself, and then generating infrared images through the radiation intensity of the controller, mainly including: a resistor array, a laser diode array, an infrared cathode ray light, and a Bly Cell. The infrared radiation modulation type is actually a spatial light modulator, which is controlled by a computer image generation system to spatially modulate the infrared radiation provided by the infrared light source, thereby generating an infrared image. The main technologies are DMD and LCLV.

3. Infrared target scene generator development

3.1. Direct radiation type infrared target scene generator

3.1.1. Resistive array infrared target scene generator. The resistor array generates infrared radiation through the current heating unit resistors. It is also possible to add large-scale micro-resistor arrays on the silicon wafer by CMOS or microelectronic technology. Each resistor unit becomes a separate pixel by applying different currents.

China: Xiao Yunpeng developed a 128*128 dynamic infrared target/scenario generator in 2006. The spectral range is 3μm~5μm and 8μm~12μm, the surface temperature is 297k~423k, the maximum frame rate is 700Hz, and the unit pixel temperature rise time is 1.1ms. The unit pixel temperature drop time is 0.3ms, and the unit micro-radiation body is mostly a multi-layer composite film structure, and the polysilicon heat-generating material is composited into a film, and the silicon substrate of the film surface is hollowed out to form an overhead bridge body mechanism. It is mainly used in infrared guided missiles. Later, Shanghai Institute of Technical Physics completed the development of the second generation 256*256 resistor array chip. Advance the development of the third generation 512*512 suspension thin film resistor array, improve the engineering, standardization and non-uniformity correction technology of the existing 512*512 resistor array, and develop the 1024*1024 resistor array device based on the third generation technology development [1].

![Image](image_url)

(a)128*128 resistor array analog image   (b)256*256 resistor array module

Figure 2. Shanghai Institute of Technical Physics develops resistance array

Foreign: The scale of foreign resistor array monolithic devices has been developed to 1024*1024 pixels, the output band range is 2~14μm, the gray level can reach 16BIT, the equivalent blackbody temperature of the output can reach 650K, and the frame rate reaches 200Hz [2].
3.1.2. BLY CELL infrared target scene generator. The BLY CELL infrared target scene generator absorbs visible light by using black metal plated on the upper layer of the film, which causes the film to generate heat and generate infrared images. When working in a vacuum environment, the resolution is related to the response speed and the degree of vacuum. The thinner the film, the faster the response. However, the film is too thin and its mechanical properties are affected.

China: Beijing Institute of Technology has designed and produced a new type of gold-black visible-light infrared image conversion film, which has the advantages of simple process, less environmental impact, simple structure, stable performance, high reliability and low cost. The design evaporates the metal black on the organic sinking bottom and puts it into the vacuum chamber. The left and right sides of the vacuum chamber are visible light windows and infrared windows respectively. The visible light with image information is incident on the film through the window, and the film absorbs the light energy to generate an infrared image. Its performance meets the needs of most simulation systems. At present, a thin film system with an emission spectrum of 2~12μm, a frame rate of 160Hz, a spatial resolution of about 256×256, a dynamic range of 147:1, and a fill factor of 68% has been successfully developed [3].

![Visible light infrared film conversion device](image)

Figure 3. Visible light infrared film conversion device

Foreign: The French Office National d'Études ET de Rechenches Aéros improved the Bly Cell structure by using a very thin nitrocellulose membrane covering the black gold-plated layer. When visible light is incident, it absorbs visible light and produces local heating [4].

3.1.3. IR-CRT infrared target scene generator. The principle and mechanism of the infrared cathode ray tube are similar to those of the television set. They have an electron gun and a light-emitting screen, and have a low frame rate and low radiation intensity, but need to be cooled during operation.

China: In 2001, the 211 Institute of Ordnance Industry, Yan Daiyi and others studied 8~12μm video/infrared conversion materials and found that a material has a strong emissivity in the 6.5~12.5μm band. Its field frequency is 50Hz, and the maximum temperature difference is simulated 264.7℃. Subsequently, the 256TVL long-wave IR-CRT prototype was successfully developed and put into use, with a frame rate of 50Hz and a temperature dynamic range of 362.7℃. Harbin Institute of Technology also developed an infrared imaging guidance simulation device using infrared CRT as an image source for the Third Academy of Aerospace, and developed a device suitable for multiple bands [5].
256TVL IR-CRT Infrared target scene generator

Foreign: In 2009, T. Simpkins replaced the cathode ray tube with a high-voltage CMOS chip and fabricated the thin film mirror into an array by MEMS technology, and developed a 200×200 pixel ultra-large-scale thin film mirror light modulator. The modulator has a compact structure and low power consumption. The biggest advantage is that it can cover the optical full band [6].

DMD Infrared Target Scene Generator. DMD technology is a patented product of Texas Instruments. Each pixel is a tiny lens. Each lens can adjust the intensity of the reflected light by controlling the deflection of the circuit. It can modulate the wider spectrum of light and has high image contrast. However, its processing technology is quite complicated.

China: In 2008, Jia Xin and Xing Tingwen from the Chinese Academy of Sciences proposed the design idea and optical parameters of dynamic infrared scene projection optical system based on DMD. The refraction diffractive hybrid long-wave infrared projection lens was designed by Changchun Institute of Optics and Fine Mechanics. The non-thermalized medium-wave infrared projection optical system; the Chengdu Institute of Optoelectronic Technology and the Xi’an Institute of Applied Optics. Designing a transmissive long-wave infrared projection optical system, which has the advantage of compact structure [7].

After 2010, Guan Yingzi of Harbin Institute of Technology, Zhang Kai, Sun Yiliang of Northwestern Polytechnical University and others successively proposed a DMD-based mid-wave infrared target source simulation system design scheme, and obtained some experimental data, which was subsequently designed for The medium-wave and long-wave infrared dual-band optical system.
uses a half-reverse half-lens in the system, which loses light energy and has low energy utilization [8-9].

In 2014, He Yongqiang and others of the Ordnance Engineering College used a set of DMD development kits with adjustable frame rate to simulate the scene of the domestic InGaAs short-wave infrared camera. The format of the DMD chip is 0.7XGA [10].

Foreign: In 2009, DAVID J. Mansur of OPTRA Company first developed the medium-wave dual-channel infrared target simulator. The following year, based on DMD technology, the dual-band mid-infrared target scene generator was developed. The projector uses two DMD, each channel corresponding to one band, and the resolution is 3.0–4.2μm and 4.2–5.0μm, the largest apparent The temperature is 510℃, the maximum refresh rate is 40Hz, the radiation intensity, resolution and bandwidth of the projector can meet the requirements of the measured unit for the duration of the field lens [11-13].

![Figure 6. Dual-band mid-infrared target scene generator](image)

3.2.2. LCLV infrared target scene generator. Infrared liquid crystal light valve can convert visible light image into infrared radiation image. It is mainly composed of visible light window, high resistance silicon, liquid crystal and infrared window. Its spatial resolution is high, the generated image is flicker free, but the frame frequency is low, and the spectrum of the analog image is the band is narrow, the temperature range is small, and the processing process is complicated and the manufacturing cost is high, so the application is less.

![Figure 7. Infrared liquid crystal light valve structure](image)
China: In 2002, Xi’an Institute of Applied Optics used GaAs infrared liquid crystal light valve to generate 3-5μm and 8-12μm dual-band dynamic infrared scene test. The AGEMA900 dual-channel infrared thermal image thermomter was used to output the output image of GaAs infrared liquid crystal light valve. Test, the effective aperture is φ43mm, the spatial resolution is 151p/mm, the frame rate is 30Hz, the highest analog equivalent blackbody temperature is 300°C in the 3-5μm band, and the highest equivalent blackbody can be simulated in the 8-12μm band. The temperature is 120°C.

In 2006, Liu Zhengyun of Beijing Institute of Technology optimized the design of liquid crystal light valve parameters to construct a dynamic infrared target scene generator, and measured its spectral output characteristics, time response characteristics and spatial resolution. The output spectrum of the simulation system can cover the medium wave and long wave infrared bands. The frame rate is 70Hz, and the system spatial resolution is better than 10lp/mm [14].

Foreign: The infrared liquid crystal light valve developed by Hughes Research Laboratory has been applied in Eglin Air Force Base, France and Japan. The main performances are as follows: frame frequency is 30-50Hz, temperature difference is 30°C, and spatial resolution is 5-20lp/mm. The dynamic range is 500:1 [15].

3.3. Special infrared target scene generator

In 2005, the Johns Hopkins University Guidance Laboratory established a standard semi-physical simulation system for the Aegis Ballistic Missile Defense System, which supports room temperature background and vacuum cold background simulation. In 2007, Thomas M. Cantey and others of Optical Science Corporation of the United States successfully developed a prototype of a hybrid laser array combined resistance array hybrid infrared scene conversion system to realize large dynamic range infrared dynamic image conversion [16-17].

Conclusions

This paper introduces the development of infrared target scene generator of the core component of infrared target simulation technology, including direct radiation infrared target scene generator and radiation modulation infrared target scene generator. The infrared target scene generators of array, BLY CELL and IR-CRT are introduced at home and abroad. The radiation modulation type introduces the domestic and international development of the infrared target scene generators of DMD and LCLV respectively. A brief introduction to the infrared target scene generator used in a special environment.

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