STUDY ON THE INFLUENCE OF CCD DETECTOR TEMPERATURE ON THE PERFORMANCE OF THE SPACE REMOTE SENSING CAMERA

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ABSTRACT:

The CCD detector is the core device of the space remote sensing camera. The performance of CCD detector greatly affects the performance of the whole remote sensing camera. The temperature of the CCD detector has a significant influence on its performance. In order to better study this influence relationship, the temperature impact verification of remote sensing camera detector was carried out. The test scheme of dark signal under high temperature environment and the test scheme of radiation calibration under different temperature conditions are developed. And the test verification was completed. Based on the analysis of the experimental data, the quantization relationship of the influence of temperature on the parameters such as dark signal, dark noise, dynamic range, noise and signal-to-noise ratio is obtained. These results have certain reference value for the development of space remote sensing camera.

1. INTRODUCTION

The CCD detector is the core device of the space remote sensing camera. The performance of CCD detector greatly affects the performance of the whole remote sensing camera. The temperature of the CCD detector has a significant influence on its performance. In order to study the influence of different temperature of CCD detector on CCD performance, a scheme of test verification was developed. According to the test scheme, the temperature impact test of 8192 pixel TDICCD detector was verified. The experimental results are analyzed, and the quantitative relation between the performance of CCD detector (dark signal, dynamic range) and temperature is obtained.

2. TEMPERATURE VERIFICATION TEST SCHEME OF CCD DETECTOR

The detector used is a linear array type TDICCD, the pixel size is 7um x 7um, the pixel number is 8192, and the maximum TDI stages is 96. In the experiment, the horizontal transfer frequency of TDICCD was 16.67MHz, the integral time was 1.05ms, and the quantized number was 14 bits.

Test the dark signals of TDICCD at different temperatures in the atmospheric heat cycle box. TDICCD and corresponding focal plane circuit and signal processing circuit are all placed in the normal pressure heat circulation box. The power supply, thermal control equipment and image acquisition equipment are placed outside the heat circulation box. During the test, the inside of the thermal circulation box is completely black (no light). The connection relationship of each device is shown in figure 1.

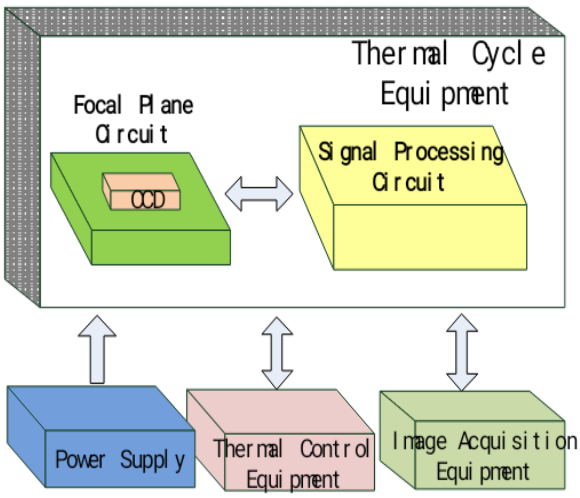

Figure 1. Test equipment connection.

Test temperature scope set to 30 ℃ to 15 ℃ ~ +. Temperature control precision is + / - 1 ℃. Every 5 ℃ set a test point. As small as possible. The heat preservation time of each temperature point is 15 minutes. The temperature of the CCD device is to be measured and the temperature is basically stable. FIG. 2 is the setting of test temperature and thermal insulation time. Figure 3 is the TDICCD, focal plane circuit and signal processing circuit participating in the experiment.

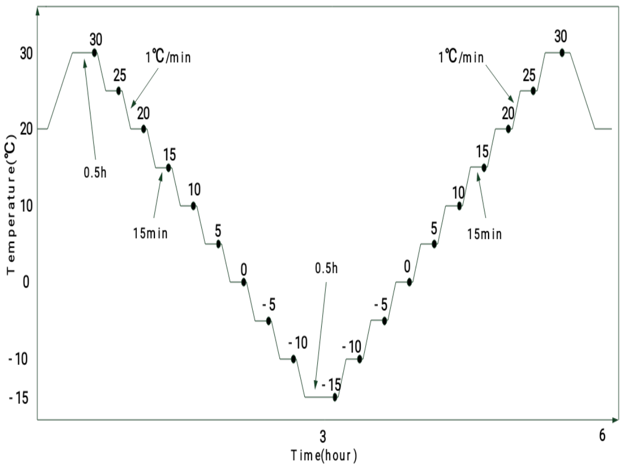

Figure2. The setting of test temperature and thermal insulation time

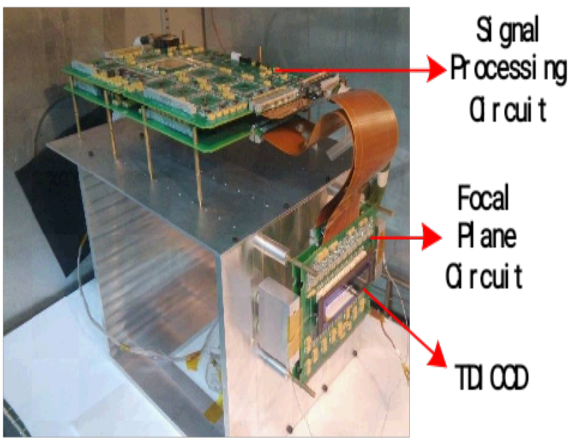

Figure 3. TDICCD, focal plane circuit and signal processing circuit participating in the experiment

The experiment is conducted according to the following steps:
(1) device connection, self-check, close the light source in the oven, block the CCD, and make the CCD completely black.
(2) by 1 ℃ / min heating rate up to 30 ℃, heat preservation after 0.5 h, electric equipment, collection and image.
(3) by 1 ℃ / min cooling rate of cooling to 25 ℃. After 15min heat preservation, the equipment is energized and the image is collected.
(4) by 1 ℃ / min cooling rate of cooling to 20 ℃. After 15min heat preservation, the equipment is energized and the image is collected.
(5) by 1 ℃ / min cooling rate and cooling, 15 min after each temperature point insulation, electric equipment, collection and image.
(6) by 1 ℃ / min cooling rate of cooling to 15 ℃. After 0.5h insulation, the equipment is energized and the image is collected.
(7) by 1 ℃ / min heating rate up to 10 ℃. After 15min heat preservation, the equipment is energized and the image is collected.
According to the 1 ℃ / min (8) heating rate, temperature of each point heat preservation for 15 min, electric equipment, after collecting images.
(9) by 1 ℃ / min heating rate up to 30 ℃. After 0.5h insulation, the equipment is energized and the image is collected.
(10) by 1 ℃ / min cooling rate and cooling to room temperature, the end of the test.
Each temperature point continuously collects 1024 lines of images, that is, each temperature point can obtain an image of 8192 (column) x 1024 (line).

3. TEMPERATURE VERIFICATION TEST RESULTS OF CCD DETECTOR

The mean value of the dark signal and the mean square root of the TDICCD at different temperatures can be obtained by calculating the image collected at each temperature point. Table 1 shows the calculation results of dark signals at different temperatures of TDICCD. Table 2 shows the calculation results of dynamic range of the detector at different temperatures.

Set temperature ℃	The actual temperature measured ℃	Dark signal value	
		The average value	Root mean square value
30	30.0	571.19	13.457
25	25.5	429.78	12.197
20	20.8	330.31	11.163
15	15.9	263.32	10.349
10	10.9	223.06	9.772
5	5.8	199.20	9.348
0	1.0	184.61	9.058
-5	-4.1	176.51	8.875
-10	-9.0	171.67	8.731
-15	-14.1	168.40	8.623
-10	-9.2	172.98	8.735
-5	-4.3	177.92	8.880
0	0.4	185.50	9.074
5	5.5	198.36	9.342
10	10.4	220.68	9.733
15	15.2	257.83	10.294
20	20.1	317.91	11.046
25	25.0	413.84	12.085
30	30.3	559.65	13.421

Table 1. The calculation results of dark signals at different temperatures of TDICCD

Set temperature ℃	The actual temperature measured ℃	Dynamic range
30	30.0	1175.06：1
25	25.5	1308.04：1
20	20.8	1438.12：1
15	15.9	1557.70：1
10	10.9	1653.80：1
5	5.8	1731.36：1
0	1.0	1788.41：1
-5	-4.1	1826.20：1
-10	-9.0	1856.87：1
-15	-14.1	1880.51：1
-10	-9.2	1855.87：1
-5	-4.3	1825.01：1
0	0.4	1785.16：1

5	5.5	1732.57：1
10	10.4	1660.67：1
15	15.2	1566.56：1
20	20.1	1454.47：1
25	25.0	1321.49：1
30	30.3	1179.07：1

Table 2. The calculation results of dynamic range of the detector at different temperatures

After analyzing the experimental data, the influence of temperature on the dark signal and dynamic range of TDICCD is obtained. Figure 4 is the quantitative relationship between temperature and the mean value of dark signals. FIG. 5 is the quantitative relationship of the influence of temperature on the mean square root of dark signal (dark noise). Figure 6 is the quantitative relationship between temperature and dynamic range of the detector.

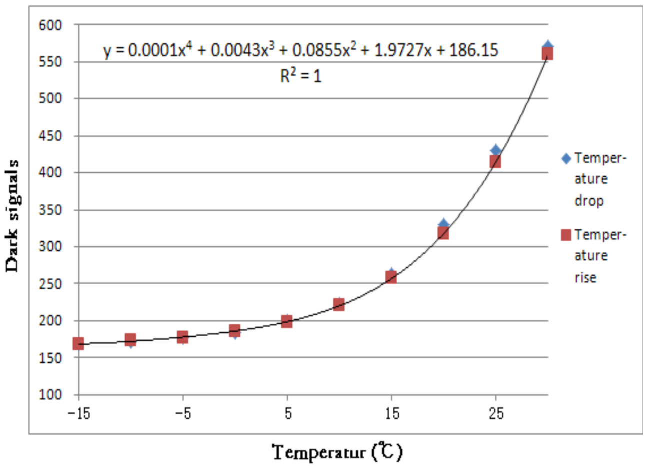

Figure 4. the quantitative relationship between temperature and the mean value of dark signals

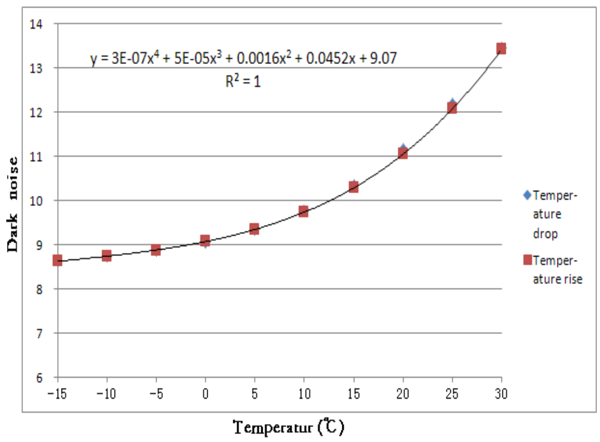

Figure 5. the quantitative relationship of the influence of temperature on the mean square root of dark signal (dark noise)

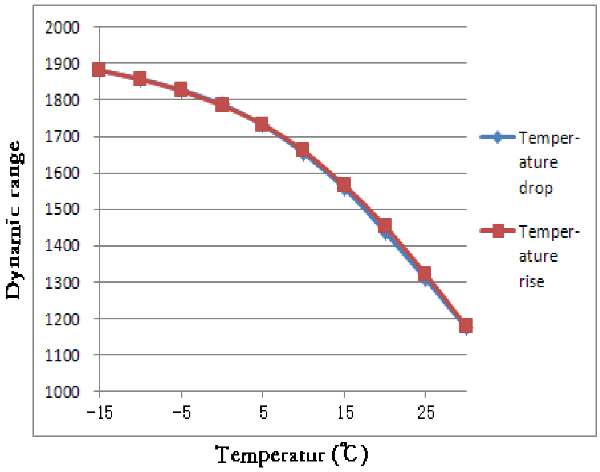

Figure 6. the quantitative relationship between temperature and dynamic range of the detector

4. CONCLUSION

The influence of temperature on TDICCD dark signal and dynamic range is obtained by analyzing the experimental results. The following conclusions can be obtained :(1) the lower the control temperature of CCD, the lower the dark signal level of CCD, and the lower the dark signal noise; (2) using temperature control technology can reduce the dark signal of CCD, especially the dark signal noise, which can improve the dynamic range of the camera and improve the imaging capability of the camera with low irradiance.

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