Installation and Operation

Single Axis Module dyn*AXIS* L, 30 mm

digital, 1080 nm

– Prototype –

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1 Delivered Product

1.1 Product Overview

The Single Axis Module is designed for a laser with a wavelength of 1080 nm and a maximum beam diameter (aperture) of 30 mm. The Single Axis Module is designed for digital data transfer via the digital servo electronics.

1.2 Unpacking Instructions and Package Contents

- Carefully remove the scan module from the package.
- Protect the scan module from dust and other contaminants.
- Keep the packaging, so that in case of repair the scan module can be properly repackaged and returned to SCANLAB.
- Check that all parts have been delivered and all parts are in good order and condition. If there are any questions, please contact SCANLAB (see page 32).
  The package includes:
  - a dyn*AXIS* L galvanometer scanner with mirror and mounting assembly
  - a DSCB digital control board
  - a DSIB interface board
  - this operating manual

1.3 Article Number and Labeling

The scan module has the following article number:

153577 (Scanner dyn*AXIS* L with mirror 30/1)

153578 (Scanner dyn*AXIS* L with mirror 30/2)

The serial number label is found on the scanner.

Please make sure to connect each scanner to its appropriate control board (see page 22).

1.4 About This Operating Manual

This operating manual is a part of the product. Please read these instructions carefully before you proceed with installing and operating the scan module. If there are any questions regarding the contents of this manual, please contact SCANLAB (see page 32).

Keep the manual available for servicing, repairs and product disposal. This manual should accompany the product if ownership changes hands.

SCANLAB reserves the right to update this operating manual at any time and without notification.

2 Single Axis Module – Principle of Operation

The scan module is designed for diverse areas of application in which, generally, a laser beam is deflected via a deflection mirror. The scan module is an OEM version which is intended for integration into a system with a proper housing.

For proper operation, the scan module must be correctly adjusted and controlled.

The remainder of this chapter provides answers to the following basic questions concerning operation of the scan module:

- Which galvanometer scanner characteristics need to be taken into account when creating or using applications that dynamically position laser beams?
- What kinds of signals are used to control the positions of the galvanometer scanner and how large is the range of controllable deflection angles?
- How should the scan module be adjusted with respect to the laser beam and how large is the range of usable deflection angles?

2.1 Galvanometer Scanner Behavior and Dynamic Positioning of Laser Beams

SCANLAB's galvanometer scanners and control boards allow precise dynamic control of the two deflection mirrors. This enables exact positioning of the laser beam with high speed – a characteristic required by a wide range of modern applications. For ensuring optimum operation, the following properties of galvanometer scanners must be considered:

- Most laser applications require the laser focus to trace contours within the working plane at a constant processing speed. To achieve this, the control (PC) subdivides the contours into microsteps. Microstep length is determined by the output period and desired speed. Galvanometer dynamics are usually optimized for such microvector control. It is therefore advisable to also use vectors when positioning with the laser switched off. Compared to hard jumps, a defined positioning speed will prevent excessive oscillation and usually produce shorter positioning times. Positioning speeds can generally be significantly higher than processing speeds. In chapter "Technical Specifications Single Axis Module", on page 34 a typical positioning speed is specified for this particular scan module. The processing speed must be adjusted according to the particular application.
- Galvanometer scanner movements do not occur instantaneously with respect to vector control, but rather after a certain time lag. Time lag characterizes the reaction properties of the galvanometer scanner. The vector control output period must be significantly shorter than the time lag. Otherwise, instead of moving the galvanometer scanner with constant speed, the servo would attempt to follow the individual microsteps. This, in turn, would increase power consumption and thermally stress the scanner. SCANLAB therefore recommends as short an output period as possible, no more than 20% of the time lag (see page 34). Oscillation behavior and time lag must be taken into account by the application software, which synchronizes the scan module and the laser control. If the scan module is controlled via a SCANLAB RTC PC interface board or via an RTC *SCAN*alone standalone board, then synchronization is easily realized by appropriately setting the scanner and laser delay parameters (refer to the RTC manual for details).
- Environmental fluctuations, especially temperature changes, can cause scanner drift, i.e. a shift (offset drift) and an increase or decrease in size (gain drift) of the working image field. Therefore, high-precision applications should only be started up when the scanners have reached their operating temperature. In addition, the magnitudes of environmental fluctuations, e.g. operating temperature changes, to which the scan module is exposed should be kept as small as possible.

2.2 Controlling the Scan Module

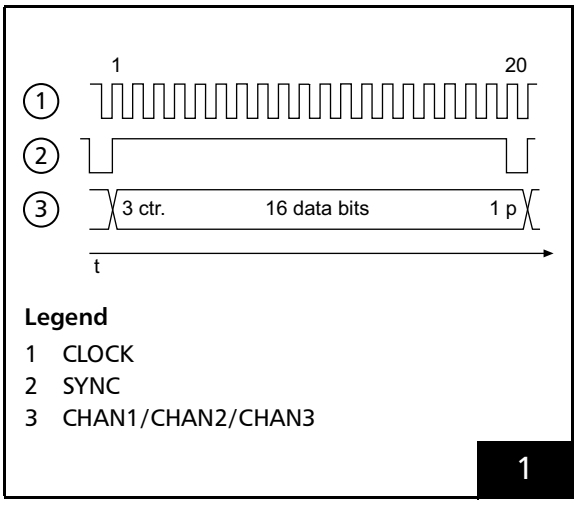
2.2.1 Data Transmission

The positions of the galvanometer scanners are controlled via the transmission of digital input signals. The controller and the scan module are interconnected via a serial interface. Data transmission follows the XY2-100 Enhanced protocol. In the process, essentially the following signals are transferred:

- The controller delivers set values for the scanner positions.
- The scan module generates data signals to be returned to the controller.
- Two additional channels transmit the data transport synchronization signal and a clock signal.

Figure 1 shows the timing of the clock signal (CLOCK), the synchronization signal (SYNC) and the three data channels (CHAN1/CHAN2/CHAN3).

Every 10 µs, three 20-bit words (3 control bits, 16 data bits, 1 parity bit) are transmitted serially as differential signals.



Timing diagram of the serial interface signals

2.2.2 Returned Data Signals

The scan module's digital servo architecture allows a wide variety of data signals to be returned to the control board. Every 10 µs data signals are transmitted via the status channel. This opens up possibilities such as monitoring the galvanometer scanner's actual values during execution of an application or carrying out comprehensive troubleshooting in case of operational malfunction.

When the scan module is operated via an RTC4 or RTC5 PC Interface Board, the command *control_command* (see the RTC4 Manual) can be used for selecting which data the scan module should return to the control board. The selected data sources will be transmitted until another source is selected. Data received by the RTC can be read asynchronously at any time via additional commands (see the RTC Manual).

To facilitate scan module operation via other RTC boards, a status word compliant with the XY2-100 protocol is transmitted after every reboot or reset (on all receive channels).

XY2-100 Compliant Status word

Five seconds after every reboot or reset, a status word compliant with the XY2-100 protocol is transmitted (on all receive channels). The status word contains three status values that can be queried via the RTC command GET_HEAD_STATUS:

- PWROK (i.e. "Power OK")
  PWROK = 0 signifies a problem in the power supply. In normal operation, the PWROK signal is 1. If the signal switches from 1 to 0 during operation, then **the laser must be turned off immediately**. Under some circumstances the system could deflect the laser beam in an unintended

direction, which may cause health hazards and severe equipment damage. The system should be checked immediately to determine the cause (also see section "Power Supply" on page 23).

- TempOK (i.e. "Temperature OK")
  The TEMPOK signal always switches from 0 to 1 when the operating temperature has been reached (which might take a few minutes). If, during operation, the galvo temperature drops below its minimum operating temperature or exceeds a maximum allowable temperature, the TEMPOK signal will switch to 0. In this case, system operation does not need to be stopped immediately, but large drift or other side-effects may occur.
  If system operation is not stopped and the scanner temperatures then reach a still higher critical value, then the built-in temperature control mechanism will switch off the galvanometer scanner drive stages to avoid heat-induced damage to the scanners or the scan module (see page 29). If the scanner temperature drops again below the power-down threshold, the scanner drive stages are automatically restarted.

- PosAck (i.e. "Position Acknowledge")
  PosAck = 1 signifies that the difference between the set value and the real position is less than 0.5% of the image field size. The PosAck signal normally switches to 1 within a few seconds after power-up.

Additional Data Types

When the scan module is operated via an RTC4 or RTC5 PC Interface Board, the command *control_command* (see the RTC Manual) can be used for selecting which data the scan module should return to the control board. Unless the configuration is changed after reset, the XY2-100 status word will be transferred (see the previous section). The selected data is transmitted at 10 µs intervals until a different data type is requested.

The following is a description of the data types that may be selected.

Status (XY2-100)

This data type corresponds to the status word specified by the XY2-100 protocol (see the previous section).

Actual Position

Actual angular position

Set Position

Set angular position

Position Error

Set angular position - Actual angular position (difference between the current actual angular position and the current set angular position)

Actual Current

Actual galvo output stage current of the corresponding axis

Relative Galvo Control

Galvo control voltage (in per mille of the maximum value)

Actual Velocity

Actual angular velocity

Operational Status

The scan module provides various blocks of extended status informations.

If the first block is selected to be returned to the control board, then the scan module provides the following information about the current operating state:

- Status of galvo output stage (on/off)
- Status of galvo heater output stage (on/off)
- Status of internal voltages (all voltages o.k. or at least one internal voltage not o.k.)
- Status of external voltage (o.k. or power supply interruption)
- Status of AD converter (successfully initialized or not initialized)
- Status of booting process (complete or not yet completed)
- Status of control parameters (valid or invalid).
- Boot signal: The control is activated, as soon as all necessary flags are set
- Status of positioning (positioning error within the allowed range (< 0.5%) or not in the allowed range)
- Status of positioning (positioning within the allowed range or critical position reached)
- Temperature Status (operating temperatures of galvanometer scanner and servo board reached or not yet reached)
- Temperature Status (temperature of galvanometer scanner and servo board below a critical value or at least one of the two temperatures above the critical value): If one of the two temperatures exceeds the critical value, then the scan module automatically enters a temporary temperature error state: the scanner's output stage is (temporarily) deactivated. The scan module resumes normal operation, as soon as the temperature drops below the maximum allowed value.
- Error Status (no critical error or system presently in critical error state). Critical errors are for instance:
  - improper internal voltages
  - external power supply interruption
  - reaching a critical edge position

  If a critical error occurs, the scan module automatically enters a permanent error state, in which the output stages of the affected axis remain deactivated – even if the critical error was only temporarily present. Normal operation is *not* resumed.

Note:
During both temporary and permanent error states, the scan module will continue to transmit data to the control board. Even in these states, switching or selection of data signals for diagnostic purposes is still possible.

The second information block can be selected to be returned to the control board if more detailed information about the current operation state is desired. This block for instance separately indicates potential error states of the various internal voltages.

Alternatively, two further information blocks can be selected to be returned to the control board: They indicate the operation states listed above at the moment of the most recently occurred operation interruption. After every successful restart – and, as long as no error has occurred – all status informations of these two blocks are irrelevant. Only, as soon as an error causes a switch into a temporary or permanent error state, the current status values will be saved into these blocks. Simultaneously, also an event code is set, indicating which particular event caused the error state. This event code can be read out separately.

Temperature

The following temperatures can be returned to the control board:

- Temperature of the galvanometer scanner
- Temperature of the servo board

Internal Voltages

The following internal voltages can be returned to the control board:

- AGC (automatic gain control) voltage: supply voltage of the position detector
- DSP core supply voltage (1.8 V)
- DSP IO voltage (3.3 V)
- Analog section voltage (9 V)
- AD converter supply voltage (5 V)

Exact values for the internal voltages can vary for different versions of the scan module.

Internal Current

The AGC current (automatic gain control) of the position detector can be returned to the control board.

Heating Output of the Galvo Heaters

Relative heating output (0 to 1000 per mille) of the galvanometer scanner's heater.

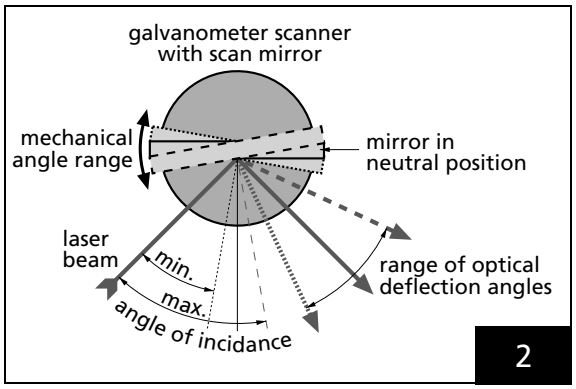
General Scan Module Information

Alternatively, the following data types may be selected:

- Serial number
- Article number
- Firmware version number
- Calibration
- Aperture
- Wavelength
- Running time

2.2.3 Range of Controllable Deflection Angles

The mirror can be dynamically positioned within a particular angle range (see "range of mechanical deflection angles" in figure 2) based on the calibration and maximum control values of the scan module specified in chapter "Technical Specifications Single Axis Module", on page 34. The neutral position (0° angle) represents the angle position while powered, but without a control signal. Mirror stoppers prevent the allowable angle range from being exceeded. The range of allowable angles [° mech.] provided by the mirror stoppers is specified in chapter "Technical Specifications Single Axis Module", on page 34. Here it must be noted that mirror stoppers are only "emergency brakes". The controller and the user's application software should ensure that "emergency braking" never occurs – i.e. the mirrors should never be deflected so far as to contact the mirror stoppers. If, for any reason, such an event does occur, the scanner and mirror should be inspected for possible damage.



Beam deflection and range of angles

The optical range of deflection angles is twice the mechanical angle range (see figure 2). The specified calibration and dynamic and optical angle parameters are in [rad optical]. The actual usable angle range is dependent on a number of factors (see following section).

2.3 Adjustment and Usable Angle Range

The laser beam should arrive at the mirror's reflective surface perpendicular to the scanner's rotation axis. It should be thereby considered that the rotation axis is typically located not on the plane of the mirror's surface, but rather in the middle of the mirror. The offset of the mirror's reflective front surface to the rotation axis is depicted in the technical diagram figure 3 on page 16. The laser beam should be centered at the midpoint of the usable mirror surface rather than at the rotation axis.

Caution!

- To avoid damage to the deflection mirror, don't allow the laser beam to arrive perpendicular to the mirror's surface. Observe the allowable angle of incidence range.
- Excessive deflection angles or beam diameters can produce vignetting at the mirror, resulting in possible health risks and damage to the mirror and equipment. If your application requires larger scan angles, then please contact SCANLAB.

The laser beam must never arrive perpendicular to the mirror surface. The deflection mirror's material and coating are designed for oblique incidence of the laser beam – with angles of incidence of typically 45° (see figure 2 on page 9). A perpendicular angle of incidence can result in destruction of the mirror. The usable angle of incidence range is dependent on the mirror's coating and dimensions as well as the arriving laser beam's diameter and the scan system's overall geometry:

(1) Mirror coating:
The mirror coating is optimized for a specified wavelength and a defined angle of incidence range. The corresponding data are listed in chapter "Technical Specifications Single Axis Module", on page 34. During adjusting the scan module, bear in mind that for technical reasons there is an uncoated border at the mirror edges with a width of typically 0.5 mm.

(2) Beam diameter and mirror dimensions:
The recommended diameter of the arriving laser beam is specified in chapter "Technical Specifications Single Axis Module", on page 34. Excessive beam diameters or deflection mirror positions can produce vignetting at the mirror's edges, with resulting health-endangering laser reflections or scan system damage. The relevant deflection mirror dimensions are provided in figure 3 on page 16. The used angle range and the beam diameter should be selected in such a way as to avoid unacceptable vignetting. Also note that the mirror's usable surface is somewhat reduced by its uncoated border edges and its mirror mount.

(3) Scan system geometry:
The scan module will be typically integrated in a housing. The housing's apertures and the scan system's overall geometry can further reduce the usable angle of incidence range.

Bearing in mind the above-listed points, the laser beam should be adjusted so that the scan module is operated in the middle of its usable angle range.

3 Safety During Installation and Operation

To reduce the risk of injury, please observe the following guidelines.

The safety and warning notices in this manual are indicated by a symbol set against a gray background:

Instructions that may affect a person's health are marked with a warning triangle next to the word "Danger".

Instructions that recommend appropriate use of this device or warn of damage that may occur to it are identified by a circle with an "X" in it, next to the word "Caution".

3.1 Operational Guidelines and Standards

When operating the scan module, the following guidelines and standards should be followed:

- EC Guideline 73/23/EEC
  Low Voltage Directive
  (including amendment 93/68/EEC)
- EC Guideline 89/336/EEC
  Electromagnetic Compatibility
  (including amendments 91/263/EEC, 92/31/EEC, 93/68/EEC and 2004/108/EU)
- EC Guideline 98/37/EU
  Machinery Directive
- EN 60204-1 (November 1998)
  Safety of Machinery – Electrical Equipments of Machines, Part1: General Requirements
  (also see similar general machinery safety standards such as VDE 0113-1, IEC60204-1 or ANSI B11.19 Machine Tools – Safeguarding When Referenced by Other B11 Machine Tool Safety Standards-Performance Criteria for the Design, Construction, Care and Operation)
- EN 60825-1 (October 2003)
  Safety of Laser Products, Part 1: Equipment Classification, Requirements and User's Guide
  (also see similar general laser safety standards such as VDE 0837-1, IEC 60825-1, Safety of Laser Products - Part 1: Equipment Classification, Requirements, and User's Guide, 21 CFR 1040, Laser Product Performance Standard or ANSI Z136.1 Standard for the Safe Use of Lasers)
- EN 12626
  Safety of Machinery - Laser Processing Machines - Safety Requirements
  (also see similar laser materials processing system safety standards such as ISO 11553, Safety of Machinery - Laser Processing Machines - Safety Requirements, IEC 60825-4, Safety of Laser Products - Part 4: Safety of Laser Products or ANSI B11.21-1997, Machine Tools Using Lasers for Processing Materials - Safety Requirements for Design, Construction, Care, and Use)

Additional application-dependent guidelines and standards may apply.

Complying with the Relevant Standards for the CE Label

The scan module is delivered as an OEM component conceived of for integration into a laser scan system.

The system manufacturer bears the responsibility for complying with the standards and guidelines required for equipment usage and for the CE label.

3.2 Electromagnetic Compatibility (EMC)

The scan module is not shielded against electromagnetic fields. The customer is responsible for the observance of the electromagnetic compatibility, for example by assembling the scan module in an appropriate housing.

3.3 Laser Safety

The scan module is designed to be operated in conjunction with a laser. Therefore, all applicable rules and regulations for safe operation of lasers must be known and applied when installing the scan module and operating the system in which it is used. Since SCANLAB has no influence over the employed laser or the overall system, the customer is solely responsible for the laser safety of the entire system.

Danger!

- Safety regulations may differ from country to country. The customer bears sole responsibility for compliance with all applicable safety regulations of their respective regulatory jurisdiction.

Shutter

The scan module has no shutter and there is no device to decrease the laser output power. It is the responsibility of the customer to include such a device in the system in a way as to comply with all regulations. The observance of laser safety must be ensured for the entire system.

Maintenance

During maintenance of the laser equipment, the class of the laser can increase. Therefore, the customer must take suitable protective measures.

Warning Symbols

The area where the emerging beam is harmful must be marked with a warning symbol indicating the class of the employed laser – in accordance with IEC 60825-1 laser safety requirements. In addition, a warning symbol must be placed at the emitting aperture of the laser system. The table on page 13 shows the appropriate warning symbols for the various laser classes specified by IEC 60825-1 (or EN 60825-1 / VDE 0837 T1).

Danger!

- During assembly or operation of the scan module, never stare directly into the laser beam or its deflected radiation. Keep all parts of the body away from the laser beam and its path. Routine maintenance should be performed as described in "Routine Maintenance of the Mirror" on page 31 and all safety instructions should be observed!
- Adjust the output beam path of the scan module by means of a Class 2 laser. If this is not possible, the laser should be operated at the lowest power. Avoid dangerous deflected radiation!
- The risk of hazardous deflected radiation can increase when optical instruments are used in combination with the scan module.
- Before checking the scan module, make absolutely certain that the laser and scan module are turned off!
- Cover the path of the laser beam via an appropriate protecting case to block laser radiation!
- Do not obstruct the movement of the scanner's mirror in any way. When the scan module is turned on, the mirrors must not be touched at all!
- Closely follow all IEC 60825-1 laser safety requirements and other applicable accident prevention regulations of your respective regulatory jurisdiction.
- Wear appropriate eye protection at all times.
- Always turn on the PC controller and the scan module's power supply first before turning on the laser. Otherwise the laser beam might be reflected in an arbitrary direction.

Laser Classes Specified by IEC 60825-1 (or EN 60825-1 / VDE 0837 T1)

Visible Laser Radiation	Invisible Laser Radiation	Potential Hazards
LASER CLASS 1	LASER CLASS 1	Class 1: This laser radiation is not harmful; is eye-safe.
 LASER RADIATION DO NOT STARE DIRECTLY INTO THE BEAM WITH OR WITHOUT OPTICAL INSTRUMENTS LASER CLASS 1 M	 INVISIBLE LASER RADIATION DO NOT STARE DIRECTLY INTO THE BEAM WITH OR WITHOUT OPTICAL INSTRUMENTS LASER CLASS 1 M	Class 1 M: Exposure to this radiation is harmful to the eyes if optical instruments are used to reduce the cross section of the laser beam. If this is not the case, this laser radiation is not harmful; is eye-safe.
 LASER RADIATION DO NOT STARE DIRECTLY INTO THE BEAM LASER CLASS 2		Class 2: This laser radiation is in the visible spectrum of 400 to 700 nm. Exposure to this radiation for less than 0.25 s is not harmful to the eyes. It is eye-safe due to the eye's natural aversion response and blink reflex.
 LASER RADIATION DO NOT STARE DIRECTLY INTO THE BEAM WITH OR WITHOUT OPTICAL INSTRUMENTS LASER CLASS 2 M		Class 2 M: This laser radiation is in the visible spectrum of 400 to 700 nm. Exposure to this radiation is harmful to the eyes if optical instruments are used to reduce the cross section of the laser beam. If this is not the case, exposure to this radiation for less than 0.25 s is not harmful to the eyes and is eye-safe due to the eye's natural aversion response and blink reflex.
 LASER RADIATION AVOID EXPOSURE OF THE EYES LASER CLASS 3 R	 INVISIBLE LASER RADIATION AVOID EXPOSURE TO THE LASER BEAM LASER CLASS 3 R	Class 3 R: This laser radiation is harmful to the eyes. Eye exposure exceeds the maximum allowable value.

Visible Laser Radiation	Invisible Laser Radiation	Potential Hazards
 LASER RADIATION AVOID EXPOSURE TO THE LASER BEAM LASER CLASS 3 B	 INVISIBLE LASER RADIATION AVOID EXPOSURE TO THE LASER BEAM LASER CLASS 3 B	Class 3 B: This laser radiation is harmful to the eyes and in some cases to the skin.
 LASER RADIATION AVOID ANY EXPOSURE OF THE EYES OR THE SKIN TO DIRECT OR SCATTERED RADIATION LASER CLASS 4	 INVISIBLE LASER RADIATION AVOID ANY EXPOSURE OF THE EYES OR THE SKIN TO DIRECT OR SCATTERED RADIATION LASER CLASS 4	Class 4: This laser radiation is very harmful to the eyes and skin. Stray radiation can also be dangerous. This radiation can cause fire or explosion and the generation of toxic gases or vapors.

3.4 Electrical Safety

Caution!

- The electronics boards must be securely fastened and protected from moisture, dust, corrosive vapors and external influences.

Power is furnished to the scan module by a user-supplied low voltage power supply. The power supply must meet the following mains insulation requirements:

- If the connectors are covered and cannot be reached without tools from the outside, single insulation between the mains and the low voltage circuit is sufficient. The mains insulation must be able to withstand a test voltage of 2 kV AC applied between the mains and the low voltage circuit.
- If the connectors can be reached from the outside, double or reinforced insulation between the mains and the low voltage circuit is necessary. The mains insulation must be able to withstand a test voltage of 4 kV AC applied between the mains and the low voltage circuit.

Additional application-dependent guidelines and standards may apply.

4 Installation

Installation consists of mounting the galvanometer scanner, installing the electronics boards and connecting the power supply and control lines.

Execute the individual mounting and cabling steps in the specified order.

Danger!

- Make sure all components of the system (laser, controller, power supply, computer) are switched off before installation.
- During installation of the scan module, never stare directly into the laser beam or at any of its deflected radiation.
- Never place parts of the body into the direct path of the laser or its deflected radiation.
- After the scan module has been mounted, there is a cone-shaped hazardous laser output area. Do not stare into the laser or its deflected radiation. Keep all parts of the body away from the laser beam.
- Always turn on the PC controller and the scan module's power supply first before turning on the laser. Otherwise the laser beam might be reflected in an arbitrary direction.

Caution!

- Carefully take the scan module out of the packaging.
- Protect the scan module from humidity, dust and corrosive vapors to prevent damage to the electronics boards and mirror.
- To avoid damage to the electronics boards by electrostatic charges, observe all applicable ESD guidelines.
- Avoid electromagnetic fields and static charges, which can damage the electronics boards. To do so, shield the scan module from external electromagnetic fields via an appropriate housing.

Caution!

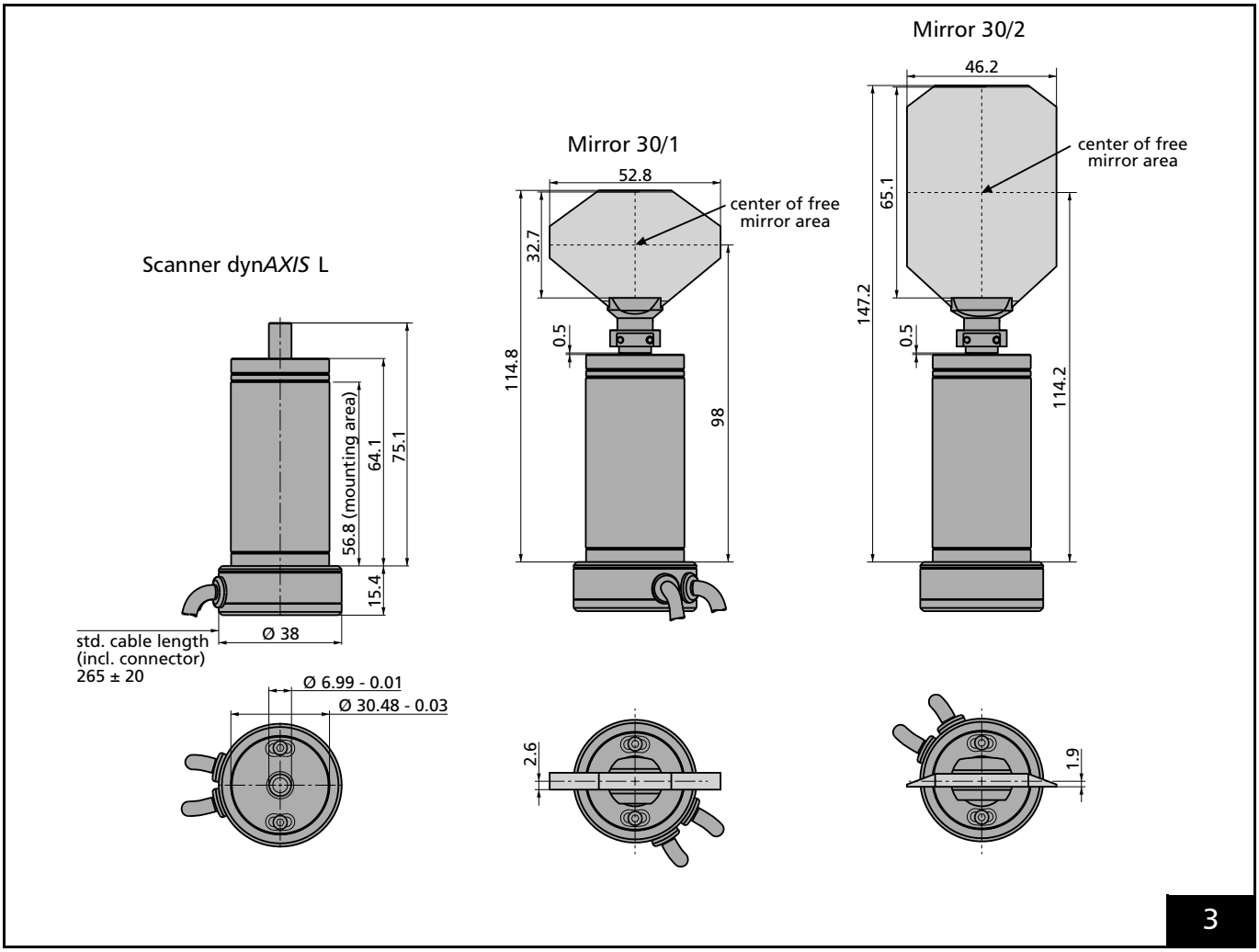
- Never touch the optical surface of the deflection mirror without appropriate cleaning material. Follow the procedures in chapter 6.1 for periodically checking and cleaning the mirror.
- Make sure all operating and storage conditions are met (see chapter 4.6, page 26).

4.1 Checking the Specifications

Make sure the specifications of the scan module meet the requirements of your application (see "Technical Specifications" on page 34). If your application requires other specifications, then please contact SCANLAB.

4.2 Dimensions

Figure 3 shows the dimensions of the galvanometer scanner (left side) and the dimensions with mirror mount and mirror (right side).



Dimensions (all dimensions in mm)

4.3 Mounting the Galvanometer Scanner

Caution!

- The galvanometer scanner must be securely fastened and protected from moisture, dust, corrosive vapors and external influences.
- Never open the galvanometer scanner.
- Avoid any conductive path between the scanner housing and the mounting plate.
- The galvanometer must never be operated without its specified mirror.

The layout and dimensions relevant to mounting are shown in figure 3 on page 16 . Mount the galvanometer scanner in the following manner.

Mirror

The mirror is usually bonded to a mirror mount and the mirror mount attached to the scanner's rotor. Mirror stops are already integrated in the scanner.

If the mirror is not mounted on the scanner yet, attach the mirror mount with the mirror to the scanner's rotor. The distance between scanner and mirror mount must be adjusted to 0.5 mm (e.g. via temporarily inserting a 0.5 mm thin metal plate between scanner and mirror mount). Tighten the screws at the mirror mount carefully but firmly. Tighten the screws alternately. SCANLAB recommends a tightening torque of 80 Ncm. Make sure to tighten the screw with this torque only once. Otherwise, there is the risk to tear off the screw head. When installing the mirror mount a second time to the scanner's rotor, replace the used screws with new ones M2,5×8 Torx screws (ISO 14580 A2). Use a TX8 screwdriver.

Mount the mirror and galvanometer scanner such that the mirror will not touch any other parts of the scan system during operation and that the mirror is adjusted with respect to the laser beam such that the scan module is operated in the middle of its usable angle range.

Scanner

The scanner housing must be electrically insulated from the machine structure. For this purpose, an insulating foil is generally provided.

Apply the insulating foil around the scanner's mounting area. Then put the scanner together with the foil in the corresponding bore hole of the mounting plate.

Fasten the scanner via a screw. Accordingly, the mounting plate must provide an appropriate threaded bore hole.

4.4 Mounting the Electronics Boards

Dimensions and mounting of the electronics boards are described on the following pages.

Install the boards so that they are securely fastened and sufficiently protected during operation from moisture, dust, corrosive vapors, electromagnetic fields and other external influences.

Observe the following instructions.

Caution!

- The electronics boards must be securely fastened and protected from moisture, dust, corrosive vapors and external influences.
- Avoid electromagnetic fields and static charges, which can damage the electronics boards. To do so, shield the scan module from external electromagnetic fields via an appropriate housing.
- To avoid damage to the electronics boards by static charges, observe all applicable ESD guidelines.
- Handle the electronics boards carefully (particularly when inserting or removing cables) so that no electronic components incur mechanical damage.
- Do not change the tuning of the electronic boards.
- Avoid subjecting the electronics boards to any form of mechanical stress.
- When installing the electronics boards, ensure that the connection cables are not strained.
- Use only the original cables.
- When mounting the electronics boards, use only the bore holes indicated in this chapter. Other holes can not be used for fastening the boards or for any other purposes.
- When mounting the electronics boards with screws, ensure that a conductive path between the screws and the boards' electronic components is not created.

Caution!

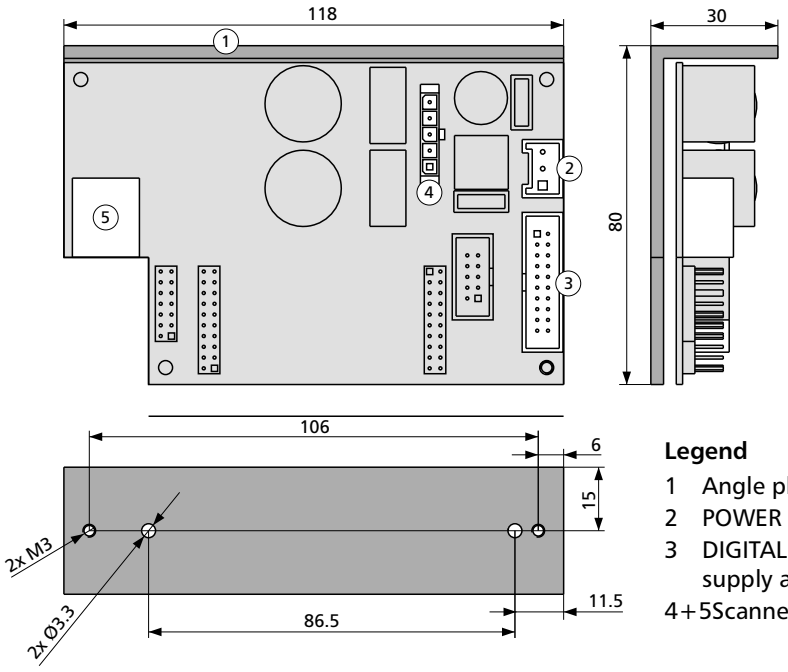
- To avoid damage or destruction caused by excessive heating of the electronics boards, it is important to attach the board's angle plate to a heat sink or an appropriate-sized part of a housing.

4.4.1 DSCB Digital Control Board

Figure 4 shows the dimensions of the DSCB digital control board with its connectors. The board is mounted on an angle plate.

For fastening the control board, the angle plate's side surface provides four bore holes. Two of the four holes are M3-threaded. All holes require M3-threaded screws. Ensure that no electrical contact exists between the screws and the board's electronic components.

To prevent damage or destruction of the board from excessive heat, it is important to attach the board's angle plate to a heat sink or an appropriate-sized part of a housing. The material and dimension of the heat sink must be chosen such that the temperature of the angle plate does not exceed 50 °C.



Legend

1 Angle plate
2 POWER IN connector for power supply
3 DIGITAL & POWER IN connector for power supply and data transfer
4+5 Scanner connectors

4

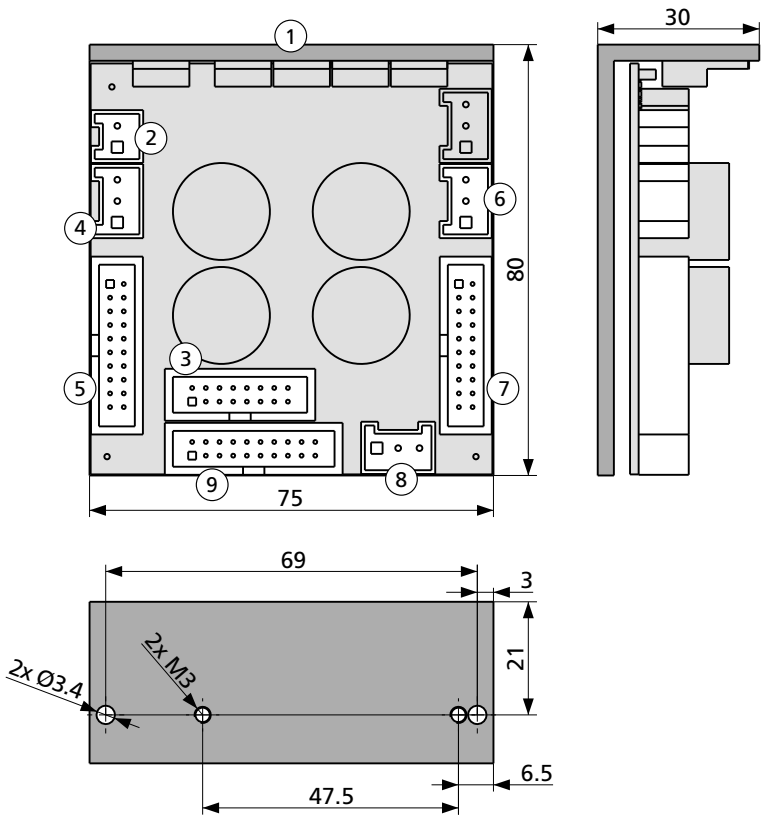
Dimensions of the DSCB digital control board (all dimensions in mm)

4.4.2 DSIB-Interface Board

Figure 5 shows the dimensions of the DSIB-board with its connectors. The board is mounted on an angle plate.

For fastening the board, the angle plate's side surface provides four bore holes (see figure 5). Two of the four holes are M3-threaded. All holes require M3-threaded screws. Ensure that no electrical contact exists between the screws and the board's electronic components.

The DSIB board must be mounted so that the included flat ribbon cables can be connected to the DSIB board and the DSCB digital servo board– see section "Internal Cabling" on page 22.



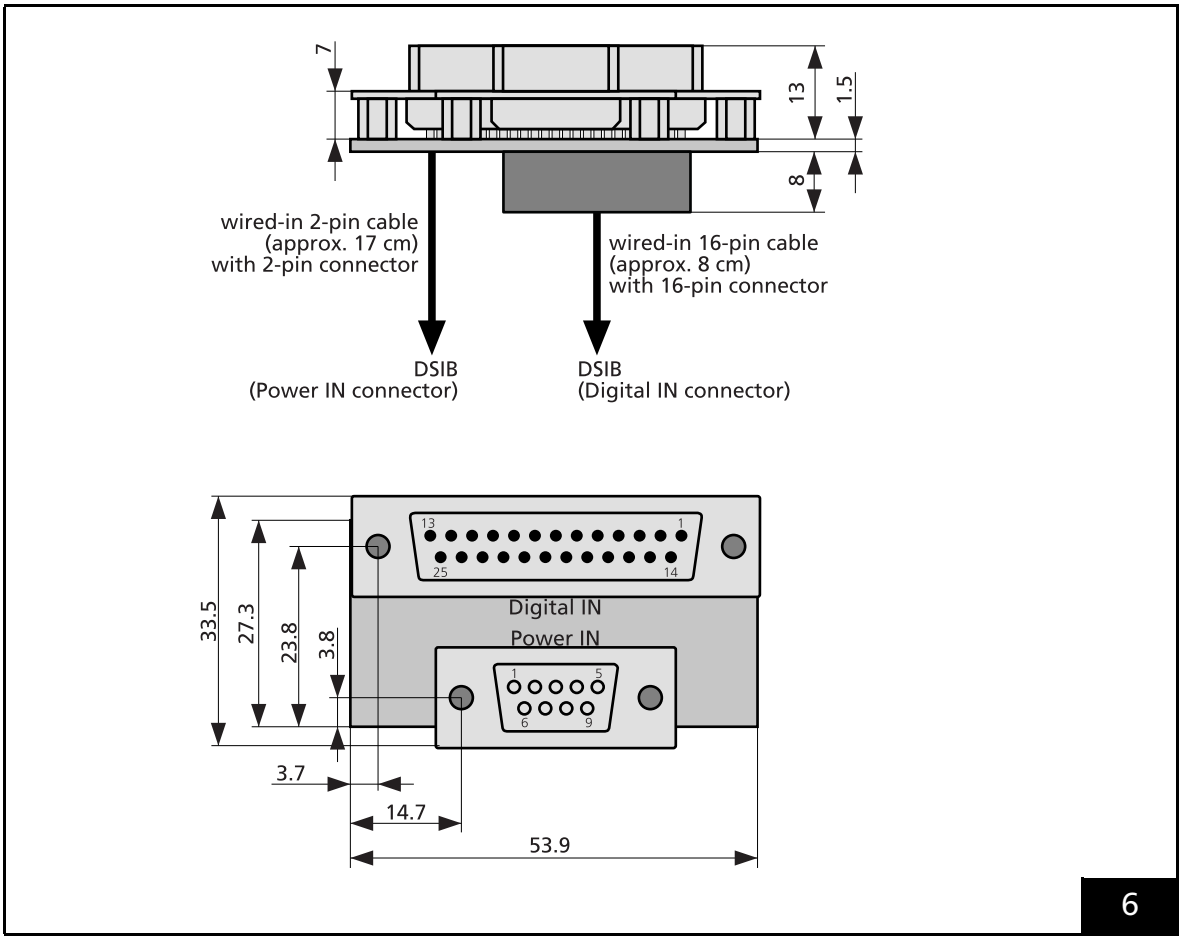
Legend

1 Angle plate
2 POWER IN connector for power supply (also see figure 7 on page 23)
3 DIGITAL IN connector for connecting to a PC controller (also see figure 9 on page 24)
4 POWER OUT connector for supplying power to the DSCB via its POWER IN connector
5 DIGITAL & POWER OUT connector for supplying power and data transfer to the DSCB via its DIGITAL & POWER IN connector
6 POWER OUT for a second DSCB
7 DIGITAL & POWER OUT for a second DSCB
8 Optional: POWER OUT for a third DSCB
9 Optional: DIGITAL & POWER OUT for a third DSCB

5

Dimensions of the DSIB interface board (all dimensions in mm)

DA20 Adapter Board.



Dimensions of the DA20 adapter board (all dimensions in mm)

4.5 Electrical Connection

Caution!

- Before starting to establish connections, ensure that the power supply and controller are switched off and that none of the connecting cables is powered. Electrically active cables can destroy the board's electronics upon connection.
- Always switch off the power source prior to removing a connected cable.
- Follow all power supply electrical specifications exactly.
- Before operating the unit, verify the polarities of the power supply connections.

4.5.1 Scanner Connection

The digital control board forms a closed servo loop in conjunction with the galvanometer scanner. Each digital control board is individually tuned by SCANLAB for its assigned scanner-mirror configuration. Do not interchange the control boards. Optimum scan quality cannot be guaranteed if control boards are interchanged. Therefore, if you received more than one control board, make sure the various electronic components are properly combined. To help achieve this, the angle plate of each control board is marked with the serial number of its assigned galvanometer scanner..

The scanner is equipped with a connection cable 265 mm (±20 mm) in length, including the connector.

- Attach the scanner's connectors to the corresponding connectors of the control board (see figure 4 on page 19).

4.5.2 Internal Cabling

- Connect the DSIB board's POWER OUT and DIGITAL & POWER OUT connectors via the included flat ribbon cable (ca. 0.3 m long) to the corresponding connectors of the DSCB (see figure 5 on page 20 and figure 4 on page 19).
- If a DA20 adapter board is included, connect the 2-pin connector of the DA20 board's wired-in 2-pin cable to the DSIB board's POWER IN connector and the 16-pin connector of the DA20 board's wired-in 16-pin cable to the DSIB board's DIGITAL IN connector.

4.5.3 Power Supply

Specifications

The scan module requires a power supply of (+30+3) V DC and a maximum current of 6 A. The residual ripple of the power source should not exceed 100 mV_{pp}.

The power supply is galvanically isolated from the XY2-100 interface. In addition the scan module provides reverse-polarity protection and start-up current limiting.

Moreover, the scan module's electronics monitors the supply voltages. If, during operation, the supply voltage falls below a minimum of approx. 25 V (e.g. due to excessively long or thin cables, a weak power supply or high loads), then the electronics disconnects the scan module from the power supply. If the supply voltage has returned (within a short time) to permissible levels, the scan module is restarted.

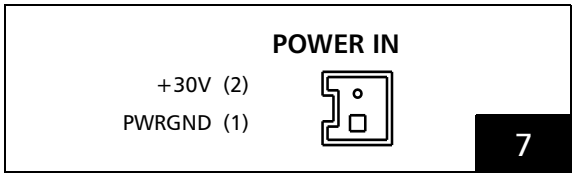
If the external supply voltage fails to return to permissible levels, the scan module will then remain disconnected from the power supply. The supply voltage problem must be resolved and the scan module switched off and then restarted.

Connection

Power input to the scan module is via the 2-pin POWER IN connector on the DSIB interface board (also see figure 4 on page 19). Figure 7 shows the pinout of this connector.

The 2-pin POWER IN connector must be mated to a connector housing (JST VHR-2N) and crimp contacts (e.g. JST SVH-41T-P1.1). Use a cable diameter of AWG20-16.

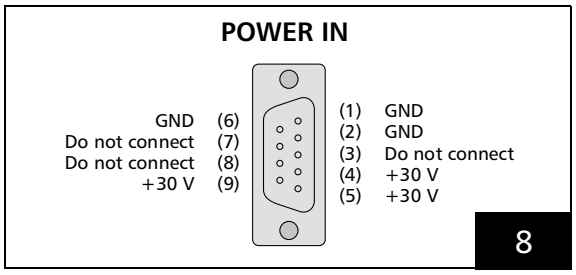
The DSCB receives its power from the DSIB – also see the section "Internal Cabling" on page 22.



Pinout of the DSIB board's POWER IN connector

A DA20 adapter board with a 9-pin D-SUB power supply connector is optionally available.

The adapter cable should be connected as described in section "Internal Cabling" on page 22. Then the scan module receives its power from the 9-pin male D-SUB connector. Figure 8 shows the pinout of this connector.



Pinout of the DA20 board's POWER IN D-SUB connector

Appropriate matching connectors for attaching the power supply are generally included. When connecting, observe the following tips:

- Make sure each power connection has the correct polarity.
- To avoid overloading the individual cables, all identically designated connections should be attached to the power source's corresponding polarity output.
- The cable connecting the power supply and the scan module must be shielded and should have a cross-sectional area of at least 1.5 mm^2 per pole and a length not exceeding 5 meters. RFI must be minimized by connecting the cable's shielding at one end (utilizing a large surface area) to the power supply's metal shielding and at the scan-module-end to the housing of the corresponding connector.

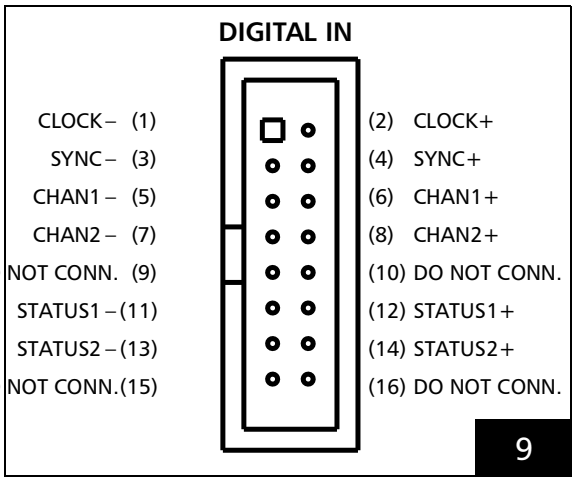
4.5.4 Data Transfer

Specifications

Digital data transfer is in accordance with the XY2-100 Enhanced protocol. A detailed description is provided in the section "Controlling the Scan Module" on page 6.

Connection

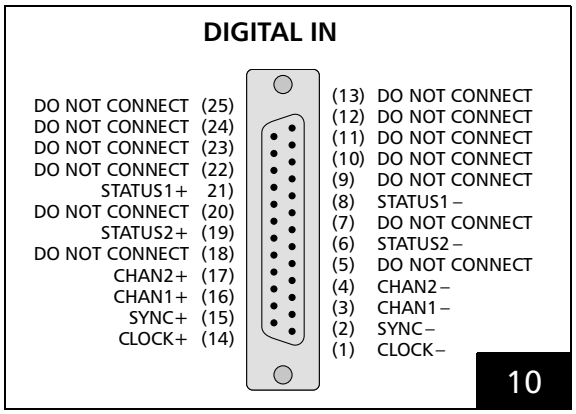
The digital signal lines should be attached to the corresponding pins of the DSIB's 16-pin DIGITAL IN connector (see figure 5 on page 20). Figure 9 shows the pinout of this connector.



Pinout of the DSIB board's DIGITAL IN connector

An optional DA20 adapter Board with a 25-pin D-SUB socket for data transfer is supplied.

The adapter cable should be attached as described in the section "Internal Cabling" on page 22. Data transfer is then via the 25-pin female D-SUB connector. Figure 10 shows the pinout of this connector.



Pinout of the DA20 board's DIGITAL IN connector

- Attach the control lines and power supply lines to the corresponding pins.

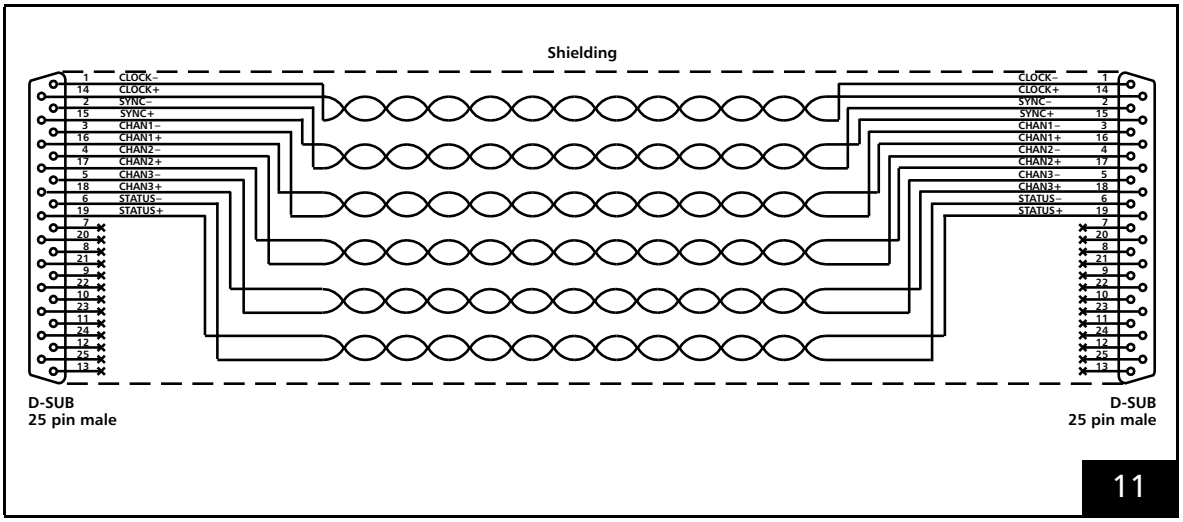
4.5.5 Data Cable Guidelines

The digital signals are transferred from the controller to the scan module via a data cable. Scan modules from SCANLAB are generally delivered without a data cable. If the data cable is not included in your package, SCANLAB recommends the following cable configuration. If both the power supply voltages and the data signals have to be connected to the same connector, SCANLAB recommends implementing a cabling solution that allows the use of separate cables for data and power. The data section of such a cabling solution should be designed as described below.

- The SCANLAB data cable has identical 25-pin D-SUB connectors on both ends. The data cable is made up of eight twisted cable pairs and connects the scan module to the controller via the channels SYNC±, CLOCK±, CHAN1±, CHAN2±, CHAN3±, STATUS1±, STATUS2± and STATUS3±. CHAN3 and STATUS3 are provided for optional control of the Z-axis.
  A description of these signals can be found in "Controlling the Scan Module" on page 6.
- The data cable must have coaxial copper braided shielding.
- The cable should not be longer than 10 m. If a longer data cable is needed, the signal timing of the RTC should be adjusted to ensure correct communication between the RTC and the scan module. For details, see the RTC command "set_p-iso_control" in the RTC manual. The cable length must not exceed 20 m.
- The D-SUB connectors must have fully shielded metal housings.
- The data cable's controller end must be fitted with a ferrit ring (e.g. Würth WE 742 711 32).
- The electrical connection of the cable's braided shielding to the D-SUB housing should not be implemented as a wire. Instead, the cable's braided shielding should be *coaxially* connected to the D-SUB housing via shielded clamps.

Figure 11 shows the data cable layout and pin assignments.

- Connect the scan module via the data cable to the customer-specific controller.
- If an RTC board is used as the controller, then follow the installation instructions in the RTC manual.



Data cable layout and pin assignments

4.6 Operating and Storage Conditions

For storage, operation and servicing, make sure the following environmental conditions are met:

- The storage temperature for the scan module should be between −35 °C and +60 °C.
- The operating temperature is 25 °C 10 °C.
- Protect the scan module from humidity, dust and corrosive vapors to avoid damage to the mirrors, optics and electronics.
- Avoid strong electromagnetic fields and static electricity. These can damage the electronics boards.

5 Start-up and Operation

5.1 Checking the Installation

Before operating the scan module, carefully check the following:

- Were the mechanical installation and electrical wiring fully and correctly carried out as described in chapter 4, "Installation"?
- Is the scan module equipped with an appropriate mirror? Compare the technical specifications in chapter 8 with the requirements of your application.
- Is the mirror clean and free of dust? If necessary, clean the mirror as described in "Routine Maintenance of the Mirror" on page 31.

5.2 Checking the Laser Parameters

The scan module's deflection mirror is designed for a laser beam with defined parameters.

- Compare the technical specifications on page 34 with the requirements of your application. For information on tolerances and deviations, please contact SCANLAB.
- The coatings of the deflection mirror is designed for a defined wavelength or wavelength range. If the wavelength of the employed laser deviates from the specified value, the mirror will not work properly and can be destroyed.
- A maximum laser power density is defined for the mirror coating. If the power density applied to the mirrors exceeds its specified maximum power density, destruction of the coating might result.
- The coating is only intended for a specific angle of incidence range. The laser beam will be more weakly or not at all reflected outside the specified angle range.
- The deflection mirror is designed for a specific beam diameter and scan angle range. Excessive beam diameters or deflection angles can result in vignetting of the beam. The beam is then no longer fully deflected by the mirror. The consequence is a loss of laser power. Moreover, there is a risk of damage to the scan mirror or equipment (also see "Adjustment and Usable Angle Range" on page 10). The amount of possible power loss depends, among other things, on the beam profile of the employed laser.

The user has to ensure that the parameters of the entering laser beam (wavelength, power density, diameter and angle of incidence) match the specifications of the scan module.

Caution!

- Make sure the aperture and the coating of the deflection mirror meet the requirements of your application (see chapter "Technical Specifications Single Axis Module", on page 34). For information on tolerances and deviations, please contact SCANLAB.
- Check if the wavelength of the input beam and the maximum ratings for beam diameter and laser power match the specifications of the scan module (see page 34).
- Excessive deflection angles or beam diameters can produce vignetting at the mirror. This can result in health risks and damage to the mirror and equipment. If your application requires larger scan angles, then please contact SCANLAB.

5.3 Adjusting the Laser Beam

Danger!

- Do not stare directly into the laser beam or at any of its deflected radiation. Keep all parts of the body away from direct contact with the laser beam or any of its deflected radiation.
- Adjust the output beam path of the scan module by means of a laser with a laser class not higher than 2. If this is not possible, the laser should be operated at the lowest power. Avoid dangerous deflected radiation!

Follow the adjustment guidance given in chapter "Adjustment and Usable Angle Range", on page 10.

5.4 Checking the Parameters of Application Software

Before you start a laser application, you must carefully check your application software with regard to the maximum allowed scan angle range (see section "Range of Controllable Deflection Angles" on page 9 and chapter "Adjustment and Usable Angle Range", on page 10).

If the maximum allowable range of angles is exceeded, some vignetting at the scan mirror can occur and damage to the scan module might result

If your application requires larger scan angles, then contact SCANLAB for guidance.

5.5 Safe Start-up and Shutdown Sequences

To assure safety during start-up, proceed exactly as follows:

(1) Turn on the controlling PC and start up the control software.

(2) Turn on the power supply for the scan module.

(3) Turn on the laser.

When shutting down the system, turn off the components exactly in reverse order.

Caution!

- Before first-time operation, check the polarities of the power supply connections for the scan module.

Danger!

- Always turn on the control (PC) and the power supply for the scan module prior to turning on the laser. Otherwise the laser beam might be deflected in an arbitrary direction.
- Power for the scan module must be applied only when the control (PC) is active.

5.6 Assuring Safe Operating Temperatures

If the scanner is driven for long periods of time at high positioning speeds or if the application includes a high rate of vector changes, the correspondingly high current consumption of the galvanometer scanner can lead to excessive temperatures – especially in the case of insufficient cooling, for instance due to a weak thermal link to the machine.

To prevent damage to the scanner, the scan module provides a two-stage temperature control mechanism.

Caution!

- The user must ensure that the application program evaluates the temperature control signals correctly, as described below.

Stage 1: Temperature Status Warning

The temperature status signal TempOK indicates that the scanner is operating at a safe temperature level. During normal operation, the signal is 1.
If the scanner temperature rises above a certain value or drops below a minimum value, then the TempOK signal switches to 0. If the TEMPOK signal switches to 0 during operation, system operation should be stopped and the system should be checked to determine the cause. If system operation is not stopped, large drift or other side-effects may occur.

Stage 2: Critical Temperature Shutdown

In addition to the temperature status warning, the following scanner protective function is implemented:

If the scanner's temperature rises above the critical value for temperature status warning and reaches a second, still higher critical value, then the scanner's output stage is turned off to prevent damage to the scanner. In this situation, the scanner's position is stationary and no longer under programmatic control.

If the scanner's temperature drops again below the power-down threshold, the scanner's drive stage is automatically restarted and the scan module will resume normal operation.

5.7 Monitoring the Scan Range

The scan module has a built-in monitoring function to prevent damage to its galvanometer scanner or electronics when a problem occurs.

If the galvanometer scanner's scan angle exceeds the allowed range due to an operational disturbance, its output stage will be shut down. In such situations, the galvanometer scanner can no longer be controlled.

Danger!

- If an output stage is shut down due to a scan range overrun, **laser power must be switched off immediately.** Otherwise, health hazards and severe equipment damage can occur due to uncontrolled laser radiation.

5.8 Monitoring Functions

When the scan module is operated via an RTC4 or RTC5 PC Interface Board, then a number of different data signals can be evaluated for monitoring or test purposes.

For applications with critical accuracy requirements, the actual galvo scanner value can be monitored during the entire runtime of an application.

Alternatively, other data signals (e.g. scanner temperature) can be analyzed during normal operation or even when testing user applications.

Malfunctions can be quickly detected if you regularly query (and store) the scan module's operational states before, after or during operations. Furthermore, determination of a malfunction's cause is simplified considerably.

6 Routine Maintenance and Customer Service

6.1 Routine Maintenance of the Mirror

A dirty mirror increases the absorption of laser power by its optical surface. Dirt, dust and other contaminants can distort the laser beam, burn into the surface and damage the mirror. The warranty does not cover any damage due to improper use, cleaning or handling. Regularly inspect the scan module's mirror for dirt, dust and other contaminants in accordance with the procedures described below.

Deflection mirrors are especially sensitive components and should not be touched or removed from the galvanometer scanner. The mirror must be inspected and cleaned in-place. Make sure the mirror is at room temperature before manually rotating or cleaning them.

With the laser and power supply switched off, you can manually rotate each mirror to a position convenient for inspection and cleaning. To manually rotate a mirror, carefully hold the mirror by its edges with clean disposable gloves or finger cots and turn it to the desired position.

Danger!

- Switch off the laser and switch off the power supply prior to performing routine optics maintenance.

If dust or dirt particles are found on the mirror's surface, remove the particles by blowing with a rubber squeeze bulb or a source of clean compressed air.

If the mirror is still not clean, then use solvent and lens cleaning tissues and employ one of the two following cleaning methods:

Cleaning Notes

- Avoid skin contact with the optical surface.
- Use only clean lint-free tissues specially manufactured for cleaning optics (e.g. "Kodak lens cleaning paper"). Always use lens tissues with a solvent, because dry tissue can scratch optical surfaces.
- Use a solvent such as acetone or isopropanol of high purity (evaporation residue < 0.001%). Read and follow the safety advice and warnings for the solvents you will be using.
- Use clean powder-free gloves or finger cots that are impermeable to the organic cleaning solvents you will be using.
- Always wipe slowly but steadily and with slight pressure! Do not rub back and forth.

Method A

(1) Place a clean piece of unfolded lens cleaning tissue over the mirror. Do not touch any part of the tissue that will touch the mirror.

(2) Drop some solvent onto part of the tissue from above. Don't use too much solvent, because otherwise drying marks might appear.

(3) Slowly and gently drag the dampened part of the tissue across the mirror's optical surface. Do not rub back and forth!

Method B

(1) Create a lens-tissue brush by folding a clean lens tissue so that the fold is about as wide as the mirror.

(2) Dampen the lens-tissue brush with solvent. Don't use too much solvent, because otherwise drying marks might appear.

(3) Carefully grip one end of the dampened lens-tissue brush without touching any part of the tissue that will touch the mirror. Place the lens-tissue brush at one edge of the mirror, then wipe gently across the optical surface. Do not press hard or rub back and forth!

Repeat method A or method B until the mirror's optical surface is completely clean. For every cleaning swipe, use a new lens cleaning tissue.

If the dirt cannot be removed in this manner, then contact SCANLAB for guidance. In extreme cases, the complete scan module must be returned to SCANLAB for inspection and cleaning of the mirrors. However, in some situations SCANLAB might be able to recommend a user-performed special cleaning procedure.

6.2 Customer Service

Servicing and Repairs

Except for routine maintenance of the mirror surface, the scan module does not contain user-serviceable parts. All servicing and repairs should be performed only at SCANLAB. Only SCANLAB has the proper test facilities and procedures to service, repair and calibrate the system optimally.

If repairs are needed, always ship the complete scan module (galvanometer scanner, mirror and electronics boards), so that SCANLAB can recalibrate the components.

Product Warranty

SCANLAB guarantees this product to be free of defects in manufacturing and material. The warranty is valid for 12 months after delivery. Repairs covered under the warranty will be performed at SCANLAB.

The scope of the warranty is limited to repair or replacement of the SCANLAB product.

SCANLAB is responsible for the return delivery of products repaired under warranty; the customer is responsible for delivery to SCANLAB.

SCANLAB will not be held responsible:

- when the product has been damaged through misuse or improper operation
- for damage due to improper laser power (e.g. focused beam on optical surfaces) or improper adjustment
- for damage to the mirror caused by improper handling or cleaning
- for consequential damages
- if the galvanometer scanner, the mirror or the electronics boards have been altered

If a returned scan module must first be brought into a serviceable state by SCANLAB (e.g. by cleaning the scan module) before servicing can begin, then the customer must bear the additional cost.

Contacting SCANLAB

For service, repairs, advice or information, simply contact SCANLAB using one of the contact possibilities listed below:

SCANLAB GmbH
Siemensstr. 2a
82178 Puchheim
Germany

Tel. +49 (89) 800 746-0
Fax: +49 (89) 800 746-199

info@scanlab.de
www.scanlab.de

Product Disposal

The scan module can be returned to SCANLAB for a fee to be properly disposed of in compliance with environmental regulations.

7 Troubleshooting

If problems occur while operating this device, verify that all operating instructions have been adhered to and then carry out the following troubleshooting procedures:

Problem	Possible Cause	Remedy
Low laser power	Altered controller software parameters	Check input parameters
	Dirty or damaged mirror	Check mirrors. If necessary, clean as described in section 6.1. If the mirror is damaged return scan module for repair.
Changed laser spot	Dirty or damaged mirror	Check mirrors. If necessary, clean as described in section 6.1. If the mirror is damaged return scan module for repair.
	Laser out of adjustment	Adjust laser
No laser beam	Problem with the laser	Check laser and electrical connections
	Problem with the laser controller	If the RTC board is used, check all electrical connections and the power supply
	Laser beam path blocked or shutter closed	Check laser beam path
The scan module does not steer the laser beam	Problem with the controller	Check power and data cables. Check software commands. Switch off scan module, and then restart.
The scan module stopped responding	The scan module's electronics have disconnected the scan module from the power supply due to impermissible supply voltages (see page 23)	Ensure correct supply voltages, switch off scan module, and then restart

If the problems persist, please send the scan module to customer service.

8 Technical Specifications Single Axis Module

(all angle specifications optical if not explicitly specified else)

Aperture

Recommended beam diameter	30 mm

Control

Input and output signals	XY2-100 Enhanced
Maximum range for control values (input signals)	0 to 65535 (1)
Calibration	±0.408 rad with (32768 ±31457) Bit (Tolerance: ±5 mrad)

Power supply

Requirements	(30+3) V DC, max. 6 A each pole

Optical Performance

Nonlinearity	< 3.5 mrad / 44°
Repeatability (RMS)	< 2 µrad
Long-term drift over 8 hours (after warm-up)	< 0.6 mrad

Dynamic Performance

Typical positioning speed	45 rad/s
Tracking error	< 0.60 ms
1% Step response time (7.5 mrad step, settling to 0.75 mrad)	< 1.30 ms

Mirror

mechanical mirror stop	at ±20(±1)° mech.
Coating	dielectrical high performance coating
Working wavelength	1080 nm
Reflectivity	
– Angle of incidence range	
Mirror 1	30° - 55° mech.
Mirror 2	25° - 52° mech.
– at 1080 nm	more than 99.5%
– at 633 nm	more than 50%
Maximum laser power	2000 W
Maximum laser power density continuous wave	1000 W/cm^2
Damage threshold for pulsed operation (with specified working wavelength, pulse length 10 ns, 200 on 1)	5 J/cm^2

Weight

Galvanometer scanner	approx. 430 g
DSCB digital control board	approx. 300 g
DSIB interface board	approx. 160 g

Operating and Storage Conditions

Operating temperature	25 °C ± 10 °C
Storage temperature	−35 °C to +60 °C
Environmental conditions	non-condensing, non-corrosive

(1) The usable control value range may be restricted, see section "Adjustment and Usable Angle Range" on page 10.