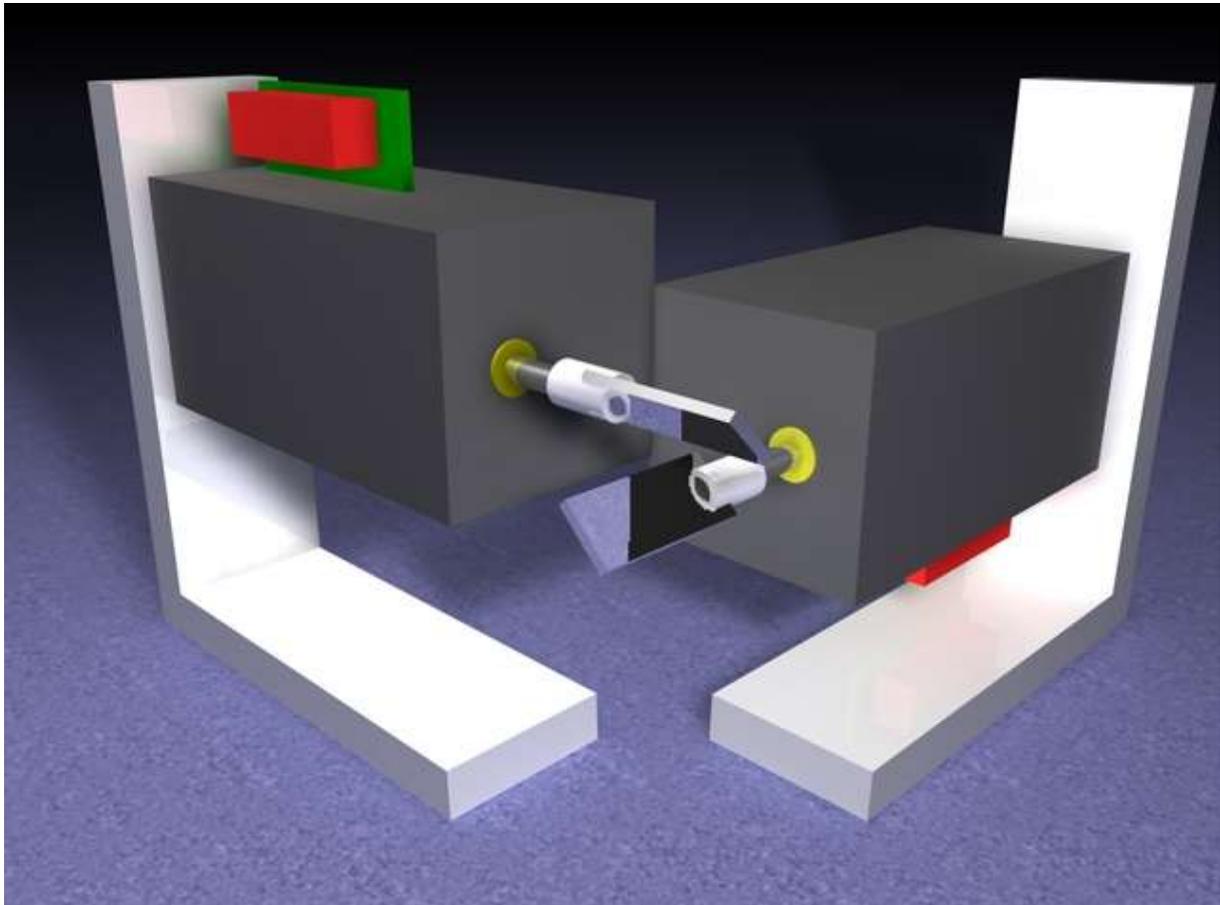


# ***M9024 DC Scanner***

## ***Instruction Manual***



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## Contents

Technical Data	Page 3
Operating Conditions	Page 4
Responsibility Lasersafety Delivery contents	Page 5
Handling instructions ESD-Precautions Mirrors Cleanliness	Page 6
Setting-up operation Installation Galvocable	Page 7
Mounting variants	Page 8
Mirror distance	Page 9
Replacing mirrors	Page 10
Basic position of the mirrors Effects of disturbance Overload Position drift	Page 12
Driverboard	Page 13
The scannersafety	Page 16
Responsibility	Page 17
Safety connections	Page 18
Overload protection	Page 20

## Technical Data

### Electrical

Coil resistance	0.8 Ohm
Inductivity (1KHz)	250 $\mu$ H
Peak current	2.5 A
Power supply driver	+/-24V DC >1A
Signal inputs	X and Y symmetrical inputs max. 20V pp
Position feedback	100mV/degree optical angle

### Optical

Steptime <8 deg. opt.	250 $\mu$ s
Steptime 40 deg. opt.	1.0 ms
Steptime 90 deg. opt.	1.6 ms
Steptime 180 deg. opt.	2.5 ms
Scanspeed ILDA	26K with mirror 5 x 10 mm 24K with mirror 5 x 12 mm
Pointing stability	<1mrad
Noise	<0.5mrad 0-10KHz
Mirror size L x B	5 x 10 mm (5 x 12 mm on request)
Mirror type	Floatglass enhanced Aluminium coated
Reflection	>95% 400-700nm

### Mechanical Galvo

Dimensions L x H x W	40 x 21 x 22 mm
Total length	68 mm
Recommended shaft dist.	5.5 mm min. between X and Y
Cable length	50 cm
Connector type	10 pin DSUB

### Mechanical Driver

Dimensions L x H x W	100 x 45 x 80 mm
Galvo connector	10 pin DSUB
Signal connector	10 pin in line

All specifications at 20°C ambient temperature after 5 minutes warm-up time.

## Operation conditions

It is recommended to read this instruction manual completely before starting working with the scanners.

Warranty can be void due to mishandling.

The scanner should only be used under dry condition and 10°C to 35°C roomtemperature.

Technical specifications were measured under a room temperature of 20°C after a warmup-time of 5 minutes.

Using the scanners outdoor only is allowed under dry condition and allowed ambient temperature.

The product should only be used under dry condition and 10°C to 35°C roomtemperature. An additional heatsink is required for operation. To ensure cooling, the attached mounting bracket must be mounted to a heatsink or the baseplate of the optical bench. The temperature of the aluminium bracket should not exceed 70°C.

The internal overtemperature shutdown will be triggered at 100°C at the poweramplifier. **The supplied mounting bracket will not be capable to cool the device stand alone!** When mounting the power parts (output amp and voltage regulators) **directly** to an external heatsink, there must be sure that the voltage regulators are isolated and there is a good thermal path to the heatsink. Use thermal conducting paste and/or silicon pads between the power amp and the heatsink.

The mirrors or shafts of the galvos should be free movable and not touch each other. It should be taken into account that the mirrors and shaft are not exposed to any mechanical stress or force.

Do not heat the galvoshaft over 80°C long-term. Heating the mirror-mount for mirror replacement should not take more than 10 seconds.

Cleaning mirrors should be done without strong forces affecting mirrors or shafts.

When shaft movement is blocked, overheating can occur, which can cause failure or irreparable damage.

The scanner should not be driven beyond specified limits.

The user has to make shure that the system or device, where this scanner is installed, meets the local standards of electromagnetic emission.

## **Responsibility**

The manufacturer excludes liability in case of the following damages, unless it is verifiable that damage existed when the product left factory.

Also any liability claims regarding damage caused by the use of this product will be rejected.

- Damage as a result using the product beyond recommended operation conditions.
- Damaged mirrors or loose mirrors and mirror-mounts.
- Damage to scanners or drivers caused by overheating.
- Damage caused by dust and corrosion.
- Damage to shafts and magnetic components caused by overheating the shaft.
- Damage caused by faulty driver adjustment or input signals and power supply beyond specified limits.

## **Lasersafety**

The user has to make shure that the system, where this product is installed, meets the local laser safety regulations.

The manufacturer recommends the use of additional safety circuits for monitoring the safety of the system.

### **NOTICE!**

It should be taken into account, that the scanner mirrors have no default position when driver power is off. In this case, laser radiation can be deflected in any direction. The user has to make shure, that such deflection when changing between power off and power-on can not point to a person's eye by accident.

This is also an important point to keep in mind, when working on the laser system for maintenance or adjustments.

## **Delivery contents**

The complete X/Y-set includes:

- Driver board for 2 scanners with safetyboard
- 2 Galvos with fixing bracket, screws and a galvocable 50cm long.  
Each galvo is supplied with 5 x 10 mm mirrors.
- Drivers are preadjusted but finetuning must be done by the user.

## **Handling instructions**

Handle with care when unpacking components!

Surface mirrors are very sensitive. Do not touch mirrors when taking the galvos out of the package.

Before switching-on the scanners, the user has to make shure, that shaft or mirror can be moved free and is not blocked.

When driving the scanners with blocked shafts, maximum current flows and will cause overheating on galvos and drivers.

When using the scanner for the first time, check that shafts are not blocked by slightly turning the mirror.

Blocked shafts can be made moveable by slightly pushing and pulling the shaft in axial direction.

This check only is necessary when using the scanner for the first time or after manipulation at the scanner shaft or mirror (replacing mirror or mirror-cleaning).

During normal operation, also after power off and power-on, the shafts are automatically centered to initial position.

## **ESD-Precautions**

Parts of scanners and drivers are very sensitive against electrostatic discharge ESD.

## **Mirrors**

Do not touch the surface of the mirrors with fingers or tools.

Coatings of mirrors are very sensitive.

## **Mirror cleaning**

The manufacturer does not recommend mirror cleaning and will not be obligated to replace scratched or broken mirrors free of charge.

If it is not avoidable to clean the surface of the mirrors, the user should proceed under the following instructions:

Dust particles can be blown away using compressed air.

Other dirt can be removed using acetone or alcohol and a cotton swab (Q-Tip) or lens cleaning paper.

Wet a cotton swab or piece of lens cleaning paper with a generous amount of reagent grade acetone and make a single swipe across the mirror surface, starting from the side of the mirror mount. Repeat using a clean swab each time until you achieve best result.

Do not soak mirror with acetone.

Do not put too much pressure on the mirror.

Caution: Make shure that no solvent or acetone wets the galvo bearings!

## **Cleanliness**

These scanners are sensitive optical and mechanical devices.

When handling galvos and running the scanners, precaution should be taken, that no dirt, dust and other contaminants get into the shaft bearings.

Sand or metal chipping in the bearings can cause total failure of the scanner.

Bearings are oiled by the manufacturer and are normally maintenance-free.

## Setting-up operation

Galvo assembly (Fig. 1)

1. Fixing bracker
2. PCB
3. Galvocable
4. Connector
5. Lasermirror
6. Mirrormount
7. Shaft
8. Bearing

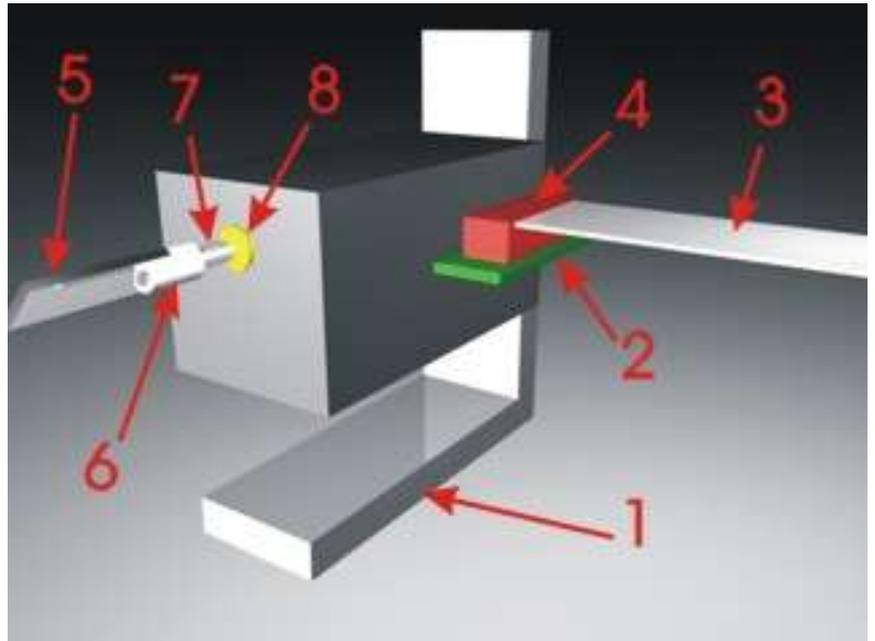


Fig. 1

## Installation

Fixing brackets are provided with a slotted hole at the bottom side to use M5-screws on optical tables. Hexagon screws should be used to attach the bracket to the groundplate. The galvo will be attached to the bracket using the threaded bolt and the wingscrew. The fiber washer should be placed between bracket and wingscrew. The rotating axis of the bolt is equivalent to the rotating axis of the lasermirror.

## Galvocable

The connector is inserted in that way, the cable is pointing away from the galvo. (Fig. 2)

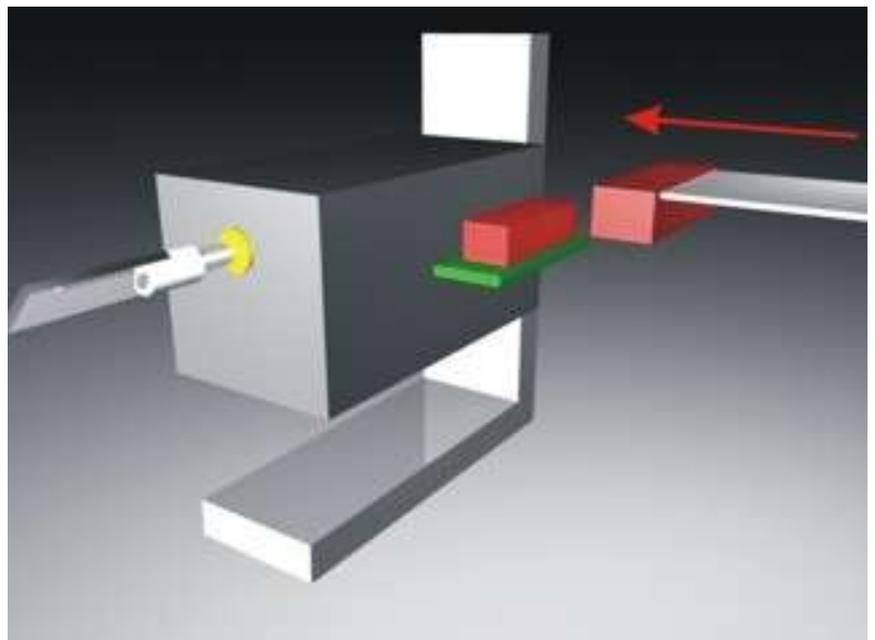


Fig. 2

**When the mirror does not move to the center position after power-on, immediately switch off the scanner!**

## Mounting variants

There are several possible variants of arranging the scanners.

When the maximum scanangle should be used, there must be paid attention, that no parts of the galvo will block the outgoing laserbeam.

The best solution in that case is to deflect the beam first using the upper galvo (Fig. 4).

Fig. 3 shows a well-established arrangement where the beam first hits the lower mirror.

It is possible that parts of the upper galvo will cover the output beam at large scanangles.

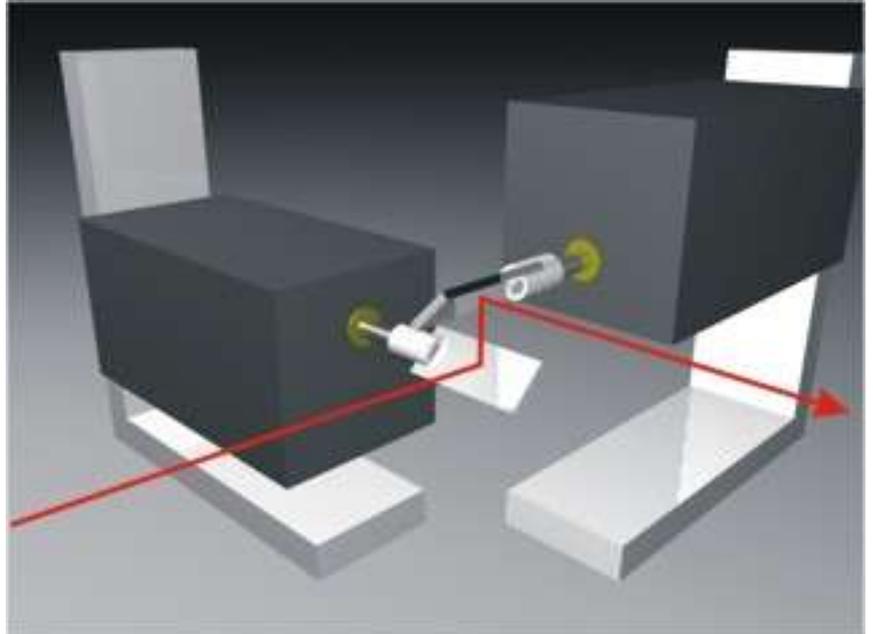


Fig. 3

Fig. 4 shows a better variant, where the beam first hits the upper mirror.

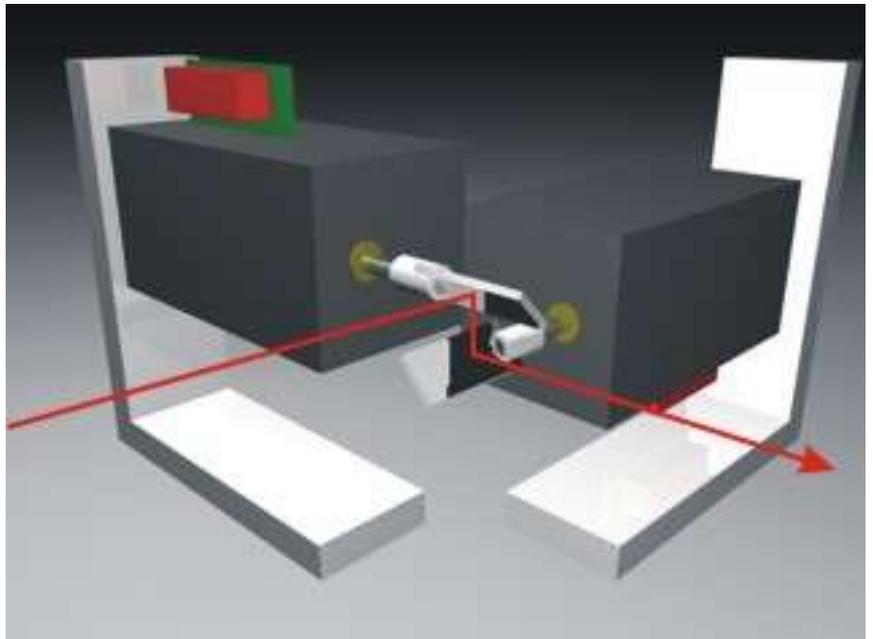


Fig. 4

## Mirror distance

To achieve the maximum deflection angle, the 2 mirrors have to be arranged against each other as close as possible. Care should be taken, that the mirrors can not touch each other. Because mirrors can turn into positions beyond scan area at power-off, make sure, that there is enough distance between the mirrors when turned to perpendicular positions. (Fig. 5).

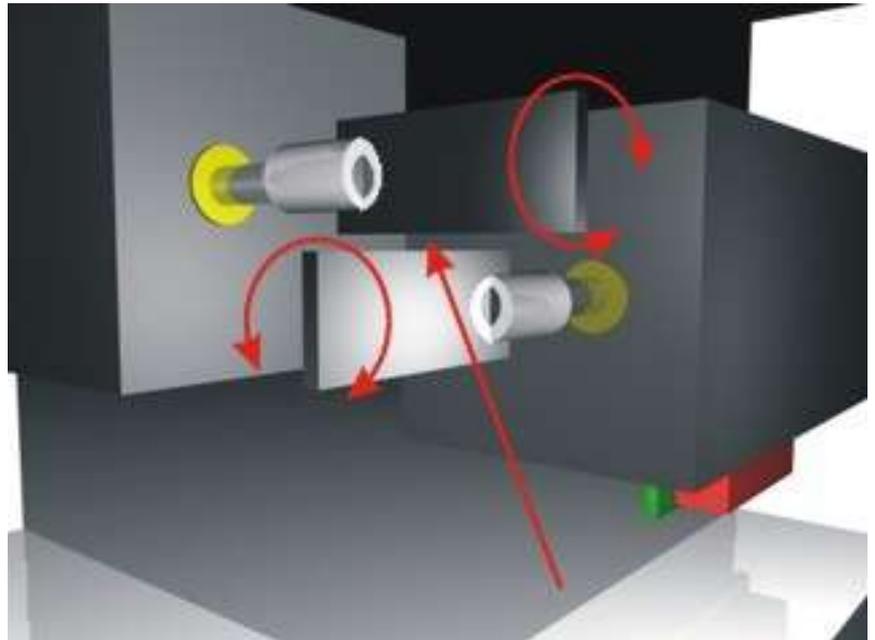


Fig. 5

When using standard mirrors, a gap of 0.5 millimeters minimum should be observed between the mirrors (Fig. 6).

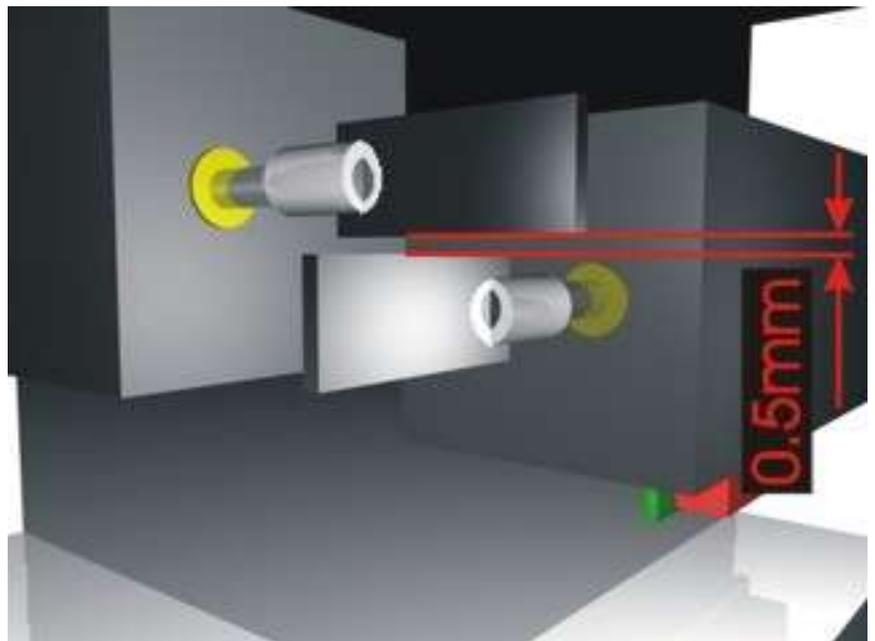


Fig. 6

## Replacing mirrors

If it is necessary to replace a mirror, always the complete assembly of mirror and mirror mount should be replaced. The following work should only be done by qualified personnel.

Improper handling can cause irreparable damage on the galvo.

The manufacturer excludes liability in case of damage, caused by manipulations for mirror-replacement.

At first, the old mirror mount has to be removed. Therefore, the bonding surface at the rear side of the mirror mount must be heated. Use a soldering iron. Switch off the scanners!

The soldering tip at a temperature of around 200°C must be placed at the rear edge of the mirror mount in such a way, that it touches both mirror mount and shaft.

While heating, push the mirror holder with the soldering iron in front direction (Fig.7).

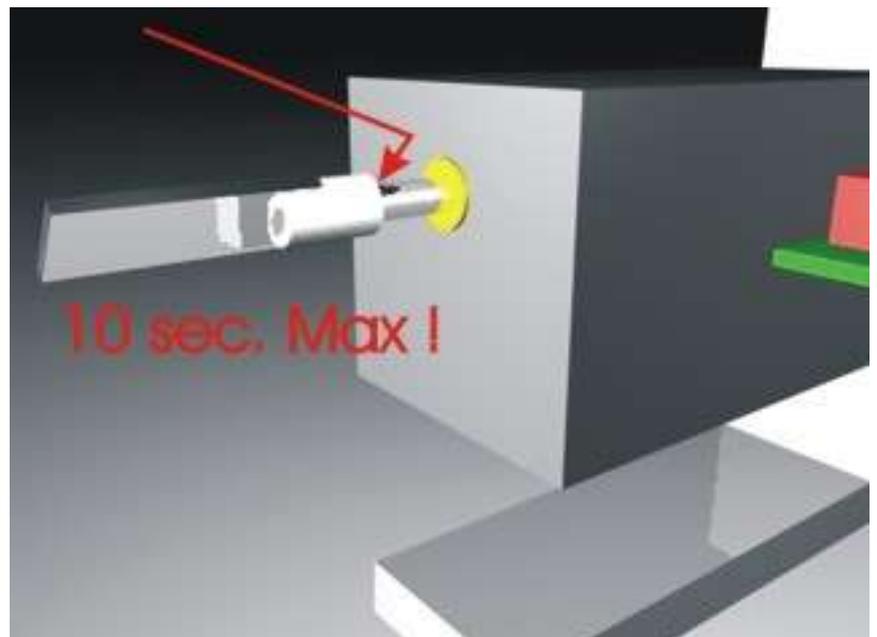


Fig. 7

Normally, the mirror mount can be stripped off the shaft after a few seconds (Fig 8).

**Important:** Do not heat the shaft more than 10 seconds, otherwise the galvo can be damaged.

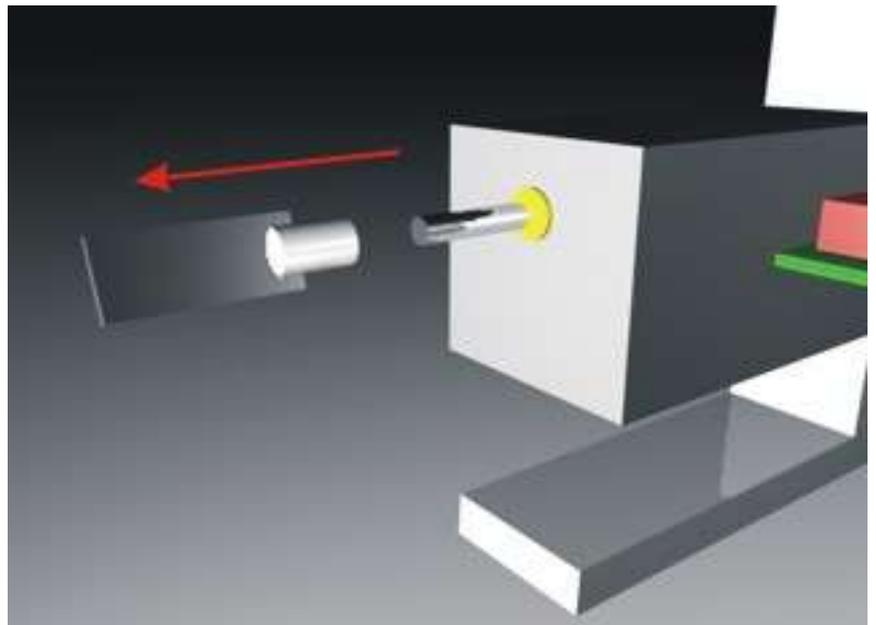


Fig. 8

Adhesive parts, remaining on the shaft, can be abraded using a knife or scalpel. Always rasp from the rear side to the front end of the shaft, so no dust contaminates the bearing.

Do not use any additional abrasives!

The shaft then must be cleaned using a tissue wetted with acetone or alcohol.

Do not soak the bearing with solvent!

Now the new mirrmount should be stuck to the shaft.

The mirrmount should be free movable on the shaft, otherwise old adhesive or dirt remains on the shaft. Also the shaft should be free movable in the bearing.

The scanner now has to be powered-on. Input a zero input signal to the driver.

The shaft will move to its center position.

The mirrmount now has to be turned on the shaft until the mirror surface points to the center position (normally  $45^\circ$  to the groundplane, Fig. 9).

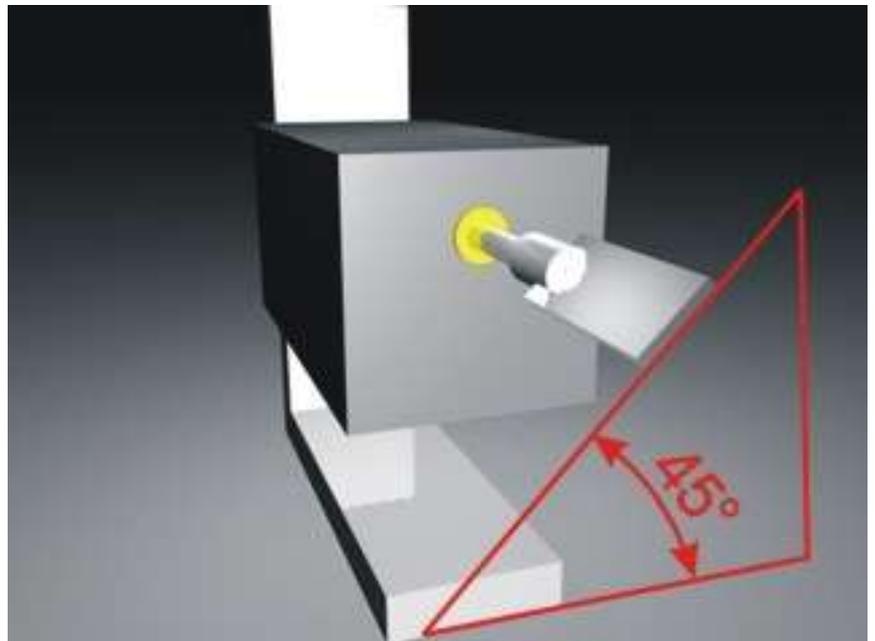


Fig. 9

Now put a small amount of adhesive (superglue) at the rear edge of the mirrmount using a piece of thin wire or a needle.

Make sure, that the adhesive covers the edge of the mirrmount all around the shaft.

Only use as much adhesive as necessary!

It must be strictly avoided to put any adhesive to the bearing.

In this case, the galvo would be irreparable damaged!

Wait at least 15 minutes before operating the galvo again.

## **Basic position of the mirrors**

This galvanometer scanner is not supplied with mechanical stoppers at the rotor-shaft.

During power-on, the shaft automatically moves to the basic position.

When switching the power off, the shaft will take a position, which will ensure a correct initial position at later power-on.

In case of overdriving or misadjustment of the driver settings, or after manipulations at the mirror, the center position could be changed, so the mirror points to the wrong direction.

This problem should be eliminated after switching-off and power on the driver again.

**When the mirror will not move to the initial position after power on, switch-off and try to find out the problem.**

## **Effects of disturbance**

The magnetic position sensing system must not be exposed to strong magnetic fields.

Do not install the galvos close to strong transformers or motors, otherwise interferences can cause waves or distortions of the scanned laser projection.

When there is not enough space between galvos and other magnetic sources, a shield made of iron (no stainless steel!) should be mounted between scanners and a source of disturbance.

The used material should be tested for magnetic conduction using a permanent magnet.

The shield does not need to be an electric conductor.

## **Overload**

Normally, the galvos only produce less heat and don't need separate cooling.

When overdrive the scanners beyond specified limits, the coil temperature can rise rapidly.

The scanners should not be driven beyond limits over longer time.

Also the driver can overheat when overdrive the scanners.

The temperature of the coil should never exceed 80°C (= max. 50°C galvo housing) and the temperature of the driver-heatsink should never exceed 70°C.

## **Position drift**

The position sensor of the galvos drifts slightly when temperature changes strongly.

To achieve maximum pointing stability, the scanner should only be used after a warm-up time.

When targeting at effect-mirrors with laser beams, the scanners should warm-up 10 minutes before scanning any beam position.

The scanners should be powered up using a zero input signal while the laser is blanked.

Also the warm-up procedure should be done before adjusting any driver settings or programming any beam positions for a show.

When using cold scanners for beam programming, scanned positions after warm-up may differ from the programmed positions.

## Driverboard (Fig. 10)

### Setting-up operation

Make sure that the powersupply is connected right polarity.  
Make sure that the input signals are connected correctly.  
Maximum signal amplitude per input is +10 Volts (20Vpp).

Do not adjust the potentiometers at first!

Install the galvos correctly and make shure that the mirros cannot touch each other.

For power-up, first use a zero input signal (center position) or start with a frame with low scanspeed and small scanangle.

When the projection is side-inverted, the jumpers INVERT can be changed by setting both jumpers in a 90 degree-positon across the two pins (Fig. 10).

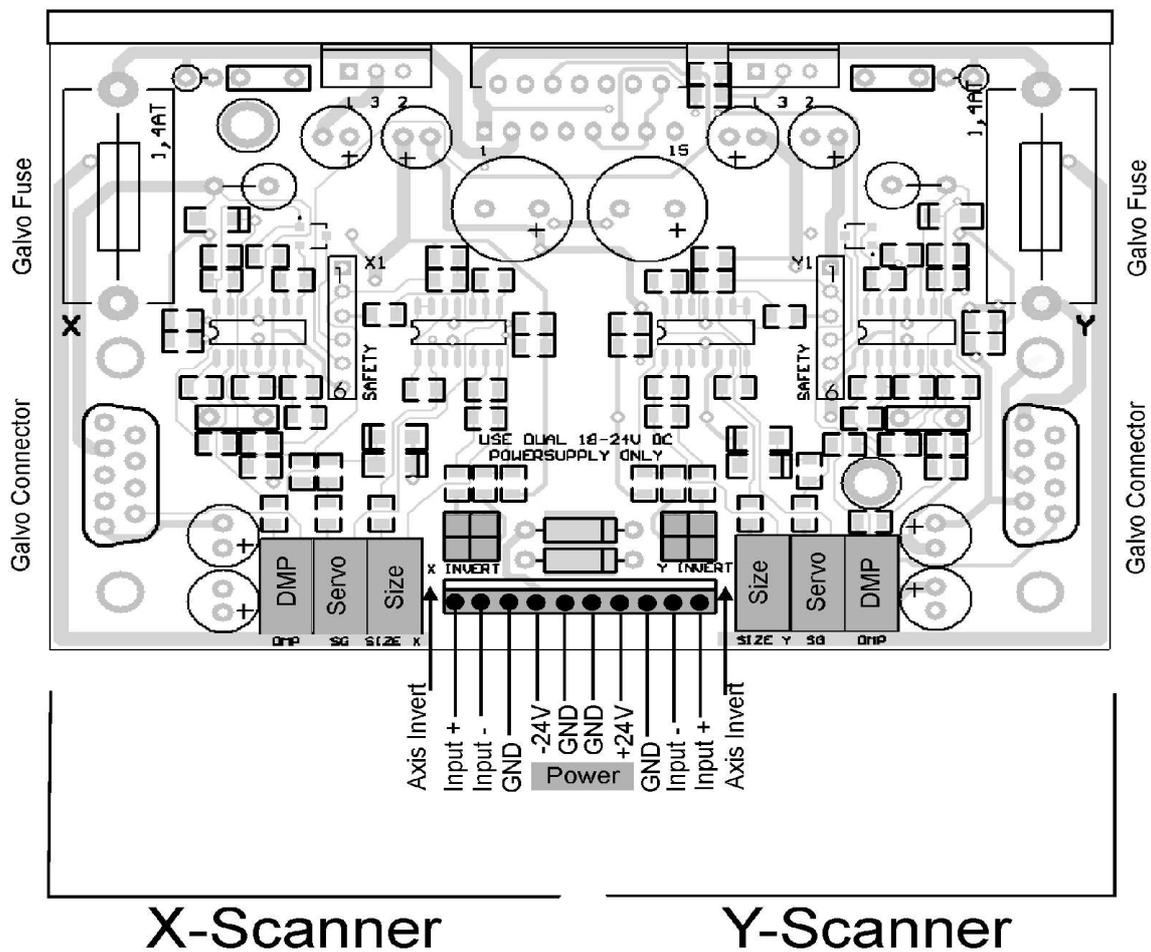


Fig.10

## **Symmetrical inputs**

When the lasercontroller uses symmetrical or differential outputs as described in the ILDA standards, the signals X+, X-, Y+ und Y- can directly connected to the corresponding inputs XIN+, XIN-, YIN+ und YIN- located at the 10 pin connector.

A connection of ground GND (Pin 25 ILDA) is used to eliminate ground loops.

## **Single ended inputs**

When the lasercontroller uses just one wire per axis and ground GND, the signals for X and Y must be wired to the inputs XIN+ and YIN+.

Inputs XIN- and YIN- must be connected to signal ground.

Also the ground pin GND has to be connected with the signal ground.

When using the negative inputs XIN- and YIN- instead of the positive ones, the image will be inverted.

## **Adjustment controls**

All potentiometers act in that way, that turning clockwise will increase function:

Larger size, higher servogain and stronger damping.

Adjustments must be done by qualified personnel only by using suitable test patterns like the ILDA testframe.

The manufacturer assumes no liability for any damage or malfunction caused by bad adjustment.

## **Size**

This potentiometer is for adjusting the scan angle. The factory settings are approximately 45° optical angle at +-5V input signal.

The maximum scan angle of 180° optical should never be exceeded!

## **Servo-Gain**

Here, the accuracy of the scanner is adjusted. Adjusting this potentiometer clockwise will increase speed of the scanners and may produce overshoots in projection.

Servo gain should only be adjusted in combination with damping.

## **Damping**

Damping reduces overshoot of the galvos. Too much damping can result in ringing or oscillations of the galvo.

## **Inverting jumpers**

Placing the 2 jumpers 'axis invert' 90 degrees against their current position will invert the galvo movement to allow a correct orientation of the laser projection.

## **Safety signals**

When using an external safety circuit, the position signals are located at two singlerow 6pin sockets, where the onboard safety is mounted piggyback.

Both signals, input and feedback are matched internally, resulting in corresponding amplitude. Both sockets have identical pinouts and correspond to each driver axis.

Socket to safety module (pin 1 is back near power parts, pin 6 directs to front side of the driver):

1	+12V
2	Position Galvo (Feedback) +/-10V
3	Position Input (Inputsignal) +/-10V
4	Galvocurrent (rectified pulse signal)
5	Driver Off (TTL)
6	GND

## **Factory settings**

All scanners are preadjusted to allow starting-up running the scanners without previous adjustments. Fine adjustments can be necessary to create maximum performance of the scanners.

## **Setting up completely deadjusted drivers**

When a driver is completely bad adjusted, the scanners can oscillate after power on.

Switch-off the driver immediately!

Adjust size and servo gain counterclockwise, until the endpositon of the potentiometer is reached (hearable 'clicks').

Apply a zero input signal to the driver inputs.

Switch on the driver.

When a frequency or oscillation is hearable, turn damping counterclockwise, until the frequency disappears.

Use a simple testframe as input, for example a square with slow speed (10Kpps).

Increase the size slightly by turning size clockwise.

Do not adjust to maximum scan size!

Increase servo gain by turning clockwise. Make sure that overshoots do not exceed maximum scan angle.

Reduce overshoots by truning damping clockwise.

Repeat increasing servo gain and damping until the image looks best.

Adjust size at maximum input signal to desired image size.

Use a standard test image (ILDA testframe) for fine adjustments.

## The scannersafety

### Features

- Digital position monitoring with 8 Bit resolution
- Sampling frequency 20kHz
- Monitoring of galvosposition **and** inputsignal
- fixed timewindow (triggerdelay) 25ms
- Maximum sensitivity  $\frac{1}{4}$  maximal scanangle scanned in 25ms
- Minimum shutdown time 250ms (selectable via intensity input)
- 3 independant colorchannels are switched-off simultaneously
- Intensity input as differential input

The scannerdriver includes a complete microprocessor controlled movement monitoring of the galvos. This was first developed in their basic function 1997 by Mueller Elektronik and is used successful under different brands since that time.

The advantage of integrating the safety into the driver is that there is no need to adjust different signals levels. This ensures that all signals are measured correctly, reducing the risk of malfunction.

The safety is mounted as module and can be removed or replaced easy.

The safety measures the moved angular distance of the galvos in a defined timewindow.

The position signals are measured as well as the input signals.

This avoids measuring wrong or oscillating signals of defective galvos as a valid movement signal.

### Description of operation

The formula of the safety is:

Scannermovement okay (safe),

**if** (inputsignal X **and** galvoposition X) **or** (inputsignal Y **and** Galvoposition Y) has moved distance n during time T.

Timewindow T is fixed to 25ms.

Distance value n can be set at 'Sensitivity' control. A maximum value means maximum sensitivity (long distance has to be scanned). Minimum value means minimum sensitivity (a short distance has to be scanned during time T).

The intelligent safety function allows to monitor both safety problems, which can happen during operation:

- Scan angle too small or standing points
- Scan pattern scanned too slow

In addition, there is monitored if the galvoposition does not follow the input signal.

Oscillating and noisy position signals will not be taken as valid movement vlaue, if they do not match approximately the input signal.

## **Responsibility**

Beside to the local safety regulations, the scanner safety offers an **additional** monitoring circuit to protect the laser system against being in unsafe condition.

The scanner safety is **no device which makes a lasershow system safe**.

The safety circuit **does not make a safe lasershow**, because the power density of the laser defines if a show can be safe or not. The safety circuit can only minimize possible risk caused by malfunction (defective galvo, driver, no power at scanner..) and mistakes of operator (standing beams during show).

The user has to make shure that the system, where this product is installed, meets the local laser safety regulations in any case, independant if a scanner safety is installed or not.

The manufacturer excludes liability in case of damages caused by a laser, even if the scanner safety was operated correctly or not.

Any liability claims regarding damage caused by unsafe laser systems using this safety circuit will be rejected.

Using this scanner safety will not replace the need of meeting the local safety regulations for lasershow.

**Note:** Test the correct operation of the scanner safety before beginning of a show event.

Program a too small projection or a standing beam or reduce scanspeed to minimum until the safety triggers and blanks the laser.

## Connections scannersafety

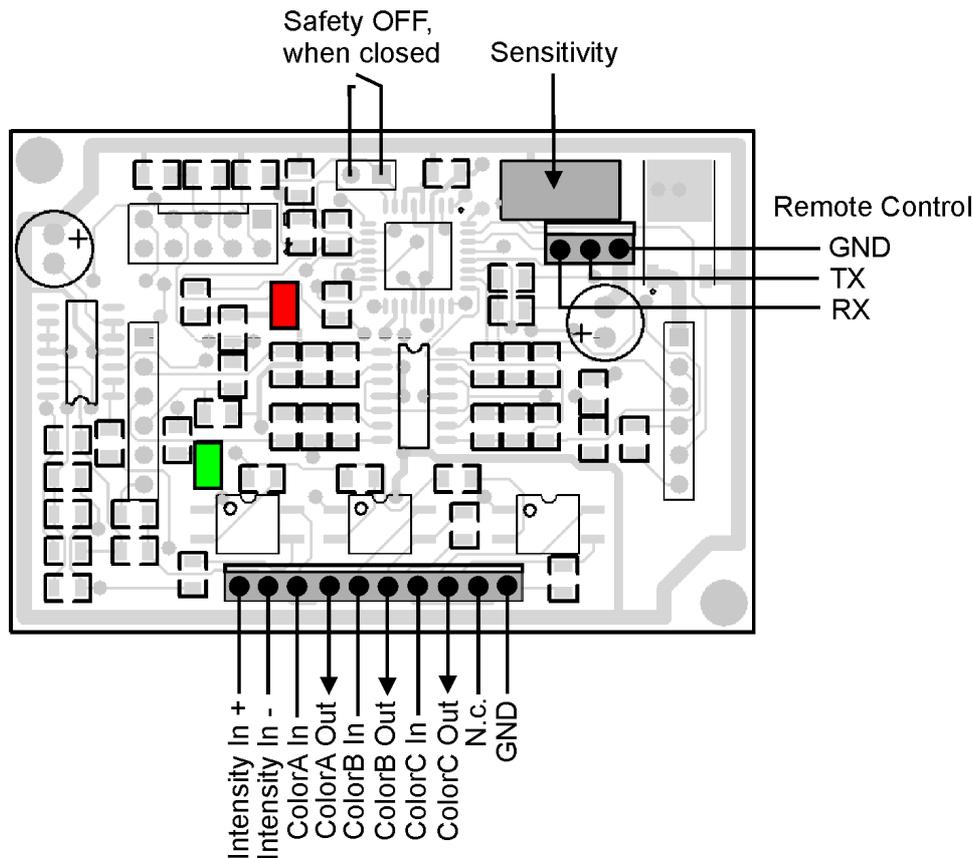


Fig. 11 'Remote Control' currently is without function

### Intensityinput

This input is designed as differential input. It can also be used as single-ended input by connecting Intensity In- to GND.

The signals 'Intensity/Blanking' of the show controller (or ILDA-cable) are connected to these pins.

Ensure that your software or showcontroller supports the output of intensity or blanking.

The intensity signal should represent the condition of all color signals of a lasershow.

When using RGB systems, a digital blanking signal should be used, if possible.

When used in singlecolor systems, even the colorsignal itself can be used, if there is no additional blankingsignal available.

The safety circuit will take 5% of the total value of 5V (differential) as 'On'-condition.

The Intensityinput is **not** connected to any output signal, like it is done at some other safety boards.

The Intensityinput has the simple function of controlling the shutdown duration of the safety outputs. When the safety detects a problem, normally the color outputs are shut-off for at least 250ms.

Some lasershows include dark scenes where the scanners are not moving (Laser is blanked).

The safety now will detect an unsafe condition. The shutdown duration of 250ms can be a

problem, when the show output restarts. Then some showframes can be blanked by the safety.

When the Intensity signal is used, the shutdown time will be set to a minimum, so that the output comes without any delay at show restart.

**Note:** A much more effective way to avoid any 'blackouts' is to use a blanked figure during dark scenes. The scanners will not stop movement during show and the safety will not detect an unsafe condition.

## Colorsignals

The 3 color signals, named ColorA, ColorB and ColorC, are all designed identical and are shut-off during unsafe condition simultaneous.

The signals can only be used as singleended inputs. No differential signals can be used.

When the showcontroller (ILDA board) uses differential or symmetrical signals (for example EasyLase), the corresponding (-) signals must be tied to GND (Pin 25 of ILDA connector). GND must also be connected to GND of the safety circuit as well as GND of the laser to control.

The colorsignals are designed as optocoupler outputs. The input signal ColorX-In is wired to the collector and the outputsignal ColorX-Out is available at the emitter of the optocoupler. Maximum current through the optocouplers should not exceed 100mA.

All outputs have a 10 Kohm pulldown resistor to GND. This ensures that the outputs are not left open or floating in error condition. Some cheap lasers will continue emission at open modulation inputs.

The colorsignals are not marked as RGB, because it is not important how many colors and which colors are used. When a laser system just uses a single color, the signal should be connected to the Intensityinput (use singleended mode) of the safety and also connected to one of the color Inputs.

## Safety-OFF Jumper

By closing the jumper pins the scanner safety can be deactivated. This may be necessary, when the system is used for creating standing beams (no audience scanning) or during beam alignment of the system itself.

**Important:** The condition of the jumper is accepted only at power-up of the scanner driver. To change from one condition to another condition, the device must be switched-off and powered-on again.

When the jumper pins are wired to the outside of the laserprojector, a keyswitch should be used to avoid unallowed deactivation of the safety.

**Warning:** Deactivating safety can cause serious danger! During normal operation, the safety should be activated all time.

Unqualified personnel should not have any access to this function.

## Sensitivity

The sensitivity of the safety can be adjusted here.

The factory setting is minimum sensitivity (max. left or counterclockwise).

By turning clockwise, sensitivity increases.

When scanning a simple pattern, for example a square at >10kpps, current sensitivity can be checked by changing scansize of the pattern. When trigger level of the safety is reached, the laser must be blanked automatically.

Scan the pattern as small as it becomes dangerous or critical and adjust sensitivity, until the laser will be blanked.

## **Status-LED Green**

The green LED shows the condition of the scanner safety.

When LED is on, the coloroutputs are set active and the colorsignals can go through the circuit.

The safety was not triggered by an unsafe condition.

When the LED is dark, the colorsignals are interrupted by the optocouplers.

A blinking LED shows that there are some short unsafe parts during showoutput and the safety is triggered multiple times.

## **Overload protection**

The safetyboard also includes a galvo overload protection.

The average current through the galvo coil is monitored. When a fixed limit ( $>1A$ ) is detected over a duration of 10 seconds, the driver outputs will be shutdown. The coloroutputs of the safety will also be switched-off to avoid a standing beam created by the unpowered galvos.

The power-off duration is 10 seconds.

After this period, the circuit tries to reactivate scanners. When the overcurrent still is detected, the driver will be shutdown immediately for another 10 seconds.

Shortterm current peaks will not cause shutdown. The limit must be reached for at least 10 seconds.

The limit is set by factory above the normal operating conditions of the galvos.

The damage treshold of the galvos can be reached independant of this protection, when the galvo is driven near the limit over a long time period.

This protection will not ensure a longterm operation at power limit without any damages of the galvos.

This protection should prevent damage caused by unexpected conditions.

Galvos can start oscillate (for example when a mirror is broken or lost). Also galvos can be blocked mechanically or the operator can create a situation by accident, which can cause damage at the galvos (too large scanangle at too high scanspeed). A galvo can be overheated in seconds!

The overload protection should prevent damage caused by such situations.

Fuses are normally too slow to ensure protection, because the trigger current must be  $2x - 5x$  of the specified current limit of the fuse.

When the current through the galvocoil is very high, the fuses on the driver will be blown.

Overload protection cannot be deactivated by Safety-Off jumper.

## **Status-LED Red**

The red LED blinks several times during power-on of the driver to show the correct operating condition of the safety.

When the maximum allowed average current of the galvo is reached, the LED starts blinking with 1Hz. It will stop blinking, when the current goes below the limit.

When the overcurrent condition is detected over more than 10 seconds, the driver outputs are switched-off and the LED blinks faster.

The driver will be off for 10 seconds. The LED will be switched-off and the driver will be reactivated.