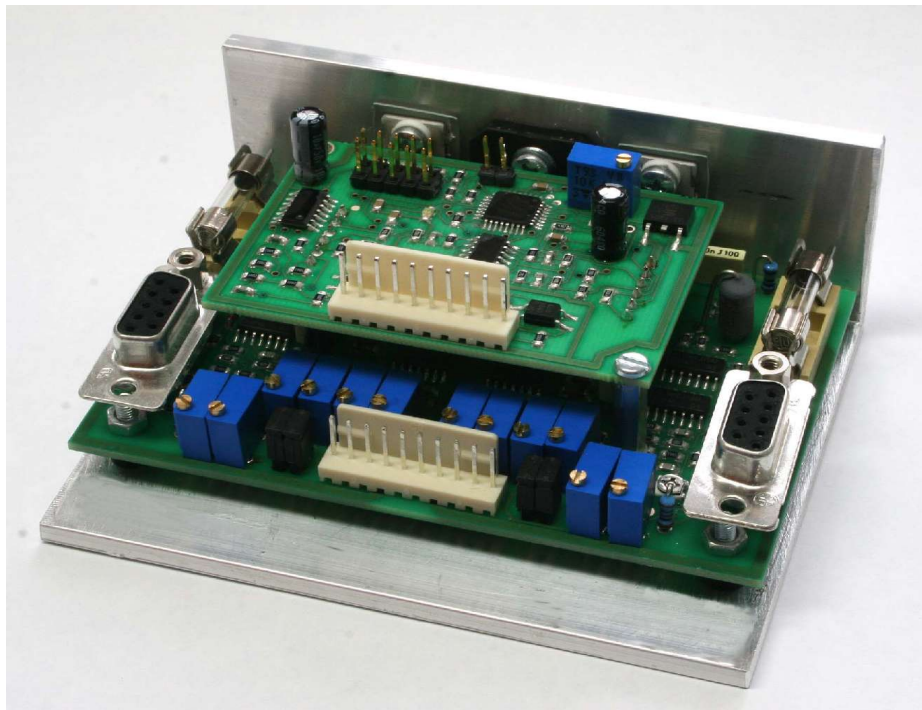


# **Raytrack<sup>®</sup> CT Driver**

Compact Dual Driver for CT-Galvos with Scannersaftey

## **Users Manual**

(Please read before setting up)



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# Contents

<b>1</b>	<b>Description</b>	<b>Page 3</b>
1.1	Features and technical data	
1.2	Operating conditions and responsibility	
1.3	First setting up	Page 4
<b>2</b>	<b>Signal connections</b>	<b>Page 5</b>
2.1	Powersupply	
2.2	Input signals	
2.3	Inverting jumpers	
2.4	Galvoconnections	Page 6
2.5	Safety signals	
<b>3</b>	<b>Adjustment controls</b>	<b>Page 7</b>
3.1	Function of drive controls	
3.2	Function of feedback controls	
3.3	Factory settings	Page 8
<b>4</b>	<b>Setting up deadjusted drivers</b>	<b>Page 9</b>
4.1	Note on scanspeed	Page 10
<b>5</b>	<b>The scannersafety</b>	<b>Page 11</b>
5.1	Features	
5.2	Description of operation	
5.3	Responsibility	Page 12
<b>6</b>	<b>Connections scannersafty</b>	<b>Page 13</b>
6.1	Intensityinput	
6.2	Coloursignals	Page 14
6.3	Safety-Off Jumper	
6.4	Sensitivity	
6.5	Status-LED Green	
<b>7</b>	<b>Overload protection</b>	<b>Page 15</b>
7.1	Status-LED Red	

## 1 Description

The scannerdriver Raytrack CT combines an ultracompact dual driver for galvanometers of the series CT6800 and CT6210 with a scannersafety.

### 1.1 Features and technical data

- Compact driver for 2 galvos (X/Y) 100 x 80 x 45 mm
- Supply voltage +/-24V DC (min. +/-18V to max. +/-30V DC)
- Internal voltage regulators +/-15V
- Output peak current ~ 5A
- Overtemperature shutdown
- Undervoltage protection
- Protected when one single power supply voltage is missing
- Overload protection by intelligent current monitoring
- Additional overcurrent protection by fuses (galvocoils)
- Differential input signals +/-10V
- Signalinverting by Jumpers
- Maximum signal (Size) adjustable
- Driver controls for Servogain, LF-Damping, HF-Damping
- Galvofeedback controls for movement angle, offset and linearity
- DSUB-connectors for connecting galvos (no special connectors)
- All pins for power supply and scanner signals located at front side
- Complete scannersafety as piggyback module

### 1.2 Operating conditions and responsibility

This product is not an electrical device ready to use.

It is a component, which requires additional components, installation and adjustments to run as a complete electrical apparatus. This product will form an apparatus, when installed in a housing, together with the galvos, a powersupply, and when it is adjusted and all signals are connected.

For this reason, this product does not have to comply with the regulations of CE marking or WEEE.

The product is designed and produced to meet CE regulations and all parts are RoHS conformal.

When the product and all additional components are properly installed in a metal housing and all other components, like powersupples, are of high quality, the final apparatus will meet CE-regulations very easy.

This product is a poweramplifier for closedloop galvanometerscanners for entertainment lasershow. The product should be used only for the specified galvo types.

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

Warranty can be void due to mishandling.

The manufacturer excludes liability in case of any damages, which are result of mishandling or operation under unspecified conditions.

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

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.

Assembly, setting up and adjustments must be done by qualified persons only.

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

- Wrong polarity of power supply voltages
- Supplyvoltage too high or unstabilized
- Damage as a result using the product beyond recommended operation conditions.
- Thermal galvo overload caused by excessive scanspeed or scanangle
- Damage caused by faulty driver adjustment or input signals beyond specified limits
- Damage caused by longterm operation near limits of the protection circuits.
- Damage caused by electronic or mechanical manipulations
- Damage caused by dust and corrosion

### **1.3 First setting up**

Before applying power to the device, the galvos must be connected to the driver.

Never connect galvos at powered drivers! This will result in damage of the galvos.

When setting up the first time, make sure that the Size controls are set to minimum (mechanical limit 'click' counterclockwise).

It is recommended to use symmetrical, stabilized DC-voltage of +/-24V for powersupply.

The voltage must not be lower than 18V or higher than 30V. When using switchmode powersupplies, these should deliver 1,5A minimum current (better 2A).

**Important: This driver is not protected against wrong polarity of supply voltage!**

**Wrong polarity will damage the driver and also the connected galvos!**

**If both galvos will not move close to center position at power-on, or if there is noise or ringing, shut down the power immediately!**

**The on-board safety creates a short startup-delay (some fractions of a second), while doing initialization process. During this time, the galvos are unpowered and the red status-LED blinks several times.**

## 2 Signal connections

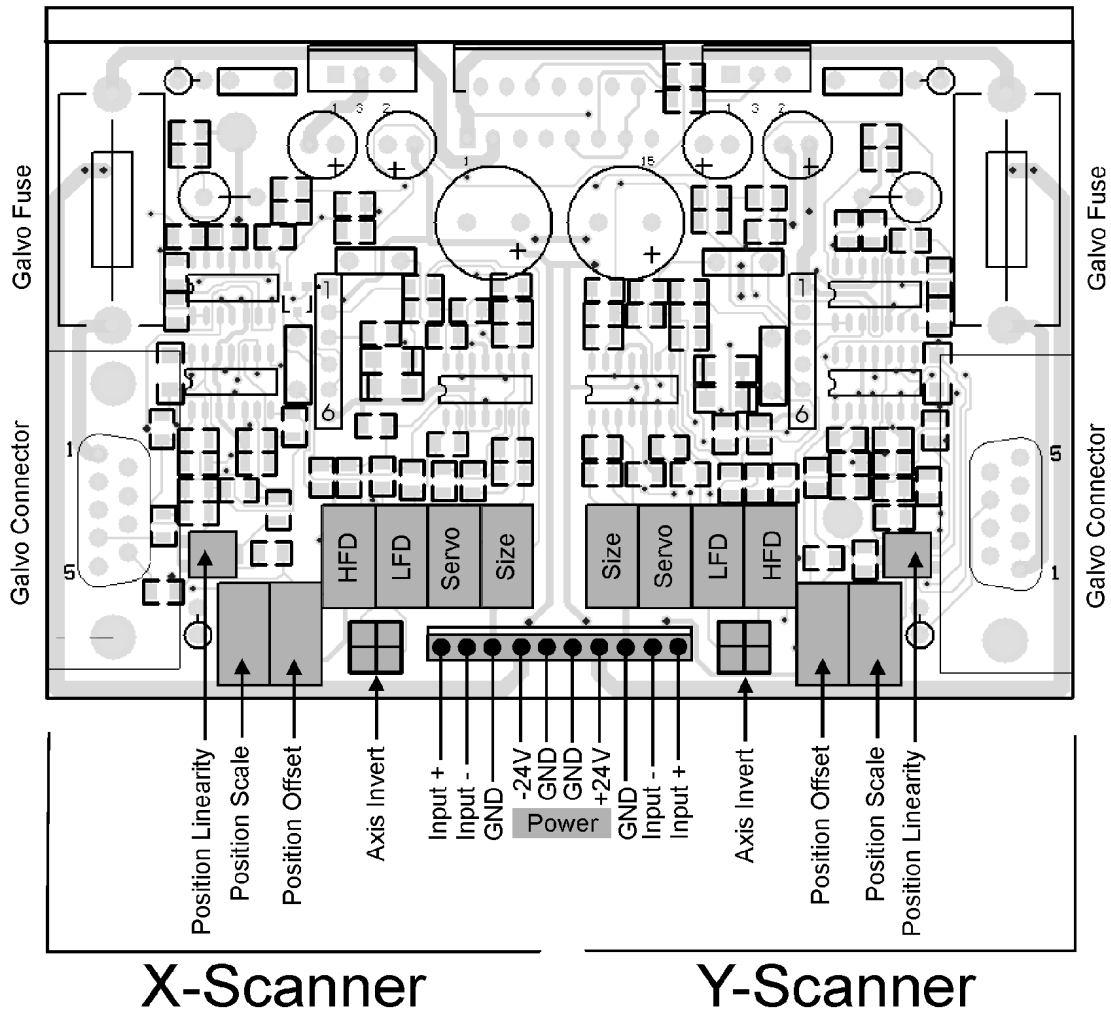


Fig. 1 View without sacnnersafety

### 2.1 Powersupply

The connectors for the symmetrical powersupply are located in the center of the 10pin main connector. Be sure to use right polarity! Left side = (-), right side = (+). All GND-pins are connected internally.

### 2.2 Input signals

The two drivers are arranged symmetrical on the board, so all signal connections and adjustment controls are mirrored.

The inputs Input+ and Input- operate in symmetrical or differential mode (ILDA), with an input voltage of max. +/-10V (differential).

Should the inputs be used 'singleended', for example because the signal controller will not offer differential signals, one of the inputs must be tied to GND.

Under normal conditions, Input- will be connected to GND and Input+ will be driven by the signal. When Input+ is tied to GND and Input- is used as signal, the galvo movement will be inverted.

**Never let one of the inputs unconnected or floating!**

### 2.3 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.

### 2.4 Galvoconnections

The galvo connectors are located at the left and the right side of the driver and are identical in pinout for both axis.

Pinout DSUB-9 Female

1	Motorcoil +
2	Motorcoil Return -
3	GND (Shield Motor)
4	Position B
5	n.c.
6	GND (Shield Position)
7	GND (Position+LED Common)
8	AGC Out (LED Anode)
9	Position A

### 2.5 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	+15V
2	Position Galvo (Feedback) +/-10V
3	Position Input (Inputsignal) +/-10V
4	Galvocurrent (rectified pulse signal)
5	Driver Off (TTL)
6	GND

### 3 Adjustment controls

#### 3.1 Function of drive controls

The driver controls are responsible for the behavior of the servo loop and the speed and accuracy, the galvo position is controlled.

Aging of the galvos, change of the mirrors, change of a complete galvo and also extreme temperature changes can result in a re-adjustment from time to time.

**Important: A minimum of knowledge is required to do this.**

**Adjustments should be done only by qualified persons.**

**The manufacturer excludes liability in case of damage resulted by misadjusted controls.**

**Adjustment to factory setting will be charged, when misadjusted drivers are sent back for warranty repair.**

See also chapter 4 for adjusting driver (page 9).

#### Size

With the size control, the picture size (input signal level) can be adjusted from zero to maximum.

To avoid angular movement out of range, the control software should be set to a small scanangle, and then go to maximum deflection angle carefully.

The size controls should never be set to maximum to allow some corrections (for example making a circle round).

#### Servo

Servo (Servogain) sets the amplification (proportional part) of the position control loop.

An excessive high value can cause oscillations and resonances at the galvo.

#### LFD

Low frequency damping reduces position overshooting.

#### HFD

High frequency damping softens the movement step to final position. This can eliminate the '3<sup>rd</sup> order bump' caused by LFD when galvoposition reaches the final value after a position step.

#### 3.2 Function of feedback controls

The feedback controls are reserved for adjusting galvo-specific parameters.

An adjustment is only necessary after changing galvos.

The adjustments can eliminate some mechanical tolerances in the feedback sensor of the galvos.

These controls should not be changed after initial setup of the galvo.

#### Position Offset

Creates an offset to the position signal. The mechanical center of the galvo can be adjusted to avoid an early angular deflection limit in one direction.

Input signal should be zero when adjusting. The mirror should be aligned parallel to the connector at the galvo.

**Important: Do not use this control to adjust picture position of the projection.**

**This can be done by software or by mechanical turning of the galvos in the galvo mount.**

### **Position Scale**

Adjusts the signal amplitude of the position sensor. The amplitude of both galvos should be set to a similar value. Otherwise, the identical driver setup of both galvos could be difficult.

The setting can be checked by adjusting both 'Size' controls to about 80%.

Project a square at low scanspeed.

Reduce picture size by software to avoid the mirrors bumping against mechanical stops.

Increase software settings to maximum for both axis while watching the projection.

Adjust Position Scale until both axis have maximum deflection angle (60 or 80 degrees, depends on galvo type).

### **Position Linearity**

Adjusting the linearity of the position sensor. Many galvos do not deflect linear from zero to maximum angle. This adjustment is not critical, so a normal SMD-poti was used.

The factory settings are center position.

A correct adjustment can only be done when projecting a grid testpattern.

The distance of the various lines should be similar at upper and lower half (right and left side) of the projection. When adjusting linearity, the line distances move.

There is no risk to overturn the poti. A small jump in size will happen.

Be sure that the final setting will be not in the 'dead' (overturned) area of the poti.

## **3.3 Factory settings**

When drivers are delivered without galvos, the adjustments are preset in a way that a safe operation without any risk for galvos is possible.

The gain is not set very high. So not maximum speed and not maximum accuracy can be reached with these settings. Also some overshoots can occur.

The scan angle (Size) also is not set to maximum.

The factory settings can be used to start the adjustment without the risk of damaging galvos at power-on.

When drivers are delivered with corresponding galvos as a scanset, they are full adjusted and normally no or just a small adjustment is required.

In this case, both galvos are marked as X and Y and must be connected to the right driver channel.



## 4 Setting up deadjusted drivers

After replacing one or both galvos or mounting another mirror size to the galvos, it sometimes can happen, that the driver loop becomes instable when first switching-on. This can cause ringing and oscillation. The driver must be shut down immediately to avoid damage of the galvos! A new adjustment setup must be done from zero.

The following procedure is recommended for complete driver adjustment:

- Driver is switched off!
- Set size counterclockwise to minimum (until 'click')
- Then set size 4 turns clockwise
- Servogain counterclockwise to minimum (until 'click')
- The set servogain 3 turns clockwise
- Both LFD and HFD counterclockwise to the limit (until 'click')
- Then turn LFD 5 turns clockwise.
- Switch on driver and scan a simple testpattern with 4 to 5 squares which are arranged inside each other. The outer square should be drawn at maximum size. Scanspeed is 8-10kpps. Scansize by software set to maximum.
- Set servogain clockwise until a movement of the galvos occurs. The shape of the picture should now be recognizable. Continue turning size until there will start overshoot at the edges.
- Adjust size until the projection is about 70% of maximum scanangle. If you cannot reach size, use the position scale control to compensate.
- Reduce overshoots by turning LFD. Change between increasing servogain and reducing overshoots until you see bumps or 'undershoots' at the edges, which cannot be corrected with LFD.
- Turn HFD clockwise to move these bumps outside the square until you can adjust the resulting overshoot again with LFD.
- Scanspeed should now be increased until the shape of the edge is clearly visible.
- Do not overdrive speed.
- Repeat increasing servogain, eliminate overshoots with LFD, eliminate bumps with HFD, until it is no longer possible to eliminate the bumps. Reduce servogain a bit and readjust LFD and HFD until all edges look sharp and no curves in the lines.
- When the picture starts to be instable or oscillate, reduce servogain.
- Try to set the shapes of the edged for both axis the same. Control by LFD: When adjusting a small amount of overshoot, you can see if both axis are set to same values.
- Increase of scanspeed for a short moment can also show same shapes of both axis.
- When the picture is set to a maximum quality, reduce scanspeed to not overload the galvos.
- When driving the scanner beyond limit over longer time, the overload protection can shut down the driver. Reduce scanspeed or picture size by software to avoid shutdown.
- Now scan a grid testpattern with maximum software size an max. 15kpps.
- Increase size at driver to maximum. Caution! Don't scan beyond the maximum scan angle of the galvos. Check the possible angle in the datasheet of the galvo. Adjust position scale until you can reach the maximum scan angle with set 'Size' to about 80% of maximum.
- Set up both galvos to the same angle.
- If the projection looks limited at one half of the picture, correct center with position offset.
- If the grid seems to be distorted in one direction, adjust Position Linearity.
- After setup, the picture should be scanned centric, symmetrical and with same and maximum scanangle.
- The same projection angle of both axis can better be checked to use a simple circle. Do not scan it too fast to avoid distortion.
- Now scan the ILDA standard pattern at an angle of 8 degrees
- Increase scanspeed until the circle of the testpattern touches the small square at the inner sides.

When the circle is oval, the larger size is the faster axis. Try to get the smaller side to the same size by use of servo gain, LFD and HFD. If this is not possible, the faster galvo has to be reduced in speed. In the best case, a perfect circle should be shown.

- Naturally, there should be no overshoots or bumps in the testpattern, when adjusting the circle.
- When the ILDA-testpattern is projected properly, read the scanspeed. It should be about the value, the scanners are specified for.
- The scanner is now adjusted. Use different testpatterns at different angles to check all details and correct slightly, if necessary.

The ILDA testpattern is good to check speed and finetuning. For initial adjustments, it is not very useful. Therefore we suggest to use own, simple testpatterns, for example squares, diagonal lines or circles. Also the 'Lasermedia' testpattern is very suitable for initial adjustments. But it should not be scanned too fast (about 15K at 30-40 degrees).

To check same size of both axis, use simple circles or the 'Orientation' testpattern.

#### **4.1 Note on scanspeed:**

The measuring of the maximum scanspeed under the use of the ILDA testpattern can only give a true value, when the software will not influence the projection of the testpattern.

Programs, which do self interpolating of points or edgerepeats will increase the measured value.

A galvospeed of 30K ILDA does not mean that every show can be scanned with 30K.

Because ILDA-speed is specified at a very small angle (8 degrees and smaller), the scanspeed in reality is much lower. At ILDA 30K, normal graphics shows can be scanned between 20K and 26K, depending on scanangle. Beamshows should not be scanned beyond 20K, because these shows normally contain many position jumps but less points. A high scanspeed results in high thermal load at the galvos and may cause triggering of overload protection.

## 5 The scannersafety

### 5.1 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.

### 5.2 Description of operation

The formula of the safety is:

Scannermovement okay (safe),

**if** (inputsignal X **and** galvosposition X) **or** (inputsignal Y **and** Galvosposition 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 galvosposition 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.

### 5.3 Responsibility

Beside to the local safety regulations, the scanner safety offeres 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.

## 6 Connections scannersafety

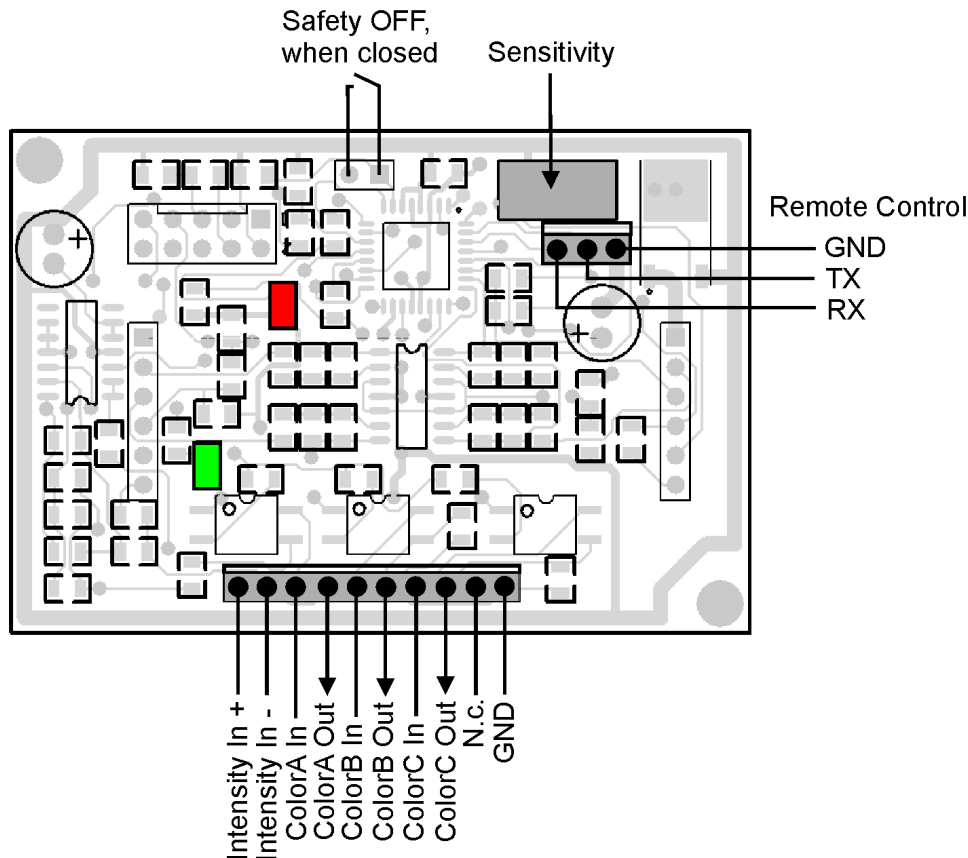


Fig. 2 'Remote Control' currently is without function

### 6.1 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 laser show.

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

When used in single-color systems, even the color signal itself can be used, if there is no additional blanking signal available.

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

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

The Intensity input 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 laser shows 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 show frames 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.

## 6.2 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.

## 6.3 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.

## 6.4 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.

## 6.5 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.

## 7 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.

### 7.1 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.