Firebird Light Engine

Fact sheet

In-Vision

10/30/2019

Contents

1 Revision history

1.1 Parameter definitions

Version	Date	Author	Description and reason of change
2.15	10/28/2019	MB	Updated definitions of Intensity uniformity
2.14	10/25/2019	MB	Updated definition of Irradiance uniformity
2.1	05/07/2019	MB	Initial version

Table 1: Parameter definitions revisions

1.2 Specifications

Version	Date	Author	Description and reason of change
2.16	10/30/2019	MB	Updated optical specifications
2.15	10/28/2019	MB	Updated specification of Intensity uniformity
2.14	10/25/2019	MB	Updated optical specifications
2.11	10/15/2019	MB	Updated available off-the-shelf lenses
2.1	05/17/2019	MB	Initial version

Table 2: Firebird revisions

2 General

The Firebird DLP® light engine module offers native WQXGA/2K (2560×1600) pixel resolution based on TI's DLP9000 advanced light control chipset.

Tailored to generic light exposure and resin-curing applications such as stereolithography (SLA) 3D-printing or maskless lithography, Firebird offers both the performance as well as modularity to address a wide range of customer-specific requirements.

For example, both optical illumination and projection system are optimized for high-intensity light emission ranging from 365 to $460nm$ and can be adapted to various light source types and wavelengths on request. Furthermore, the light engine module contains an optional, internal light intensity measurement module to continuously monitor irradiance and provide feedback for e.g. light-source ageing compensation.

A key component of the light engine is the on-axis illumination system using an RTIR/TIR prism system. This enables a low-distortion, highly uniform light distribution across the whole projection area as required for high-accuracy, industrial light exposure applications.

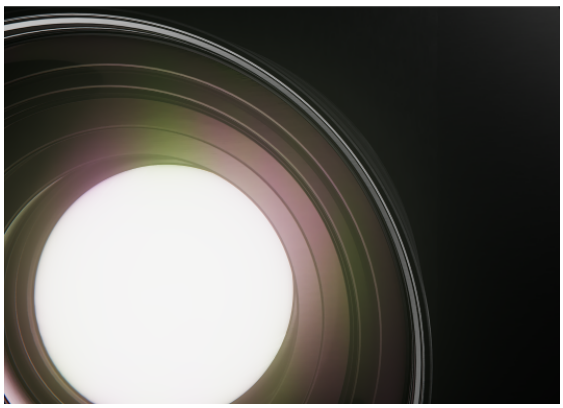

Figure 1: On-axis prism illumination system for highest projection quality and light output efficiency

Firebird is available either in an air- or liquid-cooled version and can be customized in regard to light source and projection lens type.

The DLP® controller board builds on the Texas Instruments DLP9000 advanced light control chipset, featuring single-pixel control and a high-speed Display Port interface. By default, Firebird ships with electronics enabled for single or continuous image projection applications. For other applications, such as image stitching and scrolling algorithms, electronics can be adapted on request.

3 Definition of parameters

3.1 CTF

First, we must define the so-called Michelson contrast. This value represents the amplitude difference between the peaks and valleys of a periodic function (e.g. sine, rectangular). The Michelson contrast is defined as:

$$Contrast = \frac{I_{peak} - I_{valley}}{I_{peak} + I_{valley}} \tag{1}$$

The CTF (Contrast Transfer Function) represents the measured Michelson contrast at a certain line pair frequency in mm (Lp/mm). The line pair frequency is a measure of resolution. Typically, CTF values are stated for a Lpf which represents one pixel row/line in ON-state and one pixel row/line in OFF-state (e.g. for a lens with 75 pixel pitch in the image space, the Lpf is $1000/75/2 = 6.67Lp/mm$). Figure 2 represents a section of the light engine image The yellow line represents a path along which the intensity values are

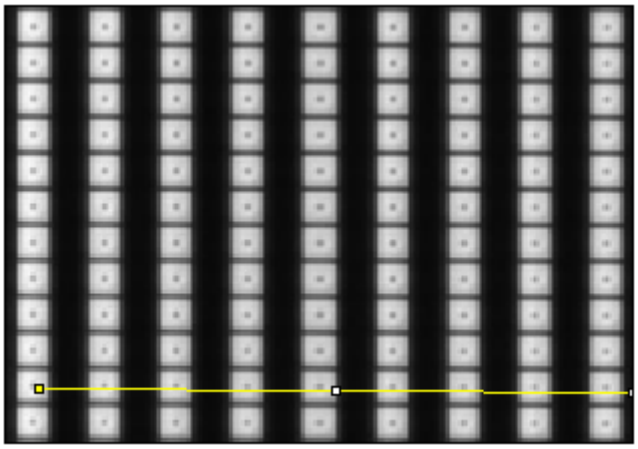

Figure 2: CTF definition, image 1

extracted, which can be used to determine CTF (see figure 3).

3.2 Radial distortion

Distortion is a value representing the deviation of the image height y (pixel position) which is expected from the magnification compared to the measured, real image height (all positions are relative to the position of the central pixel, so a position deviation of the complete image does not count). Its value is defined as, typically stated in % (multiplied by 100):

$$Dist = \frac{y_{real} - y_{ideal}}{y_{ideal}} \tag{2}$$

A lower distortion value represents higher-quality lens designs, but typically needs more lens elements to be achieved.

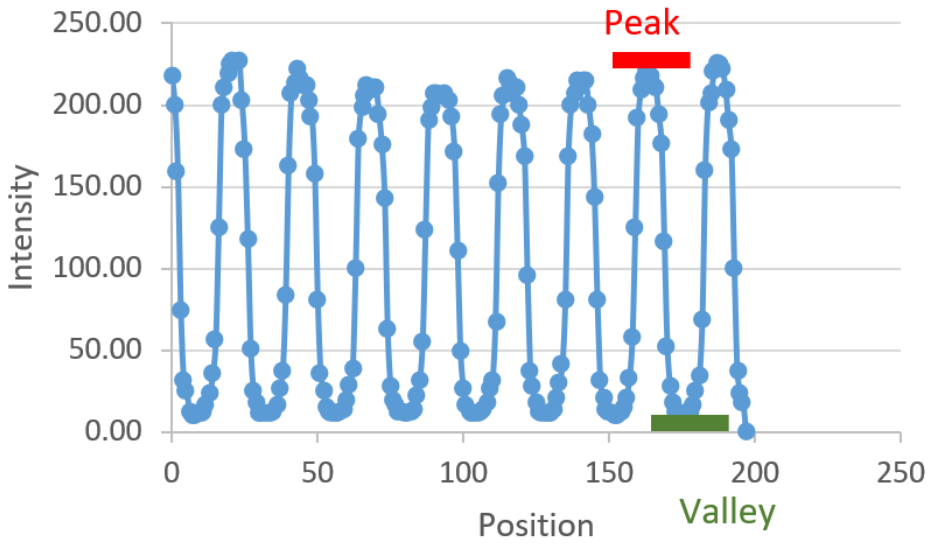

Figure 3: CTF definition, image 2

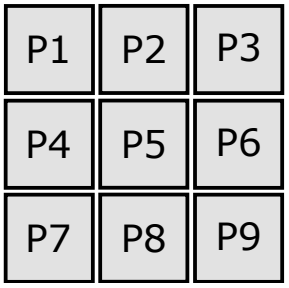

Figure 4: Scheme for Intensity uniformity calculation according to [1]

3.3 Intensity uniformity in image

This value presents how the intensity differs across the image.

3.3.1 Intensity uniformity according to standard IEC 61947

This definition of Intensity uniformity refers to [1] and can be calculated (in %) with respect to fig. 4 as follows:

$$U_{min} = 100 \times \frac{Min\,[P1, \ldots, P9]}{Average\,[P1, \ldots, P9]}$$

3.3.2 Intensity uniformity according to In-Vision standard

Itensity uniformity according to In-Vision standard is measured by using 25 distributed measurement points, each representing 40×40 pixels in ON-state. The intensity is measured locally. The uniformity is defined by the ratio between the dimmest and brightest measurement point, a uniformity of 100% would mean that all measurement points are equally bright. Typically, higher values represent higher-quality systems.

4 Specifications

Parameter	Specification
Display type	TI DLP9000
DLP controller	TI DLPC900
Resolution	2560×1600
Chip pixel pitch	$7.56\mu m$
Min. Intensity uniformity (IEC definition – see section 3.3.1)	$> 92\%$
Min. Intensity uniformity (In-Vision definition – see section 3.3.2)	up to 92%
Full On/Off Contrast	up to $1500 : 1$
ANSI Contrast	up to $500 : 1$
Optical output power in the image plane	$365nm$: up to $3.0W$ $385nm$: up to $5.0W$ $405nm$: up to $5.0W$ $460nm$: up to $7.5W$
Operating temperature range	$15..35°C$
Max. relative humidity	non-condensing
IP code	IP40
Pattern rate binary	$9523Hz$
Pattern rate grayscale	$247Hz$
Control interfaces	USB DLP and LED Trigger inputs Status Signal
Data interfaces	DisplayPort USB

Table 3: Firebird specifications

Tables 4 to 7 show data for the available off-the-shelf lenses.

5 Mechanical drawings

The mechanical drawings for the LE can be seen in figs. 5 to 11.

Parameter	Specification
Available wave lengths	$385, 405nm$
Distance mechanical reference to image plane	$266.3mm$
Image pixel size	$75.75\mu m \pm 1\%$
Image distortion	$< 240\mu m$
Image distortion	$< 0.2\%$
Contrast Transfer Function (CTF) @ $6.6LP/mm$	$> 65\%$

Table 4: Gars specifications

Parameter	Specification
Available wave lengths	$385, 405nm$
Distance mechanical reference to image plane	$266.3mm$
Image pixel size	$162\mu m \pm 0.5\%$
Image distortion	$< 260\mu m$
Image distortion	$< 0.1\%$
Contrast Transfer Function (CTF) @ $3.09LP/mm$	$> 60\%$

Table 5: Litschau specifications

Parameter	Specification
Available wave lengths	$385, 405nm$
Distance mechanical reference to image plane	$300mm$
Image pixel size	$84\mu m \pm 1\%$
Image distortion	$< 135\mu m$
Image distortion	$< 0.1\%$
Contrast Transfer Function (CTF) @ $5.95LP/mm$	$> 65\%$

Table 6: Weitra specifications

Parameter	Specification
Available wave lengths	$385, 405nm$
Distance mechanical reference to image plane	$266.7mm$
Image pixel size	$75.75\mu m \pm 1\%$
Image distortion	$< 96\mu m$
Image distortion	$< 0.12\%$
Contrast Transfer Function (CTF) @ $10.0LP/mm$	$> 70\%$

Table 7: Buk specifications

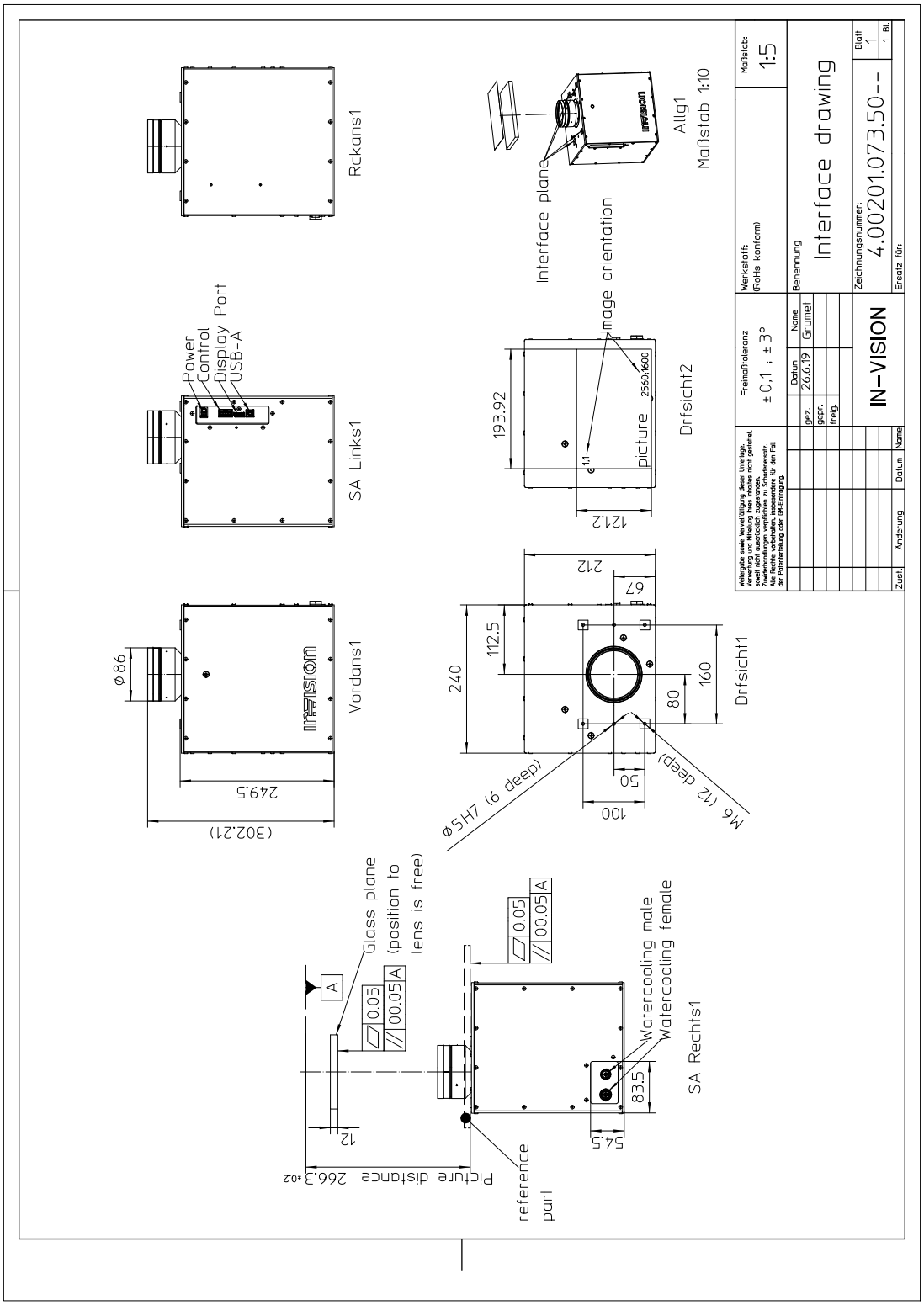

Figure 5: Firebird Light Engine drawing (with Gars lens, $385nm$ light source and water cooling)

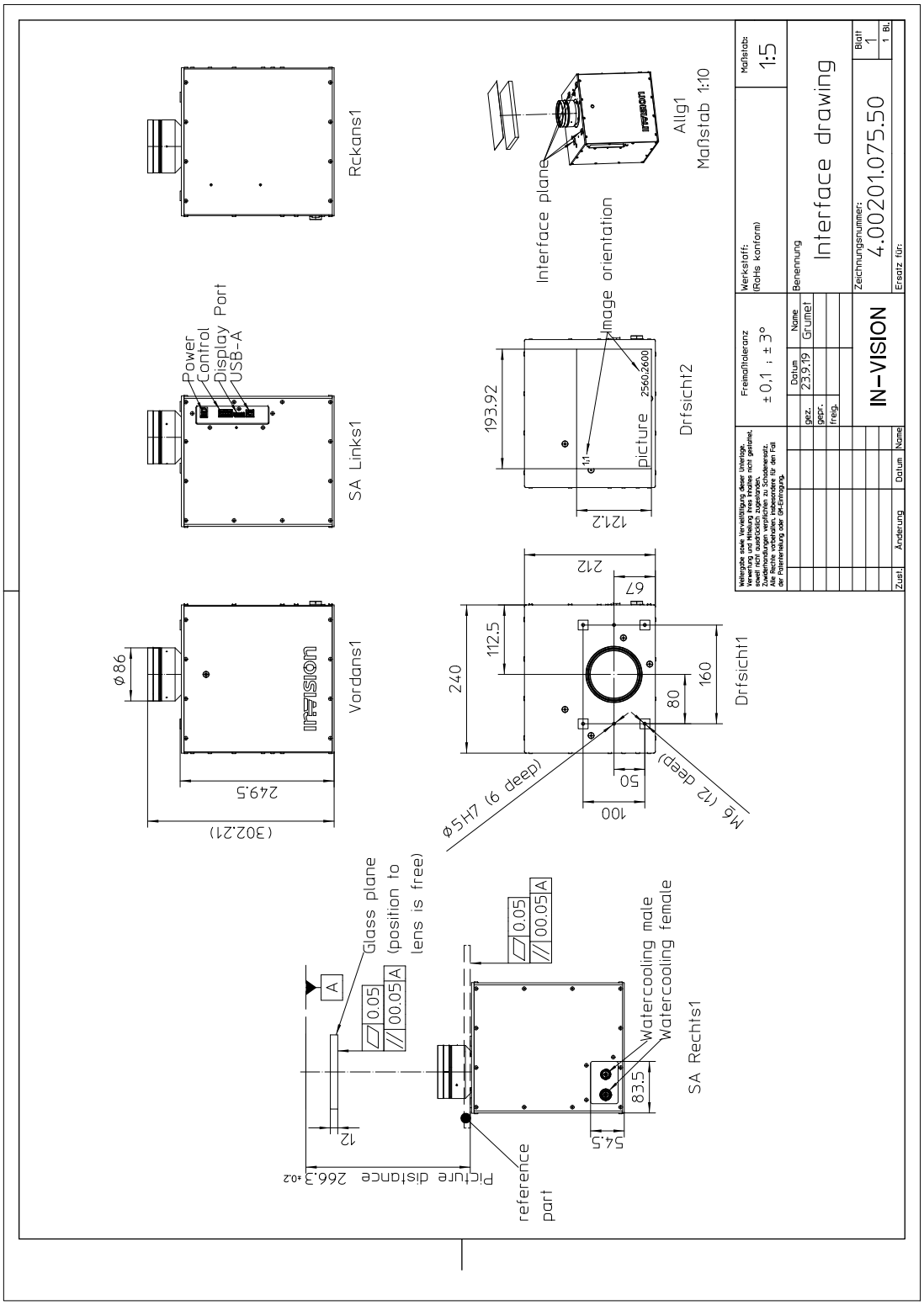

Figure 6: Firebird Light Engine drawing (with Gars lens, $385nm$ light source, XY module and water cooling)

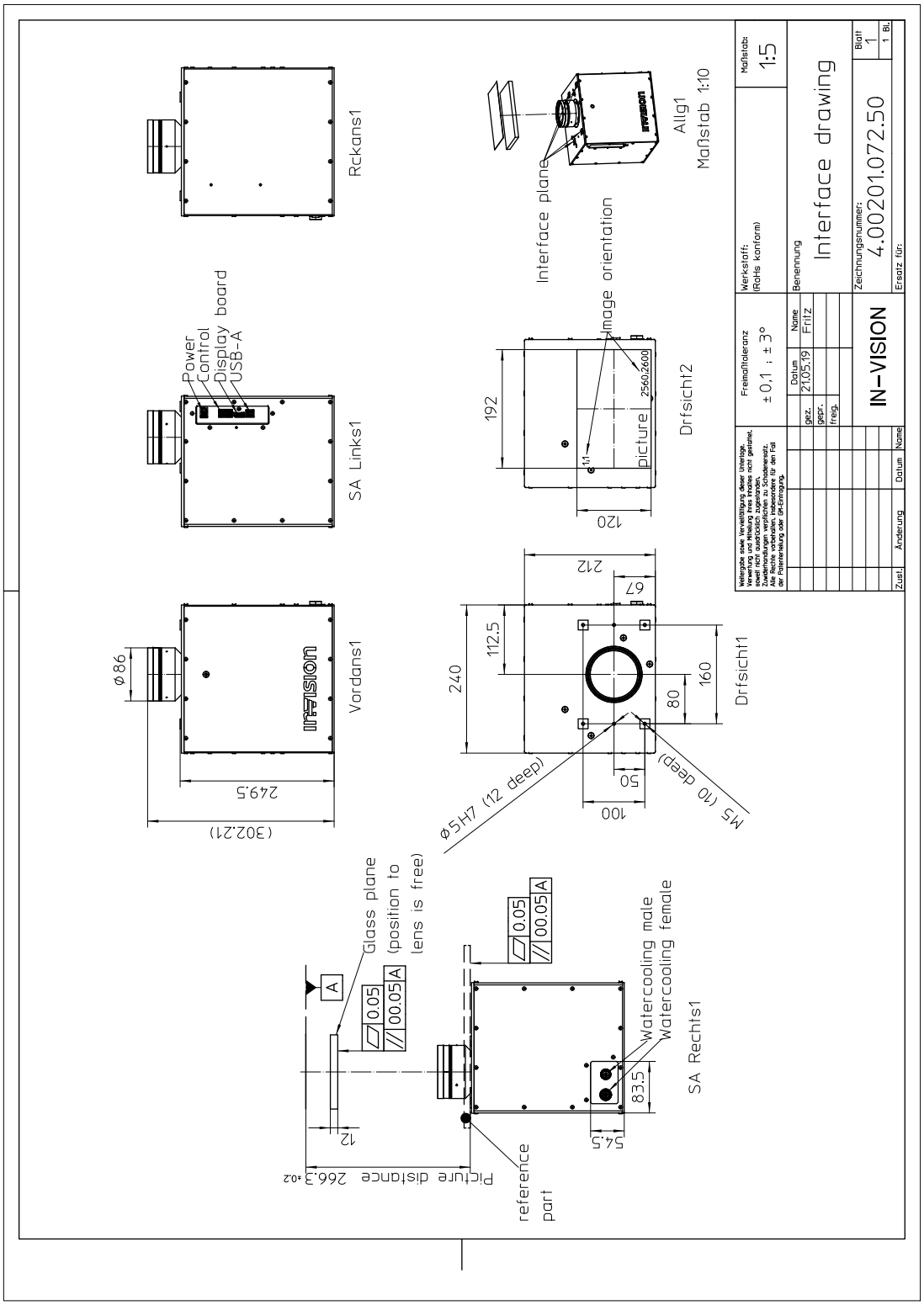

Figure 7: Firebird Light Engine drawing (with Gars lens, $405nm$ light source and water cooling)

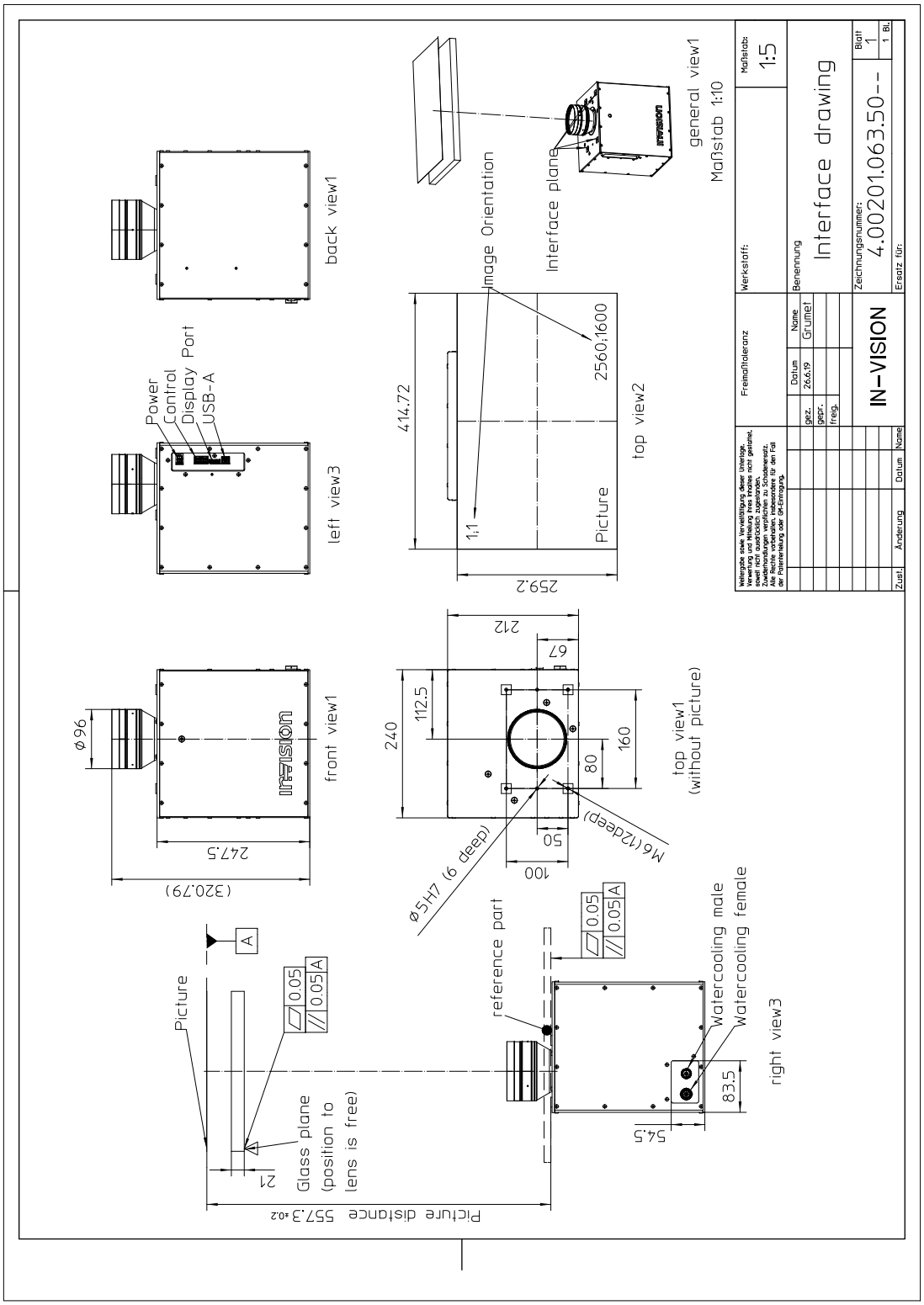

Figure 8: Firebird Light Engine drawing (with Litschau lens, $385nm$ light source and water cooling)

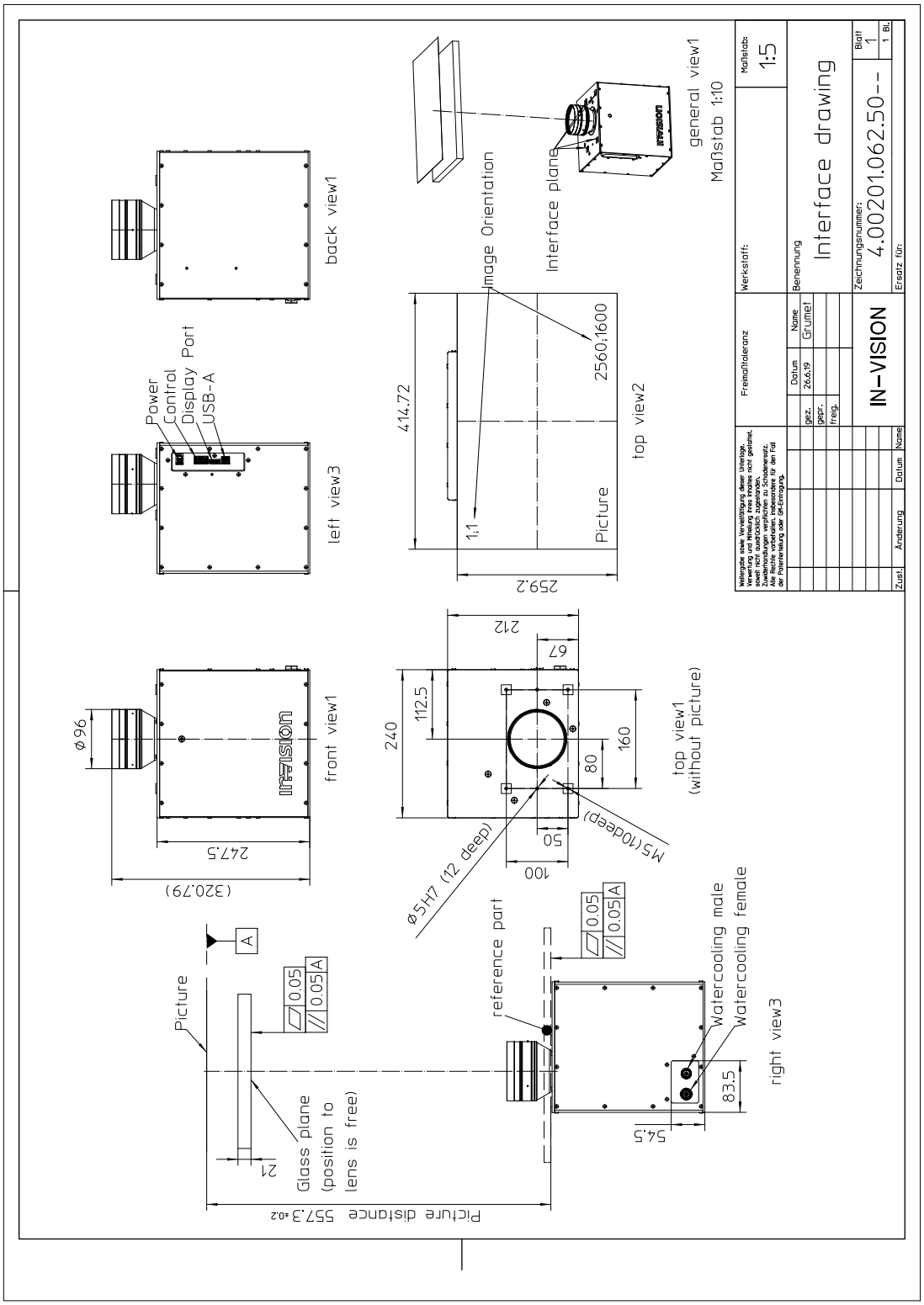

Figure 9: Firebird Light Engine drawing (with Litschau lens, $405nm$ light source and water cooling)

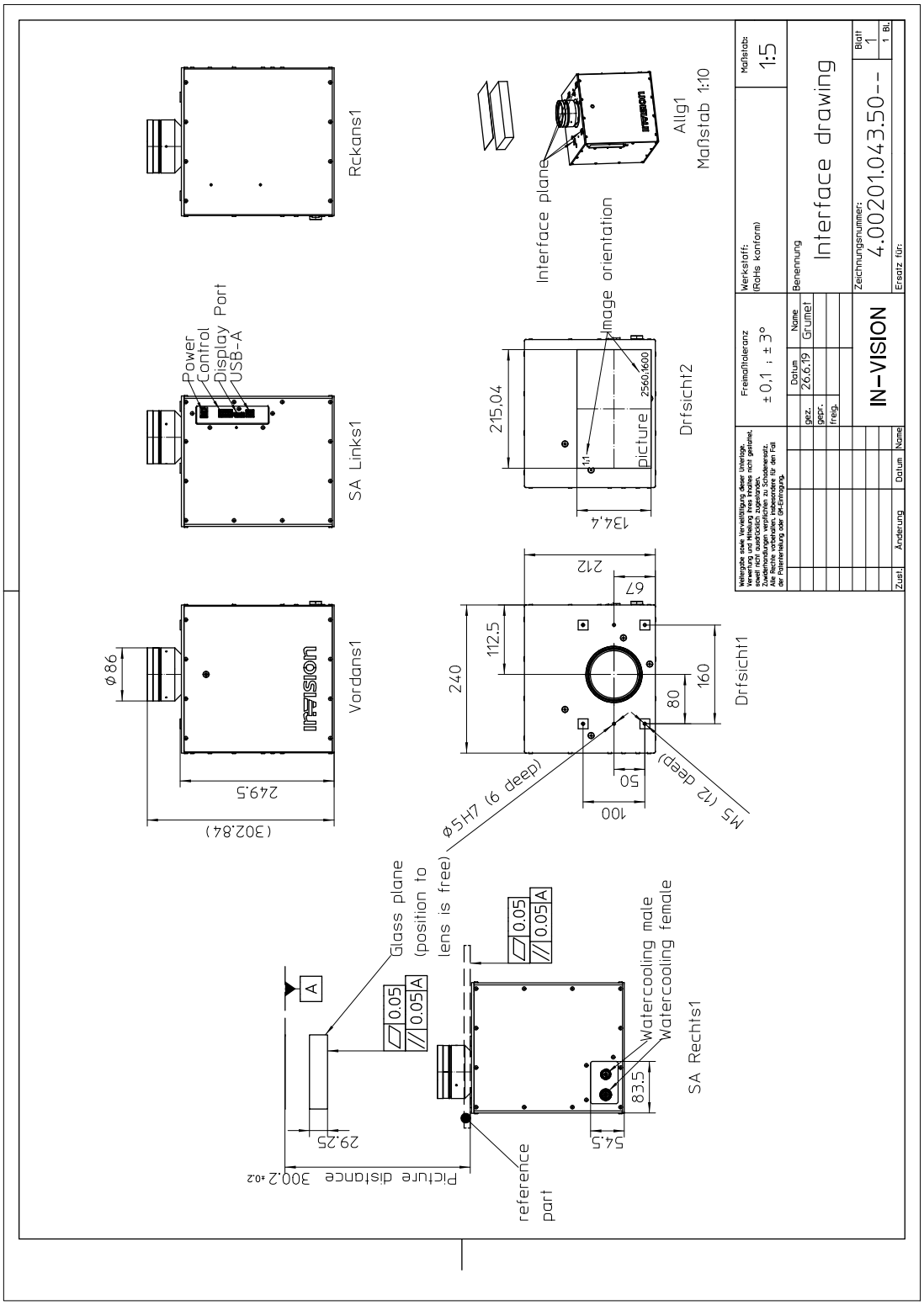

Figure 10: Firebird Light Engine drawing (with Weitra lens, $385nm$ light source and water cooling)

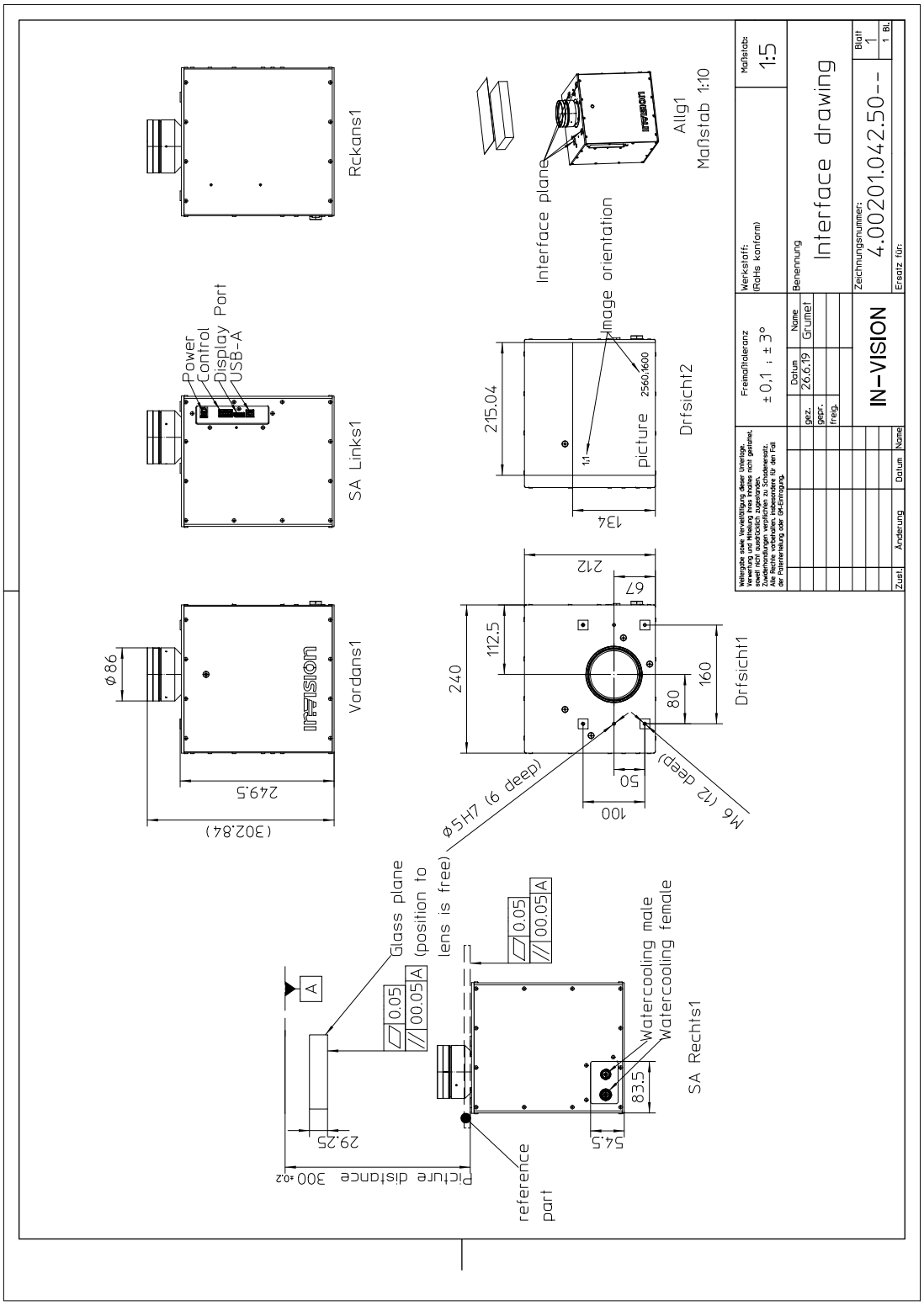

Figure 11: Firebird Light Engine drawing (with Weitra lens, $405nm$ light source and water cooling)

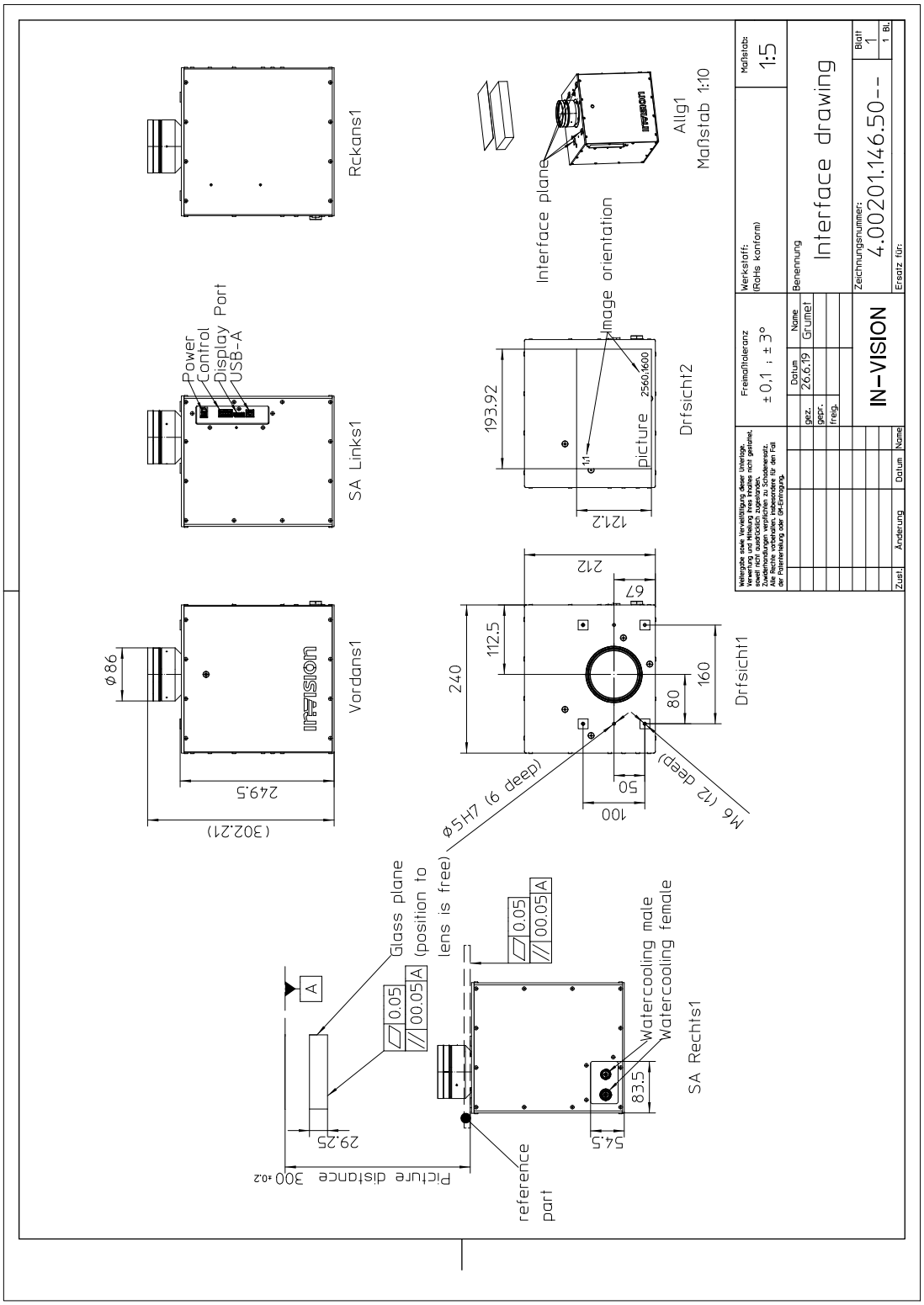

Figure 12: Firebird Light Engine drawing (with Weitra lens, $405nm$ light source, XY module and water cooling)

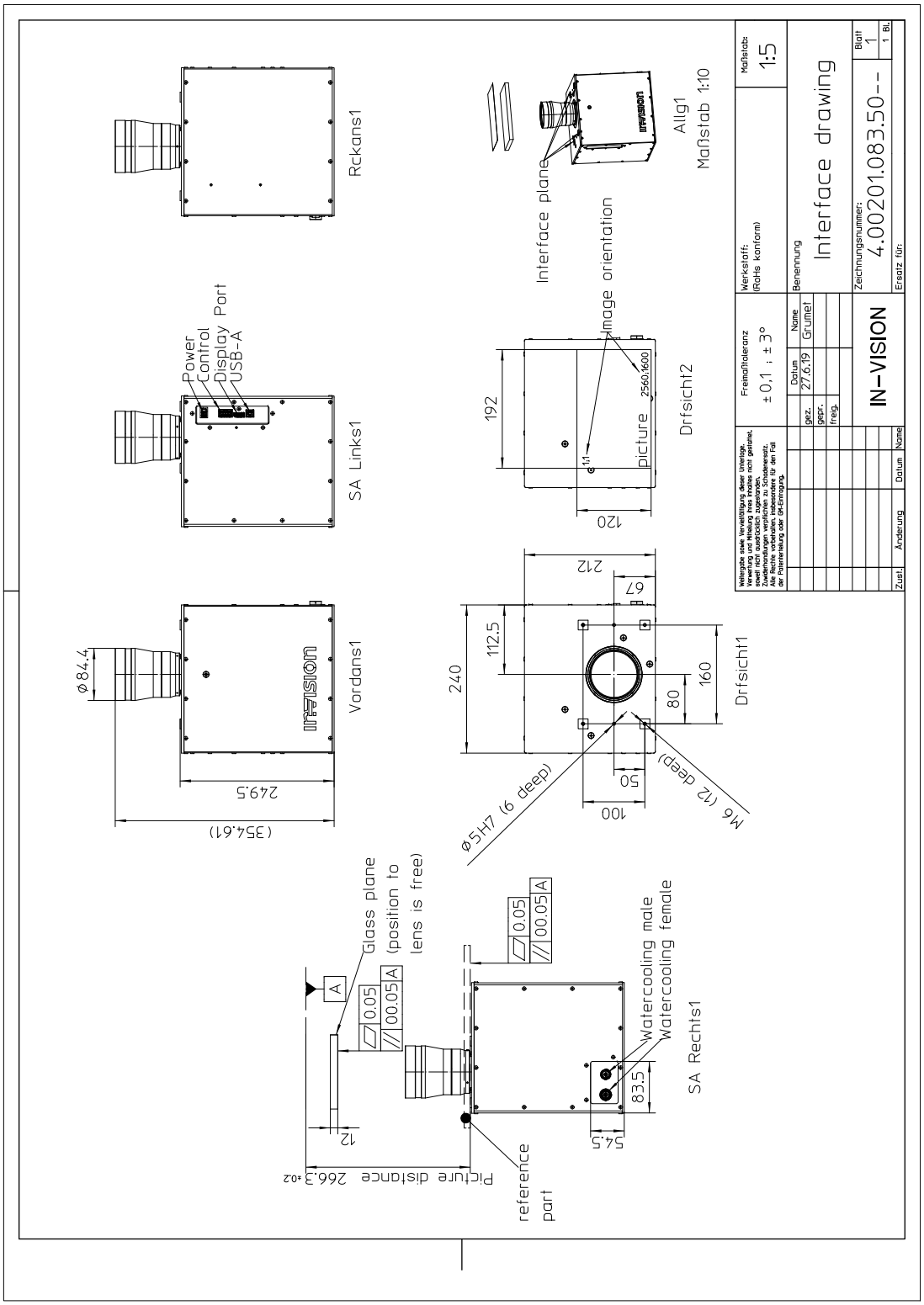

Figure 13: Firebird Light Engine drawing (with Buk lens, $385nm$ light source and water cooling)

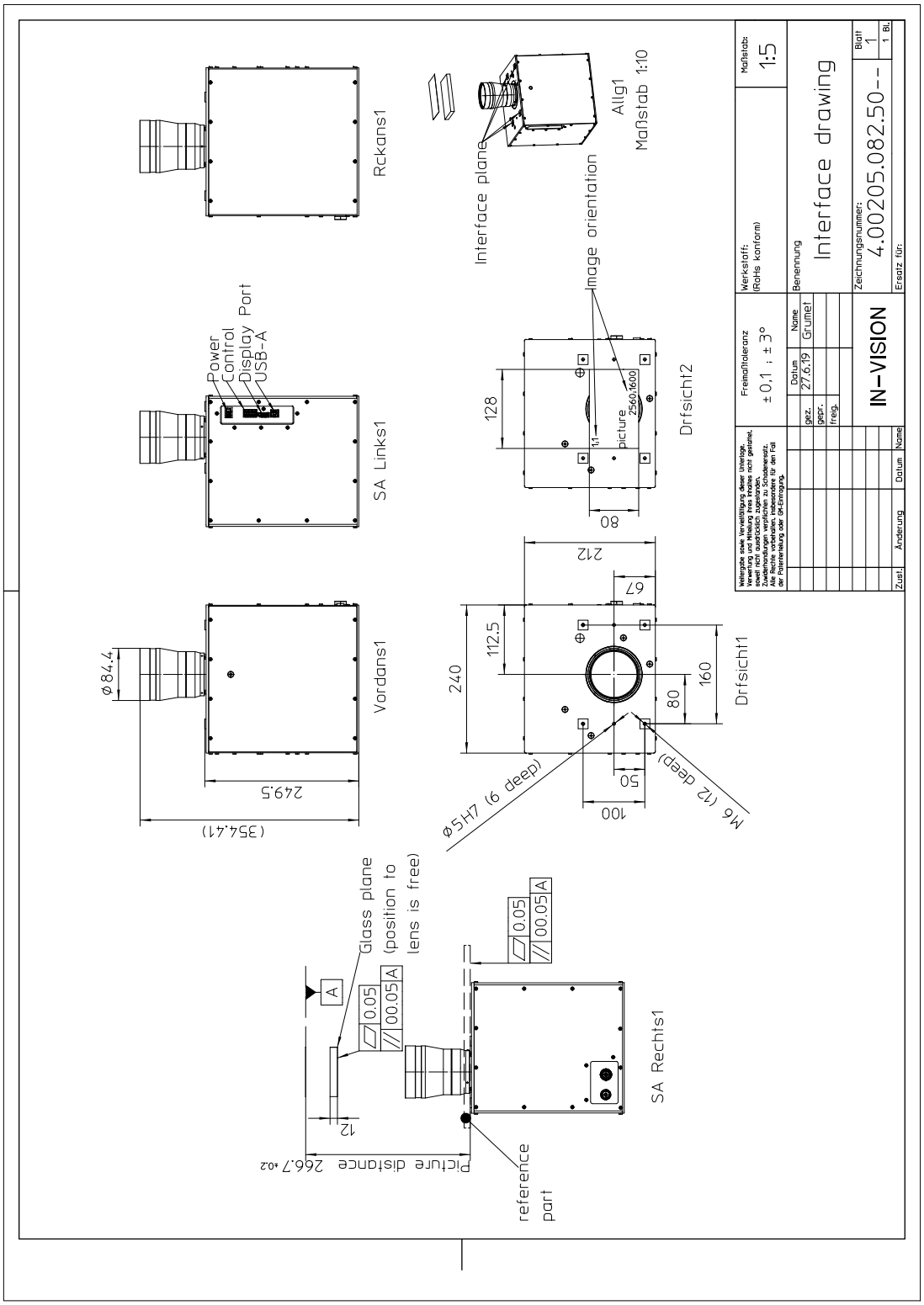

Figure 14: Firebird Light Engine drawing (with Buk lens, $405nm$ light source and water cooling)

A Abbreviations

Abbrev.	Meaning
n.c.	not connected
LED	Light Emitting Diode
USB	Universal Serial Bus
HID	Human Interface Device
API	Application Program Interface
MSB	Most Significant Byte/Bit
LSB	Least Significant Byte/Bit
DMD	Digital Micromirror Device
DLP	Digital Light Processor
DLPC	DLP Controller
LUT	Look-Up table
FW	Firmware
LE	Light Engine
HW	Hardware
SW	Software
CTF	Contrast Transfer Function
IP Code	International Protection Marking
LP	Line Pairs
MTF	Mean Time to Failure

Table 8: Abbreviations

B Table of figures/tables

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C References

[1] IEC 61947-1:2002: Electronic projection – measurement and documentation of key performance criteria – part 1: Fixed resolution projectors. Technical report, International Electrotechnical Commission, Geneva, CH, August 2002.