Corning® Varioptic® Lenses

Market-leading adjustable lens solutions for industrial applications

Table of Contents

About Corning

Corning is one of the world's leading innovators in materials science. For more than 165 years, Corning has applied its unparalleled expertise in glass science, ceramic science, and optical physics to develop products that transform industries and enhance people's lives.

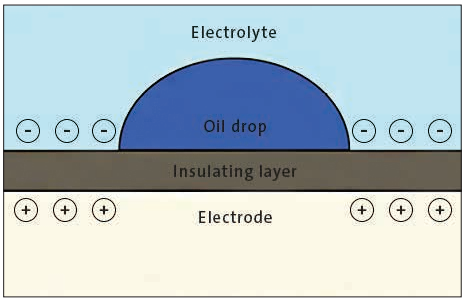
Corning succeeds through sustained investment in R&D, a unique combination of material and process innovation, and close collaboration with customers to solve tough technology challenges.

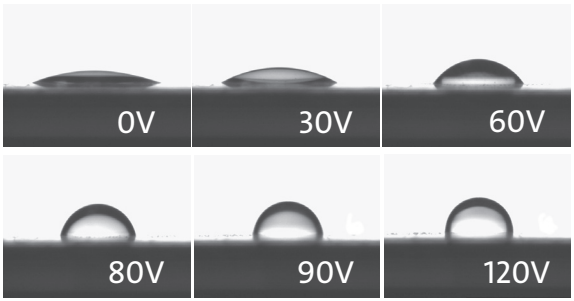
Corning's businesses and markets are constantly evolving. Today, Corning's products enable diverse markets such as mobile consumer electronics, display, optical communications, automotive, and life sciences vessels.

Corning® Varioptic® Lenses are optical devices that adjust voltage to change the shape of a liquid interface. This technology addresses demanding markets for industrial imaging applications. The technology was originally developed by Bruno Berge when he founded Varioptic in 2002, and Corning acquired the company in 2017.

Electrowetting

Electrowetting occurs when a drop of insulating liquid (e.g. oil drop) is deposited on a flat surface, made of a conductive material covered with an insulating and hydrophobic layer, and then both the drop and surface are immersed in a conductive liquid (e.g. electrolyte). Voltage is then applied between the conductive substrate and the conductive liquid causing the liquid drop to change shape. This effect is known as electrowetting.





The shape of the drop then changes as voltage increases

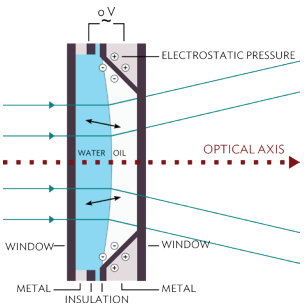
Lens Structure

The design of the adjustable lens structure ensures:

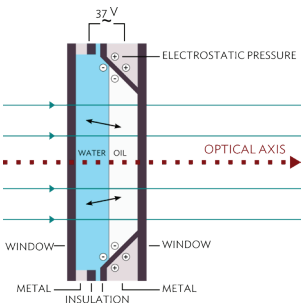
- Stable optical axis, by a conical centering of the drop
- Non sensitivity to orientation, by using two liquids of equal density
- High shock resistance, by a simple mechanical structure and equal density

Depending on the voltage applied, the lens can be a divergent lens, a flat lens, or a convergent lens.

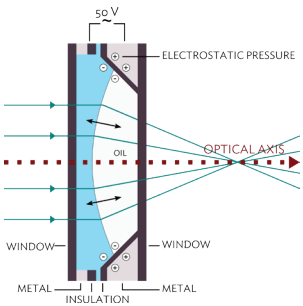
Divergent Lens



Flat Lens



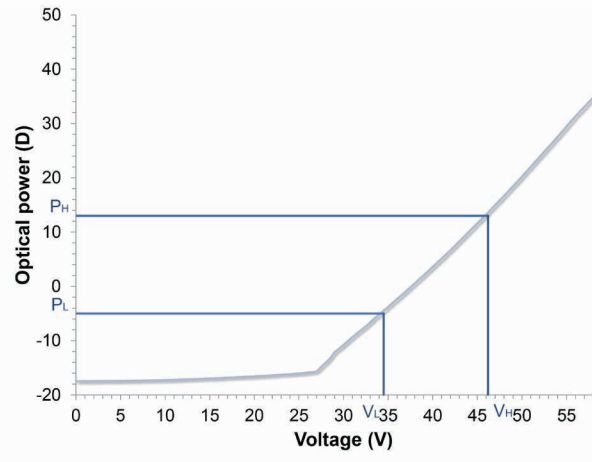
Convergent Lens



Key Performances

Optical Power vs. Voltage

The optical power of Corning® Varioptic® Lenses is a linear response versus voltage.

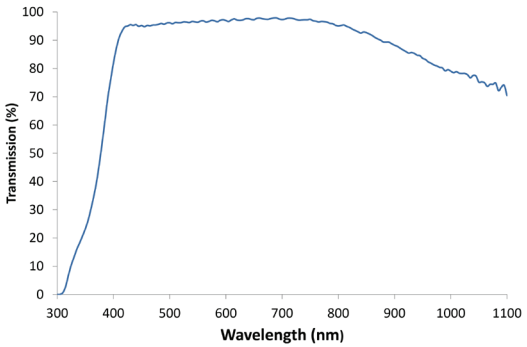


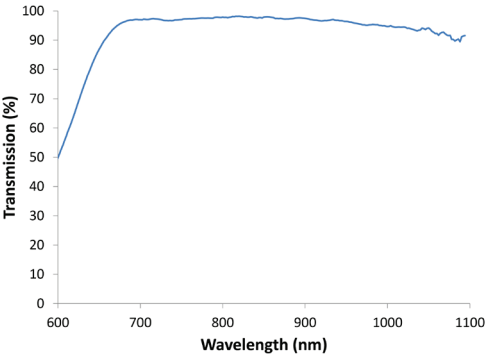
Optical Quality

The optical quality of each adjustable lens is specified by the Wave Front Error (WFE). The WFE characterizes the deviation of the actual shape of the lens compared to a perfectly spherical lens – and measured in nanometers rms. The typical WFE of the lens is in the range of 50 nm rms, which is the equivalent of a lambda/10 lens.

Transmission

The standard version of each lens come with an anti-reflective coating which is optimized in the visible range. Therefore, the transmission drops slightly in the near infrared. The loss of transmission below 400nm is linked both to the anti-reflective coating and to the glass that is used in the lenses, which is a standard borosilicate glass.





With an anti-reflective coating optimized in the near infrared, the transmission curve flattens from 700nm to 1100 nm.

System Integration

Corning® Varioptic® Lenses can be used in several types of systems:

- **Manual focus:** the user adjusts the focus manually, with a knob for example
- **Closed-loop:** this is the standard auto focus method, where a processor runs a contrast optimization loop to maximize the sharpness of the image
- **Open-loop:** this is a mode where the focus command is directly sent to the lens, from an external distance measurement for instance
- **Mixed mode:** a combination of open loop for coarse search, and closed loop for fine tuning of the focus

Closed-loop Auto Focus

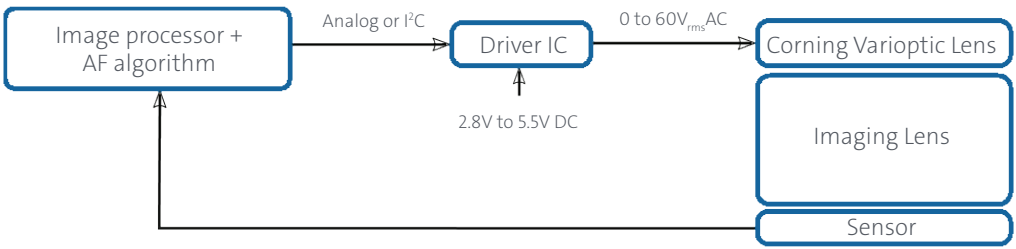
A closed-loop system consists of:

- An image sensor
- An optical lens consisting of fix-focus optics and an adjustable lens
- An adjustable lens driver IC
- A processor (ISP, FPGA...)

The processor performs the following tasks:

- Contrast measurement on the image output by the sensor
- Modification of the driver IC command to maximize this image contrast.

Corning Varioptic Lenses provides auto focus algorithms that have been optimized for the adjustable lens. The overall performance depends on many system parameters such as sensor frame rate and processing speed; typically, the complete auto focus loop can be completed in 8 to 12 frames.



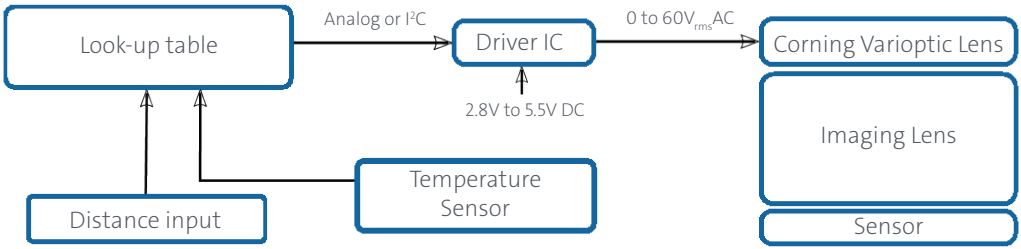
Open-loop Driving

Although the adjustable lens closed-loop is extremely fast, there are situations where it is not possible to acquire several frames to perform a focusing loop. In this case, the solution is to use open-loop focusing, where the sensor feedback is not used.

Open-loop focusing is based on a look-up table where the desired focusing distance is linked to the driver IC command. This look-up table is initially calibrated through an easy process since the lens response is linear and stable. Focusing is then triggered through an external device, for instance:

- A distance measurement device (telemeter) that measures object position in real time;
- A predetermined set of distances, etc.

Through the addition of this extra device, open-loop driving enables ultra-fast focusing where focus can be achieved within one frame only.



Closed-loop vs. Open-loop

The main advantage of the closed-loop system is its simplicity of integration. Indeed, an open-loop system will need:

- A distance measurement device
- A temperature sensor
- A calibration of the device during production

Also, an open-loop system may be susceptible to any variation in the system. For optimum performances, open-loop and closed-loop should be combined: open-loop for coarse search and closed-loop for fine search.

Advantages of Corning® Varioptic® Lenses

The traditional way to perform the auto focus function is to mechanically move the lens module to adjust the back focal length (distance to the image sensor) depending on object distance. This method presents several drawbacks:

- Requires bulky and fragile motors
- Friction of small parts leading to damage and malfunction after a few hundreds of thousands of actuations
- Noise and high power consumption while moving the mass of the lens module

The unique characteristics of Corning Varioptic Lenses offer the following:

- No moving parts
- Hundreds of millions of cycles endurance
- Speed: much faster than mechanical actuators
- Robustness and unmatched mechanical shock resistance: tested at 2000g / 0.25ms / 100 times (x2 directions)
- Close focus ability: from infinity to below 5 cm
- Low power consumption: <1 mW (~20 mW with driver)
- Silent operation

Applications

- Barcode readers
- Biometrics
- Endoscopes
- Lasers
- Low vision devices
- Machine vision
- Medical imaging
- Ophthalmology equipment

Variable Focus Lenses (A-Series)

Corning® Varioptic® Lenses enable variable focus functionality when designed into imaging or beam shaping lenses. They offer a high degree of design freedom for mechanical, electrical, and optical integration.

A-16F

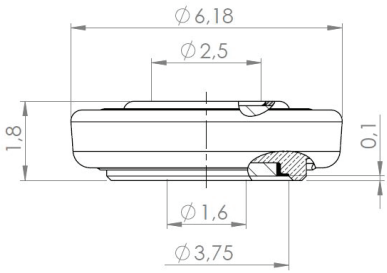
The latest and smallest member of the A-Series family, and the smallest lens currently available. It is specifically designed for ultra-compact cameras, such as barcode engines, industrial and medical endoscopes, etc.

Key Features:

- 6.2 mm outer diameter
- 1.85 mm thickness
- 1.6 mm clear aperture
- Excellent optical quality and fast response time
- Focus range from 5 cm to infinity
- Easy to integrate

Ordering Information:

- **A-16F0:** with an anti-reflective coating optimized in the visible range
- **A-16F1:** with an anti-reflective coating optimized in the near infrared
- **A-16F9:** with no anti-reflective coating



Specifications:

Typical performance at 25°C

Useful aperture at 0° field of view	1.6 mm
Useful aperture at 50° field of view	3.5 mm
Low optical power	-5 diopters (m^{-1})
High optical power	+15 diopters (m^{-1})
Wave Front Error on 1.6mm aperture	35 nm (rms)
Transmission at 587nm (or 850nm for H1)	97% for A-16F0
Storage temperature	from -40 to 85°C
Operating temperature	from-20 to 60°C

A-25H

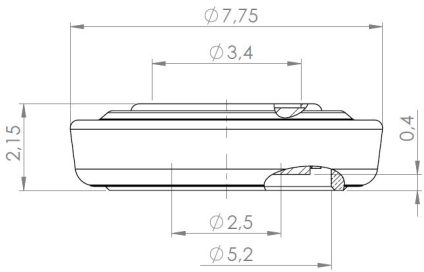
Designed for compact optical systems such as: barcode readers, industrial cameras, medical imaging and biometrics. The A-25H small size, large dynamic range, and low wave front distortion, delivers outstanding performance.

Key Features:

- 7.75 mm outer diameter
- 2.15 mm thickness
- 2.5 mm clear aperture
- Silent
- Focus range from 5.5 cm to ∞
- Easy to integrate

Ordering Information:

- **A-25H0:** with an anti-reflective coating optimized in the visible range
- **A-25H1:** with an anti-reflective coating optimized in the near infrared
- **A-25H9:** with no anti-reflective coating



Specifications:

Typical performance at 25°C

Useful aperture	2.5 mm
Low optical power	-5 diopters (m^{-1})
High optical power	+13 diopters (m^{-1})
Wave Front Error on 2.5mm aperture	45 nm (rms)
Transmission at 587nm (or 850nm for H1)	97%
Storage temperature	from -40 to 85°C
Operating temperature	from-30 to <85°C

A-39N

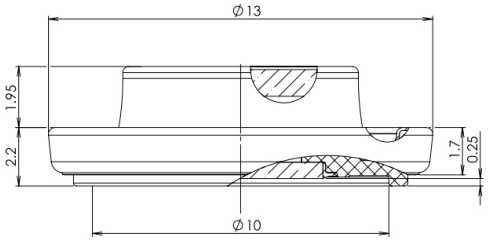
Designed specifically for variable focus products needing a large clear aperture: long focal objectives, large sensors, C-Mount objective lenses and laser beam shaping applications. The A-39N is perfectly suited for applications such as industrial vision, medical imaging cameras, optical equipment, biometric devices, etc.

Key Features:

- 13 mm outer diameter
- 4.0 mm thickness
- 3.9 mm clear aperture
- Silent
- Focus range from 5 cm to ∞
- Easy to integrate

Ordering Information:

- **A-39N0:** with an anti-reflective coating optimized in the visible range
- **A-39N1:** with an anti-reflective coating optimized in the near infrared
- **A-39N9:** with no anti-reflective coating



Specifications:

Typical performance at 25°C

Useful aperture at 0° field of view	3.9 mm
Useful aperture at 50° field of view	3.5 mm
Low optical power	-5 diopters (m^{-1})
High optical power	+15 diopters (m^{-1})
Wave Front Error on 3.5mm aperture	50 nm (rms)
Transmission at 587nm (or 850nm for H1)	97%
Storage temperature	from -40 to 85°C
Operating temperature	from-20 to 60°C

A-P Series

Packaged A-Series lenses are designed to make integration easier. By avoiding the hassle of mechanical and electrical integration of the lens, the variable focus capability can be integrated much faster into customer's system. The lens is built-in with an FPC cable, and can be connected to a standard FPC connector.

Ordering Information:

- **A-16F0-P12**: Packaged A-16F0 with straight Flex Cable (FPC-A-12)
- **A-25H0-PXX:** Packaged A-25H0 with:
  - **XX = 06:** bent Flex Cable (FPC-A-6)
  - **XX = 07:** straight Flex Cable (FPC-A-7)
  - **XX = 09:** straight Flex Cable (FPC-A-9)
  - **XX = 10:** straight Flex Cable with thermistor (FPC-A-10)
  - **XX = 13:** straight Flex Cable (FPC-A-13)
- **A-39N0-PXX:** Packaged A-39N0 with:
  - **XX = 04:** bent Flex Cable (FPC-A-4)
  - **XX = 08:** straight Flex Cable (FPC-A-8)
  - **XX = W065:** with wires

For more information on FPC specifications, refer to page 20.

Specifications:

	A-25H0-PXX	A-39N0-PXX
External diameter	9.4 mm	15.5 mm
Thickness	3.5 mm	5.2 mm

A-39N0-PW065

A-25H0-P-10

A-39N0-P-04

A-25H0-P-07

A-25H0-P-06

Auto Focus Modules (C-Series)

Corning® Varioptic® Lenses enable auto focus functionality when a fixed lens module and a variable focus lens are integrated into a Corning Varioptic receptacle mount. Corning provides auto focus algorithms that are optimized for Corning Varioptic Lenses.

C-S-Series

Integrates a fixed lens module and an A-Series variable focus lens in an M12 receptacle (S-mount). It can be easily mounted into a standard M12 sensor board and driven by the same drivers as the A-Series lenses.

Key Features:

- M12x0.5 thread
- Flex Cable compatible with 1 mm pitch connector
- Compatible FPC connectors:
  - —SFW4S-2STE9LF from FCI
  - —04FMN-BTK-A (LF)(SN) from JST
- Built in auto focus actuator
- Built in IR cut filter for -IR version

Ordering Information:

- **C-S-25H0-026-0X:** includes A-25H0 and FPC-A-X (X=6 or 7), EFL = 2.6 mm
- **C-S-25H0-038-0X:** includes A-25H0, and FPC-A-X (X=3 or 7), EFL = 3.8 mm
- **C-S-25H0-047-0X:** includes A-25H0, and FPC-A-X (X=3), EFL = 4.7 mm
- **C-S-25H0-075-0X:** includes A-25H0, and FPC-A-X (X=3), EFL = 7.5 mm
- **C-S-25H0-096-0X:** includes A-25H0, and FPC-A-X (X=3 or 7), EFL = 9.6 mm
- **C-S-39N0-158-0X:** includes A-39N0, and FPC-A-X (X=4), EFL = 15.8 mm

For module with IR cut filter (650nm cut-off wavelength), please add I to one of the above reference when ordering

From left to right : C-S-25H0-026-06 / C-S-39N0-158-04 / C-S-25H0-075-03 / C-S-25H0-096-03 / C-S-25H0-037-03

Specifications:

Typical performance at 25°C

	C-S-25H0-026	C-S-25H0-038	C-S-25H0-047	C-S-25H0-075	C-S-25H0-096	C-S-39N0-158
Effective Focal Length	2.6 mm	3.8 mm	4.7 mm	7.5 mm	9.6 mm	15.8 mm
F-number	2.5	2.2	2	2.9	3.7	4
Chief Ray Angle (CRA)	17°	32.4°	34.4°	16.5°	12.5°	5.5°
Focusing range	4 mm to ∞	5 cm to ∞				

FOV vs. Sensor Format	C-S-25H0-026	C-S-25H0-038	C-S-25H0-047	C-S-25H0-075	C-S-25H0-096	C-S-39N0-158
1/4"	86°	61°	46°	33°	26°	16°
1/3"	134°	78°	65°	44°	35°	22°
1/2.7"	152°	-	71°	48°	39°	-
1/2.5"	160°	-	75°	51°	41°	-
1/2"	-	-	-	-	45°	-
1/1.8"	-	-	-	-	50°	-

	C-S-25H0-026	C-S-25H0-038	C-S-25H0-047	C-S-25H0-075	C-S-25H0-096	C-S-39N0-158
Back Focal (no IR)	5.26 mm	0.98 mm	0.83 mm	4.07 mm	6.12 mm	6.02 mm
Back Focal (IR filter)	5.36 mm	0.84 mm	0.69 mm	4.26 mm	6.3 mm	6.2 mm
Image circle diameter	7.2 mm	6.1 mm	7.5 mm	7.2 mm	9.1 mm	6 mm
Sensor compatibility	1/2.5"	1/3"	1/2.4"	1/2.5"	1/1.8"	1/3"

Setting Procedure

For optimum performance of the module, please refer to the setting procedure detailed in the Technical Data Sheet of the C-S-Modules.

C-u-Series

Combined with the use of specific adapters, either for C-Mount or M12, an inexpensive Auto Focus microscope can be built. It uses the same FPC cable as the C-S series, and therefore requires the same FPC connectors.

Ordering Information:

- **C-u-25H0-075-03:** inverted C-S-25H0-075

Specifications:

Typical performance at 25°C

	Extension Ring		
Magnification	**X2**	**X4**	**X5**
Working distance	7 mm	6 mm	5 mm
Focusing range	±0.85 mm	± 0.7 mm	± 0.65 mm
Mechanical Back Focal	15 mm	22 mm	37 mm

C-u Microscopy Set

Allows customers to achieve various magnifications, both for M12 and C-Mount cameras. This set is delivered with the C-Microscopy development kit.

- 1 microscope spacer
- 1 set of M12 and C-Mount adapters allowing X2, X3 and X5 magnifications
- 1 locking nut for M12 adapters

C-C-Series

Electronically focused, controllable C-mount module based on the A-39N0 variable focus lenses. The C-C-Series incorporates all necessary electronic components to drive the lenses and only requires a DC power supply.

Key Features:

- Variable focus from 10 cm to ∞
- Silent
- Supports I²C Analog, RS232, and SPI interfaces
- Supports closed-loop operations

Ordering Information:

- **C-C-39N0-XX0-I²C:** I²C or Analog operation
- **C-C-39N0-XX0-R33:** RS232 with 3.3 V signal or analog operation
- **C-C-39N0-XX0-R12:** RS232 with 12 V signal or analog operation
- **C-C-39N0-XX0-SPI:** SPI operation only

XX = 16 or 25 for 16mm EFL or 25mm EFL

Specifications:

Typical performance at 25°C

	C-C-39N0-160	C-C-39N0-250
Effective Focal Length	16 mm	25 mm
Manual Iris	No	Yes
F-number	2.8	4 to 22
Image circle diameter	11 mm	11 mm
Sensor compatibility	2/3"	2/3"
DC power supply	3.3-24 VDC	3.3-24 VDC
Current consumption	25 to 100 mA	25 to 100 mA
Connector	6 pin jST SHR-06V-S-B	6 pin jST SHR-06V-S-B

C-C-39N0-160

C-C-39N0-250

Drivers

Corning works with semiconductor manufacturers to integrate driver IC's that drive the Corning® Varioptic® Lenses.

Maxim MAX14574

- Compatible with A-Series, C-S-Series and C-u-Series
- Recommended for high resolution applications (>8bits)
- It is also possible to read the temperature of an external thermistor, through the I^2C interface

To purchase, please contact Corning Varioptic Lenses at varioptic@corning.com or an approved Corning Varioptic Lenses distributor.

Microchip HV892

- Compatible with A-Series, C-S-Series and C-u-Series with voltage <60 V
- Recommended for applications where PCB space is limited.

Microchip drivers can be purchased directly from Microchip, Corning Varioptic Lenses, or an approved Corning Varioptic Lenses distributor.

Performance Summary:

	MAX14574	HV892
Maximum Voltage	70V	60 V
Resolution	10 bits	8 bits
Interface	I^2C	I^2C
Size (mm)	1.6 x 2..6	4 x 4
External Components	5	2
Output waveform	PWM	Special square AM
Maximum Power Consumption	40 mW	20 mW
Package	15 bump WLP	DFN
Temperature reading	Yes	No

Driver Boards

USB-M Drivboard

This board includes a Maxim driver, a 4 pin FPC connector for the A-Series, C-S-Series and C-u-Series. Due to the Focuslab C Software, it is easily driven through USB and delivered with the development kits. Its very small form factor enables use of this board directly with any PC-driven application with no extra hardware development.

Board size : 41.5x14x7.5mm.

Maxim Drivboard

This board includes a Maxim driver and a 4 pin FPC connector for the A-Series, C-S-Series and C-u-Series. It has a 4 pin JST connector for DC power supply and for I^2C communication. It has been designed for fast driving of the adjustable lens directly from a microcontroller, an FPGA, a DSP, etc. A cabled JST connector is supplied with the board.

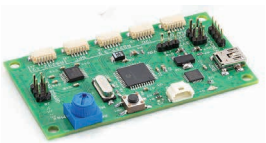
Board size : 23x12x4.8mm.

Microchip HV892 Drivboard

This board includes a Microchip HV892 driver and a 4 pin FPC connector for the A-Series, C-S-Series and C-u-Series. It has a 4 pin JST connector for DC power supply and for I^2C communication. It has been designed for fast driving of the liquid lens directly from a microcontroller, an FPGA, a DSP, etc. A cabled JST connector is supplied with the Microchip HV892 Drivboard.

Board size : 23x12x4.8mm.

C-C Com Board



This board is a USB to RS232-12 V / RS232-3.3 V / I^2C / SPI converter. Connected to a PC with a USB cable on one hand, and to the C-C module on the other hand. It enables communication directly with any of the C-C versions using FocusLab C. A potentiometer also allows direct control of the C- C voltage without a computer.

Connection Devices

Corning® Varioptic® Lenses have specially designed connection cables that enable the lenses to be easily used. The VHD series are bulky mechanical holders that can be easily fitted on an optical test bench, or in a non room-sensitive application. The FPC series are foldable flex printed circuits that enable designing compact optical systems.

Holders

The VHD-0x family is compatible with the A-Series lenses and is used in conjunction with the FPC-A-x. It can be connected directly to the Drivboards. An M4 thread is located on the outer diameter to fix the holder on a standard M4 mounting device. A 14 mm diameter recess is located on the rear side of the holder, which eases integration with a compact objective lens.

Ordering Information:

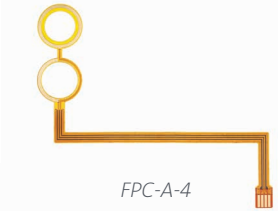
- **VHD-06:** for A-39N
- **VHD-07:** for A-25H
- **VHD-09:** for A-16F

Flex Cables

		Type				
	Compatibility	**Pins**	**Pitch**	**Thermistor**	**Shape**	**Length(*)**
FPC-A-3	A-25H	4	1 mm	No	Bent	43 mm
FPC-A-4	A-39N	4	1 mm	No	Bent	61 mm
FPC-A-5	A-39N	4	1 mm	No	Straight	28 mm
FPC-A-6	A-25H	4	1 mm	No	Bent	83 mm
FPC-A-7	A-25H	4	1 mm	No	Straight	83 mm
FPC-A-8	A-39N	4	1 mm	No	Straight	145 mm
FPC-A-9	A-25H	6	0.5 mm	No	Straight	36 mm
FPC-A-10	A-25H	6	0.5 mm	Yes	Straight	36 mm
FPC-A-12	A-16F	4	1 mm	No	Straight	71 mm
FPC-A-13	A-25H	4	0.5 mm	No	Straight	13 mm
FPC-A-14	A-39N	6	0.5 mm	Yes	Bent	61 mm
FPC-A-15	A-39N	6	0.5 mm	No	Bent	61 mm

(*) : Longest dimension of the FPC

FPC-A-3



FPC-A-4

FPC-A-6

FPC-A-5

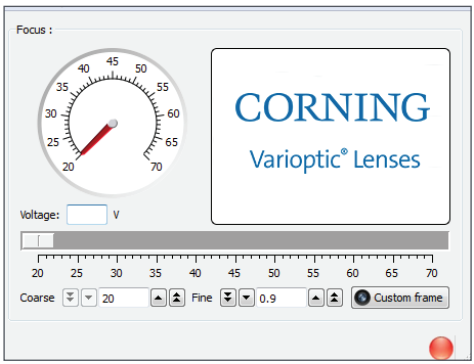
FPC-A-7

FPC-A-8

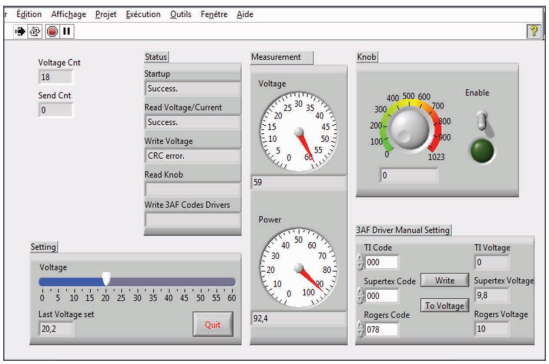
FPC-A-12

FocusLab C Software

FocusLab C allows customers to control the C-Mount lens through the C-C Com Board. The software controls the output voltage on the liquid lens. A specific dialog box allows for sending advanced commands to the C-Mount lens. A LabView VI is also provided to control the C-Mount lens through a LabView program. A specific documented DLL integrates this in a C-code program. FocusLab C also allows the control of the USB-M Drivboard.



Focuslab C windows interface



Focuslab C LabView interface

Development Kits

Development Kits for various A-Series lenses and C-Series modules are specially designed to speed up the evaluation and design process.

D-A-16F

Ordering code: D-A-16FX, X=0,1, or 9

- 1 A-16FX
- 1 A-16FX-P12
- 1 Maxim Drivboard
- 1 Microchip HV892 Drivboard
- 1 VHD-09
- 1 FPC-A-12
- 1 USB-M Drivboard, USB cable
- Focuslab C Software
- Documentation Package

D-A-25H

Ordering code: D-A-25HX, X=0,1, or 9

- 1 A-25HX
- 1 A-25HX-P07
- 1 Maxim Drivboard
- 1 Microchip HV892 Drivboard
- 1 VHD-07
- 1 FPC-A-3
- 1 USB-M Drivboard, USB cable
- Focuslab C Software
- Documentation Package

D-A-39N

Ordering code: D-A-39NX, X=0,1, or 9

- 1 A-39NX
- 1 A-39NX-P04
- 1 Maxim Drivboard
- 1 Microchip HV892 Drivboard
- 1 VHD-06
- 1 FPC-A-4
- 1 USB-M Drivboard, USB cable
- Focuslab C Software
- Documentation Package

D-S Kits

Ordering code:

- D-S-25H0-XXX, XXX=026/038/075/096, no filter
- D-S-25H0-XXXI, XXX=026/038/075/096, with IR-Cut filter
- D-S-39N0-158, no filter
- D-S-39N0-158I, with IR-Cut filter

- 2 C-S Modules
- 1 Maxim Drivboard
- 1 Microchip HV892 Drivboard
- 1 USB-M Drivboard, USB cable
- Focuslab C Software
- Documentation Package

D-u-25H0-075-03

Ordering code: D-u-25H0-075

- 1 C-u-25H0-075
- 1 Maxim Drivboard
- 1 Microchip HV892 Drivboard
- 1 C-Series Microscopy Set
- 1 USB-M Drivboard, USB cable
- Focuslab C Software
- Documentation Package

D-C-Series

Ordering code: D-C-39N0-XXX-YYY, XXX=160 or 0250, YYY= R12, R33, SPI, I^2C

- 1 C-C-39N0-XXX-YYY
- 1 C-C Com board and cable
- Focuslab C Software
- Documentation Package

Documentation Package

With each Development Kit, Corning® Varioptic® Lenses deliver a complete set of application notes to assist the integration and development of the customer's product.

User Guides

- FocusLab C user guide
- VHD user guide
- Board user guides (USB-M, Maxim DrivBoard, Microchip DrivBoard, C-Com board)
- Microscopy user guide
- Tutorial videos

Integration

- Mechanical and opto-electrical integration guide
- Design and assembly rules
- Driver implementation guide
- Closed loop auto focus implementation examples
- Overshooting and optimization overview
- Driver IC data sheets

Extended Details on Technology

- Marketing data sheet
- ZEMAX model: Focus configurations, n(λ) specifications
- IGES model: 3D design and opto-mechanical integration

General

- Measurement principles
- Optical Wave Front Error
- Cosmetic specification
- Laser Applications

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