SIMERA
SENSE

xScape100 VNIR Optical Front-End

Datasheet

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Document History

Revision	Date	Details
1	2019-08-23	First release of document

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List of Abbreviations

Abbreviation	Description
APS-C	Advanced Photo System Type-C
MTF	Modulation Transfer Function
OFE	Optical Front-End
PSD	Power Spectral Density
RMS	Root Mean Square
TDI	Time Delay Integration
VNIR	Visible and Near-Infrared

1 Introduction

1.1 Identification

Item Description: xScape100 VNIR Optical Front-End

Simera Item Number: SS100-027898

1.2 Intended Use

This document provides the specifications of the xScape100 VNIR Optical Front-End.

1.3 Context and Summary

The xScape100 VNIR Optical Front-End is an optical lens system produced by Simera Sense and is one of the products in the xScape100 product range. The xScape100 VNIR Optical Front-End is sold as a separate unit and is intended to be integrated as part of an earth observation imaging payload in a satellite. Its compact form factor allows for direct implementation into a 3U CubeSat structure; however, the it can also be used as part of imaging payloads in larger satellites.

2 Applicable Documents

Table 2-1 lists documents that are applicable, to the extent stated herein. In the event of conflict between the contents of the applicable documents and this document, the applicable documents shall take precedence.

Table 2-1: Applicable Documents

Ref. #	Reference
[1]	034254-3-xScape100 Optical Front-End Interface Control Document

For undated references, the latest released version of the reference document applies. For dated references, subsequent versions of the document do not apply. It is best practice to always refer to the latest released version. Unless otherwise stated, web links referenced above were last accessed at the release date of the current version of this document.

3 System Details

This section provides a description of the xScape100 VNIR Optical Front-End system, lists the key features of the product and provides the specifications along with the mechanical dimensions of the system.

3.1 System Description and Context

The xScape100 VNIR Optical Front-End maintains optical performance across the spectral range from 450 nm to 900 nm. This product is ideal for multispectral and hyperspectral imaging applications across the visible and near infra-red (VNIR) spectra.

The OFE is designed to survive the harsh structural loading, which is experienced during launch into space, as well as the severe operating conditions experienced in the space environment. Special attention was given to maximize the front aperture of the OFE to optimise the performance for a 3U CubeSat structure. The image plane is optimized for APS-C sensors which results in sub 5 m ground resolution and a 20 km swath width from a 500 km orbit. Figure 3-1 shows the OFE with axis definition.

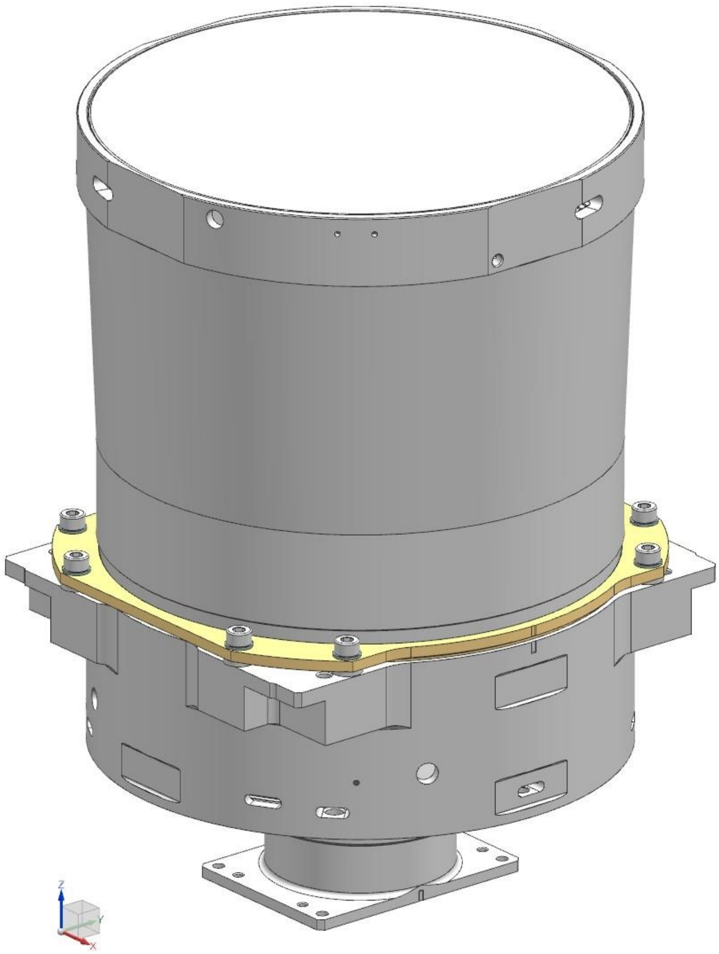

Figure 3-1: xScape100 VNIR Optical Front-End

3.2 Key Features

Key features of the xScape100 VNIR Optical Front-End are the following:

- Dimensionally and structurally optimized for a 3U and 6U CubeSat satellite
- The total volume of the payload will fit within 1.5U of a CubeSat structure
- Performance is optimized for a ground resolution of smaller than 5 m at 500 km orbit
- The optical performance maintains a high MTF across the large image plane
- Optical performance is maintained across the VNIR spectral range
- Designed for APS-C sensors with megapixel resolution (image circle 30 mm)
- Reduced distortion allows for time delay integration (TDI) imaging
- Optical performance verified under vacuum conditions
- Robust athermalised mechanical design is optimised to survive launch loads and maintain optical performance between -10 °C and 50 °C

3.3 Specifications

The optical and mechanical specifications of the xScape100 VNIR Optical Front-End are given in Table 3-1.

Table 3-1: xScape100 VNIR Optical Front-End Specifications

Description	Value
F-number	6.1
Focal length	580 mm ± 1 mm
Front Aperture Diameter	95 mm
Obscuration Diameter	47.2 mm
Full Field of View	2.96 ˚
Spectral Range	450 – 900 nm
Transmission of Unobscured System	> 81%
Distortion	< 0.165%
On-Axis MTF	40% @ 47 lp/mm 18% @ 93 lp/mm
Image Circle Diameter	30 mm
Operating Temperature	-10 ˚C to 50 ˚C
Mass	943 g ± 3%
Flange Focal Distance	5.69 mm ± 0.3 mm
Dimensions	98 x 98 x 145 mm

3.4 Mechanical Layout and Dimensions

The mechanical layout and dimensions of the OFE are given in Figure 3-2. For detailed mechanical interfaces and constraints, refer to [1].

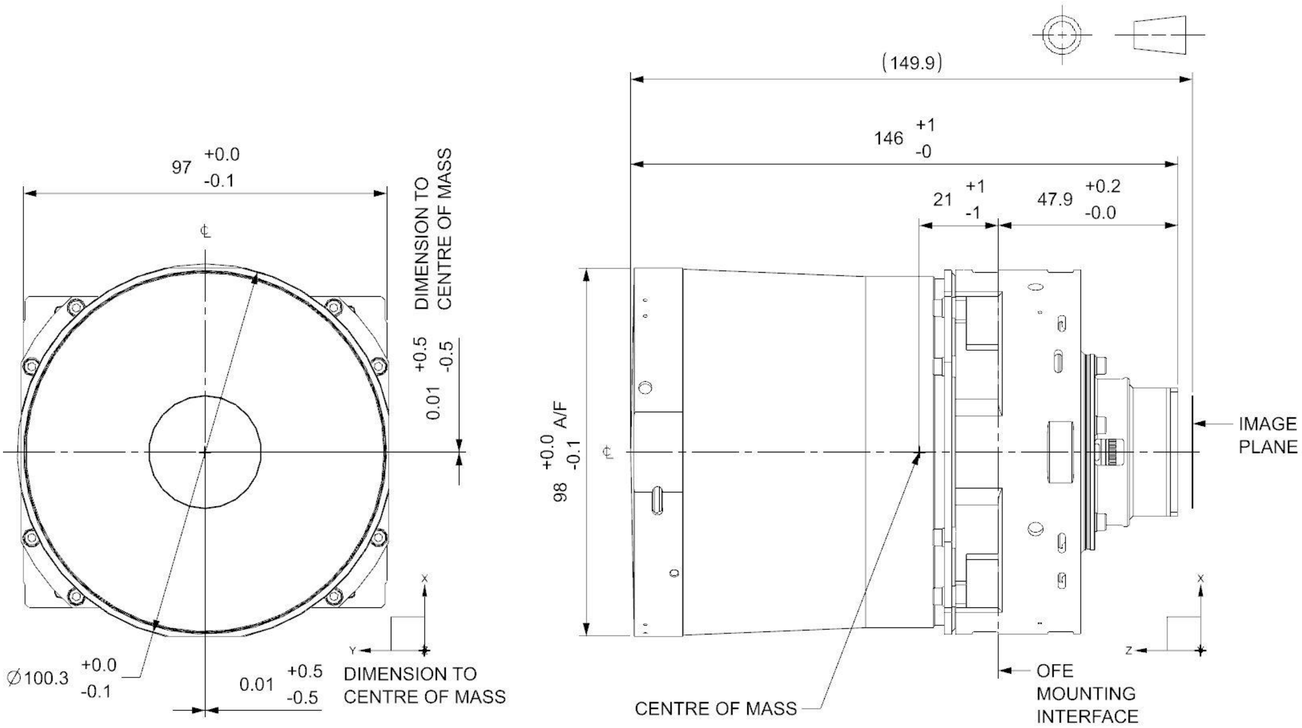

Figure 3-2: OFE Mechanical Layout and Dimensions

4 Performance of the xScape100 VNIR Optical Front-End

This section provides the as designed optical performance of the OFE.

4.1 Polychromatic (450 nm – 900 nm) Modulation Transfer Function

The modulation transfer function (MTF) of the xScape100 VNIR Optical Front-End across the polychromatic spectral range is presented in Figure 4-1. The figure provides the MTF data for different field angles across the image plane.

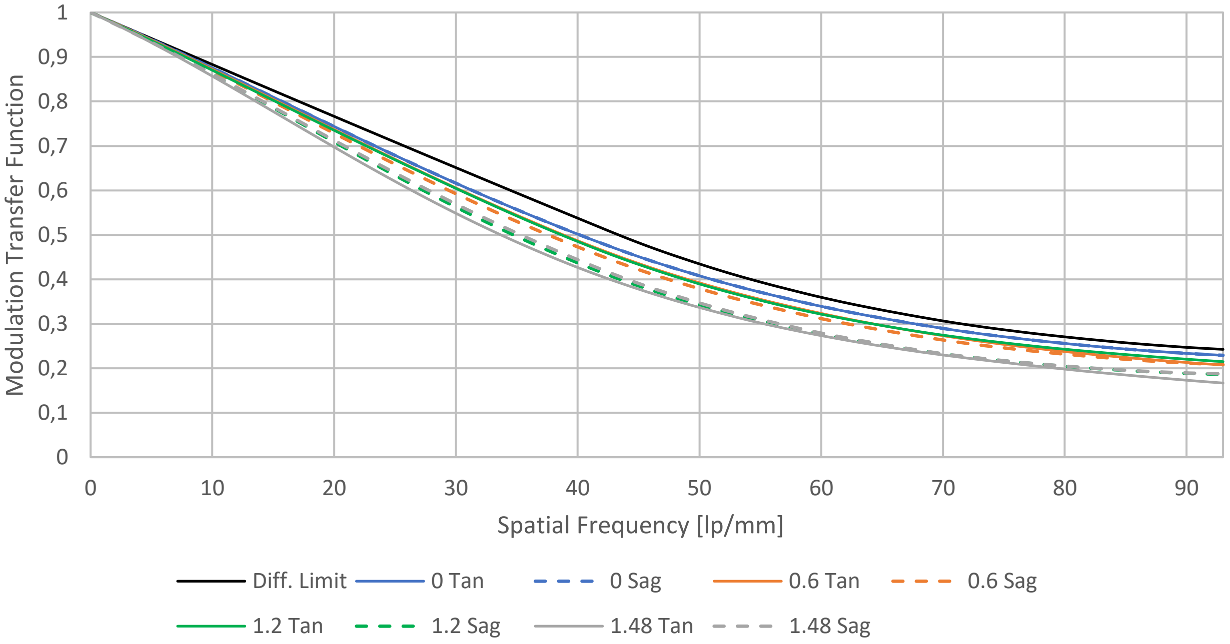

Figure 4-1: Polychromatic MTF as Function of Spatial Frequency at Different Field Angles

The data of Figure 4-1 is reproduced in Figure 4-2 where the polychromatic MTF is plotted against the relative field angle to indicate that the performance is maintained across the image plane at different spatial frequencies.

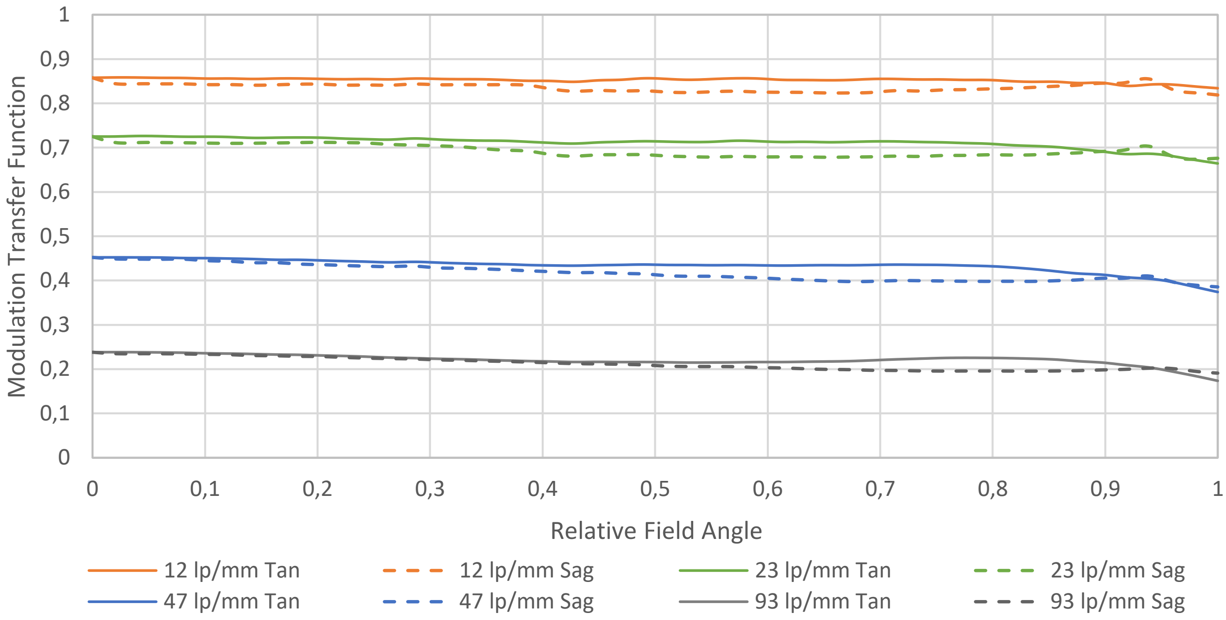

Figure 4-2: Polychromatic MTF Across Image Plane at Different Spatial Frequencies

4.2 Spectral MTF

The OFE is ideally suited to be used in multispectral and hyperspectral applications. This is illustrated in Figure 4-3 which shows the on-axis monochromatic performance of the system for various spectral bands.

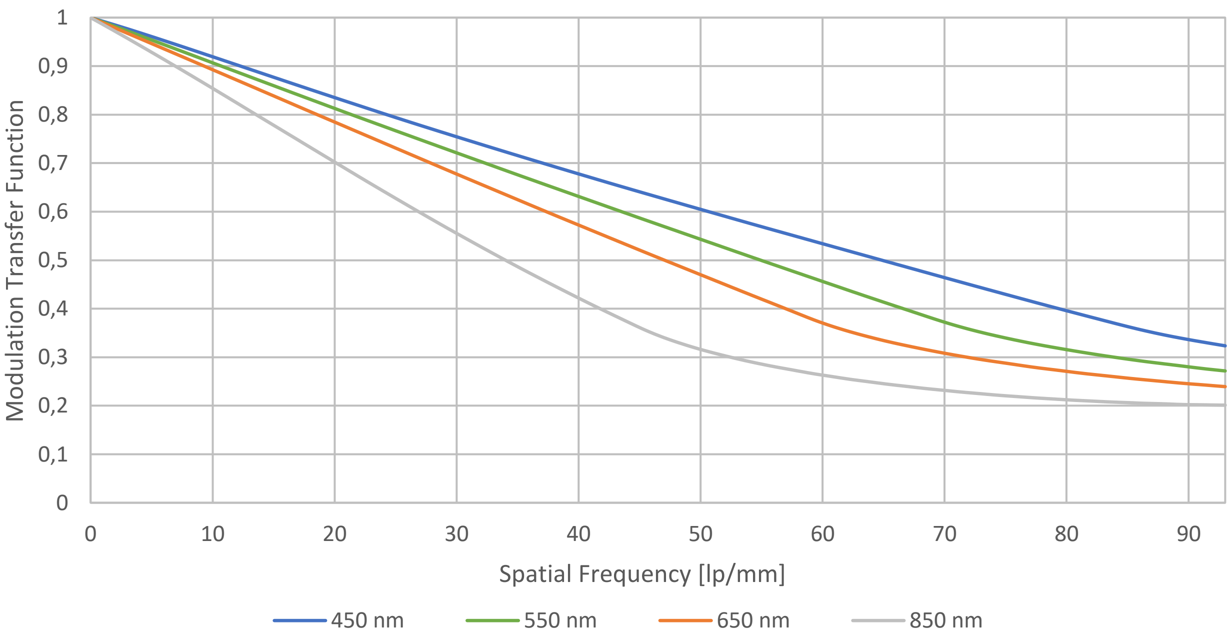

Figure 4-3: On-axis Monochromatic MTF as Function of Spatial Frequency

4.3 System Transmission

The transmission is given in Figure 4-4 where the effect of the obscuration on the transmission was included.

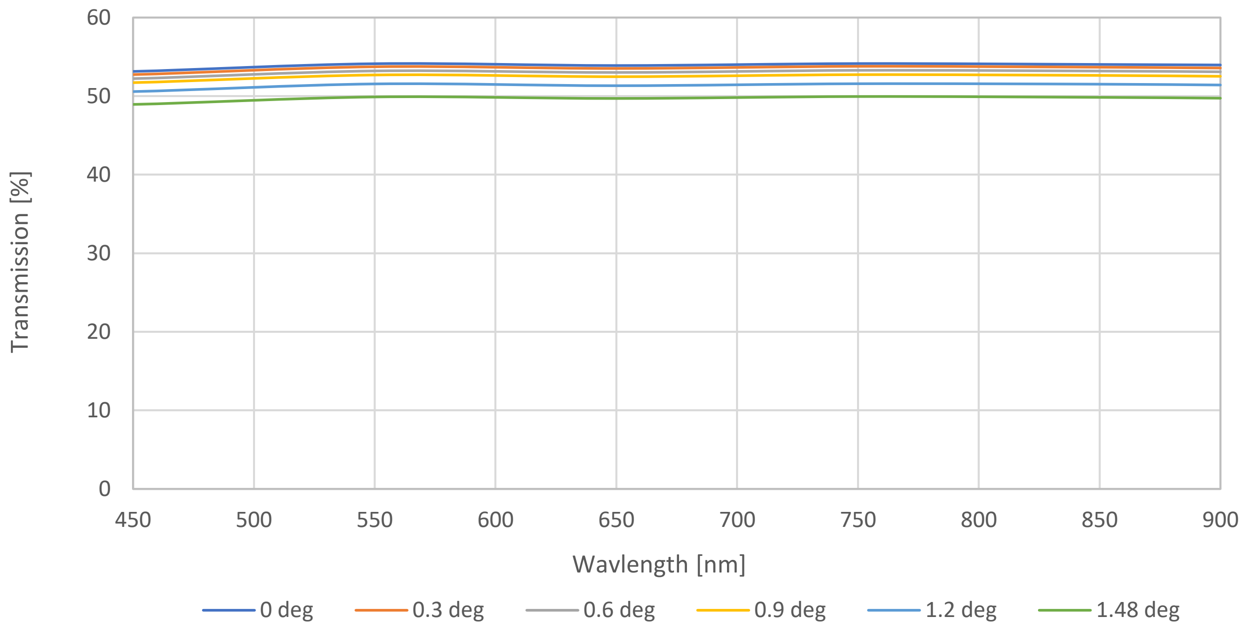

Figure 4-4: Transmission (Obscuration Included) Across Spectral Range at Different Angles

4.4 Geometric Distortion

The geometric distortion, as a function of field angle, is given in Figure 4-5 for different wavelengths.

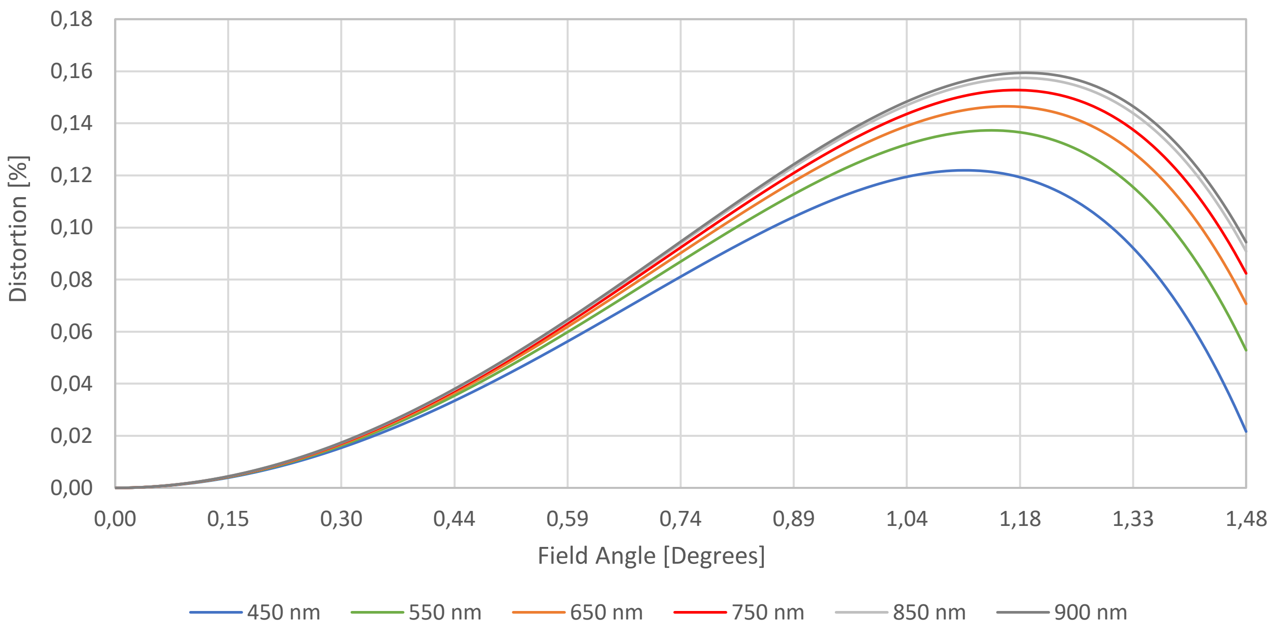

Figure 4-5: Distortion Across Image Plane at Different Wavelengths

4.5 Polychromatic (450 nm – 900 nm) Wavefront Error

The polychromatic root mean square (RMS) wavefront error of the system is given in Figure 4-6.

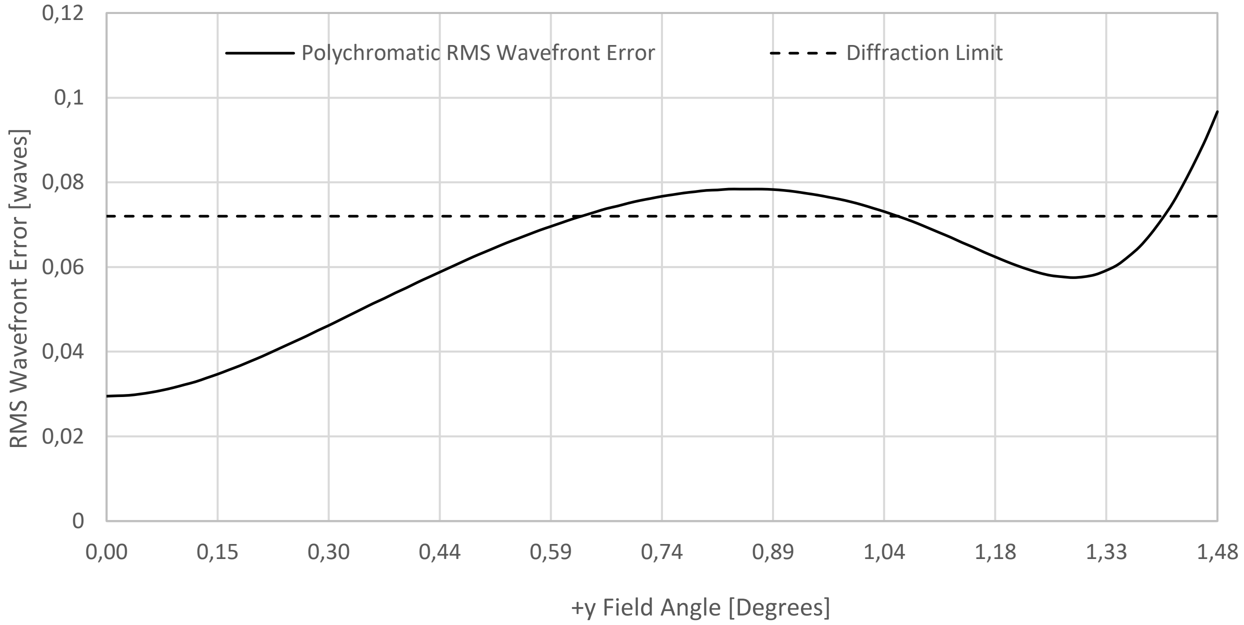

Figure 4-6: Polychromatic RMS Wavefront Error Across Image Plane

4.6 Relative Illumination

The system's relative illumination for a uniform Lambertian scene is greater than 0.92 across the field as is shown in Figure 4-7.

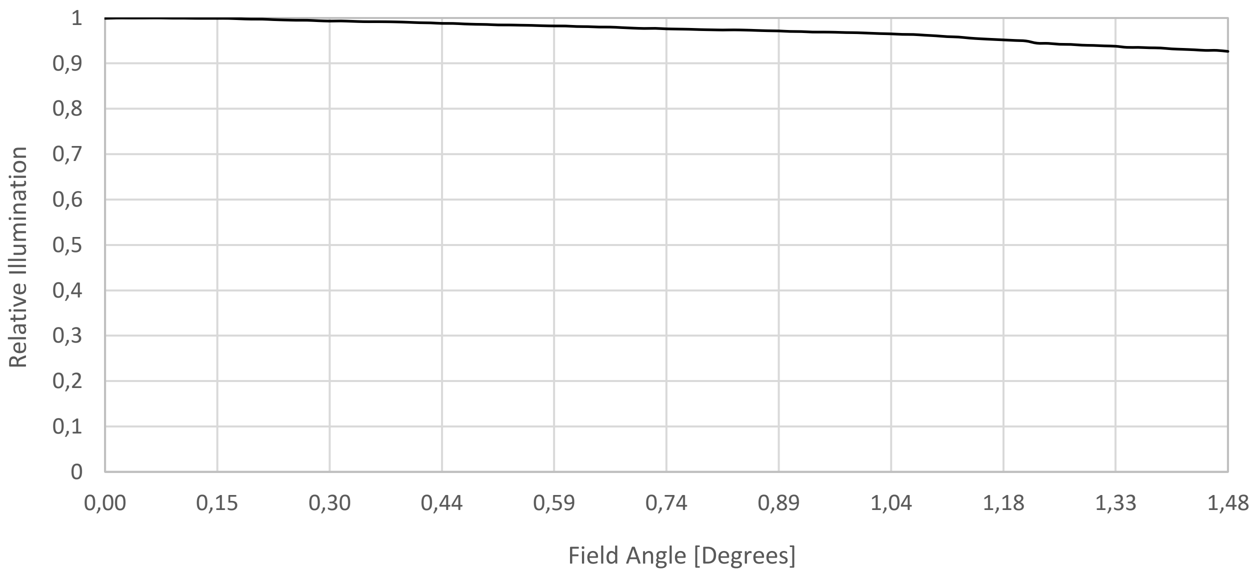

Figure 4-7: Relative Illumination Across Image Plane

5 Environmental Qualification Testing

The OFE has successfully passed through rigorous environmental testing during which the OFE has been qualified to the levels listed in this section. Optical testing conducted before and after environmental testing showed no change in optical performance.

5.1 Qualification Vibration Testing

During the qualification vibration test campaign, the OFE was exposed to the tests listed in sections 5.1.1 to 5.1.3. These tests were conducted in each of the three mutually orthogonal axes of the OFE.

5.1.1 Quasi-Static

The quasi-static loads were imposed on the OFE through means of a sine burst test during which the OFE was subjected to a minimum of 7 complete cycles at a peak acceleration of 20 g.

5.1.2 Sine-Sweep

The details of the sine-sweep test are presented in Table 5-1.

Table 5-1: Sine-Sweep Test Specifications

Frequency [Hz]	Acceleration [g]	Rate [octaves/min]
5	3.83	2
100	3.83	
140	3.83	
140	1.28	
145	1.28	
145	0.255	
150	0.255	

5.1.3 Random Response

The Random response vibration frequency and power spectral density (PSD) is given in Table 5-2.

Table 5-2: Random Response Test Specifications

Frequency [Hz]	PSD [g^2/Hz]	Duration [seconds/axis]
20	0.026	120
50	0.16	
800	0.16	
2000	0.026	

5.2 Qualification Thermal Ambient Testing

Qualification level thermal ambient testing was performed on the OFE during which the OFE was cycled between the minimum and maximum temperatures listed in Table 5-3 for 8 complete cycles.

Table 5-3: Thermal Ambient Test Specifications

Minimum Temperature [°C]	Maximum Temperature [°C]	Number of Cycles
-25	65	8

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