Phlox Optical Waveguide for Augmented Reality Displays

Phlox is a transparent optical waveguide for use in full colour, near-to-eye, augmented reality (AR) displays.

Made of glass with precision nano-structures, Phlox overlays computer-generated AR images onto the real world.

FEATURES

- RGB full colour
- 40 degree Field of View
- Large eye-box
- High transparency, typ. 80%

A miniature projector or *light engine* generates an image, which coupled into Phlox's small input region, outside the user's field of view. Light is guided under total internal reflection toward the output region, where it is directed toward the user's eye, forming a virtual image, which is overlaid on the real world.

Phlox replicates the small input pupil many times, forming a large exit pupil. This process, known as *2D pupil expansion,* allows a small light engine to create a large eye-box – the zone within which the user must position their eye. Eye-box is a key parameter for any AR display. A large eye-box allows for variations in viewing position without vignetting (cropping) of the image. This results in a more usable, comfortable display which "just works" for a wide variety of face shapes, without cumbersome per-user calibration.

The result is sharp, vibrant AR images, overlaid onto a clear view of the outside world, in a compact, comfortable product, which can fit over conventional spectacles.

Phlox is compatible with a range of light engine technologies, including LCOS and DMD.

Wave Optics Limited, a Company registered in England under Company Number 08202019
Registered office 99 Park Drive, Milton Park, Abingdon, Oxfordshire OX14 4RY VAT registered GB196008693

© Wave Optics 2017

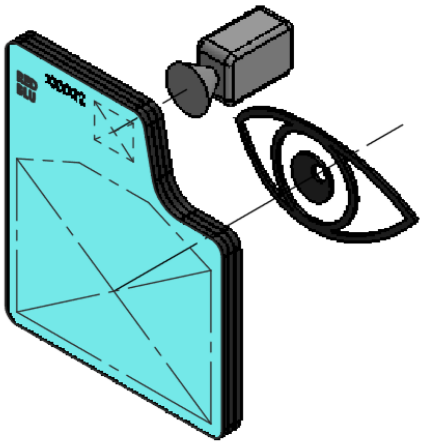

Figure 1 - Waveguide operation (Reflection mode)

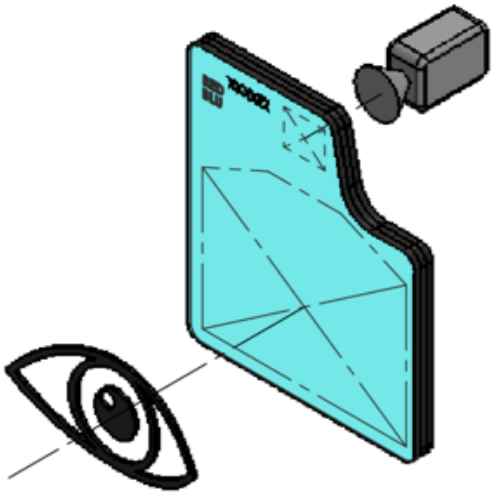

Figure 2 - Waveguide operation (Transmission mode)

Wave Optics Limited, a Company registered in England under Company Number 08202019
Registered office 99 Park Drive, Milton Park, Abingdon, Oxfordshire OX14 4RY VAT registered GB196008693

© Wave Optics 2017

Recommended Operating Conditions

Parameter	Min	Nominal	Max	Unit	Comment
Field of View, diagonal			40	degrees	
Aspect ratio		16:9			
LED centre wavelengths		R: 620 G: 530 B: 460		nm	
Input pupil diameter	3	5	6	mm	circular
Input pupil standoff (see *Figure 3*)		0	4	mm	at 5mm pupil diameter
Image focus distance		infinity			
Eye Relief*		25		mm	
Eye motion box (eye-box)*			19 x 15	mm	at 25mm eye relief

* See *Figure 4* for relationship between eye relief and eye-box

Optical Characteristics

at nominal conditions

Parameter	Typical	Unit	Comment
Efficiency	200	nit/lumen	averaged over FoV
MTF	18	cycles/degree	>30% contrast
Transmittance	80%		photopically weighted
Contrast	50:1		ANSI white checkerboard

Mechanical Properties

Parameter	Value	Unit	Comment
Overall dimensions	39.1 x 44.1	mm	
Thickness	3.1	mm	
Weight	12	g	

Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
T_{STG}	Storage Temperature Range (non-condensing)	-40 to +70	°C
T_{OP}	Operating Temperature Range (non-condensing)	-20 to +40	°C

Wave Optics Limited, a Company registered in England under Company Number 08202019
Registered office 99 Park Drive, Milton Park, Abingdon, Oxfordshire OX14 4RY VAT registered GB196008693

© Wave Optics 2017

Absolute maximum ratings are those values beyond which damage to the device may occur. Functional Operation under these conditions is not implied.

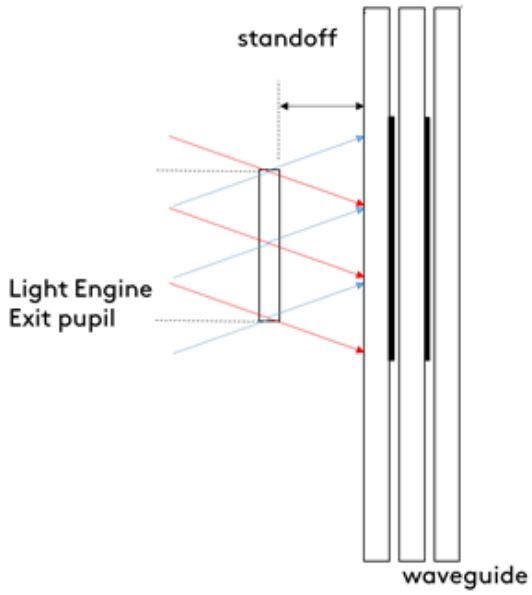

Figure 3 - Entrance pupil detail

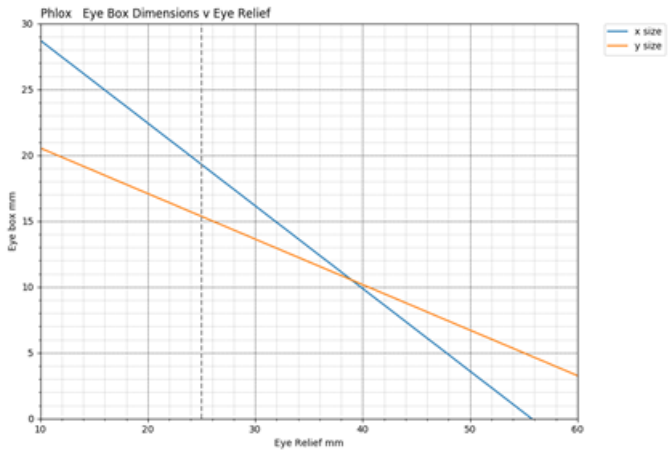

Figure 4 –Maximum eye motion box vs eye relief

Wave Optics Limited, a Company registered in England under Company Number 08202019
Registered office 99 Park Drive, Milton Park, Abingdon, Oxfordshire OX14 4RY VAT registered GB196008693

© Wave Optics 2017

Mechanical Outline

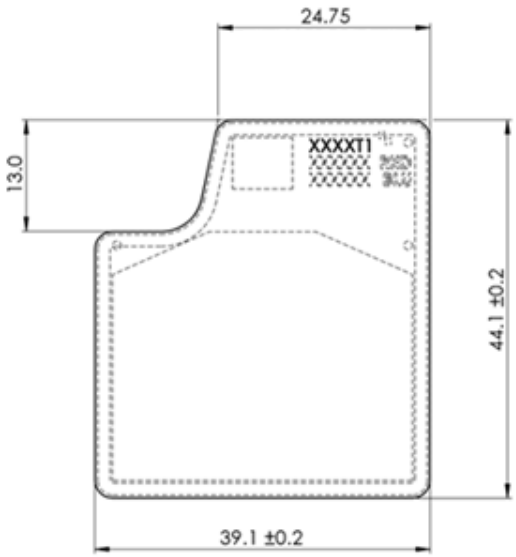

Figure 4 – Waveguide Dimensions

Revision History

Date	Revision	Changes
14/10/16	1	Initial version
7/3/17	1.1	Update with most TBCs removed
21/3/17	1.2	New mech drawing, update conditions / characteristics
5/5/17	1.3	Update fig 1, eye-box, MTF, thickness. Add contrast, weight
4/8/17	1.41	Mech updated to latest, changes to optical parameters
4/1/18	1.5	Update figures, add transmission/reflection diagrams Increase transparency to 80%

Wave Optics Limited, a Company registered in England under Company Number 08202019
Registered office 99 Park Drive, Milton Park, Abingdon, Oxfordshire OX14 4RY VAT registered GB196008693

© Wave Optics 2017

Information in this document is provided solely in connection with Wave Optics products. Wave Optics Ltd. (“WO”) reserves the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All Wave Optics products are sold pursuant to WO’s terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the WO products and services described herein, and WO assumes no liability whatsoever relating to the choice, selection or use of the WO products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by WO for the use of such third-party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third-party products or services or any intellectual property contained therein.

Unless otherwise set forth in wo’s terms and conditions of sale wo disclaims any express or implied warranty with respect to the use and/or sale of wo products including without limitation implied warranties of merchantability, fitness for a particular purpose (and their equivalents under the laws of any jurisdiction), or infringement of any patent, copyright or other intellectual property right.

Unless expressly approved in writing by an authorized wo representative, wo products are not recommended, authorized or warranted for use in military, air craft, space, life-saving, or life sustaining applications, nor in products or systems where failure or malfunction may result in personal injury, death, or severe property or environmental damage. Wo products which are not specified as "automotive grade" may only be used in automotive applications at user’s own risk.

Resale of WO products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by WO for the WO product or service described herein and shall not create or extend in any manner whatsoever, any liability of WO.

WaveOptics Ltd.
99 Park Drive
Milton Park
Abingdon
OX14 4RY
UK
www.enhancedworld.com

Wave Optics Limited, a Company registered in England under Company Number 08202019
Registered office 99 Park Drive, Milton Park, Abingdon, Oxfordshire OX14 4RY VAT registered GB196008693

© Wave Optics 2017