

空间光学相机在乃奎斯特频率处的调制传递函数测试与实验

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Measurement and experiment of modulation transfer function at Nyquist frequency for space optical cameras

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摘要

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摘要

为了精确地测试空间光学相机入轨之前在乃奎斯特频率处的调制传递函数,开展了整机在乃奎斯特频率处的传递函数测试实验。给出了相机在乃奎斯特频率处的调制传递函数测试链路图;推导了乃奎斯特频率的方波靶标在整个链路中的传递过程和终端靶标图像的精确对比度函数模型;计算了终端靶标图像的对比度与相机在乃奎斯特频率处的调制传递函数转换关系和理论误差形式。最后,在真空环境下测试了相机在乃奎斯特频率下的调制传递函数,并依据本文推导的结论对结果进行了修正。实验结果表明:某空间光学相机在实验室条件下测得的乃奎斯特频率处的调制传递函数为0.213,经折算时间延迟积分CCD(TDICCD)及处理电路的调制传递函数为0.602,TDICCD外围处理电路的调制传递函数等效衰减系数为0.946,与理论值接近。测试结果表明提出的方法基本准确,能够满足空间光学相机地面研制阶段对调制传递函数测试的要求。

关键词: 空间光学相机, 乃奎斯特频率, 调制传递函数, 对比度传递函数

Abstract:

To precisely measure the Modulation Transfer Function(MTF) of a space camera at the Nyquist frequency before entering orbit, measuring methods were researched and some experiments for measuring the MTF at the Nyquist frequency were carried out. The schematic diagram of the MTF measurement was given. On the basis of the schematic diagram, the transfer process of a square wave target at Nyquist frequency in whole chain and the contrast ratio model of a terminal target image were investigated. Furthermore, the relationship between the contrast ratio of terminal target image and the MTF at Nyquist frequency and the error formation were given. Finally, the MTF at Nyquist frequency of the camera was measured in a vacuum environment and the obtained results were corrected. The result shows that the MTF of a space camera at Nyquist frequency is 0.213 at a lab condition, and that after the optical system in the camera architecture is 0.602 by conversion. Moreover, the MTF after Time Delay and Integration(TDICCD) is calculated as 0.946, which is close to the theoretical value. These results indicate that the derivation of our method is basically precise, and is capable of satisfying the requirement of space optical cameras for the MTF measurement before entering orbit.

Key words: space optical camera Nyquist frequency modulation transfer function contrast ratio transfer function

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