

DATA SHEET
"CYA-A50, CYA-A50-A1
CYCLOPS™" SINGLE MIRROR DEFLECTION SYSTEMS

NEWSON NV

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1 SAFETY WARNINGS

THE CYCLOPS™ ACTUATOR HAS A VERY STRONG OPEN MAGNETIC FIELD AT MIRROR SIDE.
KEEP MAGNETIC PARTS AWAY FROM THE DEFLECTORS MIRROR SIDE.
TAKE PROPER PRECAUTIONS WHEN HAVING BODY IMPLANTS (PACEMAKER, HEARING AIDS...)

WHEN A CATASTROFIC FAILURE OCCURS, INCIDENT LIGHT MAY LEAK THROUGH THE BACKSIDE OF THE DEFLECTOR. ADDITIONAL COVERING MAY BE NEEDED TO GUARANTEE LASER SAFETY WHEN USED TO DEFLECT HIGH ENERGY LASERBEAMS.

2 CYCLOPS™

While commonly used, the traditional two-mirror setup for 2D optical beam positioning comes with several drawbacks. One key limitation is the physical size of the mirrors themselves. Additionally integrating such a deflection system often takes up considerable space in the laser machine.

The CYCLOPS™ actuator family offers an efficient alternative through a single-mirror architecture for 2D beam positioning. Compared to conventional dual-mirror systems, this design introduces several clear advantages:

- Significantly smaller overall system size
- Up to 50% reduction in optical losses
- Perfect telecentricity is achievable
- Much smaller moving mirror
- No torsional stress on the mirror substrate

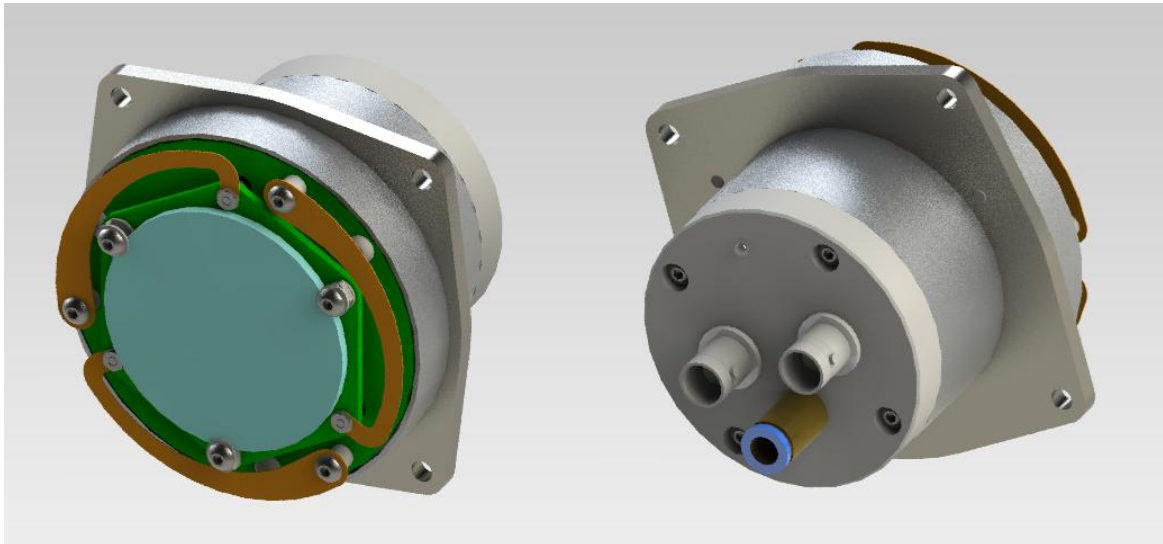
All CYCLOPS™ actuators are implemented as smart deflectors, featuring real-time mirror position tracking to optimize both speed and accuracy. The complete regulation electronics for mirror control are fully integrated within the actuator body, eliminating the need for external drivers.

2.1 CYA-A50 CYCLOPS™

The CYA-A50 CYCLOPS™ deflector is a smart deflection unit that includes all necessary electronics to control mirror tilt. It features two coaxial connectors (CH1 and CH2) for power supply, and for sending/receiving X and Y setpoints and feedback signals.

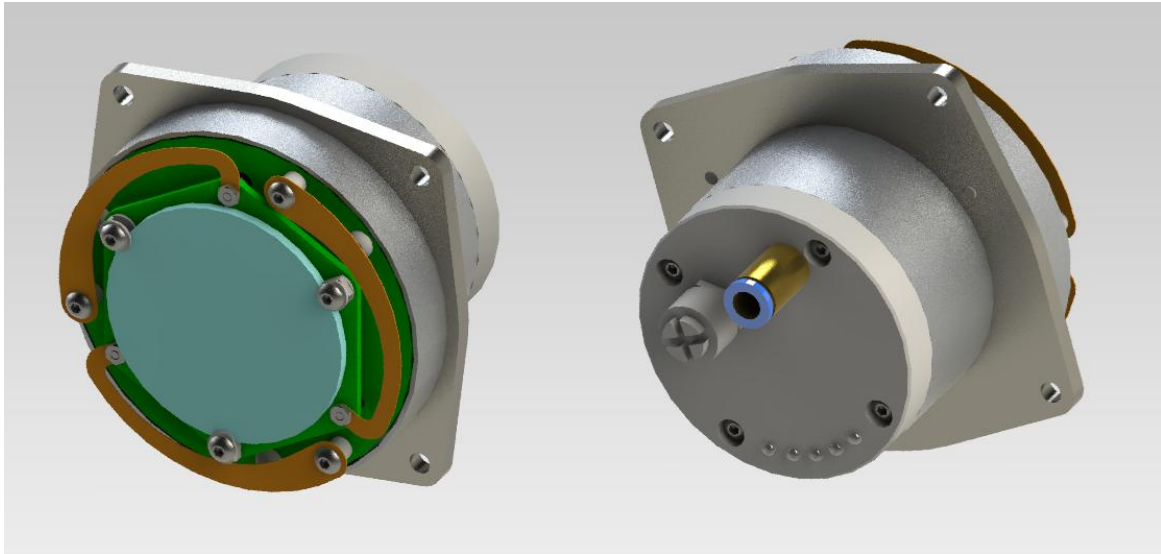
This dual-coaxial interface makes upgrading from a traditional dual-mirror setup straightforward.

A dedicated 32-bit DSP manages the system's control loop. The actuator is fully compatible with the CUA32 control card, and front-end options are available for integration with third-party controllers supporting XY2-100, analogue, and other protocols.



2.2 CYA-A50-Ai1 CYCLOPS™

The CYA-A50-Ai1 CYCLOPS™ is a smart deflector that can be operated without any additional electronics. This actuator is able to generate setpoints, handle image calibration and gate a laser all by itself. An 8 pin M12 style connector provides connectivity with any host computer or PLC over an ethernet connector. The device is fully compatible with the 802.3af power over ethernet standard.



2.3 ENERGY EFFICIENCY AND MECHANICAL DESIGN

True to our company philosophy, the low power consumption and integration flexibility of the CYCLOPS™ single-mirror 2D deflector are key advantages of our design approach.

In a typical 45° setup, the CYA-A50 actuator provides full 2D beam steering with a clear aperture of 35 mm, while consuming just 2 watts of power. This low power requirement is achieved by combining moving coil technology with high-efficiency class D amplifiers.

The CYCLOPS™ actuator is mechanically simple, consisting of only two main components:

- The stator, which houses the magnets and integrated electronics.
- The mirror mount, a free-moving printed circuit board that holds the actuator coils and supports the mirror.

The stator generates a magnetic field that extends beyond the actuator body, allowing the mirror and its mount to float freely within this field. Mirror positioning is maintained by a combination of plate springs and closed-loop regulation. X and Y steering commands are translated into hover values, which define the required tilt angles of the mirror. Tilting is achieved through the interaction of the magnetic field and the current flowing through the coils on the mirror mount. The mount is suspended above the stator by plate springs, which also serve as electrical pathways between the amplifiers and the actuation coils.

To ensure high precision, the CYCLOPS™ actuator uses AIMS (Advanced Integrated Mirror Sensing) – a multi-point height sensing method using transformer-style inductive couplings between the mirror mount and stator. This enables true closed-loop control over both axes.

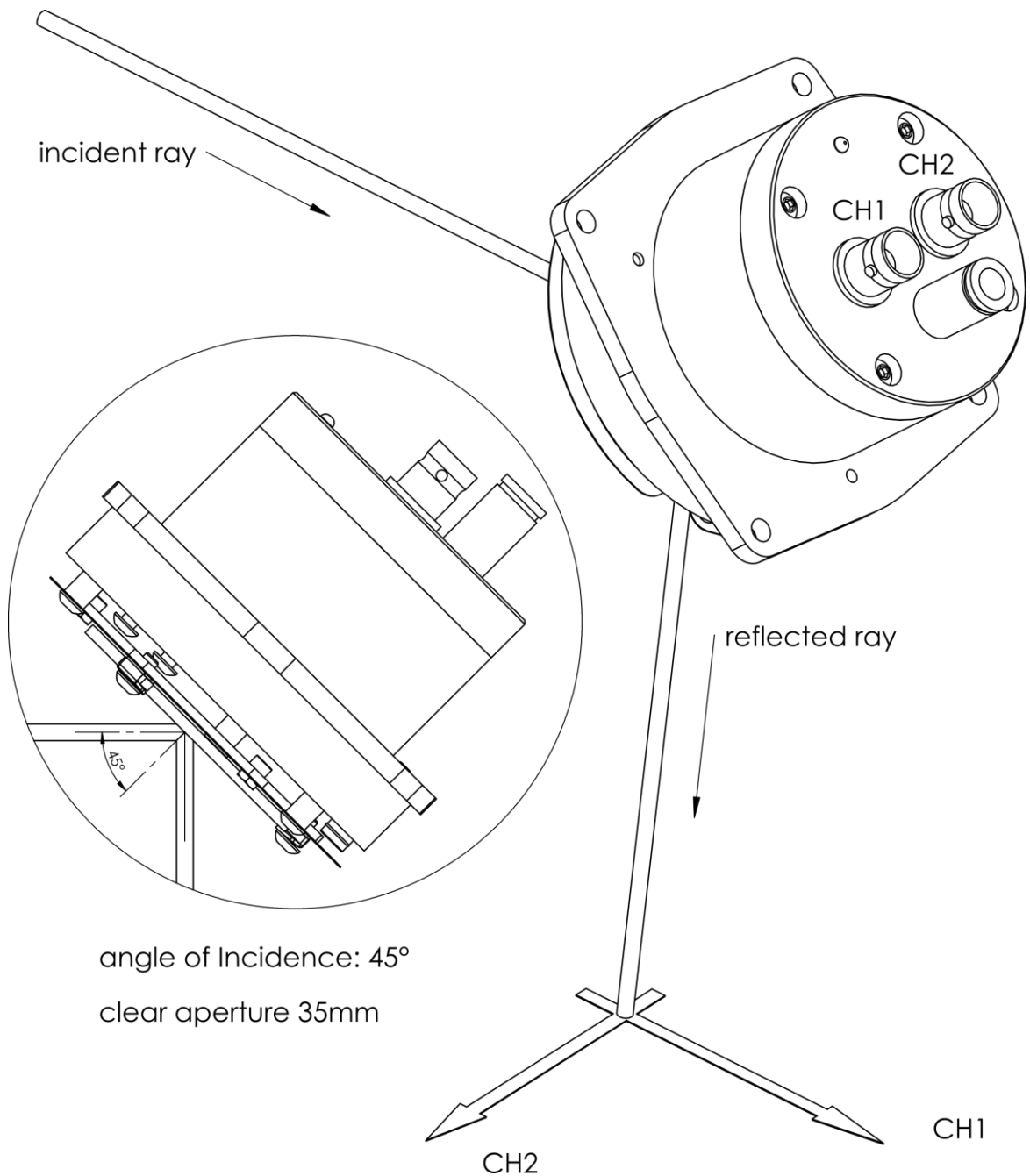
2.4 HIGH-POWER LASER USE AND THERMAL MANAGEMENT

When operating with high-power lasers (>1 kW), it is recommended to actively cool the mirror. For this purpose, the deflector is equipped with an air inlet connector. The cooling gas is directed through the actuator body to cool both the rear of the mirror and the internal electronics.

Although most optical mirrors have dielectric coatings with >99% reflectivity, even a small fraction of unreflected light can cause heating. For example, with a 1 kW laser and a mirror reflecting 99.5%, approximately 5 watts of optical power is absorbed – more than twice the electrical power consumption of the actuator itself.

To reduce thermal loading, mirrors with backside coatings are recommended. In addition, the CYA-A50 Ai1 model can be fitted with a temperature sensor on the mirror's backside. The integrated control electronics can monitor this data and safely shut down the system if the mirror overheats.

3 SETUP



When a ray is reflected on a rotating mirror, the angle between incident and reflected ray changes twice the mirrors rotation angle. This statement is true when the mirror rotating axis is perpendicular with the ray. In this setup the rotation axis in CH1 direction is perpendicular while the angle between ray and the rotation axis of CH2 is 45°. As a result, the optical deflection angles of CH2 are attenuated. The resulting marking field becomes rectangular. The deflector maps CH1 and CH2 setpoint data into mirror hover positions to achieve the desired tilt. A compensation strategy is used to counter said angle reductions and make the marking field more squarish.

4 TYPICAL CHARACTERISTICS CYA-A50, CYA-A50-AI1

4.1 SPECIFICATIONS

General

| | | |
|-----------------------------------|-----------------|---------------|
| Actuator principle | moving coil | |
| Coil inductance | TBD | μH |
| Coil resistance | TBD | mOhm |
| Regulator | digital 20 bit | |
| Amplifier | class D | |
| Mirror position sensor | AIMS (patented) | |
| Electrical connection CYA-A50 | 2x 50 Ohm BNC | |
| Electrical connection CYA-A50-AI1 | M12 ethernet | |

Mirror

| | | |
|----------------------------|------|----|
| diameter | 50.8 | mm |
| thickness (preferred) | 2 | mm |
| cooling air flow connector | 6 | mm |

Positioning (optical angles)

| | | |
|--|-----|-----------------|
| Rated angular excursion CH1 (1) | 240 | mrاد |
| Rated angular excursion CH2 (1) | 240 | mrاد |
| Regulation jitter (peak to peak) at one sigma | 15 | μrad |
| Drift measured over 8 hours | 10 | μrad |
| Repeatability | 10 | μrad |
| Step response 24 mrad, settling to 200 μrad | TBD | msec |
| Step response 2.4 mrad settling to 200 μrad | TBD | msec |
| Track delay | 800 | μsec |
| Bandwidth | 400 | Hz |

(1) angular ranges when deflector is mounted like described in chapter 3

Temperature

| | | |
|-------------------------------|------------|--------------------|
| Operating ambient temperature | -10 to +50 | $^{\circ}\text{C}$ |
| Storage temperature | -10 to +60 | $^{\circ}\text{C}$ |

4.2 STEP RESPONSE

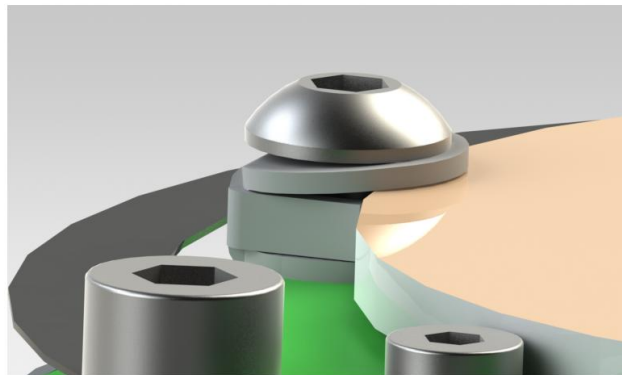
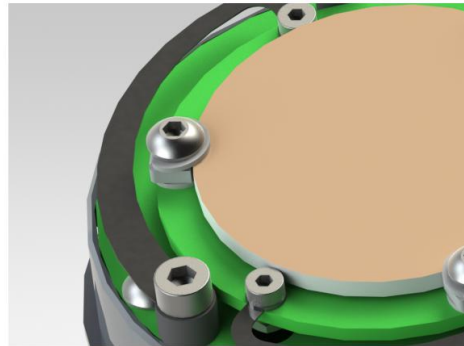
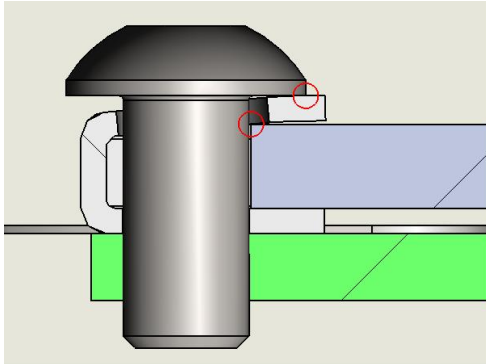
TBD

4.3 JITTER

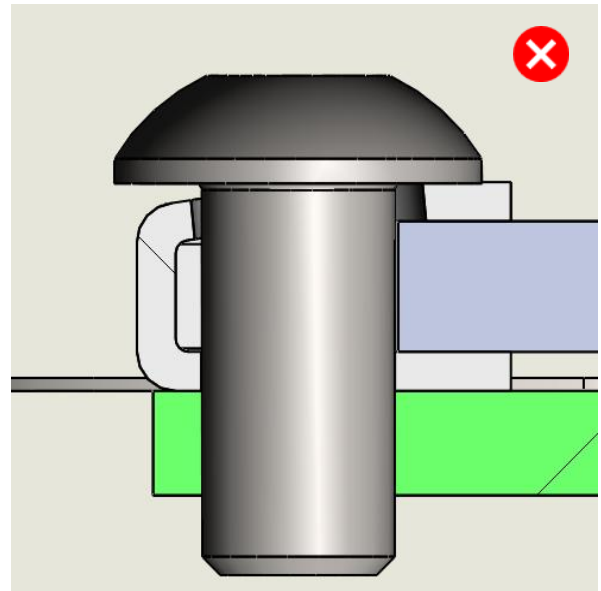
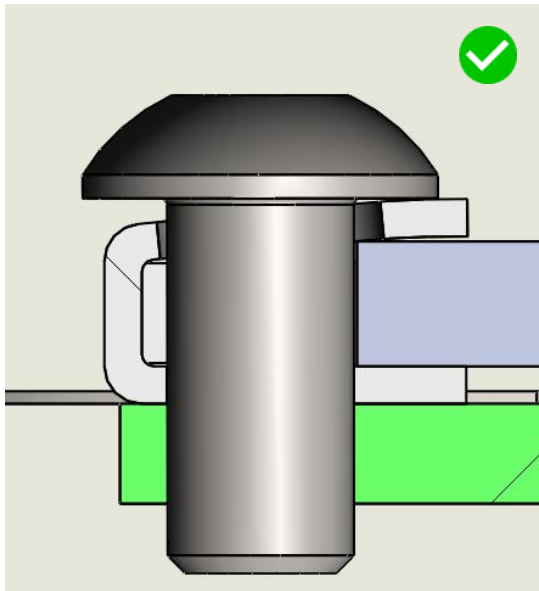
TBD

5 MIRROR MOUNTING

CYCLOPS™ actuators can be fitted with round mirrors, diameter 50.8mm (2 inch). Preferred thickness is 2 mm. Those mirrors are clamped using small aluminum brackets kept in place with M3x6 screws. Clamping presses the mirror onto the tilting part while providing lateral freedom to handle thermal expansion differences. When mounting the mirror, care should be taken when tightening the screw. The thread in the tilting part has a negative tolerance. This serves as a screw locking mechanism but implies that some torque is needed to turn the screw. In order to have a good fixture, the screw needs to be turned until it contacts the bracket, and the bracket contacts the mirror (red circles on drawing).



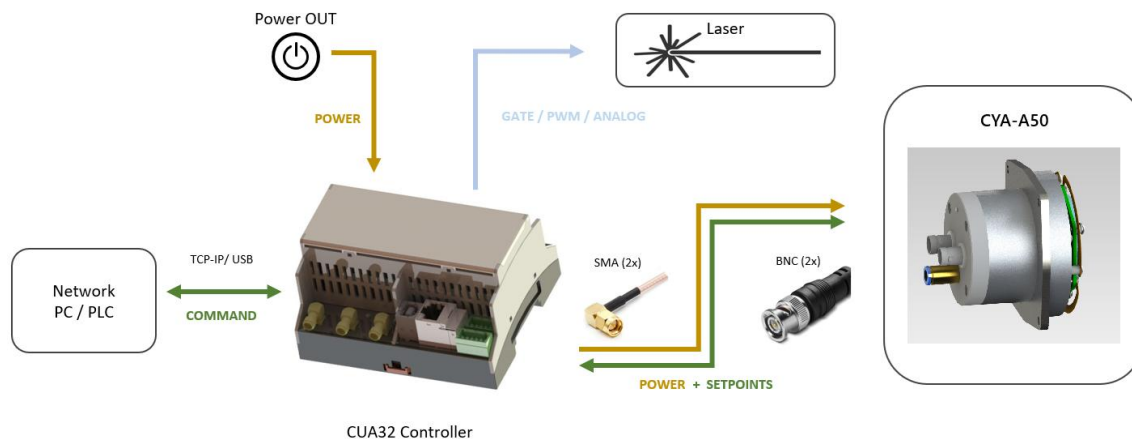
Note that the bracket only touches the mirror at its outside border. Towards the center, the bracket touches the head of the screws. This method slightly bends the bracket. This bending provides a spring-loaded fixture of the mirror. When overtightened the bracket will be fully pressed against the mirror. The mirror could chip off due to resulting pressure forces. When too loose, the system becomes mechanically unstable.



6 CONNECTING CYA-A50 CYCLOPS™

6.1 SETUP

Comprising all electronics to track setpoints, the CYA-A50 can be easily powered and controlled by external electronics. 2 coax cables connect the actuator to a CUA32 controller, one for X and one for the Y-direction. Both cables are also used to provide power supply.



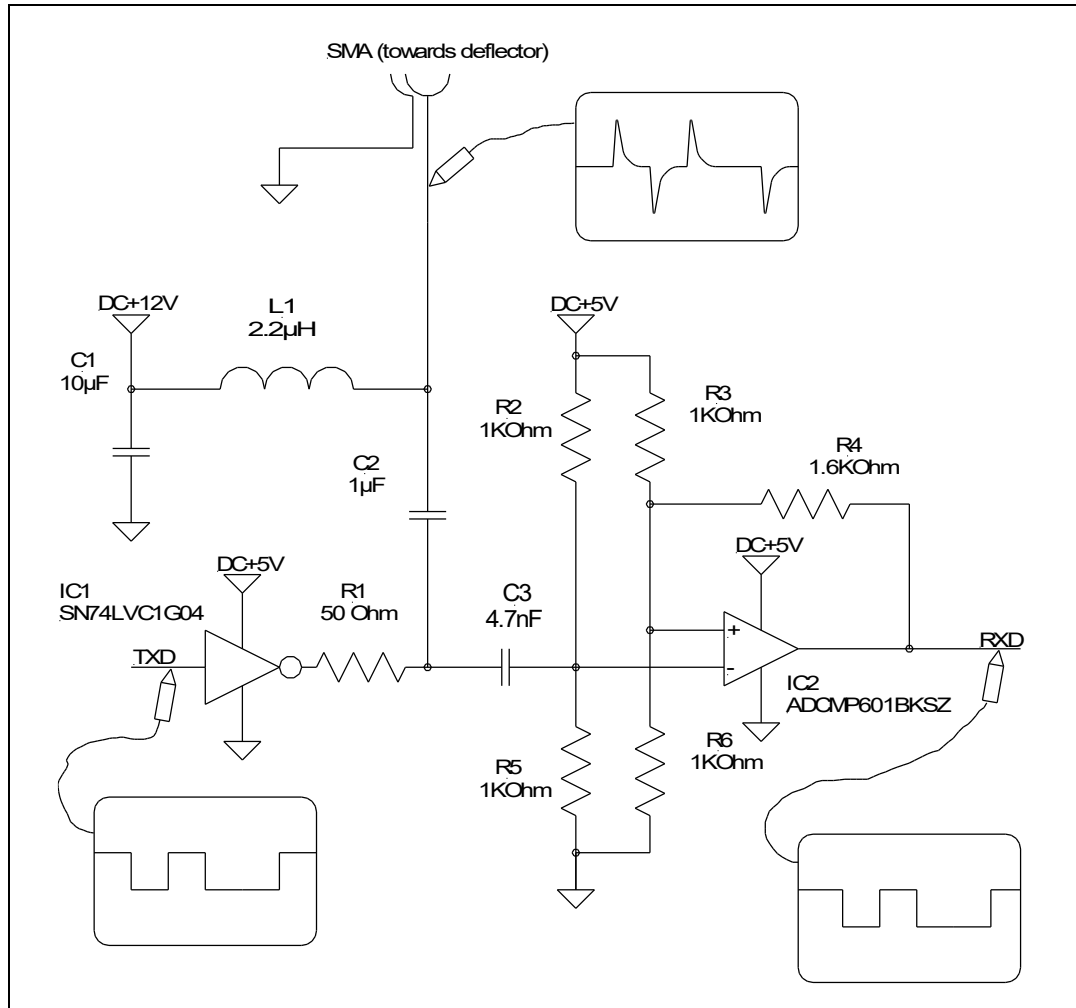
6.2 ELECTRICAL SPECIFICATION

| | | |
|---|---------|----------|
| Connector Type (1) | BNC | |
| Power supply (2) | 12 | V |
| Minimal power supply | 9 | V |
| Maximal power supply | 13 | V |
| Average PWS current (3) | 300 | mA |
| PWS peak current (3,4) | 2 | A |
| Serial modulation type | AC-UART | |
| Serial baud rate | 10 | Mbit/sec |
| Serial number of data bits | 8 + 1 | Bit |
| Serial number of stop bits | 1.5 | Bit |
| BNC inner contact to BNC shield AC resistance | 50 | Ohm |
| BNC inner contact to BNC shield AC reactance | 2.2 | μH |
| BNC shield to enclosure voltage | -5...+5 | V |
| BNC shield to enclosure resistance | 220 | Ohm |
| BNC shield to enclosure reactance | 1 | μF |

- (1) other types (SMA,SMB) on request
- (2) The deflector has limited protection (Zener diode) against reverse polarity and over voltage
- (3) Current level is the sum of currents floating into the system through CH1 and CH2
- (4) Peak current levels and duration depend on deflector excitation.

6.3 MODULATION ELECTRONICS

For compatibility with single axis smart deflectors, the CYCLOPS™ actuator is fitted with two coaxial connectors, CH1 and CH2. In general, CH1 is used for exchanging X axis data while Y data is transferred over CH2. Both connections are also used to provide power to the device. Following schematic shows the modulation electronics for one channel needed to exchange setpoint and actual positions with the deflector.



The data towards the deflector (TXD) is high pass filtered while the power supply (DC+12V) is low pass filtered. The high pass filtering is achieved through inductor L1 and resistor R1. Capacitor C2 only serves as a DC level shifter between output amplifier (IC1) and the deflector's power supply. The time constant of the high pass filter equals 44 nsec ($2.2\mu\text{H}/50\Omega$). The saturation current of inductor L1 should be high enough to handle the deflector's peak currents.

The (DC) potential between inner wire and shield of the coaxial connection equals 12V. When the control card sends a data, every TXD bit transition will induce a glitch. Due to inversion by IC1, low going flanks induce positive glitches while high going flanks induce negative glitches. The height of the glitches is about 2.5 V (IC1 powered by 5V). This is the result of the divide by 2 network constituted by the deflector's input impedance and the modulation electronics output impedance (R1). The glitch duration is set by the time constant of the high pass filter.

The returned data is obtained by demodulation using a Schmitt trigger. A positive glitch will reset while a negative glitch will set the Schmitt trigger's output (RXD). The hysteresis is set by the resistor values R3, R4 and R6. When RXD is high, the voltage on the non-inverting input equals 3.1V (IC2 powered by 5V). The voltage on the inverting input is set by the

resistors R2 and R5 to 2.5V. A hereon applied positive glitch with amplitude larger than 0.6V will bring the potential above the non-inverting one. The comparator's output becomes low setting the voltage on the non-inverting input to 1.9V. A low going glitch is now needed to set the output back to high.

When 5V power lines are not available, the modulation circuit can also be powered by a 3.3V power supply. The resistor value R4 should be decreased to 1 KOhm in order to have a similar hysteresis voltage.

6.4 INSTRUCTION SET

For both X and Y axis, the CYCLOPS™ deflector uses a 20-bit two's complement presentation for set point and actual position. During operation the set point needs to be controlled by the application. Some applications also need to verify actual deflector positions. For ease of use the deflectors have both a 20 bit and a 16-bit interface to exchange these values. The latter disregards the 4 least significant bits and only accesses the 16 most significant bits.

The instructions and their replies are exchanged with deflector through a half-duplex UART connection. Transmitting a single byte takes 1.1 µsec. Depending on the instruction type the control card sends one or three bytes to the deflector. After reception the deflector will process it and start his reply within 1.5 µsec. The time between different instructions must be at least 10 µsec.

Instruction overview

| Control | Resolution | Size instruction | Size reply | Execution time |
|---------------------------|--------------|------------------|------------|----------------|
| 20-bit absolute set point | 1048576 bits | 3 bytes | none | 10 µsec |
| 16-bit relative set point | 65536 bits | 1 byte | 1 byte | 10 µsec |

UART byte format:

| | |
|-------------|---|
| Serial data | START, B0, B1, B2, B3, B4, B5, B6, B7, LATCH, STOP |
| START | Start bit, low |
| B0..B7 | data byte (B0 least significant bit, B7 most significant bit) |
| LATCH | instruction latch (1) |
| STOP | Stop bit, high |

(1) The instruction set of a deflector comprises single and multiple byte instructions. When the LATCH bit is true, the received instruction is interpreted. Single byte instructions must have their LATCH bit set. On multiple byte instructions, only the last byte must have the LATCH bit set. All other bytes must be sent with LATCH bit cleared. All replies from the deflector are done with LATCH bit cleared.

6.4.1 20-bit absolute set point control

With a three-byte instruction, a 20-bit target position can be sent to the deflector. The deflector has internal speed and current limiters to guarantee save operation at all times. When the distance between target and set point is too far, the target position is clipped following a maximum speed principle. The maximum speed whereby the set point is allowed to change, is set at 105 Mbit/sec.

Serial bit sequence (1):

| | |
|--------------------|--|
| Instruction Byte 1 | START,0,0,0,0,S0,S1,S2,S3,0,STOP |
| Instruction Byte 2 | START,S4,S5,S6,S7,S8,S9,S10,S11,0,STOP |
| Instruction Byte 3 | START,S12,S13,S14,S15,S16,S17,S18,S19,1,STOP |

(1) S0...S19: new set point (20-bit two's complement, S0 least significant bit, S19 most significant bit)

6.4.2 16-bit relative set point control

A complete instruction set is available to control and query the 16 most significant bits of both set point and actual position using byte sized instructions. This control mode makes the deflector's full angular range accessible using 16-bit values. As a result, the physical angle change per bit is 16 times larger when compared with 20-bit control.

Controlling the set point is achieved by using μ step move instructions. When the deflector receives such an instruction, its value is added to the set point (16-bit presentation). The valid instruction range is limited from -111 to 111. All values outside this range are interpreted by the deflector as a system instruction, not as a μ step move instruction. Based on a selectable reply mode, a μ step move instruction will be replied with delta actual (mode 1) or echoing (mode 2).

The system instruction set comprises instructions to select reply mode and to query positions. At power up, the deflector switches to reply mode 1. In this mode any μ step move instruction will be replied with delta actual. When echoing is desired, the system instruction 126 must be used to change the reply mode to 2. In reply mode 1 it is possible to keep track of the actual position while reply mode 2 allows error control on the communication link.

The maximal speed whereby the set point can be changed using relative control, equals:

$$\text{max speed} = \text{max } \mu\text{step} * \text{max instruction frequency} = 111 * 200 \text{ KHz} = 22 \text{ Mbit/sec}$$

The deflector's maximal angular speed is more than three times faster than the speed achievable using 20-bit absolute set point control because (angular wise) every bit is 16 times larger.

Single byte instructions

| Instruction (1) | Description | Reply |
|-----------------|--|---|
| -111... 111 | μ step move instruction (8-bit two's complement) | Delta actual (when in reply mode 1) Echo μ step (when in reply mode 2) |
| 112 | fetch actual position | most significant byte actual position |
| 115 | fetch set point position | most significant byte set point |
| 113 | fetch least significant byte | least significant byte previous fetch |
| 117 | switch off deflector | 0 |
| 125 | switch on deflector, set reply mode 1 | 125 |
| 126 | switch on deflector, set reply mode 2 | 126 |

(1) Undeclared instruction values are used by the rhothor™ tuning and configuration software. Do not use these values.

Serial bit sequence (1):

| | |
|--------------------|--------------------------------------|
| Instruction Byte 1 | START,C0,C1,C2,C3,C4,C5,C6,C7,1,STOP |
| Reply Byte 1 | START,R0,R1,R2,R3,R4,R5,R6,R7,0,STOP |

(1)

C0...C7: 8-bit instruction (C0 least significant bit, C7 most significant bit)

R0...R7: 8-bit reply (R0 least significant bit, R7 most significant bit)

The relative targeting reduces the communication bandwidth. Only variations of the set point are communicated. A new target can't be sent directly to the deflector but needs to be translated and communicated as a chain of μ steps. This chain has to be compiled based on target position, deflector's set point and desired speed. To avoid querying the deflector's set point before every move, the control card should keep a local copy of it. After power up, this copy should be initialised by fetching the deflector's set point (boot cycle reply mode 1 and 2).

Example :

Assume that the deflector is at position 1000 and that ramping towards position 2200 at a speed of 1.2 Mbit/sec is needed.

| | |
|---|---|
| position (local copy of deflector's set point) | 1000 bit |
| target (new position) | 2200 bit |
| Speed | 1200000 bit/sec |
| Distance | target-set point = 2200-1000 = 1200 bit |
| Duration | distance/speed = 1200/1200000 = 1 msec. |
| #μsteps (number of μsteps when sending at 5μsec interval) | duration/0.005 = 200 |
| μstep | distance/#μsteps = 1200/200 = 6 |

After sending 200 times the value 6, the deflector's set point will be increased with 1200. Sending those values at 5 μsec interval will result in a 1 msec. execution time for the ramp.

The deflector has a build in security against thermal overloading. When over steered above twice the thermal rating, it stops tracking. The amplifier and regulator are switched off and the deflector stops replying μstep move instructions. The control card can respond by sending command 125 (reply mode 1) or 126 (reply mode 2) to restart the deflector. Without response within 4 seconds the deflector will reset and a full boot cycle will be needed to restore operation.

6.4.2.1 Boot cycle reply mode 1 (actual position tracking)

| | | |
|--------|----------------------|---|
| step 1 | send instruction 125 | setup to reply μstep move commands with delta actual |
| step 2 | send instruction 115 | the deflector replies with most significant byte set point |
| step 3 | send instruction 113 | the deflector replies with least significant byte set point |
| step 4 | send instruction 112 | the deflector replies with most significant byte actual position |
| step 5 | send instruction 113 | the deflector replies with least significant byte actual position |

After executing step 5, the control card has a 16-bit copy of the deflector's set point and the actual position. Changing the set point is done by sending μstep move instructions. The deflector will reply them with delta actual values. By integrating these replies, a live copy of the deflector's actual position can be obtained.

6.4.2.2 Boot cycle reply mode 2 (error control on data link)

| | | |
|--------|----------------------|---|
| step 1 | send instruction 126 | setup to echo received μstep move commands |
| step 2 | send instruction 115 | the deflector replies with most significant byte set point |
| step 3 | send instruction 113 | the deflector replies with least significant byte set point |
| step 4 | send instruction 115 | the deflector replies with most significant byte set point |
| step 5 | send instruction 113 | the deflector replies with least significant byte set point |

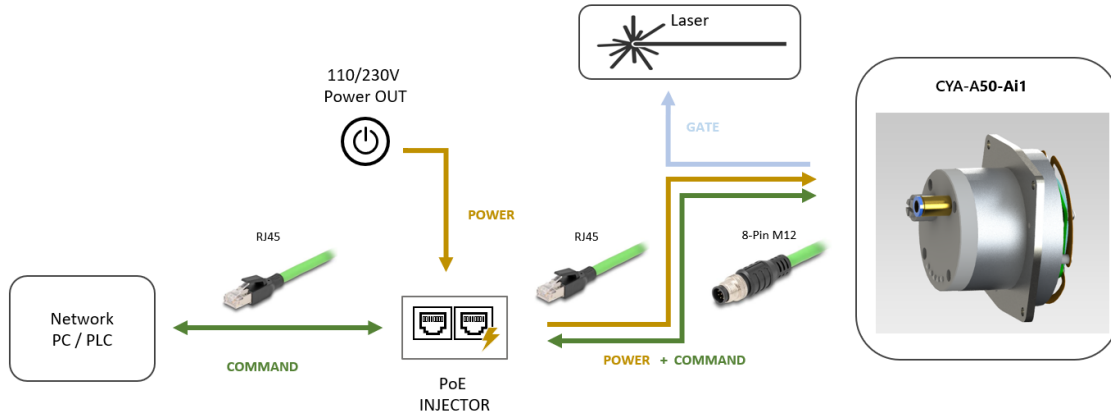
Step 4 and 5 are optional. However, they give the advantage of a double read of the set point. The reply of step 2/3 and step 4/5 should be the same. If not you should fetch the set point again. Changing the set point is done by sending μstep move instructions. By verifying the replied echo's, the integrity of the instruction flow can be verified. If an echo is different from its instruction, the set point should be fetched again (restart at step 2).

6.5 POWER UP SEQUENCE

During normal operation the deflector only replies on received instructions. All communication needs to be initiated by the control card. The only exception is at power up. 100 msec after power up the deflector sends character 204. This is done to set the Schmitt triggers in the modulation electronics. After receiving the power up byte (204) from the deflector, the control card may send instructions. When the absolute set point control will be used, the control card can start sending the 3-byte sized instructions. When relative set point control will be used, the control card needs to set reply mode and fetch the current position(s) of the deflector prior to sending μ step move instructions.

7 CONNECTING CYA-A50-Ai1 CYCLOPS™

7.1 SETUP



7.2 M12 PIN ASSIGNMENT

| | | | |
|---|---------------|----------------|--|
| 1 | TXD+/return | RJ45-pin 1 (1) | IEEE802.3at |
| 2 | TXD-/return | RJ45-pin 2 (1) | |
| 3 | RXD+/power | RJ45-pin 3 (1) | IEEE802.3at, Vpower=56V, 30Watt |
| 4 | RXD-/power | RJ45-pin 6 (1) | |
| 5 | O14 collector | RJ45-pin 7 (1) | Galvanically isolated, Vce<80V, Ic< 50mA |
| 6 | O14 emitter | RJ45-pin 8 (1) | |
| 7 | O16 collector | RJ45-pin 5 (1) | Galvanically isolated, Vce<80V, Ic< 50mA |
| 8 | O16 emitter | RJ45-pin 4 (1) | |

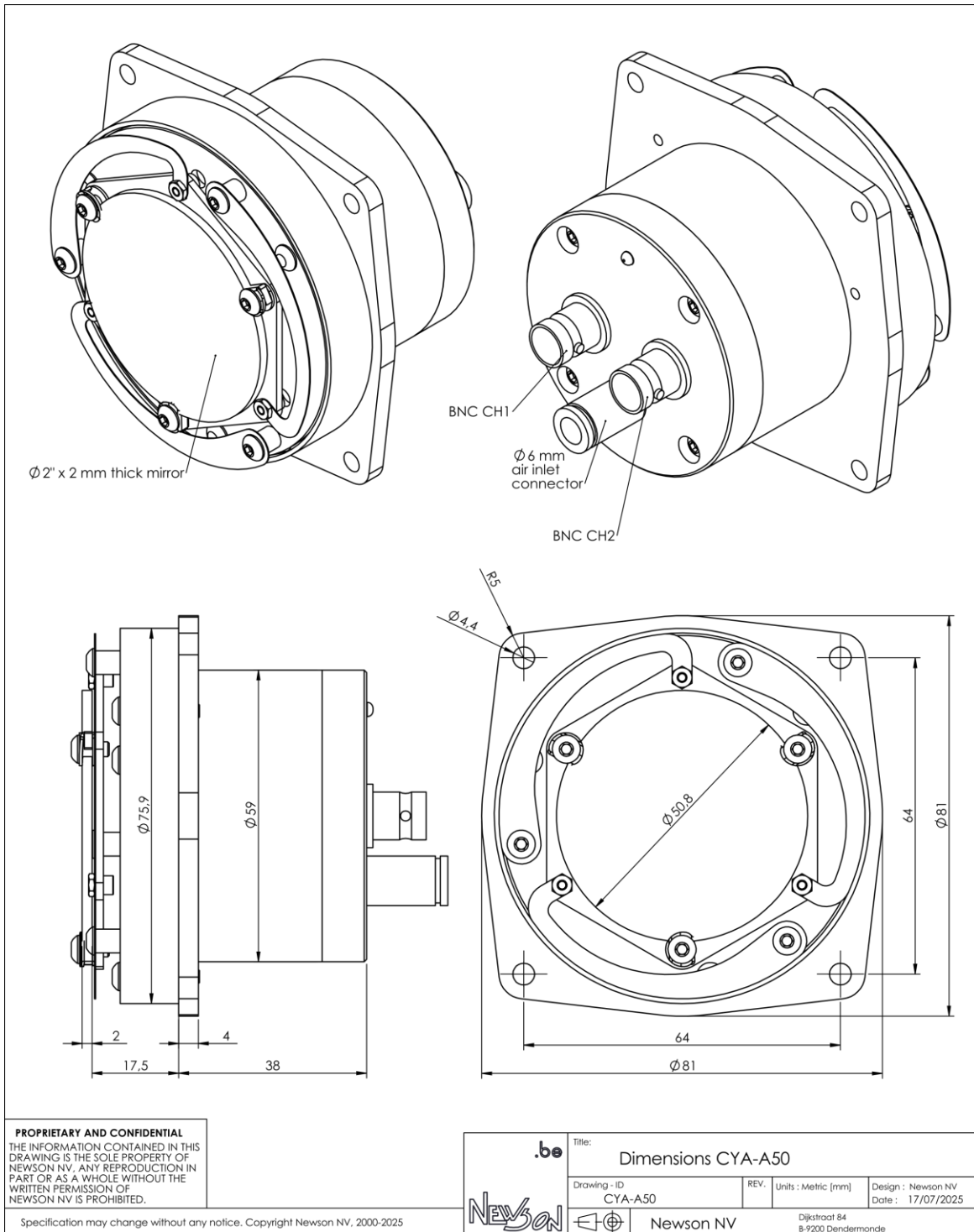
(1) connection map for bridging M12 with RJ45 style ethernet connector.

7.3 POWER OVER ETHERNET

The M12 connector is fully compatible with power over ethernet IEEE802.3at specification. Connect the actuator with the host or PLC through an ethernet IEEE802.3at compliant power supply. Power supply should be merged with data pairs 1,2 and 3,4 (M12 connector) This leaves pair 5,6 to be used as output 14 and pair 7,8 as output 16. Those outputs provide hard wired connection for an interlock and a gate signal. The interlock may be used as a system status indicator. It may NOT BE USED as a safety system. For more information regarding output signals 14 and 16 refer to datasheet and manuals covering CUA32 systems.

8 DIMENSIONS

8.1 CYA-A50



8.2 CYA-A50-Ai1

