Firefly3D Scan Head

User Manual

Read carefully before using.
Retain for future reference.

Novanta

Manufacturer

Novanta Corporation
125 Middlesex Turnpike
Bedford, MA 01730, USA
Phone: +1-781-266-5700

Email: Photonics@Novanta.com

Customer service

Before contacting us for assistance, please review appropriate sections in this manual that may answer your questions. After consulting the manual, please submit a request through our website: https://novantaphotonics.com/technical-support-request-form-header/

Americas, Asia Pacific

Novanta Headquarters
Bedford, USA
Phone: +1-781-266-5700

Email: Photonics@Novanta.com

China

Novanta Sales & Service Office

Shenzhen, China
Phone: +86-755-8280-5395

Suzhou, China
Phone: +86-512-6283-7080

Email: Photonics.China@Novanta.com

Europe, Middle East, Africa

Novanta Europe GmbH
Wackersdorf, Germany
Phone: +49-9431-7984-0

Milan, Italy
Phone: +39-039-793-710

Email: Photonics@Novanta.com

Japan

Novanta Service & Sales Office

Tokyo, Japan
Phone: +81-3-5753-2460

Email: Photonics.Japan@Novanta.com

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1 HOW TO USE THIS DOCUMENT

1.1 SYMBOLS AND SIGNAL WORDS

This manual uses the following symbols and signal words for information of importance.

DANGER

Indicates a hazardous situation which, if not avoided, will result in serious injury or death.

WARNING

Indicates a hazardous situation which, if not avoided, could result in serious injury or death.

CAUTION

Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

IMPORTANT

Indicates information considered important but not directly hazard related (e.g., security, hygiene, equipment, or property damage).

Procedure

Indicates a call to action. One or more steps to be executed are following this signal word. An exception has been made for warning notices, where this signal word has been omitted.

1.2 NOTATION CONVENTIONS

This manual uses the following notation conventions that are given in the following table.

Notation conventions

Notation	Meaning
Underlined	click-able cross reference or hyperlink
[⟨Number⟩]	cross reference to a list of further reading on page 128
Bold	element in the graphical user interface that the user shall click
Italic	name of element in the graphical user interface or emphasized text
`Typewriter`	text to be typed in by the user, filename, or path

1.3 STORAGE AND REPLACEMENT

- Keep this manual with the product to access it at any time during the product's lifetime.
- A replacement for this manual can be requested. The manual is available as a PDF-file.
- This manual is part of the product. If the product ownership changes, then this manual must accompany the product.

1.4 SPECIFICS AND STRUCTURE

Novanta reserves the right to update this manual at any time without prior notification.

This manual is limited to installation and commissioning instructions, troubleshooting and maintenance.

- Be mindful of the environment, do not print if you do not need to.

1.5 TARGET AUDIENCE AND QUALIFICATION

IMPORTANT

Only target audience, who are listed in the beginning of each instructing section in the following chapters, may perform the activities described there.

The people who perform these activities need to be of age.

The qualification of the target audience is defined below.

Laymen

without special qualification, who e.g., transport and store the boxed product.

Operators

who are trained by the company that is operating the laser unit, where the product is incorporated, in the use of that laser unit and who confirmed the training by signature.

Experts

in electrical engineering or mechatronics, who are successfully trained in handling highly sensitive electronic and optical equipment. Experts must be trained by the company that is operating the laser unit, where the product is incorporated, in the use of that laser unit, and must confirm this training by signature.

2 GENERAL SAFETY INSTRUCTIONS

2.1 INTENDED USE

- The scan head is delivered as an OEM component for integration into a laser unit that will be operated in a dry and clean indoor environment without electrically conductive contamination.
- Customers must know and apply the rules and regulations for safe operation of lasers when installing and operating the scan head and the laser unit in which it is used. Since Novanta has no influence over the employed laser device or the overall laser unit, the customer is solely responsible for the safe operation of the laser unit. The laser unit manufacturer bears responsibility for complying with the standards and guidelines required for the CE (European Conformity) label. Please contact Novanta for further information about this scan head and applicable guidelines.
- Before installing and operating the scan head, carefully read this manual for your protection.
- Retain this manual for future reference.

2.2 REASONABLY FORESEEABLE MISUSE

It is considered a misuse if you use the scan head without incorporating it into a laser unit that complies with the standards required for the CE (European Conformity) label.

2.3 DUTY OF CARE BY THE CUSTOMER

IMPORTANT

- Customers assume full responsibility for maintaining a laser-safe working environment. Original equipment manufacturer (OEM) customers assume full responsibility for CDRH (Center for Devices and Radiological Health) certification.

2.4 HAZARDS

2.4.1 LASER RADIATION

The scan head is intended for use in combination with a class 4 laser.

WARNING

Visible or invisible laser radiation can cause severe retinal and corneal burns, burns to the skin, and may pose a fire risk.

- To avoid injury and reduce risk of fire, follow the control measures and safety guidelines provided by the laser's manufacturer, and those established by your Laser Safety Officer (LSO), Radiation Safety Officer (RSO), or safety department of your business or institution.
- The integrator must take appropriate protective measures to reduce the risks of exposure to laser radiation.
- The integrator must take appropriate protective measures to reduce fire and explosion hazards of laser processed materials.

2.4.2 LASER GENERATED AIR CONTAMINANTS

During laser material processing, matter is evaporated. Laser generated air contaminants can compose of multitude hazardous products, such as nickel, chrome, alumina, zinc, butanol,

toluol, xylene, and formaldehyde. The concentration, size, and the quantity of these aerosols and particles can vary.

⚠ WARNING

Laser generated air contaminants, even if respired in lowest concentrations over long time or brought to skin contact, can cause skin irritations, contact eczema, sickness, vomiting, cauterization of the respiratory tract, nervous diseases, allergic reactions, spasms, and cancer.

- To avoid injury, follow the control measures and safety guidelines provided by the respective material safety datasheet, and those established by your Laser Safety Officer (LSO), Radiation Safety Officer (RSO), or safety department of your business or institution.
- The integrator must take appropriate protective measures to reduce risks of exposure to dust and fumes from laser processing.

2.4.3 BERYLLIUM MIRRORS

The scan head contains beryllium mirrors. Under normal circumstances, i.e., if the housing and protective windows and the beryllium mirrors are undamaged and if the product is handled and used properly then the beryllium mirrors present no danger. Danger may only arise if the beryllium mirrors are damaged and the housing is not sealed according to degree of protection IP65, as the damage may have produced small quantities of beryllium dust that may not be visible.

⚠ WARNING

Beryllium is classified as carcinogenic substance of category 1B and hazard class STOT RE1. This applies especially to beryllium as dust or vapor, i.e., if the beryllium mirrors are damaged. Beryllium causes eczema, berylliosis and cancer when getting in contact with skin or inhaled.

- DO NOT open the scan head. DO NOT remove the protective windows.
- If the housing is not sealed according to degree of protection IP65 AND if the beryllium mirrors are damaged, then immediately follow the response procedure in section 8.2 on page 127.

2.4.4 HOT LASER-PROCESSED MATERIAL

During materials processing with lasers, strong heating of the processed material may arise.

⚠ CAUTION

Hot laser-processed material can cause skin burns.

- If you are a system integrator, then place a sign at the laser processing area that warns about hot surfaces.
- When handling material by hand that was laser-processed shortly before then wear heat resistant protective gloves.

2.4.5 COOLANT AND COOLANT ADDITIVES

The scan head has a cooling loop and may use a special coolant or coolant additives, like calcination inhibitors, algae inhibitors, anti-corrosion, and anti-freeze agents.

⚠ CAUTION

Coolant or coolant additives might give rise, amongst other things, to allergies, eczema, and other irritations if they get in contact with the skin or mucous membranes.

- To avoid injury, follow the control measures and safety guidelines provided by the respective material safety datasheet, and those established by your Laser Safety Officer (LSO), Radiation Safety Officer (RSO), or safety department of your business or institution.

2.4.6 ELECTROSTATIC DISCHARGE

The scan head contains parts that are sensitive to electrostatic discharge.

IMPORTANT

Electrostatic discharge (ESD) can damage the scan head which is an electrostatic discharge-sensitive device.

- Transport equipment only in anti-static packaging and packaging equivalent to that received with the shipment.
- Keep the scan head sealed until within an ESD-controlled environment.

A proper static control station should include:

- ☐ A soft grounded conductive tabletop or grounded conductive mat on the tabletop
- ☐ A grounded wrist strap with the appropriate (1 MΩ) series resistor connected to the tabletop mat and ground
- ☐ An adequate earth ground connection, such as an uncoated water pipe or AC ground
- ☐ Conductive bags, trays, totes, racks, or other storage
- ☐ Properly grounded power tools
- ☐ Personnel handling ESD items must wear ESD protective garments and ground straps

2.5 MODIFICATIONS AND SPARE PARTS

Modifications to the scan head are not permitted. This includes but is not limited to water connectors.

Spare parts specified, supplied, or approved by Novanta are only permitted for use with this scan head.

2.6 FIRE EXTINGUISHER RECOMMENDATION

Procedure

- A carbon dioxide (CO_2) fire extinguisher must be used.
- Ensure the fire extinguisher used is compatible with the entire laser unit.
- Prior to installing the scan head, ensure the fire extinguisher is available and observe its instructions for use including its hazard notes.

3 OVERVIEW

Firefly3D is a specialist scanning module designed with the additive manufacturing market in mind but can be deployed into other application domains equally effectively.
The system incorporates measurement and synchronization capabilities that ensure additive manufacturing users can attain superior levels of process monitoring easily. In addition, Firefly3D and its complimentary controller, ScanMaster Controller, allow closed loop process control solutions to be developed with ease.

3.1 LABELS

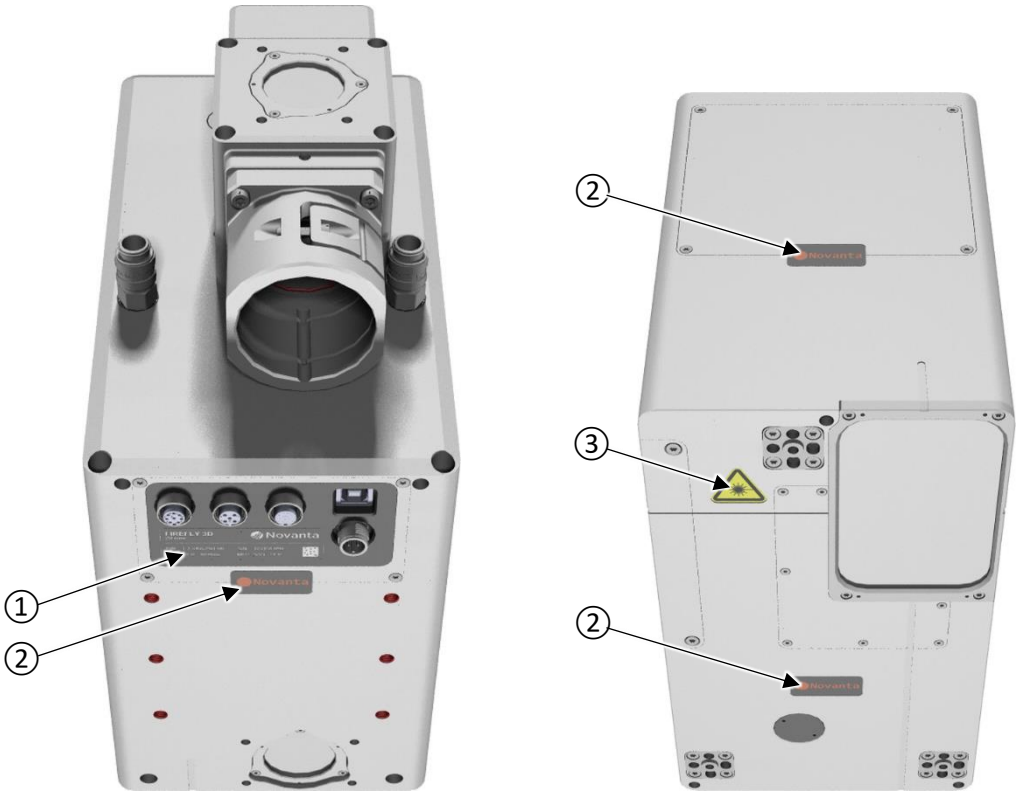


Figure 1: Position of labels

Legend to Figure 1

No.	Label	Description
1	FIREFLY 3D Novanta P/N: FF3D-SLM-GSB-D51-MR-04 S/N: 123456789	Type label
2	Novanta	Warranty label

No.	Label	Description
3		*Warning of laser beam* label

3.2 INTERFACES

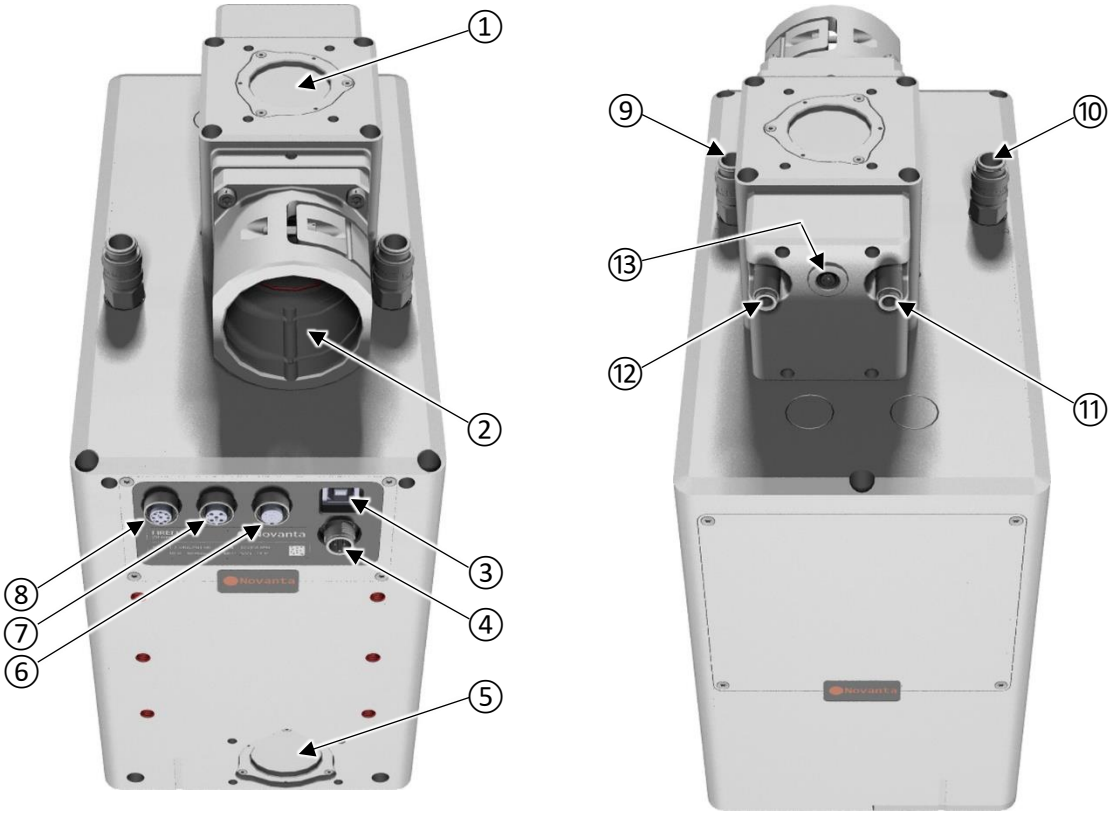


Figure 2: Position of interfaces

Legend to Figure 2

No.	Marking / function	See section	On page
1	Monitoring port (1200–2000 nm)	4.3.10	53

No.	Marking / function	See section	On page
2	D51 or D65 collimator clamp	4.3.1 and 4.3.7	24 and 39
3	– / programming and diagnostics	4.3.11	54
4	PWR / 48 V power supply (in) for the scan head	4.3.6	37
5	Monitoring port (450–950 nm)	4.3.10	53
6	COMM / GSBus communication with the controller	4.3.5	34
7	PMSI / process monitoring sensors interface	4.3.4	33
8	HSSO / high speed serial output	4.3.3	30
9	IN / cooling fluid to the scan head	4.3.2	28
10	OUT / cooling fluid from the scan head	4.3.2	28
11	– /cooling fluid to/from the thermopile/beam-dump box	4.3.2	28
12	– /cooling fluid from/to the thermopile/beam-dump box	4.3.2	28
13	Thermopile box with interface – OR – Beam dump box	4.3.9 –	52 –

3.3 CONTROLS AND INDICATORS

There are no controls or indicators on the scan head.

4 PREPARING FOR USE

This chapter describes all procedures necessary to get the scan head ready for use.

4.1 TRANSPORTING AND STORING

Target audience and qualification

Laymen, operators, and experts

Requirements

Table: Environmental

Characteristic	Specification
Conditions	Dry and clean indoor environment without electrically conductive contamination
Operating temperature	15–40 °C (288–313 K)
Storage temperature	0–60 °C (273–333 K)
Humidity	max. 80 % RH, non-condensing

Procedure

- Transport and store the scan head in its sealed original packaging or an equivalent packaging.

4.2 UNPACKING AND VERIFYING THE SCOPE OF DELIVERY

Target audience and qualification

Experts

Have ready

☐ Utility knife

Procedure

1. If any shock indicator is present and triggered, then block the delivery, and inform the sender.
2. While carefully unpacking the scan head, keep in mind that you want to retain the packaging for future use.

   In case it will become necessary to return the scan head for some reason later, we recommend documenting the unpacking e.g., by taking photographs.

IMPORTANT

Contamination can damage optics.

- Leave any protective covers in place for as long as possible to keep the optics clean.

3. Check with the delivery note whether all parts are present, in an evidently immaculate mechanical state and whether the serial numbers correspond. If one of these is untrue, then block the delivery and inform the sender.
4. Retain the original packaging for future use.

4.3 INSTALLING

This section summarizes procedures necessary to mount the scan head in the laser unit and to connect all supply lines.

4.3.1 INCORPORATING THE SCAN HEAD INTO THE LASER UNIT

Target audience and qualification

Experts

Have ready

- ☐ Machine bolts suitable for mounting the scan head in the laser unit; see Figure 3 on page 26.
- ☐ Suitable screwdriver, hexagon socket screw key set, Torx key set

Requirements

Table 1: Environmental

Characteristic	Specification
Conditions	Dry and clean indoor environment without electrically conductive contamination
Operating temperature	15–40 °C (288–313 K)
Storage temperature	0–60 °C (273–333 K)
Humidity	max. 80 % RH, non-condensing

Table 2: Physical

Characteristic	Specification
Enclosure IP rating	IP65
Max. dry weight	12 kg
Dimensions with D51 collimator clamp	See Figure 3 on page 26
Dimensions with D65 collimator clamp	See Figure 4 on page 27

Safety precautions

☐ Ensure fire extinguishing equipment is available and follow its instructions; see also section 2.6 on page 17.

☐ Switch off the laser unit, where the scan head is incorporated. Switch off the laser device, power supply, cooling and particularly disable moving parts.

Procedure

IMPORTANT

Contamination by burned protective covers can damage optics.

- Remove protective covers at the last possible moment during the installation procedure.

WARNING

Protective covers removed from unused monitoring ports can expose the user to laser radiation.

- If you do not want to use a monitoring port, then leave the respective protective cover in place.

  The high band monitoring port is located at the top of the laser interface adapter. The low band monitoring port is located at the side with the electrical interfaces.

- To mount the scan head on its place in the laser unit, use the 3-point mounting as indicated in Figure 3 on page 26.

Specifics of the interface

Turn the page, please.

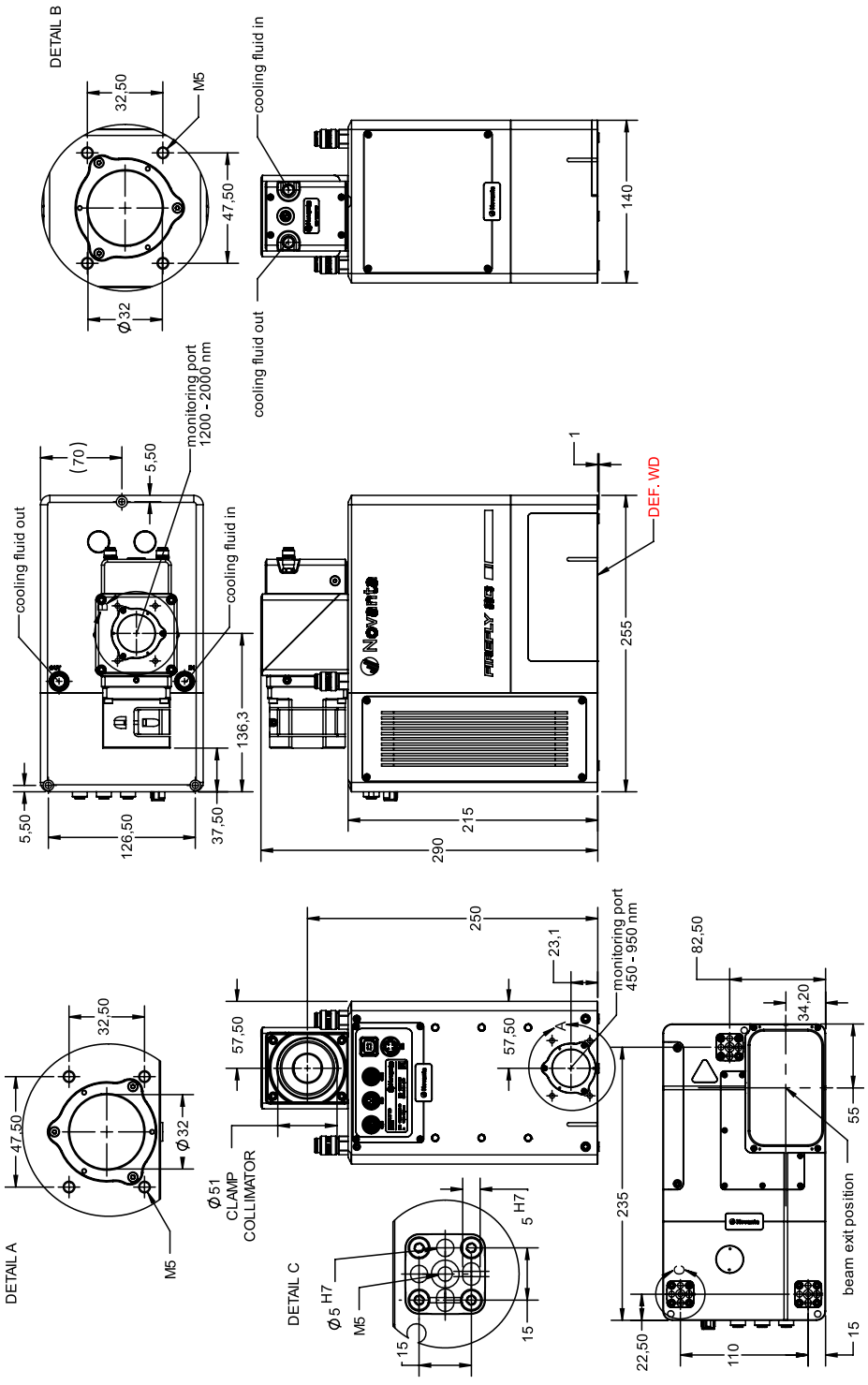


Figure 3: Dimensions in millimeter and mounting for D51 collimator clamp

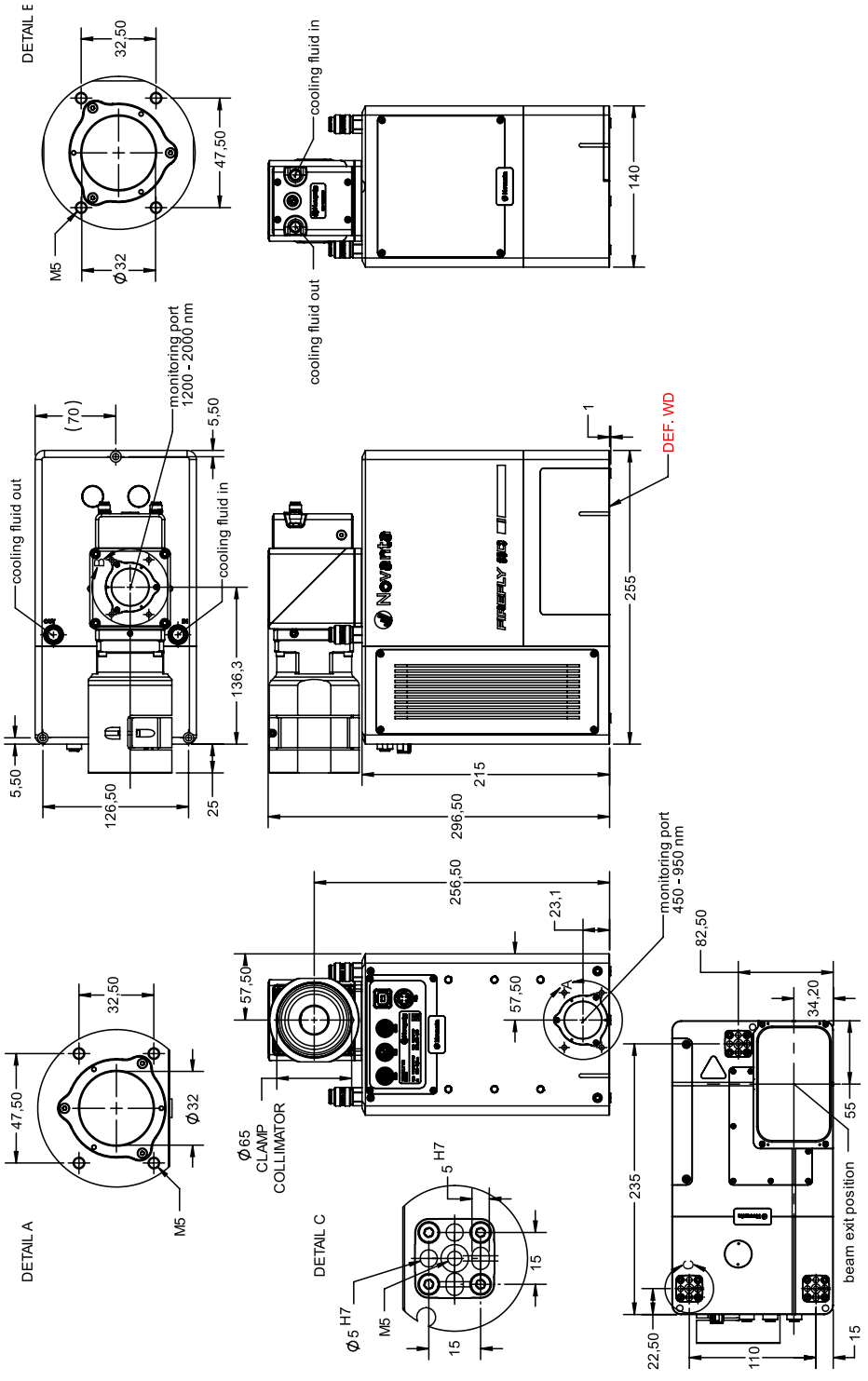


Figure 4: Dimensions in millimeter and mounting for D65 collimator clamp

4.3.2 CONNECTING THE COOLING

Target audience and qualification

Experts

Have ready

- ☐ Cooling connector at the scan head:
  mating connector: manufacturer Rectus/Parker; part number 21SBK006RVX
- ☐ Cooling connector at the laser interface adapter:
  mating connector: manufacturer Rectus/Parker; part number 20SBK006RVX
- ☐ Recommended hose:
  manufacturer Parker/Legris; part number 1025U06R08
- ☐ Utility knife to cut hoses in length
- ☐ Tissues to wipe of small amounts of coolant

Requirements

Table 3: Cooling

Characteristic	Specification
Coolant (minimum)	Filtered (max. 100 µm particle size) DI-water
Coolant (recommended)	Filtered (max. 100 µm particle size) DI-water with additive ***COOL****FLUX 42* – OR – Filtered (max. 100 µm particle size) distilled water mixed with *Coolflow DTX* (28 % concentration) – OR – 90 % of filtered (max. 100 µm particle size) distilled water with 10 % of *OptiShield Plus* or similar rust inhibitor

Characteristic	Specification
Inlet temperature (recommended) [1]	18–20 °C (291–293 K)
Inlet pressure	3–4 bar (3000–4000 hPa)
Volume flow	1.2–2.2 l/min
Conductivity	35–45 µS
Humidity	max. 80 % RH, non-condensing

Procedure

1. Note the flow direction; see Figure 5 on page 30.
2. Mount the mating connectors to the hose tips of the coolant supply and return lines.
3. Insert the mating connectors into the connectors at the scan head until they click into place.

IMPORTANT

Leaking coolant can cause a short circuit and/or damage optics.

4. Check for leakage by opening the return line first and then carefully turning on the cooling water supply line and watching the connections.
5. If coolant is leaking immediately turn off the supply line, disconnect the leaking connection, wipe away any leaked coolant, correct the fault and redo the connection.

   – OR –

   If coolant is not leaking, then let it flow until the scan head is filled with water.

6. Turn off the coolant supply line first and then the return line.

[1] If operational temperatures outside the range given are required, please consult with your Novanta representative to determine whether this might be possible.

Later during commissioning, you will turn on the cooling again.

Specifics of the interface

Marked: IN, OUT, or not marked, if the flow direction is irrelevant

Connector: at the scan head manufacturer Rectus; part number 21KBAW10RVX
at the laser interface adapter: manufacturer Rectus; part number 20KBAM05RVX

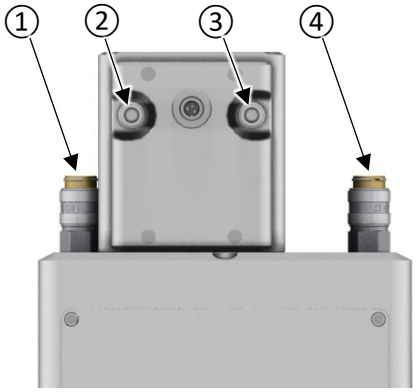


Figure 5: Position of the coolant supply and return connectors

Legend to Figure 5

No.	Labeling / function
1	IN / cooling fluid to the scan head
2	– /cooling fluid from/to the thermopile/beam-dump box
3	– /cooling fluid to/from the thermopile/beam-dump box
4	OUT / cooling fluid from the scan head

4.3.3 CONNECTING THE HIGH-SPEED SERIAL OUTPUT

The HSSO port emits a high-speed serial digital data stream comprising synchronized scanning and process data.

This interface can be used for scan job monitoring and real-time process control.

The protocol used is based on the LVDS protocol, with a data rate of 48 MHz. Data available within this protocol includes:

- ☐ X, Y, Z commanded position coordinates
- ☐ X, Y, Z actual raw galvo position (uncorrected)
- ☐ Measured analog input voltages (0–10 V DC); channels A and B (up to 200 kHz acquisition rate)
- ☐ X, Y, Z user defined probe data

Target audience and qualification

Experts

Have ready

- ☐ Interconnecting cable by PHOENIX CONTACT

  Length 1 m; male – male; part number 1407434 – OR –
  Length 2 m; male – male; part number 1407435 – OR –
  Length 5 m; male – male; part number 1407436 – OR –
  Length 5 m; male – unterminated; part number 1408743 – OR –
  Length 10 m; male – unterminated; part number 1408744

Procedure

IMPORTANT

"Hot" connection/disconnection of any power or data source is not advised and can result in damage to the product.

- Connect the high-speed serial output according to the following information and only when the power is off.

Specifics of the interface

Marked: HSSO
Connector: manufacturer PHOENIX CONTACT; part number 1437009

Table 4: Pin assignment of the HSSO connector

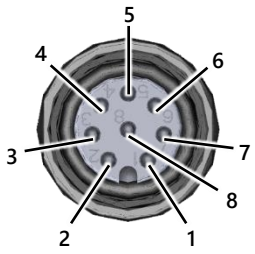
	Pin	Description	Voltage level
	5	SPI_CLK+	LVDS
	8	SPI_CLK-	LVDS
	1	SPI_SYNC+	LVDS
	7	SPI_SYNC-	LVDS
	6	SPI_DATA+	LVDS
	4	SPI_DATA-	LVDS
	2	Reserved	–
	3	Reserved	–

Table 5: HSSO frame format

Protocol ID	Reserved
Process ID	24-Bit binary representation of specific elements of job data – user defined and injected via SMC
X command (ideal)	Scan job X-coordinate (pre correction table)
X position (actual)	Actual raw X-galvo position
Y command (ideal)	Scan job Y-coordinate (pre correction table)
Y position (actual)	Actual raw Y-galvo position
ADC channel A (1st sample)	20-Bit analog sensor reading – 1st time slice
ADC channel A (2nd sample)	20-Bit analog sensor reading – 2nd time slice
X probe	User defined Lightning™ II probe monitoring X axis

Y probe	User defined Lightning™ II probe monitoring Y axis
Z command (ideal)	Scan job Z-coordinate (pre correction table)
ADC channel B (1st sample)	20-Bit analog sensor reading – 1st time slice
ADC channel B (2nd sample)	20-Bit analog sensor reading – 2nd time slice
Z position (actual)	Actual raw Z-galvo position
Z probe	User defined Lightning™ II probe monitoring Z axis
CRC 32	Error check

4.3.4 CONNECTING PROCESS MONITORING SENSORS

The scan head offers 2 analog input channels which can be connected to any sensor or signal conditioning module that supports a 0–10 V DC single ended output. The addition of process monitoring sensors allows the user to directly inject measurement data into the HSSO data stream (see section 4.3.3 on page 30), and make measurement data available via GSBus to ScanMaster Controller for use in monitoring and control schemes.

Target audience and qualification

Experts

Have ready

- ☐ Interconnecting connector by PHOENIX CONTACT for cables of 4–8 mm in outer diameter
- ☐ Straight male connector; part number 1424662 – OR –
  Angled male connector; part number 1424663 – OR –
  Straight male data (500 kBit/s) connector; part no. 1424674 – OR –
  Angled male data (500 kBit/s) connector; part no. 1424675

Procedure

IMPORTANT

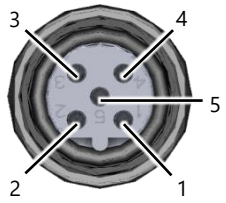
"Hot" connection/disconnection of any power or data source is not advised and can result in damage to the product.

- Connect the analog input according to the following information and only when the power is off.

Specifics of the interface

Marked: PMSI (Process Monitoring Serial Interface)
Connector: manufacturer PHOENIX CONTACT; part number 1527870

Table 6: Pin assignment of the PMSI connector

	Pin	Description	Voltage level
	1	AIN 1+	Analog input 0–10 V DC; digitized by 20-bit ADC; synchronized with position
	2	AIN 1-	0 V
	3	AIN 2+	Analog input 0–10 V DC; digitized by 20-bit ADC; synchronized with position
	4	AIN 2-	0 V
	5	GND	0 V; may be used to shield the analog inputs but must not be connected to an external ground

4.3.5 CONNECTING A GSBUS BASED CONTROLLER

The GSBus is intended for connection via an adapter to a ScanMaster Controller.

Target audience and qualification

Experts

Requirements

☐ The scan head has a 17-pin GSBus *socket* (female gender).

Have ready

☐ ScanMaster Controller

part number SMC-04-5-1-01-00-007 – OR –
part number SMC-04-5-1-01-00-81F – OR –
part number SMC-04-5-1-01-01-007 – OR –
part number SMC-04-5-1-01-01-81F

For more information on these part numbers see section 8.1 on page 125.

☐ Interconnecting cable (twisted pair) by PHOENIX CONTACT

Length 5 m; part number 1402421 – OR –
Length 10 m; part number 1402422
(Cable must not exceed 10 m in length.)

Procedure

IMPORTANT

"Hot" connection/disconnection of any power or data source is not advised and can result in damage to the product.

1. Connect the controller according to the following information and only when the power is off.

IMPORTANT

The wiring and the grounding connections are critical to safe and sustained operation.

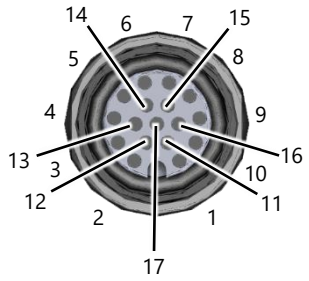
2. Be sure to follow the recommended wiring and grounding scheme in section 4.3.7 on page 39 ff.

Specifics of the interface

Marked: COMM

Connector: manufacturer PHOENIX CONTACT; part number 1424197

Table 7: Pin assignment of the GSBus connector



Pin	Description
1	CmdClk+
3	CmdClk-
6	CmdSync+
4	CmdSync-
5	CmdData+
8	CmdData-
7	CmdClkEnb+
10	CmdClkEnb-
9	StatClk+
2	StatClk-
11	StatSync+
12	StatSync-
13	StatData+

	Pin	Description
	14	StatData-
	15	Comm+
	16	Comm-
	17	Ack

4.3.6 CONNECTING POWER

Target audience and qualification

Experts

Requirements

Table 8: Electrical supply

Characteristic	Specification
Supply voltage	+48 V DC; Tolerance ±2 V DC
Input current	min. 12.5 A

Have ready

☐ Power supply; recommended: TDK RWS-600B or similar

☐ Interconnecting cable by PHOENIX CONTACT;

Length 2 m; female – unterminated; part number: 1558360 – OR –
Length 5 m; female – unterminated; part number: 1558373
(Cable must not exceed 30 m in length. A length of 10 m or less is preferred.)

Procedure

IMPORTANT

"Hot" connection/disconnection of any power or data source is not advised and can result in damage to the product.

1. Connect the power lines according to the following information and only when the power is off.

IMPORTANT

The wiring and the grounding connections are critical to safe and sustained operation.

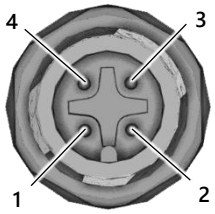
2. Be sure to follow the recommended wiring and grounding scheme in section 4.3.7 on page 39 ff.

Specifics of the interface

Marked: PWR

Connector: manufacturer PHOENIX CONTACT; M12, male 4-pin A-coded; part number 1551875

Table 9: Pin assignment of the PWR IN connector

	Pin	Description	Voltage level	Color code at cable
	1	Chassis	Protective earth [1)]	Shield
	2	V+	48 V	White
	3	V-	0 V [1)]	Blue
	4	DGND	Digital ground [1)]	Yellow

1) These lines must be tied together at the power supply.

4.3.7 RECOMMENDED WIRING AND GROUNDING SCHEME

Technical advisories

IMPORTANT

"Hot" connection/disconnection of any power or data source is not advised and can result in damage to the product.

- Connect data and power lines only when the power is off.

- All interconnection cables to Firefly3D must be shielded.
- All interconnection cables to Firefly3D must have a length of no longer than 10 meters.
- Firefly3D and ScanMaster Controller products should be earthed to the same earthing point.
- With the grounding scheme implemented as per Figure 6 on page 40 it is recommended that the SMC and Firefly3D are powered up at the same time.
- The M12 connection on the GSB Adapter PCBa (D21520) should be grounded to the common protective earth. It is recommended that this be implemented using an M12 ring crimp. The design intent was that the M12 connector would be bulkhead mounted to a surface such as a control panel that would itself be earthed. If this is not the case, then the mitigate described needs to be implemented.

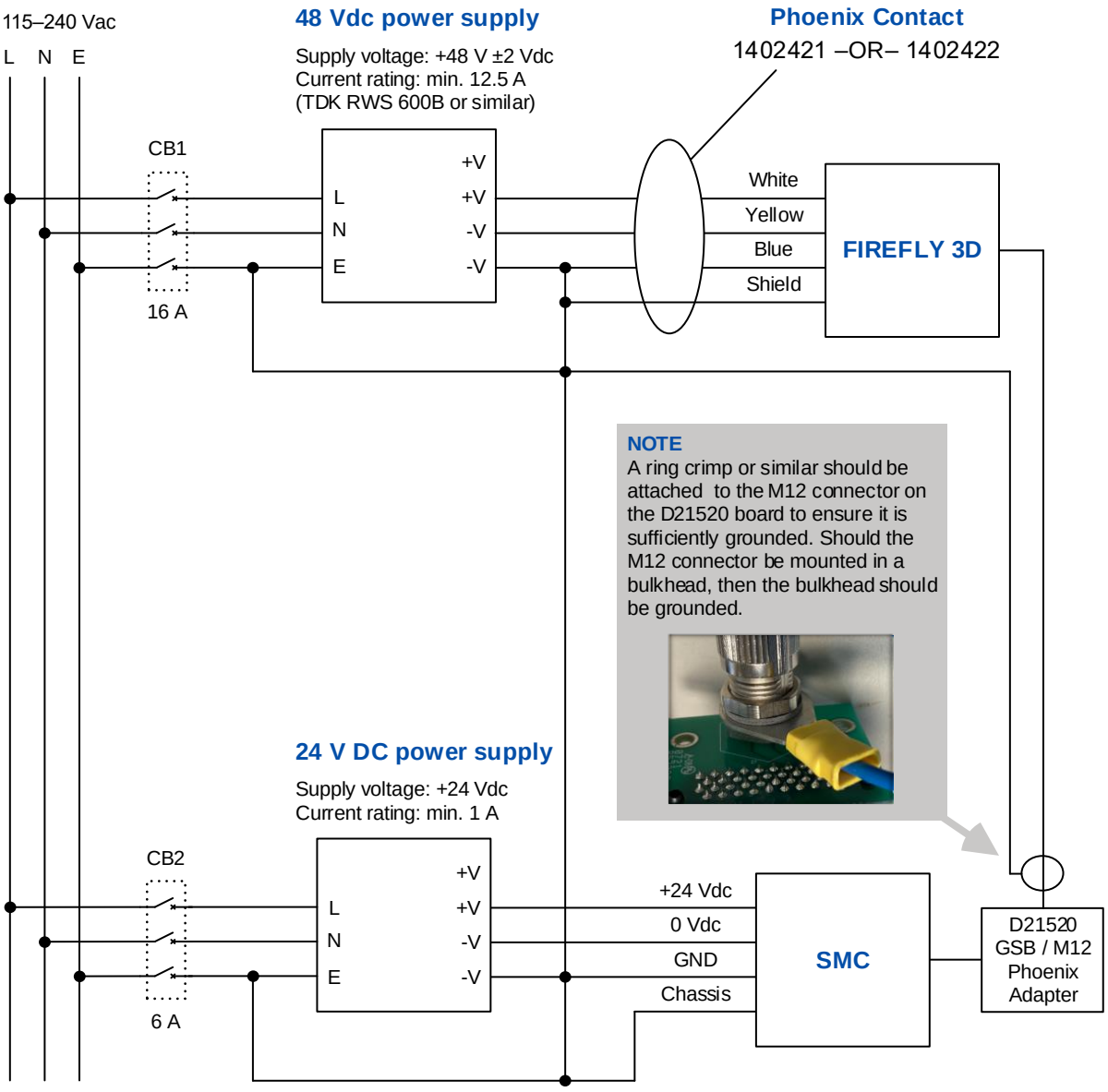


Figure 6: Recommended wiring and grounding scheme

4.3.8 CONNECTING A FIBER LASER

Laser fibers are manufactured within given tolerances. There can be an offset in X- and Y-direction and an angle in ϑ- and φ-direction between the fiber axis and the optical axis of the scan head.

To compensate for these tolerances, besides other purposes, there is the Laser Interface Adapter (LIA). Compensation is required with each mounting of the laser fiber to the LIA.

Target audience and qualification

Experts

Requirements

Table 10: Laser beam supply

Characteristic	Specification
Laser	standard industrial fiber laser in single- or multi-mode
Fiber type	standard industrial connector system (D51 or D65 collimator clamp)
Wavelength	1050–1090 nm
Laser power	max. 1100 W
Input clear aperture	20 mm
Angular velocity	max. 50 rad/s
Integrated pointer laser wavelength	633 nm

- ☐ Clean and low-dust environment as you will dismount the LIA from the scan head and partially disassemble the LIA

Have ready

- ☐ Laser safety glasses that are appropriate for the laser in use
- ☐ Laser fiber with collimator
- ☐ Alignment tool

  The LIA is mounted onto the alignment tool for adjustment, instead of mounting the LIA on the scan head.

Inside the tube is a thermopile. The thermopile can be moved between 2 positions. One position is near the LIA, the other is at the far end of the tube. These 2 locations provide a perspective that allows the user to align the laser beam through the LIA.

A handheld power monitor is connected to the thermopile which shows the laser beam position and power measurement at the set measurement point.

If the laser beam is centered to the thermopile at both ends of the tube, then the laser beam is adequately adjusted to the optical axis of the scan head.

- ☐ Torx key set to dismount and disassemble the LIA
- ☐ Cleaning utilities that are appropriate for cleaning precision optics
- ☐ Material to cover the laser beam entrance at the scan head,
  e.g., Polyamide tape

Safety precautions

WARNING

Visible or invisible laser radiation can cause severe retinal and corneal burns, burns to the skin, and may pose a fire risk.

- Switch off the laser emission.
- Restrict access to the area where the alignment is done, to the persons who perform the adjustment and who wear appropriate laser safety glasses.
- To avoid injury and reduce risk of fire, follow the control measures and safety guidelines provided by the laser's manufacturer, and those established by your Laser Safety Officer (LSO), Radiation Safety Officer (RSO), or safety department of your business or institution.

Procedure

IMPORTANT

It is required that the procedure is done on site and the laser fiber must not be separated from the Laser Interface Adapter afterwards.

1. Ensure that the alignment tool is placed on a stable surface.
2. Clamp the base of the alignment tool to a firm base considering, especially when attaching the fiber and collimator later in this procedure.
3. Dismount the Laser Interface Adapter (LIA) from the scan head by loosening these screws; see Figure 7 on page 19.

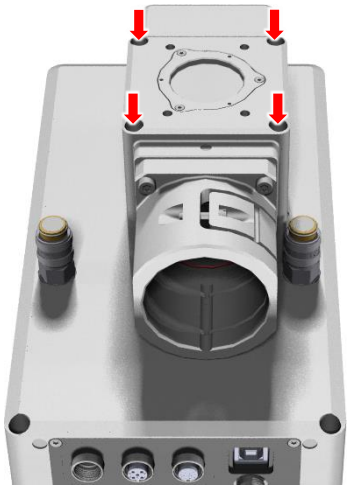


Figure 7: Dismounting the Laser Interface Adapter (LIA) from the scan head

4. Cover the laser beam entrance of the scan head to prevent contamination.
5. Disassemble the LIA:
    a. Remove the 2 lower screws at the LIA's thermopile; see Figure 8 on page 45, **red** arrows.
    b. The LIA block will come apart along its diagonal. Hold both parts securely while removing the transversal screws which are located at the bottom of the LIA; see Figure 8 on page 45, **green** arrows.

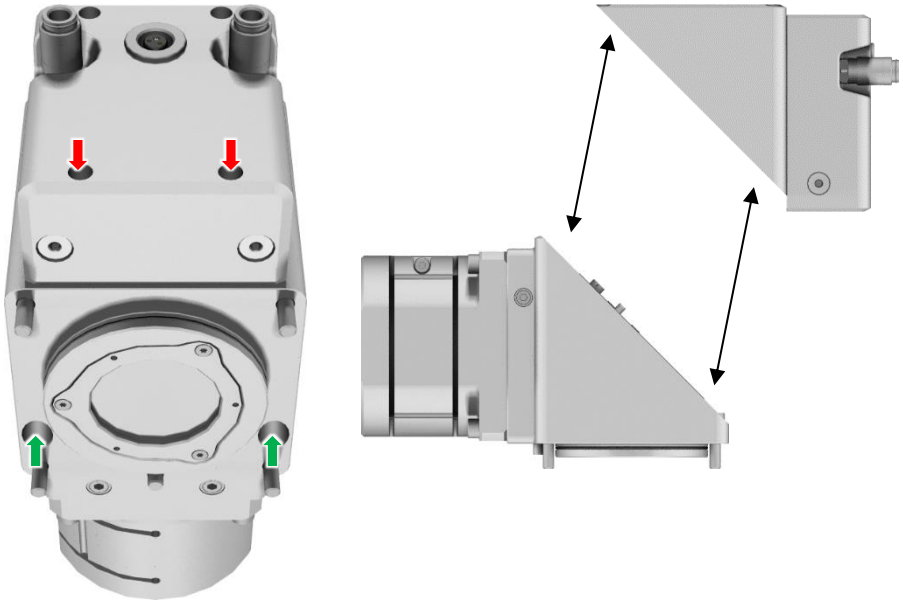


Figure 8: Disassembling the LIA

The photograph below, Figure 9 on page 45, shows the separated LIA assembly.

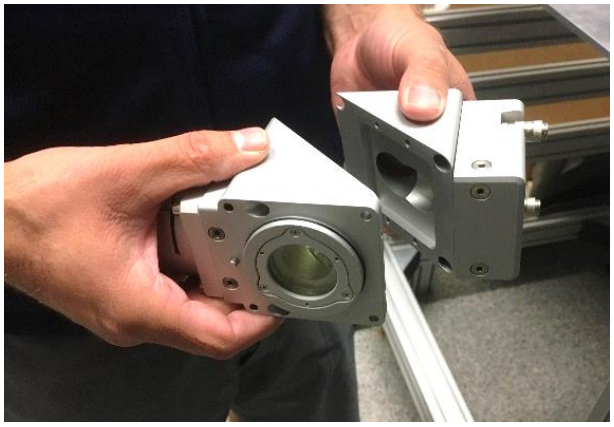


Figure 9: Disassembled LIA

c. Put the upper part of the LIA to a clean and safe place.

   You will need it later when reassembling the LIA.

6. Mount the lower part of the LIA on the alignment tool (the same way as you would mount it back on the scan head).

   The photograph below, Figure 10 on page 46, shows the LIA mounted on top of the alignment tool. Note that there is a knob on the side of the alignment tool, which can be gently pulled upon to allow the integrated detector to be moved between the 2 levels marked *Level 1* and *Level 2* in the photograph below.

   Please note that the aluminum post shown in the photograph serves as a safety element in case of light emitted from the fold mirror within LIA directs light towards the power monitor/port.

Figure 10: LIA mounted on top of the alignment tool

   Only once the LIA is securely attached to the alignment tool should coupling of the fiber collimator to the LIA be attempted.

7. Make sure that the optical surfaces at the laser fiber tip and the LIA are clean.
8. Carefully insert the collimator into the LIA up to its internal limit.
9. Clamp the collimator by tightening this screw; see Figure 11 on page 47.

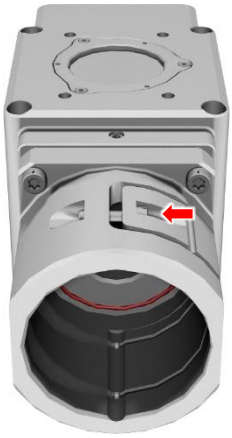


Figure 11: Clamping the collimator to the LIA

10. Ensure all safety precautions are in place, and protective glasses are worn.
11. Set the laser to the lowest controllable radiant power.

> **⚠ WARNING**
>
> Visible or invisible laser radiation can cause severe retinal and corneal burns, burns to the skin, and may pose a fire risk.
>
> - To avoid injury and reduce risk of fire, follow the control measures and safety guidelines provided by the laser's manufacturer, and those established by your Laser Safety Officer (LSO), Radiation Safety Officer (RSO), or safety department of your business or institution.

12. Activate laser emission.
13. Monitor the laser beam position on the alignment tool's thermopile via the handheld display, see Figure 12 on page 48, in the following.

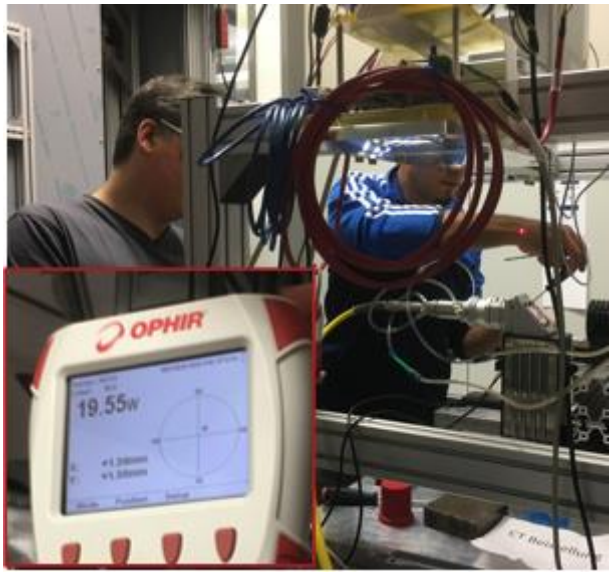


Figure 12: Handheld display of the alignment tool's thermopile

Principle of alignment as described in step 14

Using the OPHIR Starlight power meter use the mirror position adjustment screws within the LIA to move the beam such that the indicated power is as high as possible, and the beam location is centered as well as possible.

The lower *Level 2* position is likely to be more sensitive to adjustment than when the sensor is in the upper *Level 1* position.

It is very likely that there will be a compromise between power level and optimum position dependent on the angle of the incident beam and limitations of the mechanical assemblies. For instance, should there be an offset axis component in the beam's propagation from the fiber, through the collimator, LIA and into the alignment tooling, alignment to an offset location may be necessary.

The following example demonstrates this point. In this case the beam was offset, and the power level was matched to some offset position at both the *Level 1* and *Level 2* measurement positions.

Example:

Measurement at *Level 1*

Measurement at *Level 2*

The ideal state would be for the beam to pass through the exact center of both measurement levels. In this case, this alignment resulted in an angled beam approach angle as shown in the beam profile shown below.

From the two levels of measurement taken above the angle of tilt can be determined using the following calculations.

$\Delta x = 0.08$ mm,

$\Delta y = 0.05$ mm,

$Dm = 200$ mm (Distance between *Level1* and *Level2*);

$\tan\alpha = \Delta x/Dm \Rightarrow \alpha = 0.023°$,

$\tan\beta = \Delta y/Dm \Rightarrow \beta = 0.014°$

14. Compensate the fabrication defects of the laser fiber with the LIA:
    a. To adjust for offset misalignment:
        i. Position the measurement sensor in *Level 1*; see Figure 10 on page 46.
        ii. Loosen the 4 fixing-screws; see Figure 13 on page 50, **red** arrows.
        iii. Use the adjusting screws; see Figure 13 on page 50, **green** arrows; to bring the laser beam to the thermopile center.

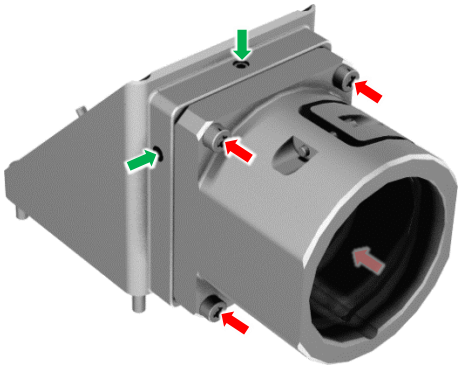


Figure 13: Adjusting for offset misalignment at the LIA

The photograph below, Figure 14 on page 50, shows the LIA mounted on top of the alignment tool. Green arrows point to the XY adjusters. The top adjuster corrects for Y offset, while the side adjuster corrects for X offset.

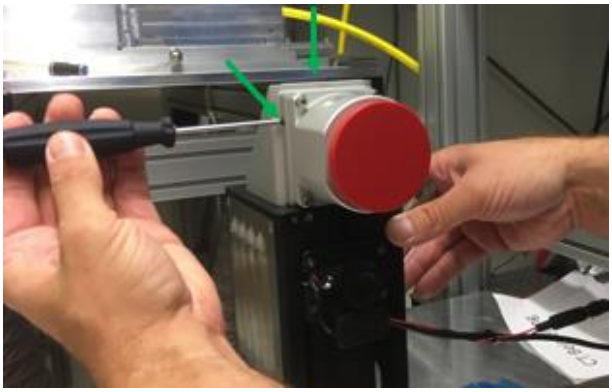


Figure 14: XY adjusters at the LIA

b. To adjust for angular misalignment:

    i. Position the sensor in *Level 2*; see Figure 10 on page 46; as the angular deviation and the impact of the adjustment are more notable in this position.

    ii. Use the 4 adjustment screws; see Figure 15 on page 51; which are arranged in pairs around the folding mirror of the LIA to bring the laser beam to the center of the thermopile.

Each pair consists of a pressure screw (1), (3); see Figure 15 on page 51; and a draw screw (2), (4) and is responsible for adjusting one axis. The pair (1), (2) on the side of the mirror is responsible for adjusting the X-axis. The pair (3), (4) above the mirror is responsible for adjusting the Y-axis. The pressure screw raises the mirror holder, and the draw screw lowers it. As the mirror holder is clamped between the screws, both screws must be equally tightened or loosened during adjustment in order to securely lock the mirror holder in position.

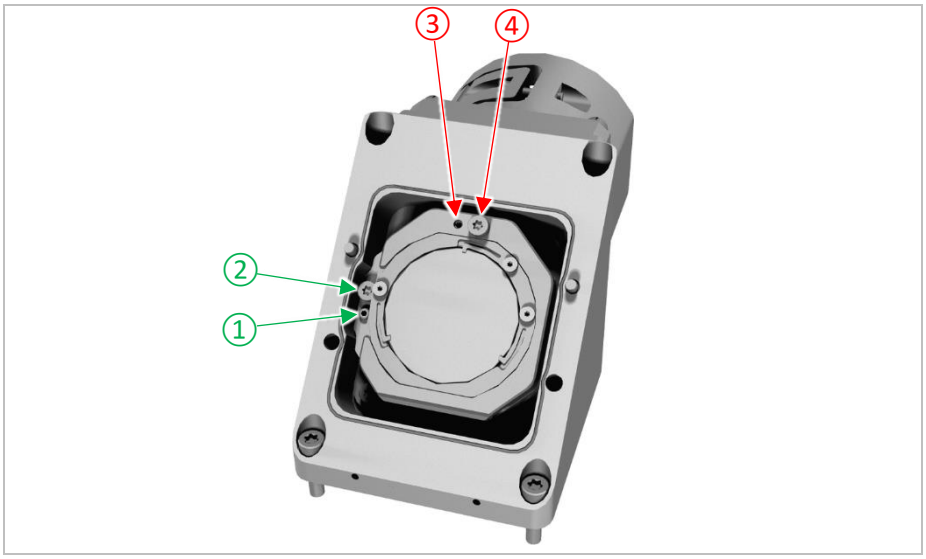


Figure 15: Adjusting for angular misalignment at the LIA

Adjustment along the X-axis:

- Loosening the pressure screw (1) and simultaneously tightening the draw screw (2) increases the X-coordinate of the laser beam.
- Tightening the pressure screw (1) and simultaneously loosening the draw screw (2) reduces the X-coordinate of the laser beam.

Adjustment along the Y-axis:

- Tightening the pressure screw **(3)** and simultaneously loosening the draw screw **(4)** increases the Y-coordinate of the laser beam.
- Loosening the pressure screw **(3)** and simultaneously tightening the draw screw **(4)** reduces the Y-coordinate of the laser beam.

As soon as the laser beam is centered to the thermopile at both measurement positions, the laser beam is adequately aligned to the optical axis of the scan head.

c. Repeat the steps above until alignment is attended.

15. Tighten the 4 fixing-screws, highlighted by **red** arrows in Figure 13 on page 50.
16. Switch off the laser emission.
17. Dismount the LIA from the alignment tool.
18. Reassemble the LIA and check the cleanliness of the optical surfaces.
19. Remount the LIA to the scan head.

4.3.9 CONNECTING THE THERMOPILE (OPTIONAL)

Target audience and qualification

Experts

Have ready

☐ Mating product: manufacturer binder-connector

On website, set the search filter for: subminiature connector, number of contacts 2, lock M9, degree of protection IP67, version connector male angled or straight.

Procedure

IMPORTANT

"Hot" connection/disconnection of any power or data source is not advised and can result in damage to the product.

- Connect the thermopile only when the power is off and according to the following information.

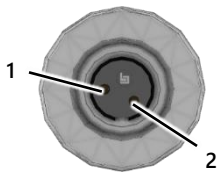
  Internally a Thermopile gRay C50-MC-LA is installed. (Correct at the time of publication. Novanta reserves the right to change without notice.)

Specifics of the interface

Marked: –

Connector: manufacturer binder-connector; part number 0904040002

Table 11: Pin assignment of the thermopile connector

	Pin	Description
	1	Negative
	2	Positive

4.3.10 CONNECTING TO OPTICAL SENSORS AND VISION CAMERAS

Target audience and qualification

Experts

Procedure

- Connect the monitoring system according to the following information.

Specifics of the interface

Figure 16: Position of monitoring ports

Legend to Figure 16

No.	Labeling / function	Dimensions see	On page
1	Monitoring port (1200–2000 nm)	Figure 3 and Figure 4	26 27
2	Monitoring port (450–950 nm)		

4.3.11 DIAGNOSTICS CONNECTOR

The USB interface is only intended for software/firmware updates and diagnostics. It allows access to servo driver function and status reporting. Details are relevant for service personnel only and not provided here.

Target audience and qualification

Trained service and Novanta personnel

Have ready

☐ Interconnecting USB cable terminated by a USB type B plug at one side

Procedure

- Do not connect.

Specifics of the interface

Marked: –
Connector: USB type B socket

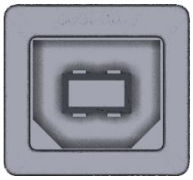


Figure 17: USB interface

4.3.12 CONNECTING A LASER TO SCANMASTER CONTROLLER

It is assumed that the Firefly3D scan head will be used with the ScanMaster Controller in a system setup similar to the example shown in Figure 18 on page 55.

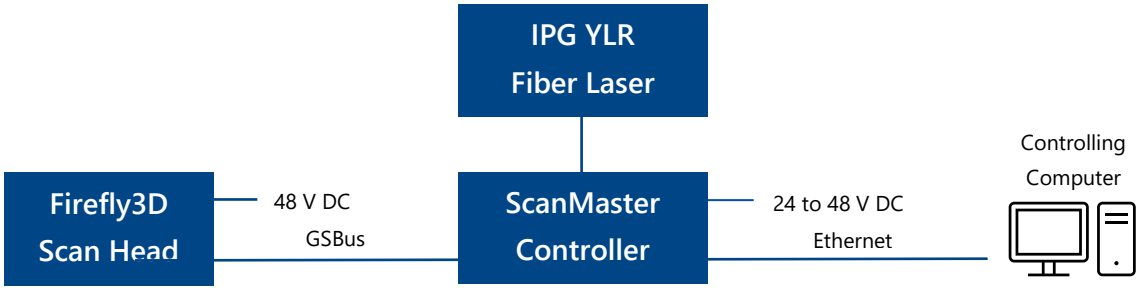


Figure 18: Example for a system setup with an IPG YLR fiber laser

Target audience and qualification

Experts

Procedure

IMPORTANT

The connections given in Table 12 on page 56 have been tested with an IPG YLR laser. At the time of writing this information is correct, however the user is urged to check these connections are suitable for the laser in use, even when connecting to an IPG YLR laser as changes to this product may have been introduced by the manufacturer. Other laser types may require different connections or methods of operation. Novanta recommends that the user check the interface requirements of the laser used in all cases. Novanta does not accept any liability for damage caused through incorrect connections, the information provided here is for guidance purposes only.

1. Before connecting the laser to the ScanMaster Controller consult with the laser manufacturers documentation.

IMPORTANT

"Hot" connection/disconnection of any power or data source is not advised and can result in damage to the product.

2. Connect the laser only when the power is off and according to the following information.

Table 12: Example for the lines between controller and laser

ScanMaster Controller High Power Laser Adapter (SMC-LSR-04)			IPG YLR Laser
Description	**Connector**	**Pin number**	**Pin number**
Laser gate	J2	3	18
Modulation	J2	4	15

ScanMaster Controller High Power Laser Adapter (SMC-LSR-04)			IPG YLR Laser
Description	**Connector**	**Pin number**	**Pin number**
GND	J2	6	14, 16, 20
Laser analog	J2	7	12
24 V	J3	1	–
GND	J3	2	–

4.3.13 INSTALLING THE SOFTWARE

It is assumed that the Firefly3D scan head will be used with ScanMaster Controller. Use the following software to fully utilize the capability and performance of the system. The software listed within this section represents a core set of applications and APIs that will allow the user to use Firefly3D in several different ways. Depending on the end user installation it is likely that not all these software solutions will be required.

Target audience and qualification

Experts

Procedure

1. Download all (recommended) software listed in Table 13 on page 58.

   The software can be obtained from your local Novanta representative or from: https://novantaphotonics.com/secure-download-scanmaster/

Table 13: Software list

Software application	Minimum version required	Purpose	User level
ScanMaster SDK, incl. Device Config. Editor, Broadcast Monitor, Firmware Loader, Remote Admin.	3.2.5	Low level communication to the controller, configuration, and legacy API functionality	Software engineer / Process engineer
ScanMaster API	3.2.5	.net Framework compliant API for all new designs	Software engineer
ScanMaster Designer	3.2.5.x	User friendly desktop application for developing scan projects	User / All
Calibration Wizard	2.1.6 Beta 3	Calibration software to set up the scanners field correction	Process engineer
TuneMaster 2 Support Module	4.5.3.34646	Diagnostics, monitoring, and configuration software of the underlying scanning system	Software engineer / Process engineer
TuneMaster 2 Support Module (Legacy mode)	4.5.3.34646		

2. Install the software applications on the controlling computer that is connected via Ethernet to the ScanMaster Controller.

   You will need administrator rights on the controlling computer.

   As a general guide it is usually good practice to install *ScanMaster SDK* first followed by *ScanMaster API* and lastly *ScanMaster Designer*. *Calibration Wizard* and *TuneMaster 2 Support Module* can be installed independently.

There is additional detailed documentation contained within each software application, accessible once installed, which the reader is urged to study.

4.4 COMMISSIONING

This section describes how to commission the scan head, i.e., what must be done when switching it on for the first time.

IMPORTANT

Uncontrolled laser emission can lead to property damage.

- The integrator must implement supervision of the scan head state and stop laser emission in fault condition.

  If necessary, the integrator must take additional appropriate protective measures to prevent damage by uncontrolled laser emission.

4.4.1 SWITCHING ON FOR THE FIRST TIME

Target audience and qualification

Experts

Requirements

☐ The installation has been completed in the described way; see section 4.3 on page 23 ff. Please check the installation once again to ensure this.

Procedure

1. Check, if the settings for cooling are correct; see also Table 3 on page 28.

IMPORTANT

Pressure surge can damage the scan head's cooling loop. Secondary damage to electronics and optics by cooling water is possible.

2. First open the coolant return line and then carefully open the coolant supply line.

3. Switch on the power.
4. Commission Firefly3D via the controlling computer as described in the following sections.

   Find further reading about commissioning and controlling the scan head and the laser in the respective documentation.

4.4.2 SETTING THE DEVICE CONFIGURATION

Target audience and qualification

Experts

Requirements

☐ The system has been switched on as described in section 4.4.1 on page 59.

Procedure

1. On the controlling computer, start the **Device Configuration Editor** software application.

   The *SMC Device Configuration* window opens.

2. In the navigation on the left-hand side, expand **Controller Configuration** and click **ControlConfig.xml**.

3. Select the *Controller Configuration* tab and within the *Galvo Axis Config* groups *Head 1* and *Head 2*, make sure the settings are as shown in Figure 19 on page 61.

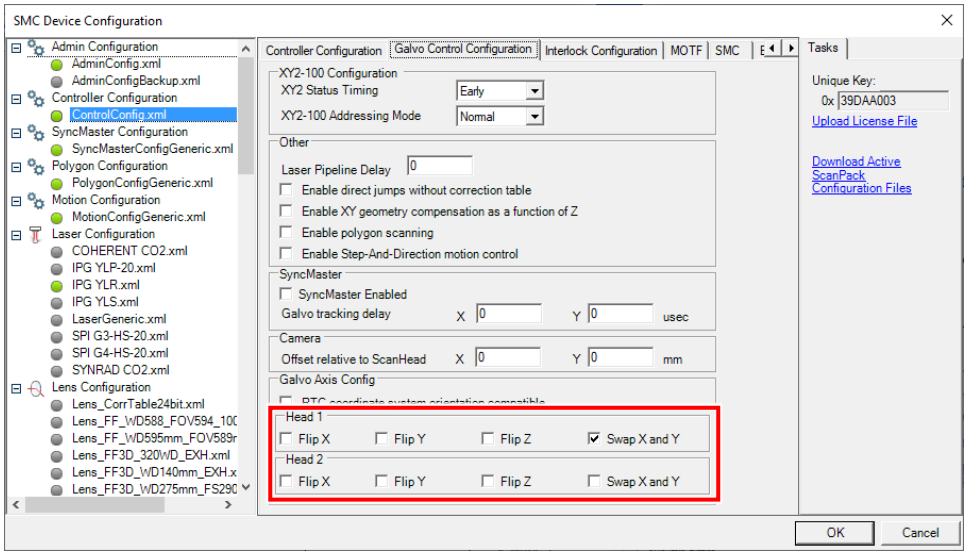


Figure 19: Editing the SMC Device Configuration

4. Click **OK**.

   This applies changed values and closes the *Device Configuration Editor* window.

4.4.3 CALIBRATING THE SCAN FIELD

Target audience and qualification

Experts

Requirements

☐ The device has been configured as described in section 4.4.2 on page 60.

Procedure

1. On the controlling computer, start the **Calibration Wizard** software application.

   The *Calibration Wizard* window opens.

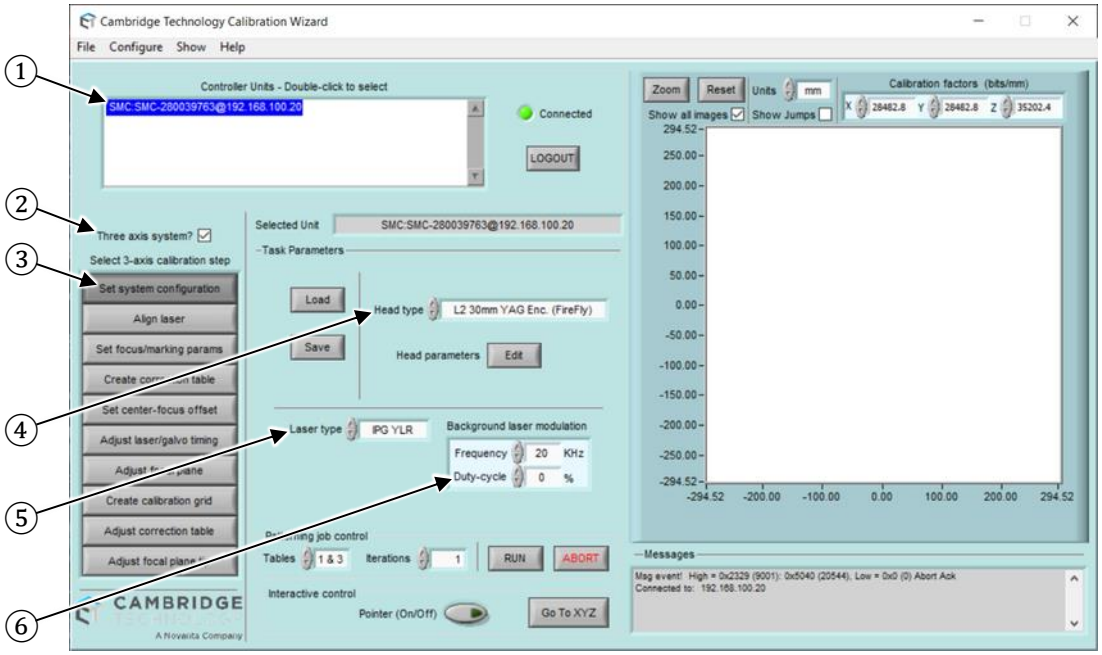


Figure 20: Calibration Wizard

2. Referring to Figure 20 on page 62, configure the software in the following way:

   (1) In the *Controller Units* list, double-click the controller displayed to establish a connection to the controller.

   A successful connection is indicated by the *Connected* light illuminated green.

   (2) Activate the **Three axis system** box to identify the system as a 3-axis system.

   (3) Click **Set system configuration**.

   (4) In the *Head type* list, select **... (FireFly)**.

IMPORTANT

This instruction is based on the use of an IPG YLR laser. At the time of writing this information is correct, however the user is urged to check these connections are suitable for the laser in use, even when connecting to an IPG YLR laser as changes to this product may have been introduced by the manufacturer. Other laser types may require different connections or methods of operation. Novanta recommends that the user check the interface requirements of the laser used in all cases. Novanta does not accept any liability for damage caused through incorrect connections, the information provided here is for guidance purposes only.

- Before connecting the laser to the ScanMaster Controller consult with the laser manufacturers documentation.

(5) In the *Laser type* list, select **IPG YLR** or the laser type that is planned to be used.

(6) In the case of using an IPG YLR laser set the *Duty-cycle* to **0** %.

3. If a test firing of the laser is needed to confirm the alignment of the laser beam, then click **Align laser**.

   If it is needed to intensify or clarify the marking, then click **Set focus/marking params**.

4. To start the process of setting up a field correction, click **Create correction table**.

   The *Correction Table Editor* window with default settings opens; see Figure 21 on page 64.

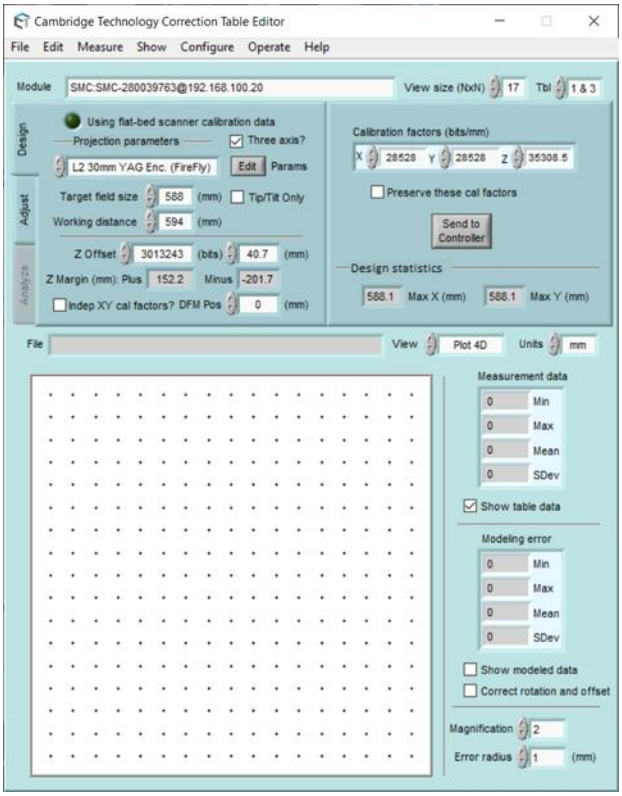
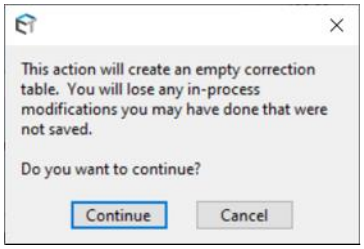
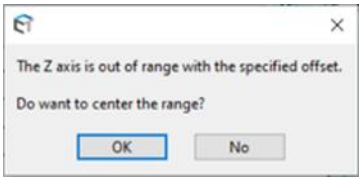


Figure 21: Correction Table Editor

During the following process the messages shown below may pop up. Please take the action advised in the respective caption.



Click **Continue**.



Click **OK**.

5. Enter the **Target field size** – OR – **Working distance** to define the model parameters that will be used to develop the correction table.

   The Working distance is defined as the distance between the target and the bottom side of the scan head. (This excludes the protruding fastening screw threads.)

As an example, we will configure the *Working distance* to 594 mm as shown in Figure 22 on page 65, point (2). This will allow us to attain a maximum theoretical *Target field size* of 588 mm, as shown in the figure, point (1), below.

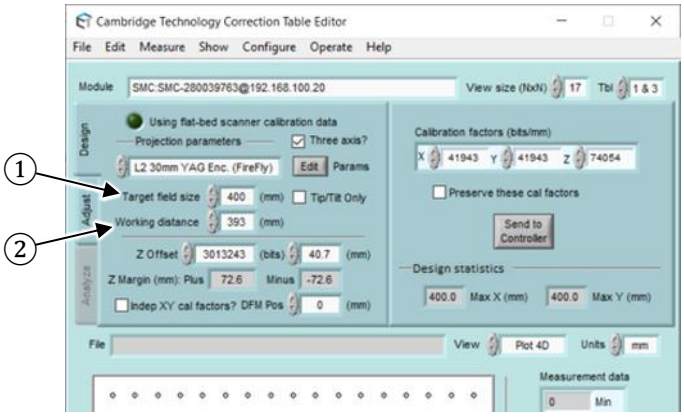


Figure 22: Example: Setting the Working distance

Next the baseline correction needs to be set.

6. In the menu, click **Edit → Synthesize baseline correction**.

   The program will calculate the field corrections and generate a field view like that shown in Figure 23 on page 66 on the right-hand side.

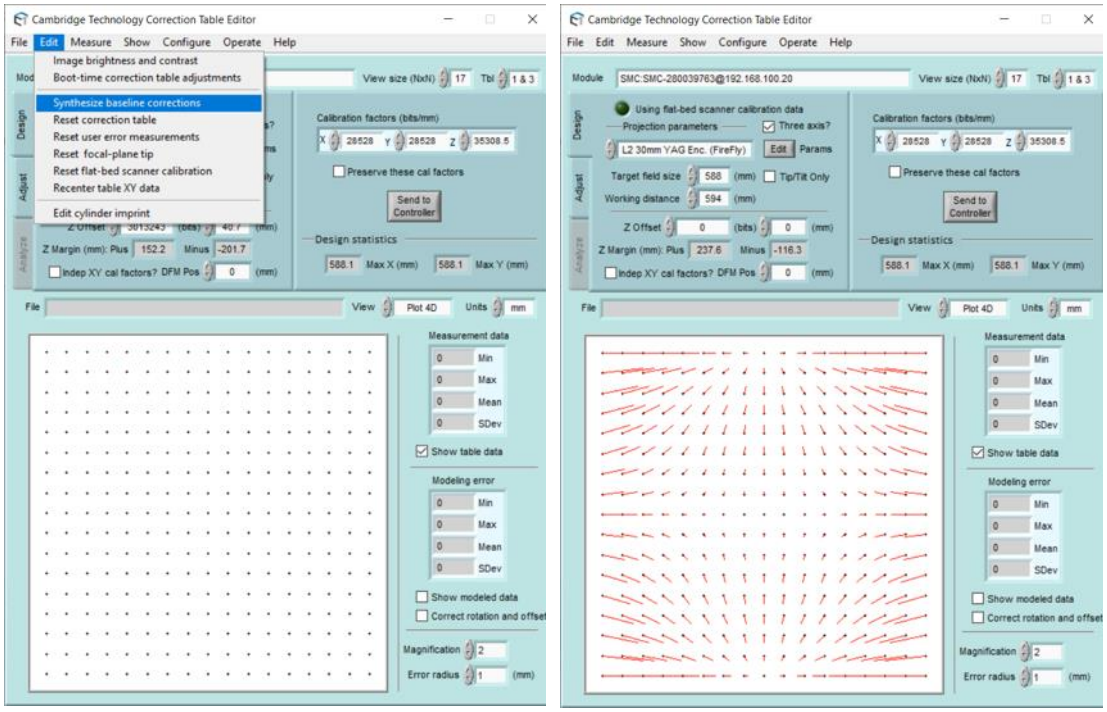


Figure 23: Synthesizing the baseline correction

7. Close the correction table editor, upon which several confirmation message boxes will be presented to the user.
8. Answer each question by clicking the respective button.

   The table will be activated and loaded into the controller for the change to take effect.

   The *Calibration Wizard* window is open now; see Figure 24 on page 67.

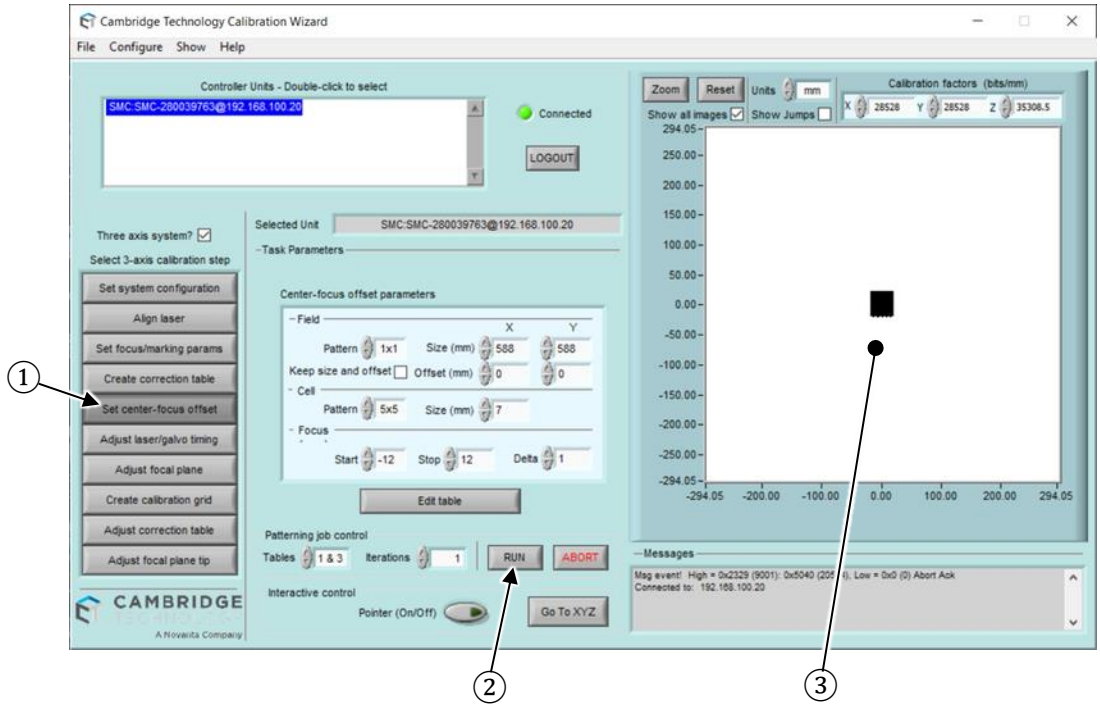


Figure 24: Scanning the center focus pattern

Next a center focus pattern needs to be scanned successfully.

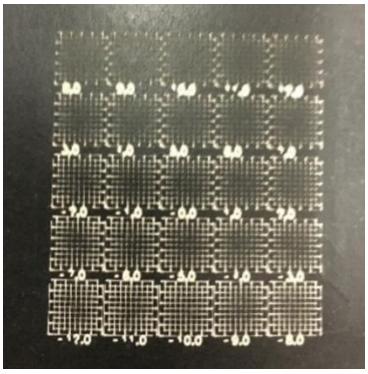
9. Referring to Figure 24 on page 67, this is achieved by taking the following steps:

   (1) Click **Set center-focus offset**.

   (2) After reviewing the pattern parameters, click **Run**.

   The laser will fire, and the scanner will scan the pattern depicted in the window (3).

   If the focus distance is set correctly then the laser should mark the marking paper or marking plate with a pattern that resembles the photograph below.



However, this may not always be the case, and the user may have to adjust the *Z Offset* until such time that the laser visibility marks the target material. During this process, laser power and/or scanning speed may need to be optimized on several occasions.

If required, the focus can be adjusted by clicking **Adjust focal plane** and then entering a *Z Offset* value into the *Correction Table* as shown in Figure 25 on page 69.

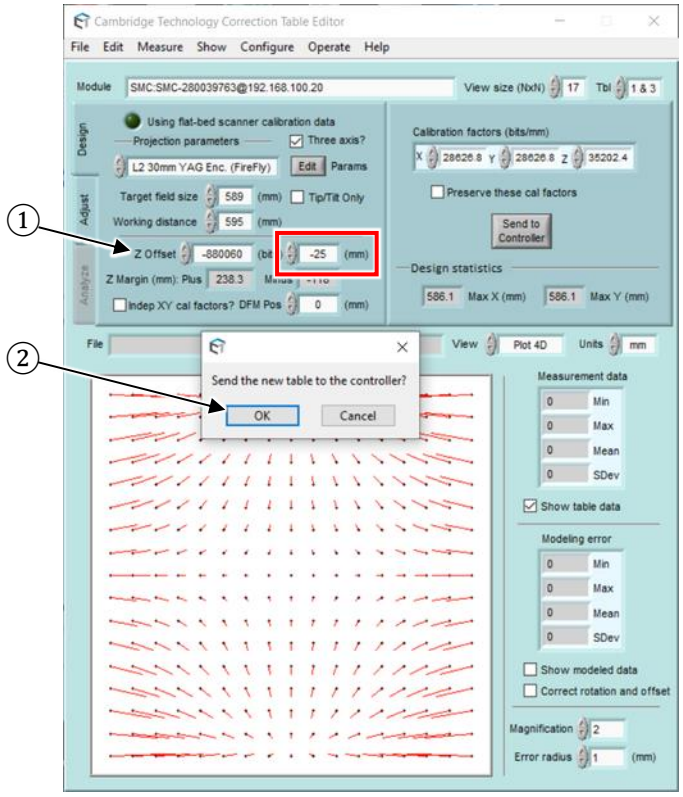


Figure 25: Adjusting the Z Offset

a. *Z Offset* correction is the field that is marked by a red box in Figure 25 on page 69. Enter the offset value in millimeters there.

b. Close the correction table editor, upon which several confirmation message boxes will be presented to the user.

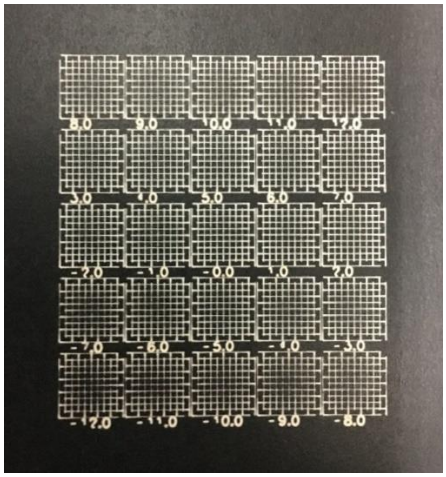
   Answer each question by clicking the respective button.

   The table will be activated and loaded into the controller for the change to take effect.

   It is expected that the focus will be more difficult to find as the field size increases. Consequently, the number of iterations may increase. It is recommended that steps of 25 mm be used when searching for the focus.

Once the center focus has been obtained it is expected that the scanned pattern should look like that shown in the photograph below. Although not extremely

easy to see the middle row carries the highest intensity, with decreasing levels of intensity as the focus passes above and below the focal point.



Next the focal plane correction needs to be performed.

10. This is achieved by scanning a selection of patterns across the entire scan field set within the field correction model. Figure 26 on page 71 describes the set up.

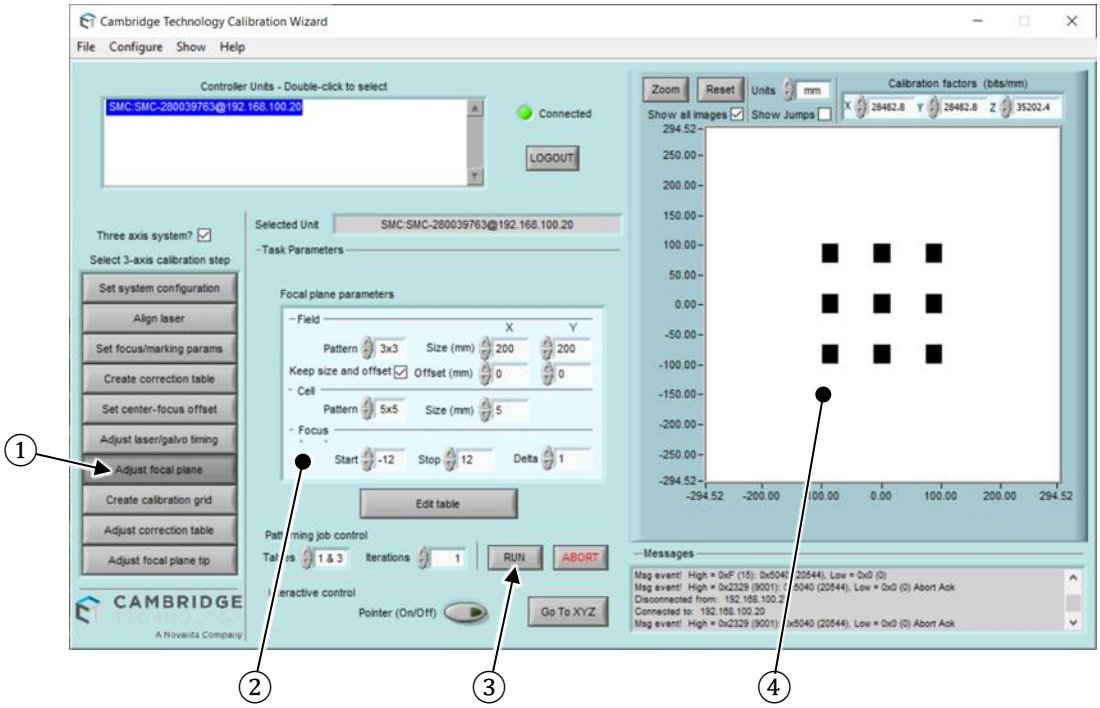


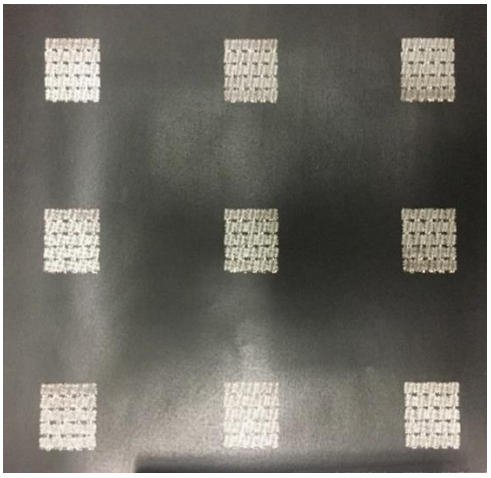
Figure 26: Adjusting the focal plane

(1) Click **Adjust focal plane**.

(2) In the *Focal plane parameters* group, define the focal plane parameters to attain the most appropriate resolution and quality for the system.

(3) Click **Run** to scan the pattern shown in the window (4).

An example of a scanned pattern is shown in the photograph below.



11. Corrections can be applied to regions that are not in focus:

    a. Click **Edit table**.

    The *Correction Table Editor* window opens.

    b. In the main menu, click **Measure → Collect focal plane data**.

    The *Collect focus array data* window opens.

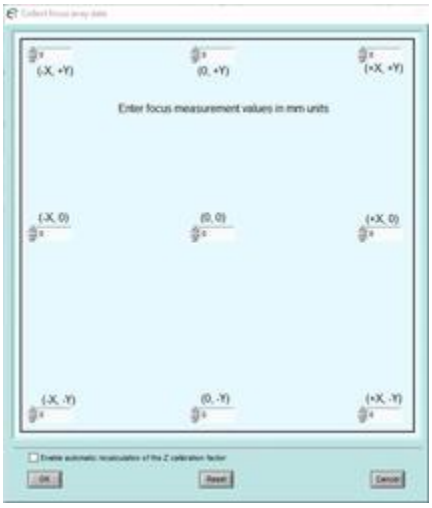
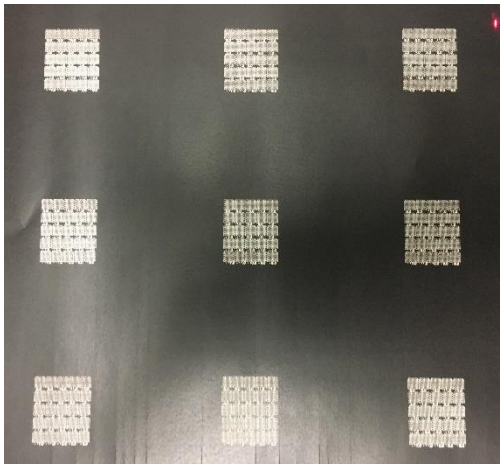


Figure 27: Collecting the focus array data

    c. Enter the correction values.

    d. Click **OK**.

Typically, a few iterations are expected, given a good center focus calibration, to attain a good focal plan calibration, an example of which is shown in the photograph below.



The last stage in the calibration process is to configure a Correction grid, from which measurements can be taken. These measurements are used to correct pin cushion, barrel effects and final field flattening compensation. The example below is based on a manual measurement and data entry approach. For high precision applications it is assumed that a CMM or camera-based system will be used to measure the grid accuracy. Data from this measurement can be imported back into Calibration Wizard using the procedure described at the end of this section.

12. Referring to Figure 28 on page 74, a correction grid can be created by taking the following steps.

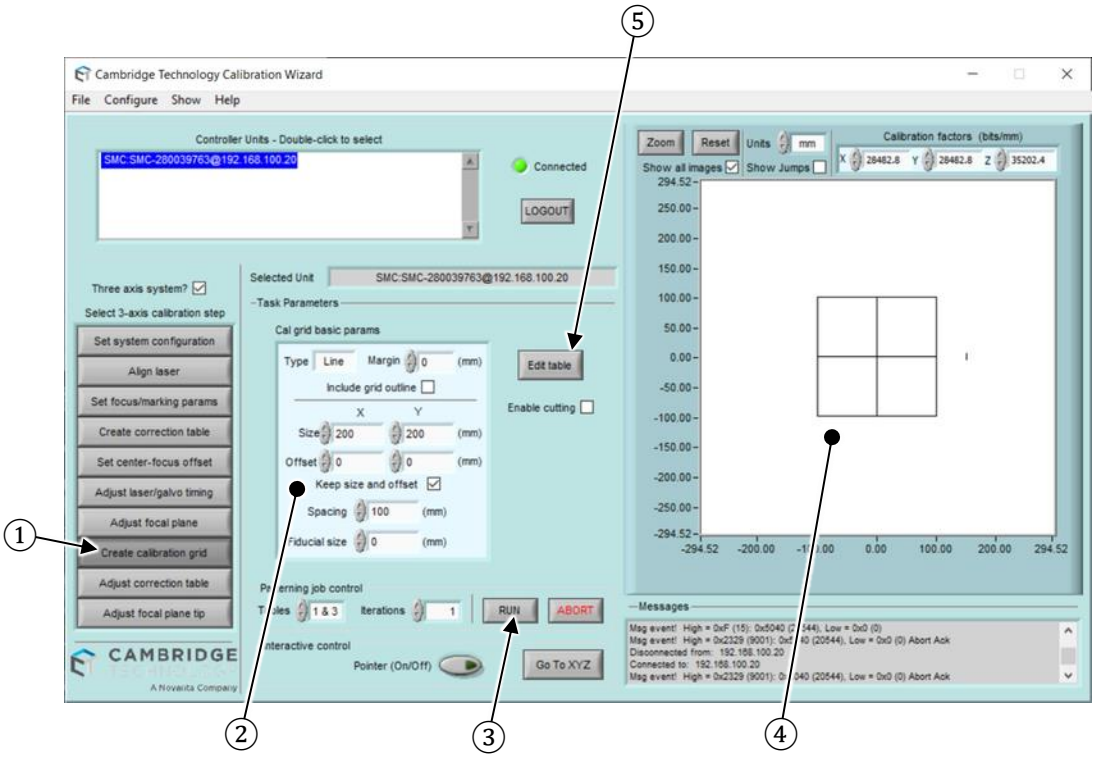


Figure 28: Adjusting the correction table

(1) Click **Adjust correction table**.

(2) Set the marking parameters, in this case for a calibrated grid *Size* of 200 × 200 mm.

(3) Click **Run** to scan the pattern as shown in (4).

As shown by point (2) in Figure 28 on page 74, there is a wide range of calibration grids that can be defined by adjusting these values. With the correction grid scanned it needs to be measured and correction often correction factors applied. This is often an iterative task. In this example the measurement acquisition method is manually based. In precision applications this method is of limited use, and more precise measurement techniques should be used. A description at how to import measurement data into the Calibration Wizard can be found in section 4.4.4 on page 76.

(5) Click **Edit table**.

The *Correction Table Editor* window opens.

13. In the main menu, click **Measure → Collect Box/Cross grid data**.

    The *Collect Box/Cross grid data* window opens, where measured values can be entered which are used by the software to correct the field; see Figure 29 on page 75.

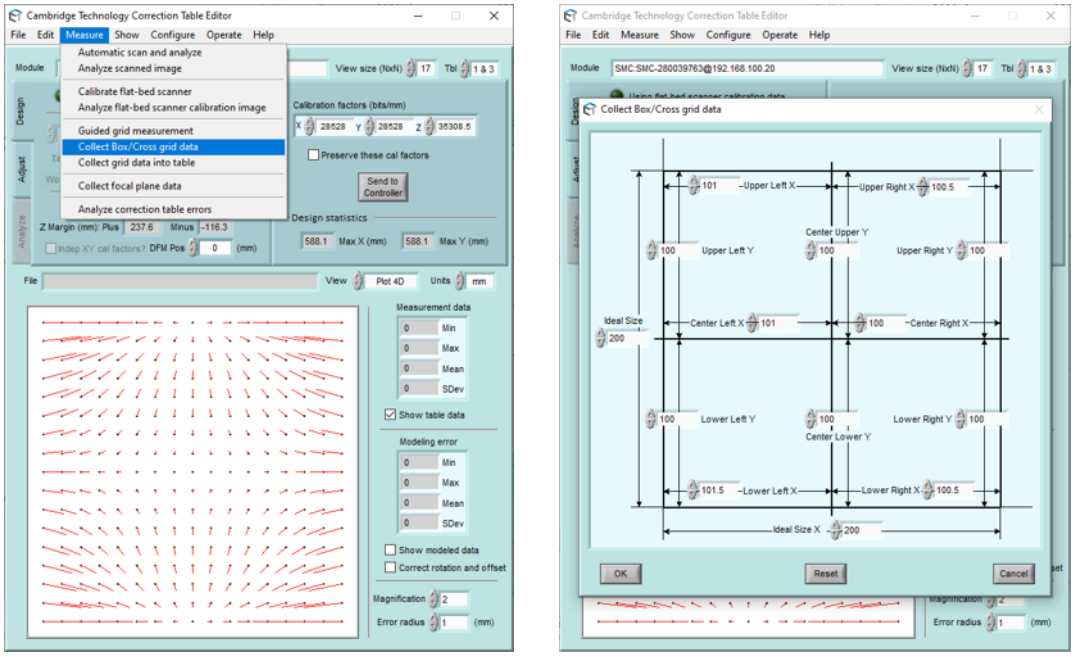


Figure 29: Collecting Box/Cross grid data

14. Enter all corrections.

15. Click **OK**.

    There is an option to save the measurement correction data should this be required.

    Click the *Edit Correction Table* window and save the file to the controller when asked.

    When the software returns to the screen shown in Figure 28 on page 74 and if the field requires further corrections then re-scan the correction grid and repeat the process of scan→ measure → edit correction values. If the field accuracy is acceptable the process of field correction is complete.

4.4.4 IMPORTING MEASUREMENT DATA INTO THE CALIBRATION WIZARD

If the application requires a higher degree of precision, manual measurement techniques are limited. The correction grid will need to be measured using other techniques such as an optical CMM. The data that is reported from these measurement equipment's can be imported back into Calibration wizard. The process to import this correction data is briefly described below.

Target audience and qualification

Experts

Procedure

1. Referring briefly back to Figure 28 on page 74, click **Edit table**.

   The *Correction Table Editor* window opens; see Figure 30 on page 77.

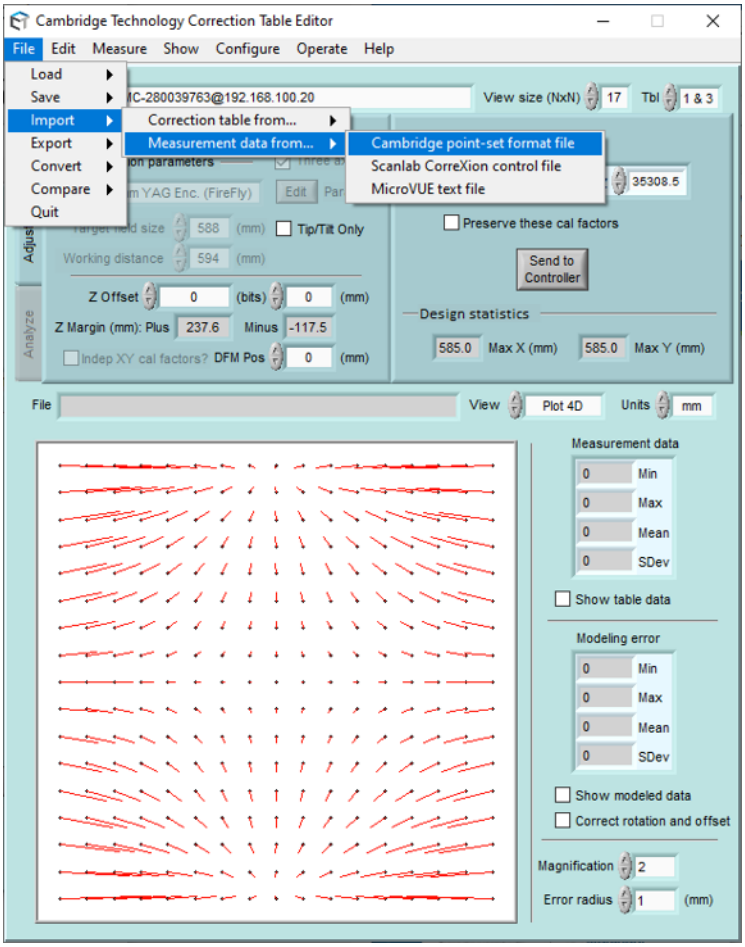


Figure 30: Importing measurement data into the Calibration Wizard

2. From the main menu, click **File → Import → Measurement data from**.

   This offers the possibility to import a text file in one of two defined formats and allows the user to input precision measurement data. All other steps to correct the field remain the same as described in section 4.4.3 on page 61.

4.5 DIAGNOSTICS AND TOOLS TO OPTIMIZE THE SCANNING PROCESS

At the heart of Firefly3D is an advanced digital scanning system, Lightning™ II. TuneMaster Support Module software can be used to connect to Firefly3D to access its features. There are

2 methods of connection, via a ScanMaster Controller card connected to Firefly3D or a less functional connection path via Firefly3D's USB connector. This section will explore functionality available via ScanMaster Controller card only.

4.5.1 USING THE SCANMASTER CONTROLLER AS A HOST

TuneMaster™ II Support Module is a standalone windows application that allows users to perform the following tasks:

- Ascertain current status of the beam steering system
- Upgrade software, firmware, and configuration
- Monitor specific parameters relating to the scan head operation including position, velocity, operating temperature, acceleration, and in addition process monitoring sensors channels can be configured and monitored
- Frequency response and friction plots can be generated to provide Novanta personnel with parametric information that may be useful in the event of an issue
- Plots of actual scanned versus planned trajectories can be generated for scan pattern development, optimization and debugging purposes

Target audience and qualification

Experts

Procedure

1. Within TuneMaster™ II Support Module, check the version installed on your computer by clicking **Help → About** as shown in Figure 31 on page 79.

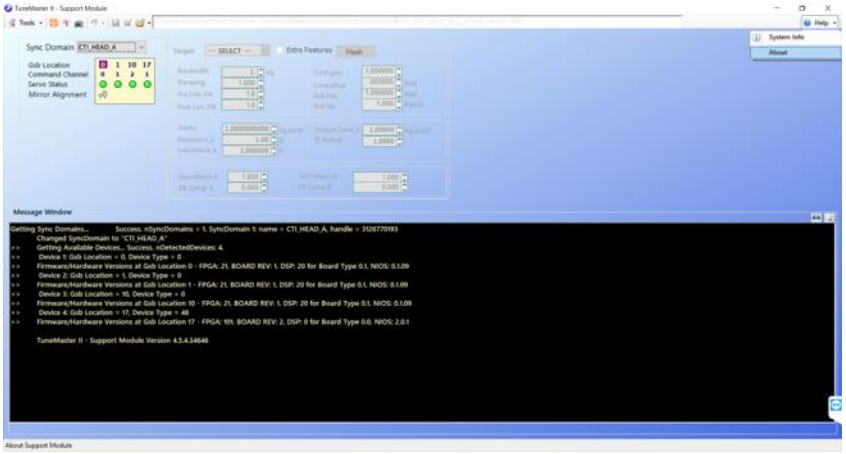


Figure 31: Opening the TuneMaster™ II Support Module *About* box

A window opens, see Figure 32 on page 79, which displays the version number, in this case 4.5.4.34646. The version must be at least version 4.5.4.34646.

Figure 32: TuneMaster™ II Support Module *About* box

2. Close this window by clicking **OK**.
3. Close the TuneMaster™ II Support Module application.

You can configure TuneMaster™ II Support Module application to use ScanMaster Controller as a host by adding the text `smc` after the command line call to the program's executable. How to achieve this is explained below.

4. Find the installed instance of the TuneMaster™ II Support Module executable file `TM2_Support.exe`.

   This can usually be found by navigating to the path given below in the file system.

   `C:\Program Files (x86)\Cambridge Technology\TM2 Support\TM2_Support.exe`

5. Right click file `TM2_Support.exe` and select **Create shortcut**.
6. If not done automatically ensure the shortcut is placed on the desktop.

   There should now be an icon on the desktop that looks similar to that shown in Figure 33 on page 80.

Figure 33: TM2_Support SMC icon

7. Right click this shortcut and select **Properties**.

   The TM2_Support SMC Properties window opens.

8. In the *Target* field add the text `smc` at the end of the string as shown in Figure 34 on page 81.

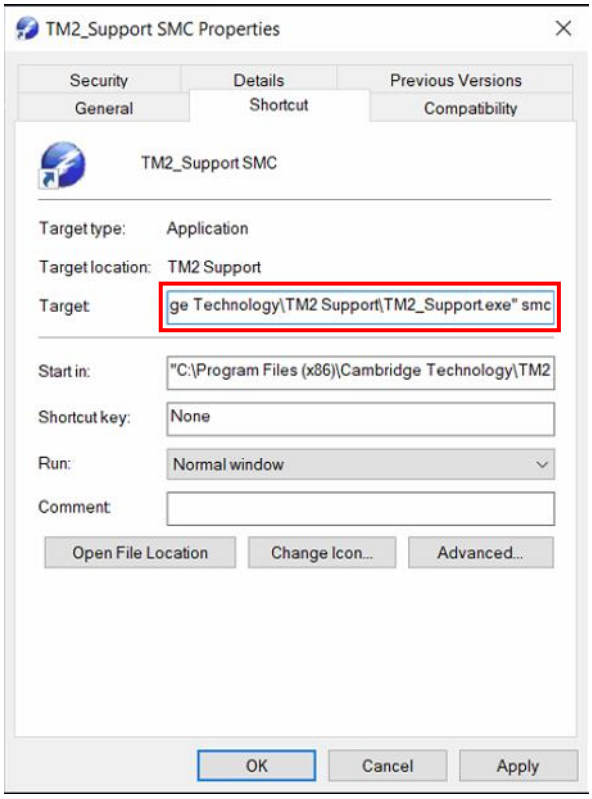


Figure 34: Editing the TM2_Support SMC shortcut properties

9. Click **Apply**.
10. Click **OK**.
11. To start TuneMaster™ II Support Module, double click the desktop shortcut.

    The first time the program is executed a windows security alert, similar to that shown in Figure 35 on page 82, may appear.

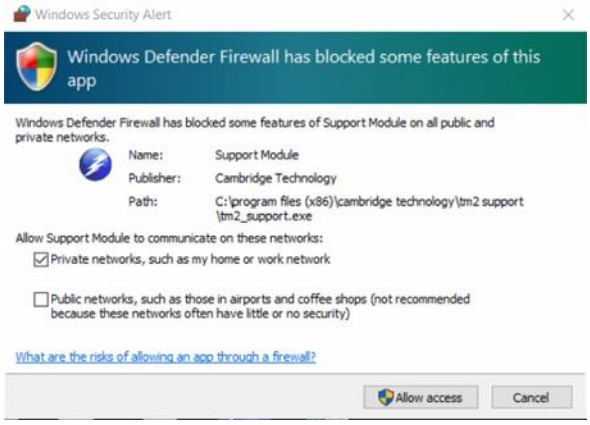


Figure 35: Allowing access through the Windows Defender Firewall

12. Ensure that *Private network* and *Public network* are checked to ensure correct function.
13. Click **Allow access**.

    The program starts, and after 10 to 20 seconds the *TuneMaster II – Support Module* window opens; see Figure 36 on page 82.

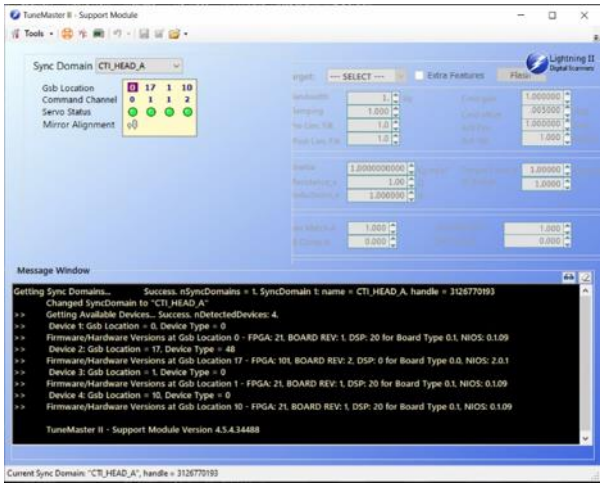


Figure 36: TuneMaster II Support Module main screen

The next section describes in brief how some performance plots can be obtained.

Procedure to obtain a Bode Plot or Friction Plot

1. From TuneMaster™ II Support Module, in the menu, click **Tools → Retrieve TM2 file from Gsb Location 0**; see Figure 37 on page 83.

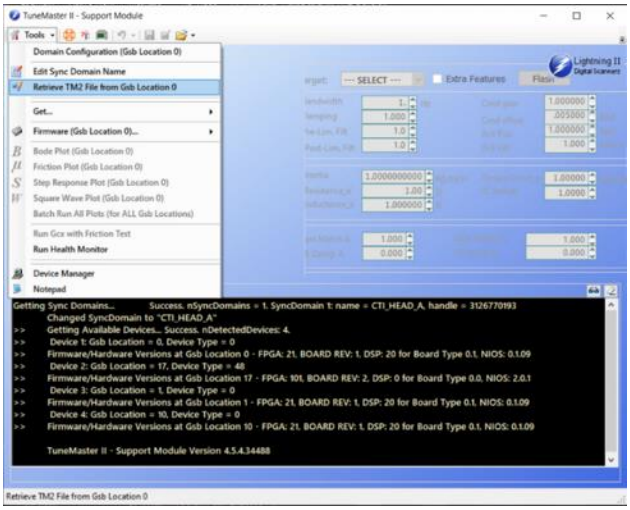


Figure 37: Retrieving TM2 file from Gab Location 0

2. Save the TM2-file to a location on your computer.
3. In the menu, click **Tools → Bode Plot** or **Tools → Friction Plot**, depending on the type of plot desired; see Figure 38 and Figure 39 on page 84.

   The software will instruct the scan head to commence a series of movements, acquiring data as it does, to generate plots similar to those shown below.

   While the system is generating this waveform, do not make additional selections or interrupt operation.

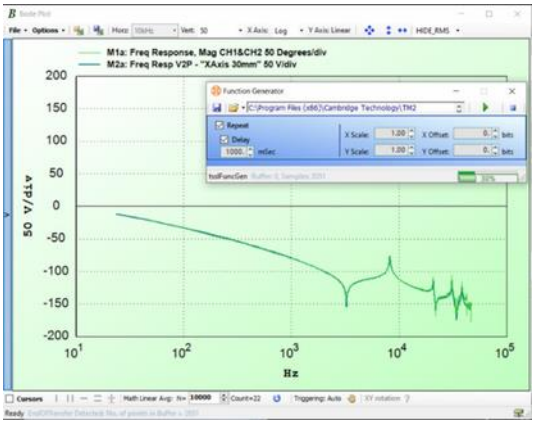


Figure 38: Example: Bode Plot

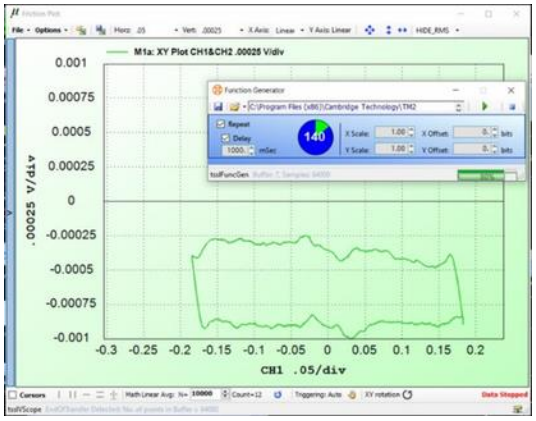


Figure 39: Example: Friction Plot

4. To stop taking the active measurement, close the larger window, also known as the virtual scope.

   This will stop the mirror motion and reconfigure the system back to a normal state ready for operation.

4.5.2 READING CONFIGURATION INFORMATION

Additional information can be obtained which can be helpful in determining the configuration of the scanning system. This information can be helpful when communicating with Novanta.

Target audience and qualification

Experts

Procedure

1. Using TuneMaster™ II Support Module, from the main menu, select **Tools → Get available devices**.

   The Message Window open; see Figure 40 on page 85. It reports the presence and configuration of each of the active elements within a Firefly3D scan head.

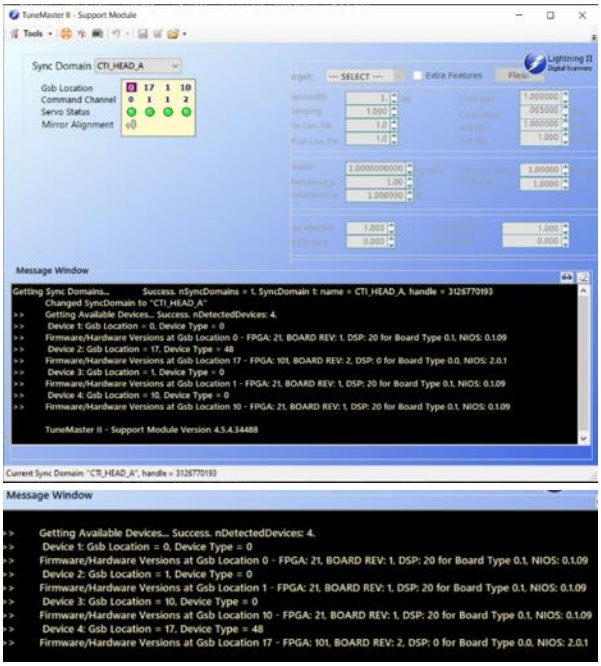


Figure 40: Example: Listing available devices

Detailed firmware information can be displayed as follows.

2. From the main menu, select **Tools → Show firmware versions**.

   An example of the typical output expected from this command is shown in Figure 41 on page 85.

Figure 41: Example: Listing firmware versions

4.5.3 CONFIGURING TUNEMASTER II – SUPPORT MODULE TO OBSERVE SCANNING TRAJECTORIES

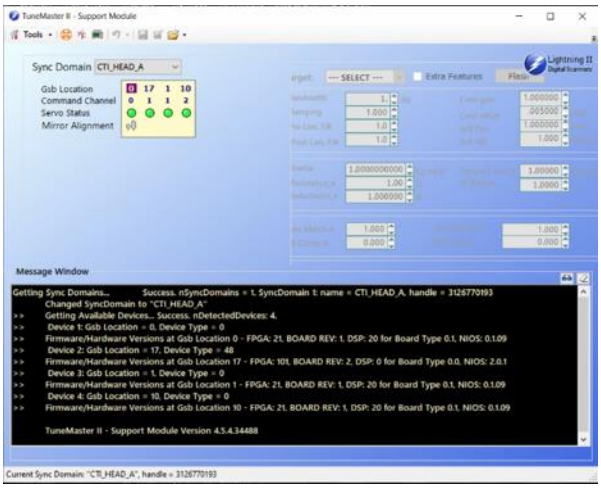
Firefly3D incorporates a *Lightning™ II* pure digital scanning system. This allows the user to make use of some advanced trajectory planning and monitoring tools. In this section the reader is walked through a series of steps required to configure *TuneMaster™ II Support Module* to observe the planned and actual scan trajectories in real time.

Target audience and qualification

Experts

Procedure

1. Using *TuneMaster™ II Support Module*, from the main menu, select **Tools → Retrieve TM2 file from Gsb Location 0**; see figure below.



TuneMaster II Support Module main screen

2. Save the TM2-file to a location on your computer.
3. From the toolbar, click the **probe set up icon** .

   The *Probe Setup* window opens; see Figure 42 on page 87.

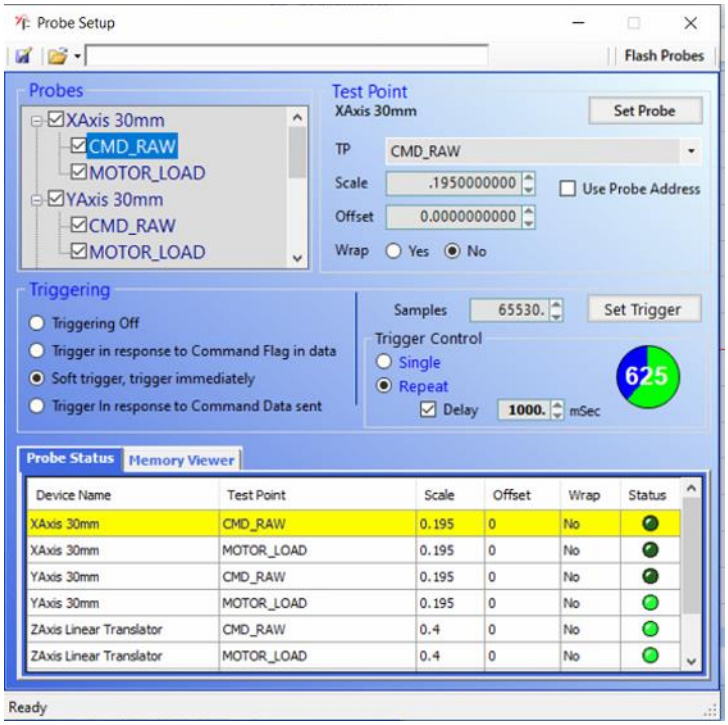


Figure 42: Setting up the probes

4. Use the settings shown in Table 14 on page 87 and Table 15 on page 88 to setup the *Probes* so that it looks similar to that shown in Figure 42 on page 87.

   Note for the purposes of this exercise the *ZAxis* and Adapter Board Probes need not be configured.

Table 14: Probe settings 1 (2)

Axis	Probe name	Scale	Offset	Wrap
XAxis 30mm	CMD_RAW	0.195	0.000	No
	MOTOR_LOAD	0.195	0.000	No
YAxis 30mm	CMD_RAW	0.195	0.000	No
	MOTOR_LOAD	0.195	0.000	No

Table 15: Probe settings 2 (2)

Triggering mode	Soft trigger, trigger immediately
Samples	65530
Trigger control	Repeat
Delay	1000 ms

5. Adhere to the following procedure when setting up each probe; see also figures below.

   Test Point Settings:

   a. In the *TP* list, select the probe you want to assign.

   b. Edit the *Scale* such that it is appropriate for the probe.

      For example, most motion related measurements use a *Scale* of 0.195, whereas temperatures will require a higher *Scale* of say 100 to represent 100 °C.

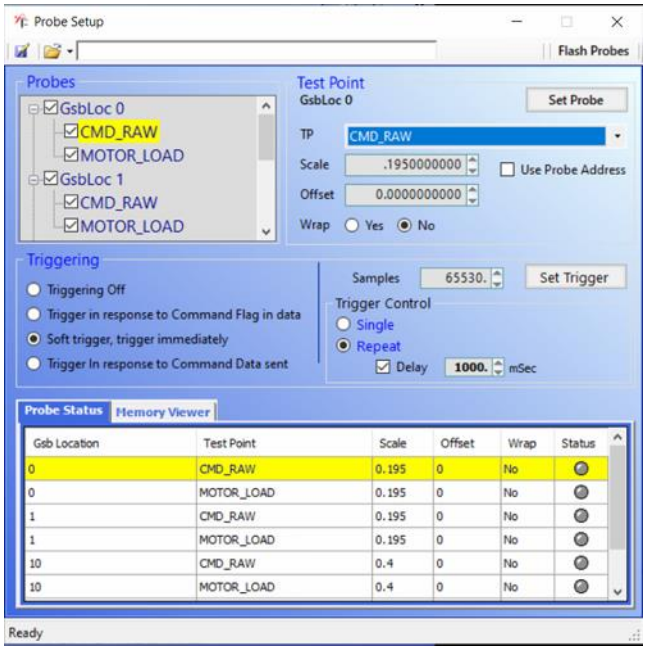
   c. Click **Set Probe** to commit the values.

   Trigger Settings:

   a. For general monitoring, set the *Triggering* mode to **Soft trigger, trigger immediately**.

   b. Increase the *Samples* count to a suitable number of samples for the measurement being taken.

      The maximum count is 65530.



c. Click **Set Trigger** to commit the values.

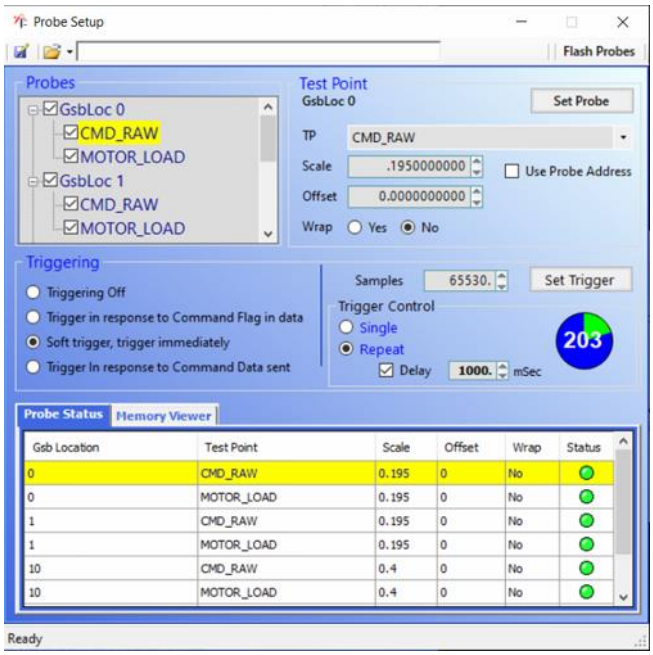
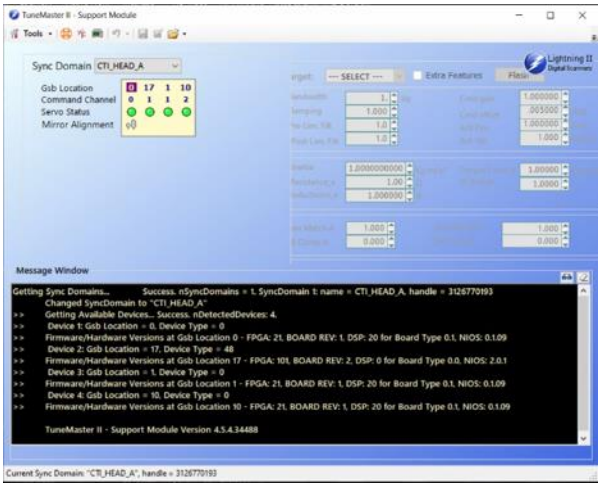


Figure 43: Setting the *Scale* and *Triggering*

6. From the tool bar, open the *Virtual scope* by clicking button ; see figure below.



TuneMaster II Support Module main screen

The virtual scope brings with it many of the common features of a real oscilloscope. Within the virtual oscilloscope we use the *Math 1* and *Math 2* options as shown in Figure 44 on page 90 to configure the scope to display trajectories.

7. Click on the *Scale all* button .

   The virtual scope displays a screen similar to that shown below.

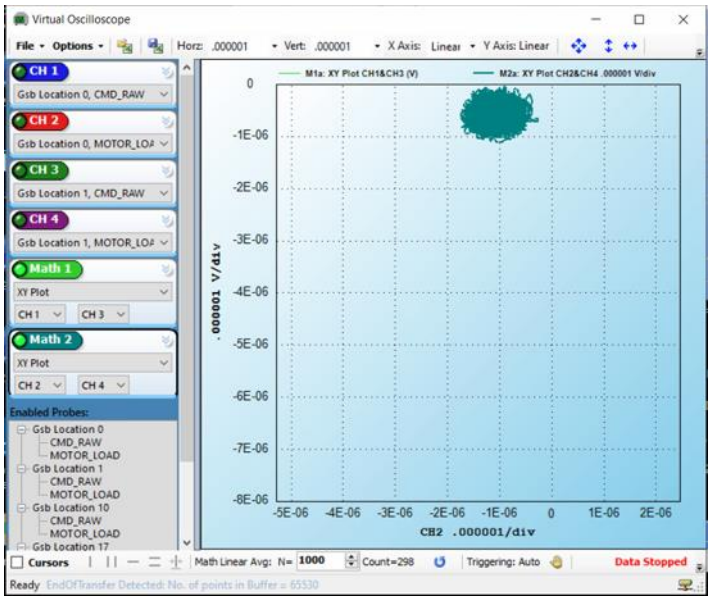


Figure 44: Virtual oscilloscope

8. Start the scanning job you wish to analyze.

   For the purposes at this example we use *ScanMaster Designer*, see Figure 45 on page 91, to scan a simple square as shown in the image below. In this example we iterate the square 100 times to give us time to observe and capture the trace within the virtual oscilloscope; see Figure 46 on page 91.

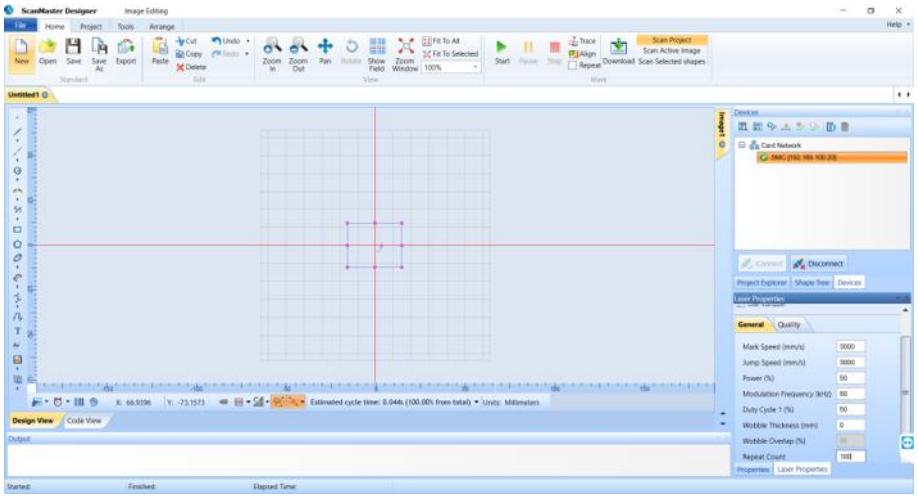


Figure 45: ScanMaster Designer

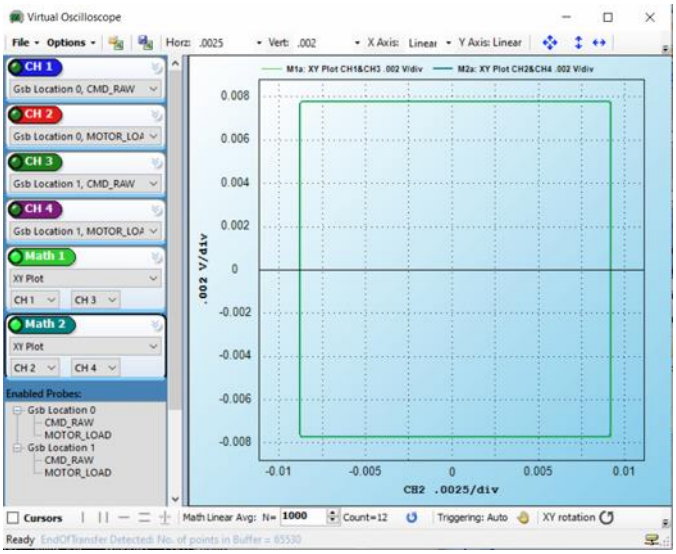


Figure 46: Example: Virtual Oscilloscope

By using the mouse wheel or creating a bounding box over the region of interest we can zoom in and out of the plot.

Referring to the example in Figure 47 on page 92 we can see how the actual scan path deviates from the ideal trajectory in the corner.

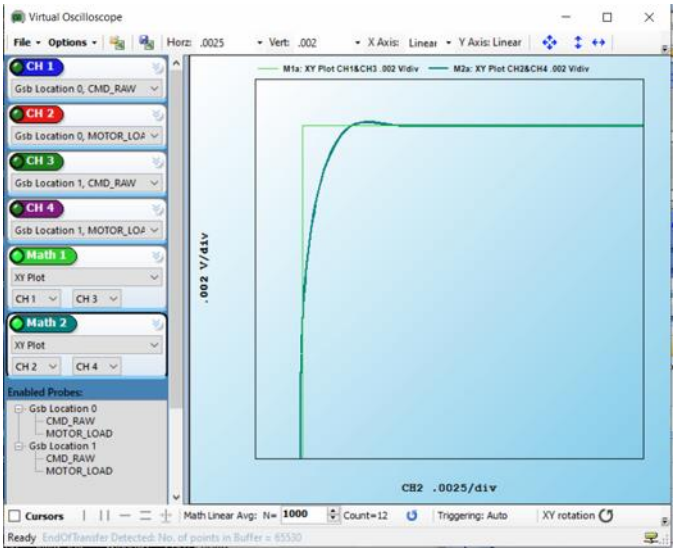


Figure 47: Example: Actual scan path deviates from ideal trajectories

This concludes our short introduction to functionality offered by TuneMaster™ II – Support Module. Should you require more information please contact your local Novanta representative or the download section of our website.

4.6 TUTORIAL: TUNE MODE SWITCHING

The purpose of this tutorial is to guide the reader through the following actions.

- Confirming the current tune status
- Exchanging tunes between *Traditional* and *Scan Pack* tune modes
- Confirming tune behavior

For the purpose of this guide, it is assumed that Firefly3D is in its default *Traditional* mode of operation. This is the default state when the product is shipped from the factory.

Please note that within this guide *Traditional* and *Vector* will be used interchangeably and refer to the same tune.

4.6.1 REQUIREMENTS

Switching between tunes requires that the user has the appropriate tune file. In the case of Firefly3D at the time of writing the 2 tunes and their associated file names are listed below.

Tune type	File name
Vector	CF-000944_L2Q30X3-xxxA-xx-Q489.TM2
Scan Pack	CF-000953_L2Q30X3-xxxA-xx-Q494.TM2

These files can be obtained from your Novanta representative on request. Firefly3D is shipped by default in *Vector* tune mode. The tuning is defined by the tune loaded and the control mode set in the ScanMaster Controller (SMC) configuration. This control mode is called *Command Generation Mode* (CGM).

4.6.2 CHECK THE TUNE MODE

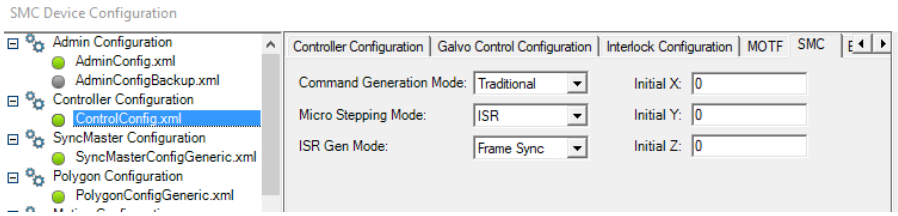
Target audience and qualification

Operators and experts

Procedure

1. Run the *Device Configuration Editor* to check the operation mode.
2. In the left-hand pane, click **ControlConfig.xml**.

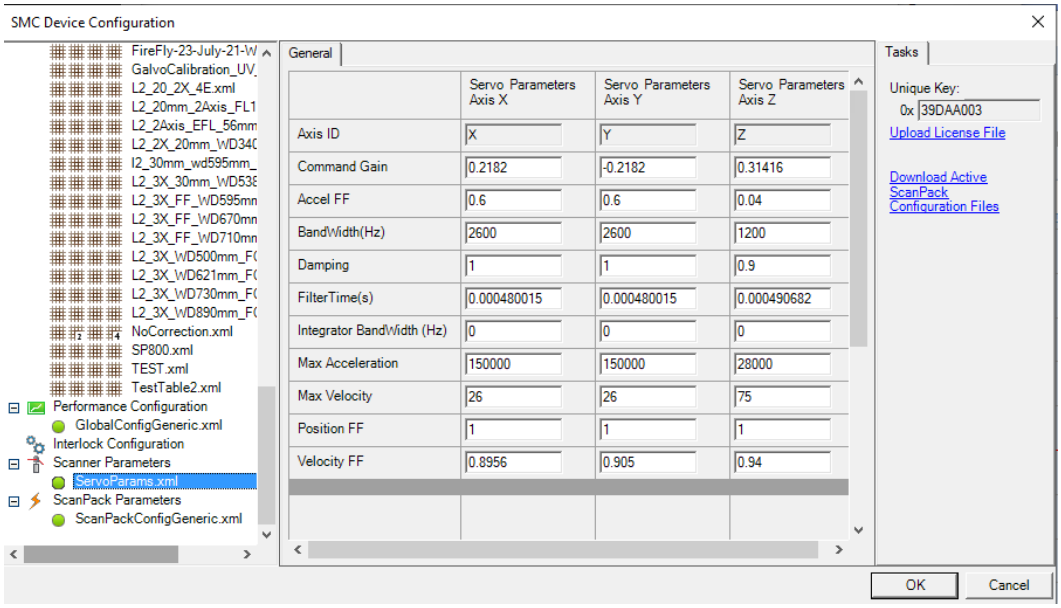
   As can be seen in the figure below, the *Command Generation Mode* is set to *Traditional* or *Vector* control mode.



It is wise to also have an awareness of the servo parameter settings initially.

3. In the left-hand pane, click **ServoParams.xml**.

   Observe the parameters as shown in the figure below.



4. Next, we are going to explore the *Traditional* / *Vector* tune mode behavior.

4.6.3 EXPLORING TRADITIONAL / VECTOR TUNE MODE BEHAVIOR

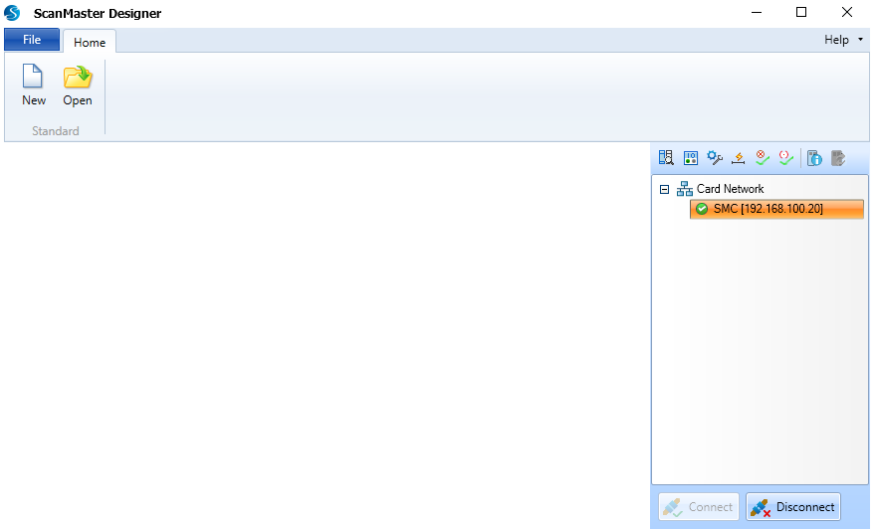
To confirm the operation mode practically, the following procedure in *ScanMaster Designer* can be followed.

Target audience and qualification

Operators and experts

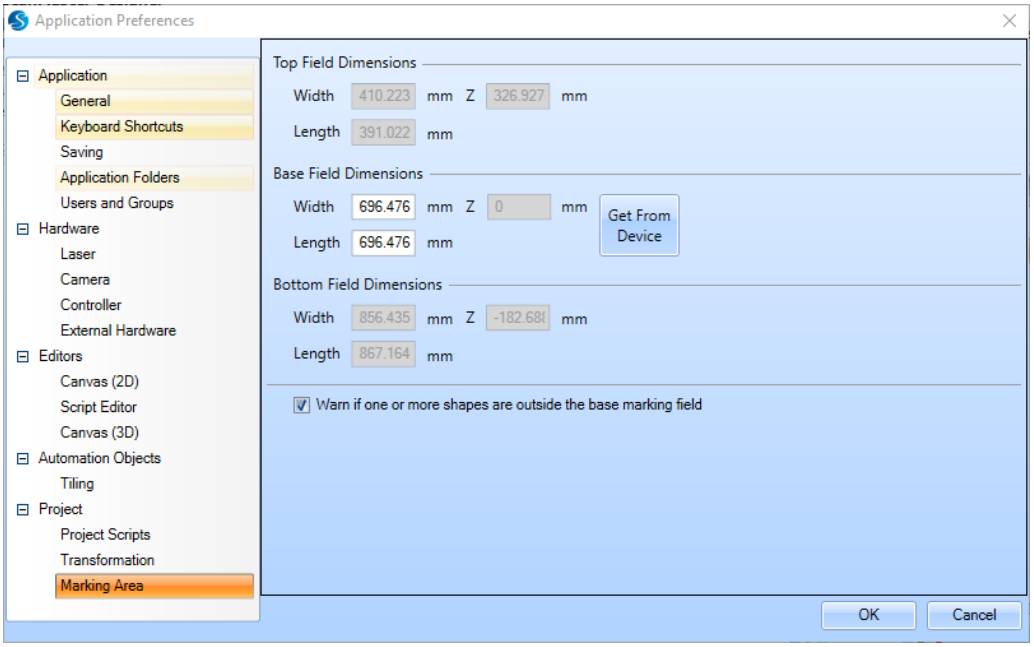
Procedure

1. Disconnect any other software that may be communicating with ScanMaster Controller (SMC), as this may interfere/prevent progression or successful completion of the procedure.
2. Start *ScanMaster Designer*, and when available double-click on the **SMC** to connect as shown in the figure below.

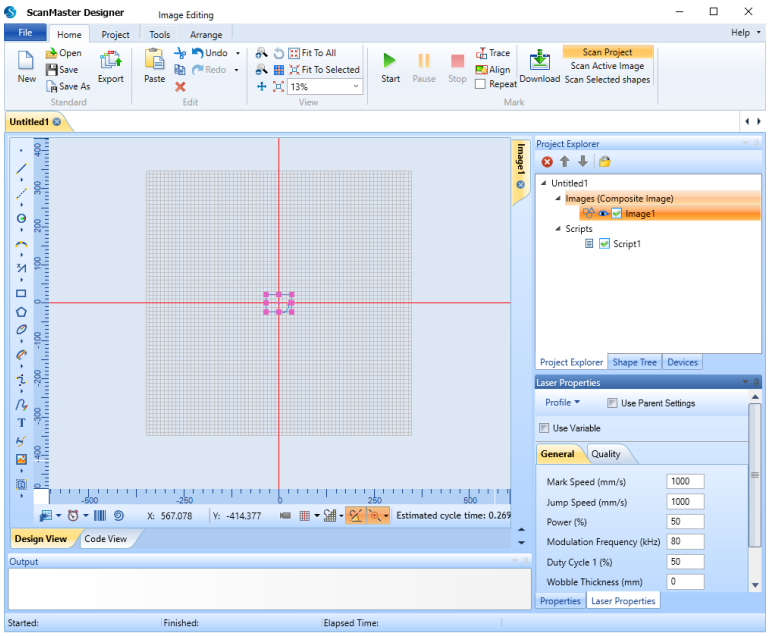


3. Navigate to **File → Preferences → Marking Area**.
4. Click on **Get From Device**.

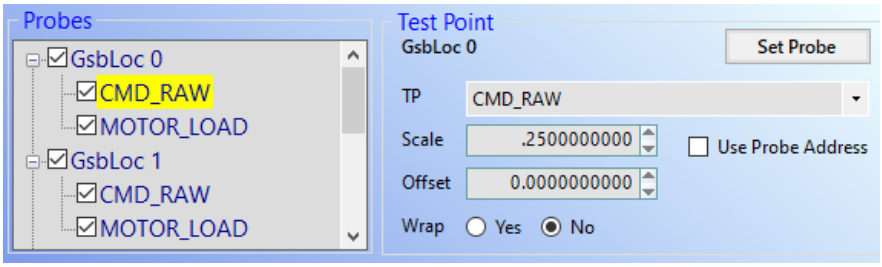
   This will load the base dimensions of the calibrated field, in this case 696 mm, as shown in the figure below.



5. Click on **OK** to close the window and return to the main screen.
6. Click on **New** to start a new project.
7. Draw a small square in the middle of the canvas.
8. Set up the *Mark Speed* to **1000** mm/s as shown below in the figure below.



9. Open *TuneMaster Support Module*, and configure the *Probes* as shown in the figure and table below.



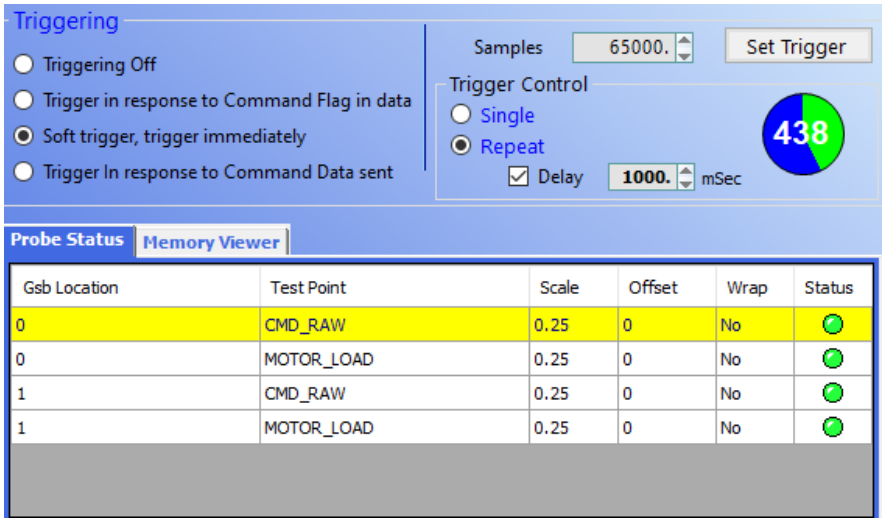
Channel	Probe name (TP)	Scale	Offset
GsbLoc 0	CMD_RAW	0.25	0.0
GsbLoc 0	MOTOR_LOAD	0.25	0.0
GsbLoc 1	CMD_RAW	0.25	0.0
GsbLoc 1	MOTOR_LOAD	0.25	0.0
GsbLoc 10	Disabled	n/a	n/a

Channel	Probe name (TP)	Scale	Offset
GsbLoc 17	Disabled	n/a	n/a

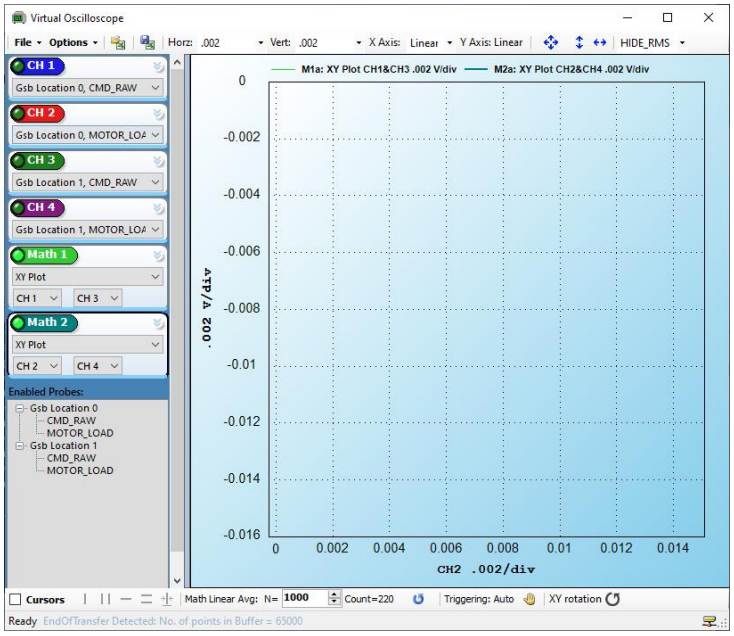
10. Set the *Triggering* as shown in the figure below.

11. Click on **Set Trigger** ensuring that all the LED's are lit as shown in the figure below.

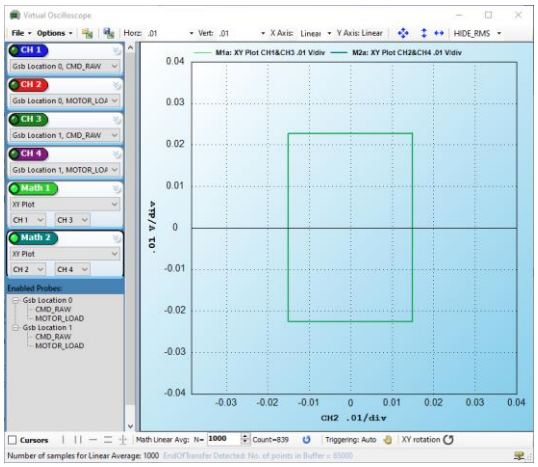
    Should this not happen within a few seconds, set the *Triggering* mode to **Triggering Off**, click **Set Trigger**, revert the *Triggering* mode to **Soft trigger, trigger immediately** and click on **Set Trigger** again.



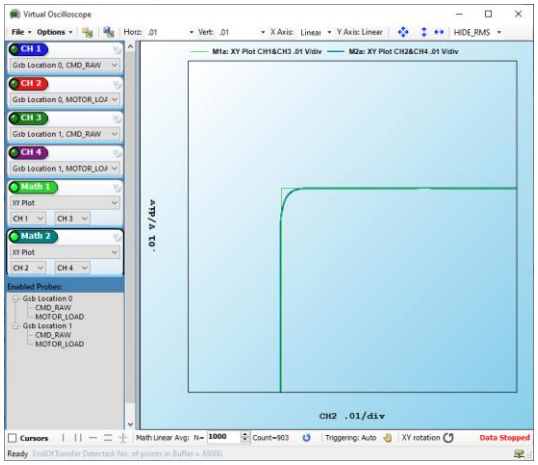
12. With the probe channels set up and active, the *Virtual Oscilloscope* now needs to be configured, as shown in the figure below.



13. Run the scan job from *ScanMaster Designer*, allowing enough repetitions to give enough time to capture the trace in the *Virtual Oscilloscope* as shown in the figure below.

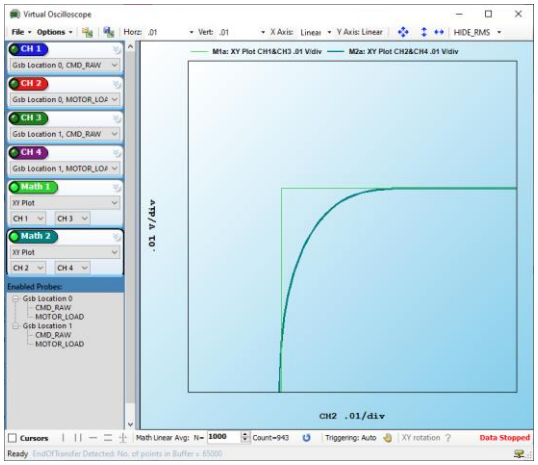


14. Zoom into the upper left corner and note the effect as shown in the figure below.



15. In *ScanMaster Designer* stop the scan job and increase the *Mark Speed* of the shape to a higher speed **such as 5000** mm/s.

    Note how the error increases as the system needs to cut the corner of the geometry to maintain as much speed as possible as shown in the figure below.



    This is typical behavior of a *Vector / Traditional* configured system.

16. Return to *TuneMaster II - Support Module*, main window.
17. Close all the windows except for the main one shown in the figure below (in next subsection).

    Next, we are going to switch the tune to *ScanPack* mode.

4.6.4 SWITCHING TO SCANPACK TUNE MODE

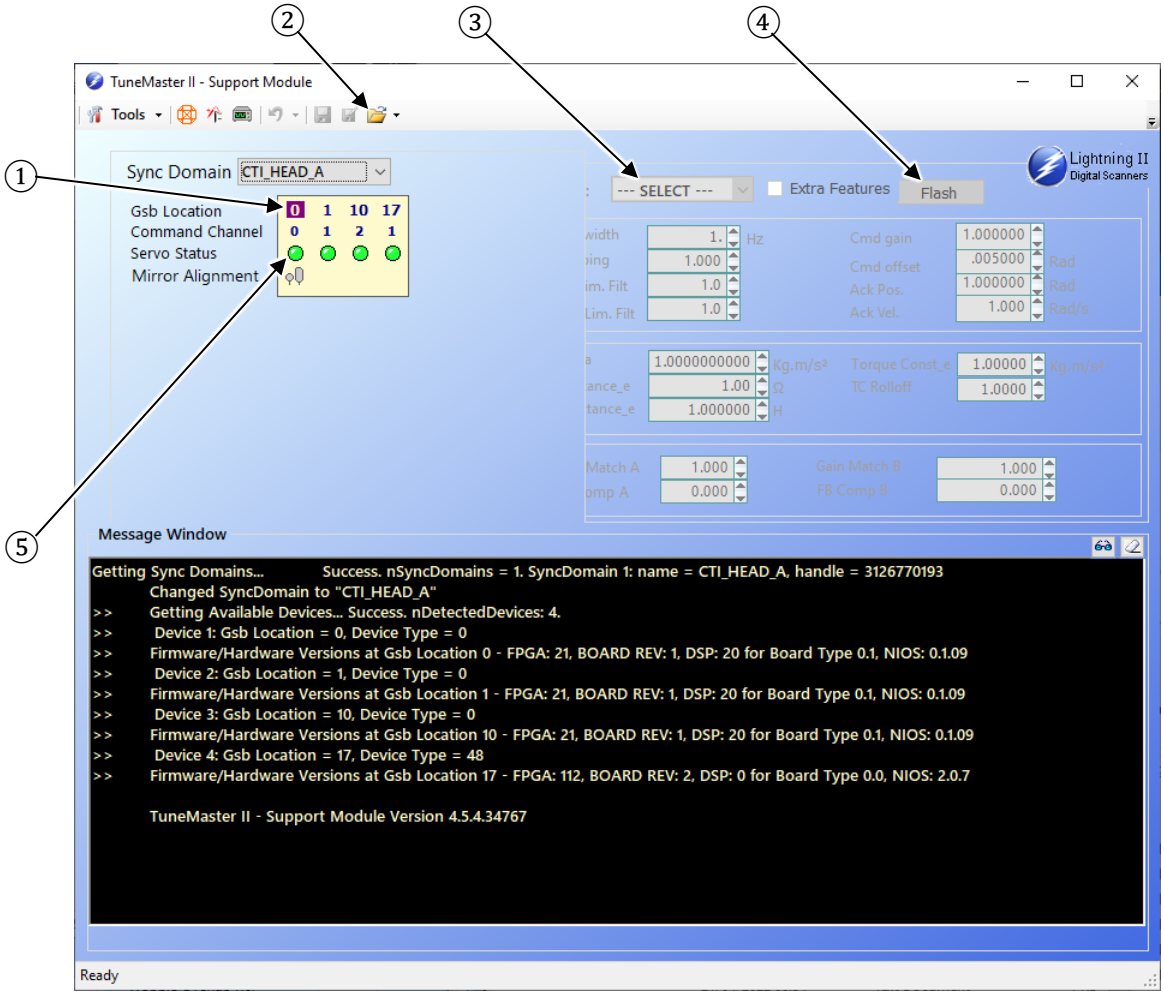
Target audience and qualification

Operators and experts

Procedure

It is often preferable to leave a few seconds between each step in the process described below.

1. In the *TuneMaster II - Support Module*, select **Gsb Location 0**; (1) in the figure below.



2. Select the folder icon; (2) in the figure above.

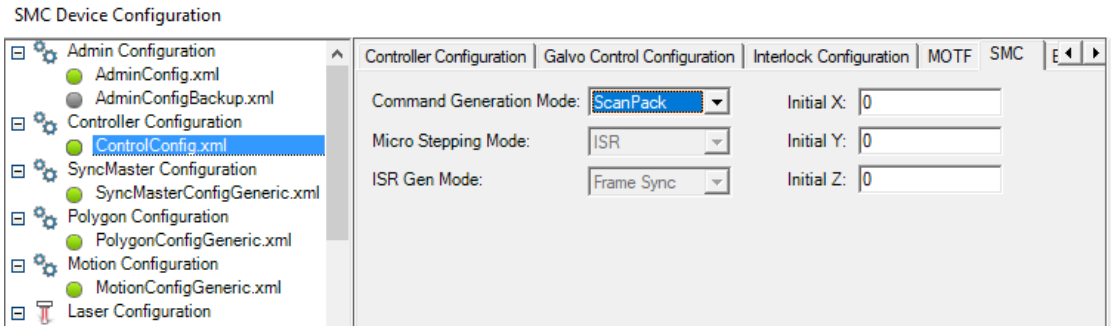
3. Select the *ScanPack* tune file, which in this case is as listed below CF-000953_L2Q30X3-xxxA-xx-Q494.TM2.

Tune type	File name
Traditional / Vector	CF-000944_L2Q30X3-xxxA-xx-Q489.TM2
ScanPack	CF-000953_L2Q30X3-xxxA-xx-Q494.TM2

4. Once the tune is loaded into *TuneMaster II – Support Module*, select **Reset** from the drop-down menu; (3) in the figure above.
5. Click on **Flash;** (4) in the figure above.

   It is often preferable to leave a few seconds between each step in the process described above.

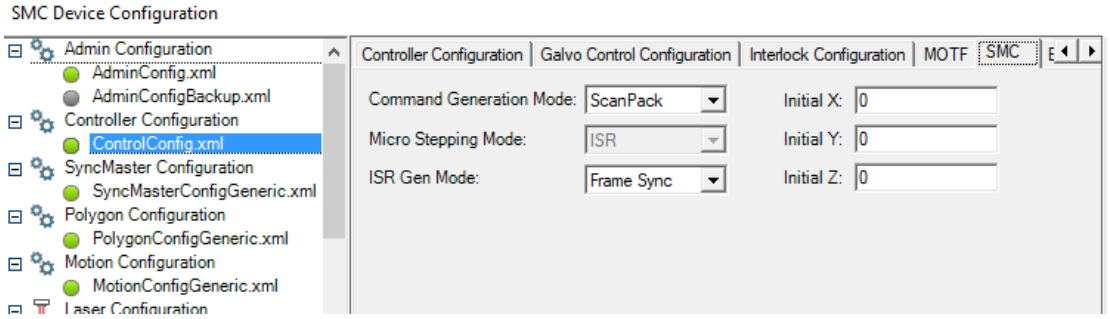
   To fix the tune in place the servo needs to be reset:
6. Click on the LED associated with the axis being worked on indicated by (5) in the figure above.
7. Repeat the process described above for *Gsb Locations* 1 and 10.
8. Make sure you have disconnected from *ScanMaster Designer*.
9. Use the *Device Configuration Editor* to set the *Command Generation Mode* to **ScanPack** as shown in the figure below.

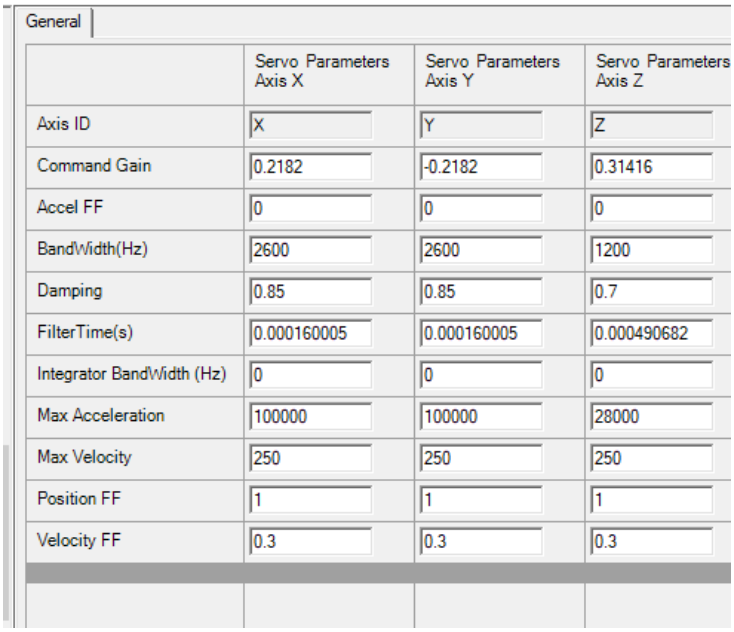


10. Power cycle both, the SMC and Firefly3D.
11. Open *Device Configuration Editor* again and check the *Command Generation Mode* and *Servo Parameters*.

They should be similar to that shown in the next 2 figures.

The change in *Max Velocity* is indicative of a correctly configured *ScanPack* system.





4.6.5 EXPLORING SCANPACK TUNE MODE BEHAVIOR

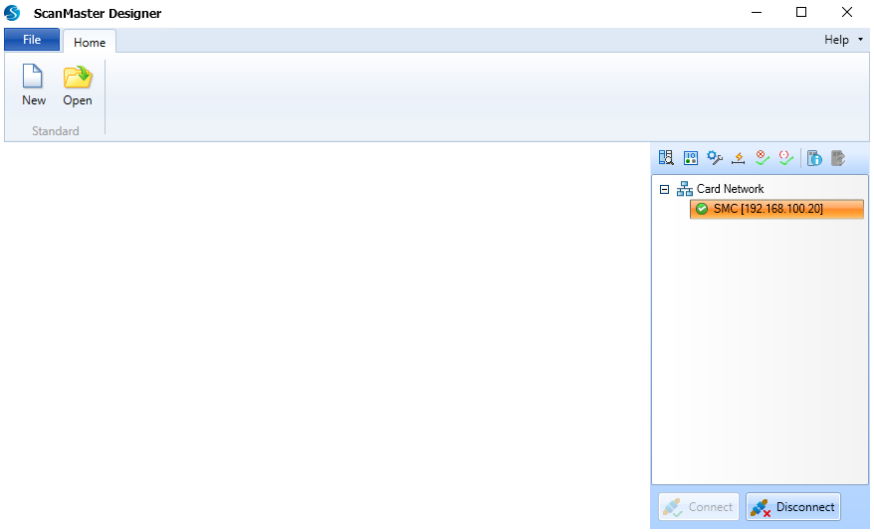
To confirm the operation mode practically, the following procedure in *ScanMaster Designer* can be followed.

Target audience and qualification

Operators and experts

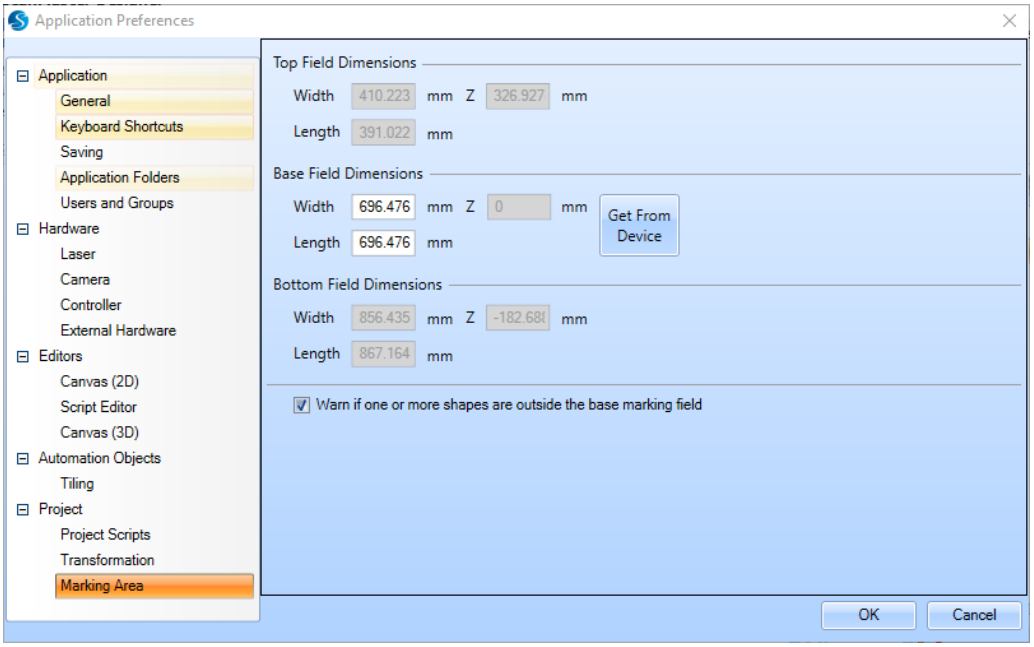
Procedure

1. Disconnect any other software that may be communicating with ScanMaster Controller (SMC), as this may interfere / prevent progression or successful completion of the process defined below.
2. Start *ScanMaster Designer*, and when available double-click on the **SMC** to connect as shown in the figure below.

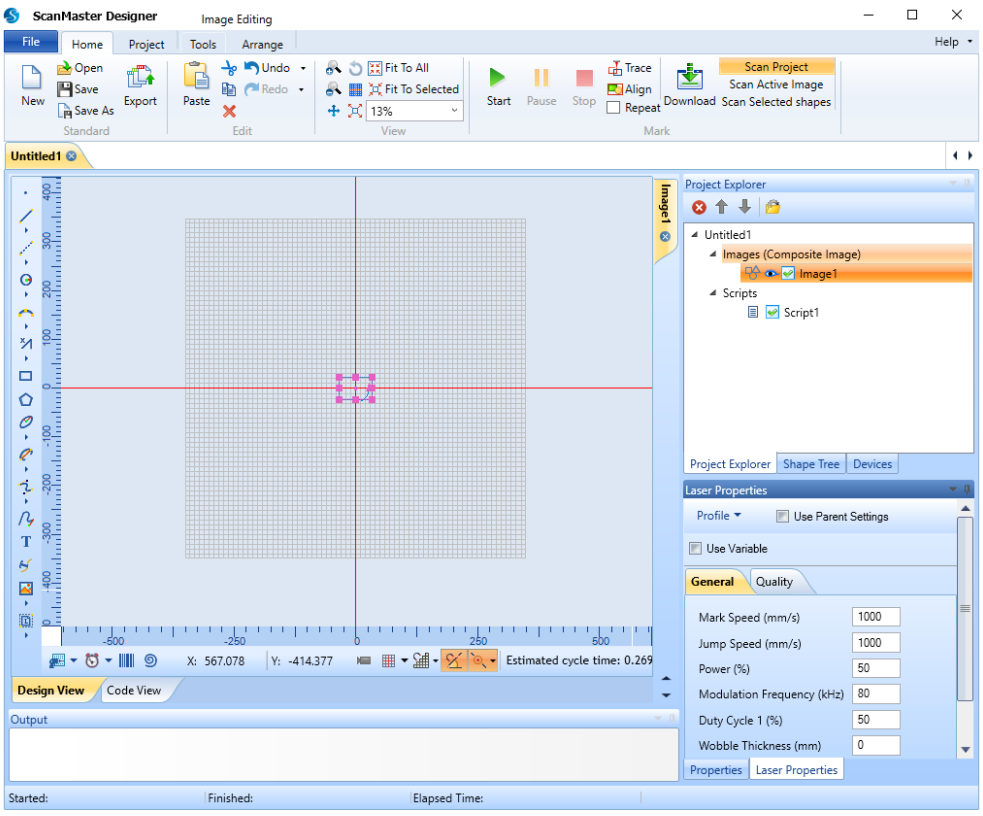


3. Navigate to **File → Preferences → Marking Area**.
4. Click on **Get From Device**.

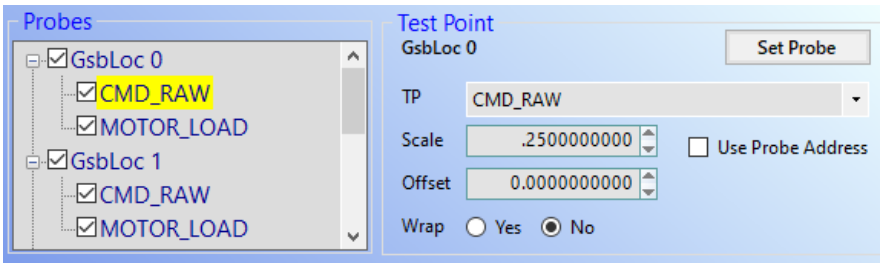
   This will load the base dimensions of the calibrated field, in this case 696 mm, as shown in the figure below.



5. Click on **OK** to close the window and return to the main screen.
6. Click on **New** to start a new project.
7. Draw a small square in the middle of the canvas.
8. Set up the *Mark Speed* to **1000** mm/s as shown in the figure below.



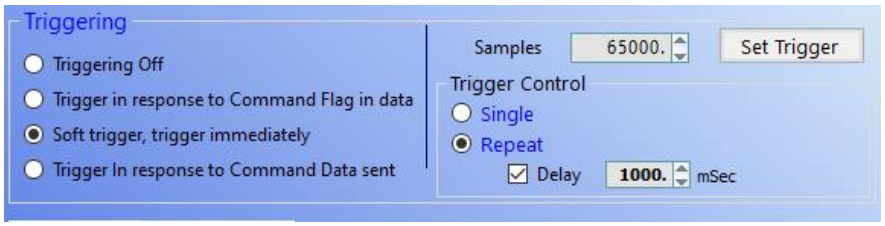
9. Open *TuneMaster Support Module*, and configure the *Probes* as shown in the figure and table below.



Channel	Probe name (TP)	Scale	Offset
GsbLoc 0	CMD_RAW	0.25	0.0
GsbLoc 0	MOTOR_LOAD	0.25	0.0
GsbLoc 1	CMD_RAW	0.25	0.0

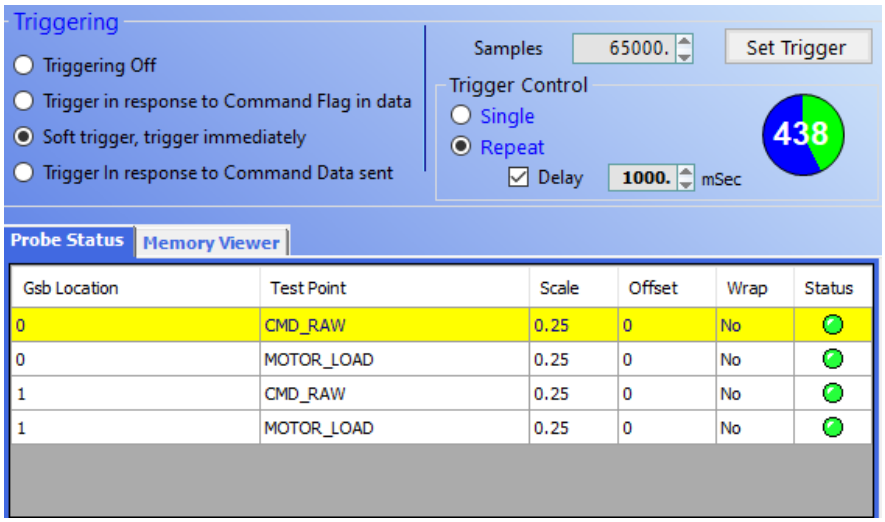
Channel	Probe name (TP)	Scale	Offset
GsbLoc 1	MOTOR_LOAD	0.25	0.0
GsbLoc 10	Disabled	n/a	n/a
GsbLoc 17	Disabled	n/a	n/a

10. Set the *Triggering* as shown in the figure below.

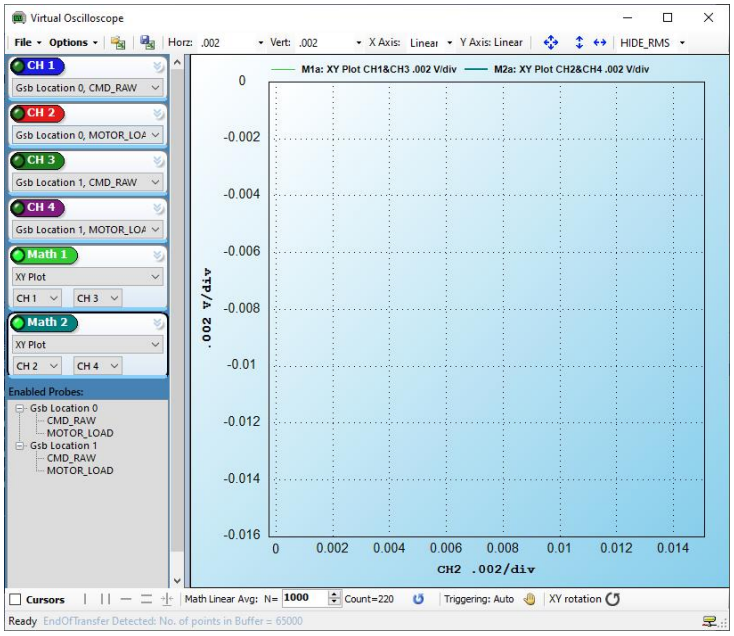


11. Click on **Set Trigger** ensuring that all the LED's are lit as shown in the figure below.

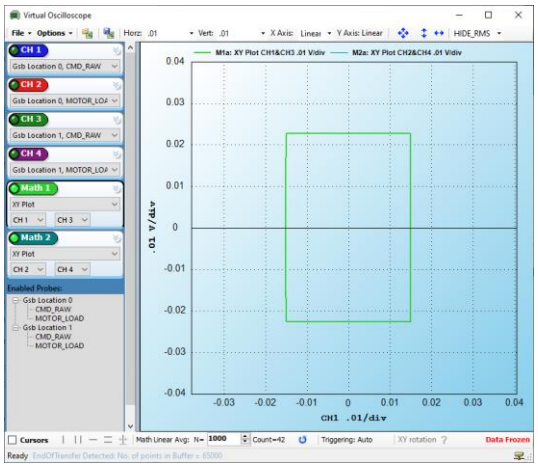
    Should this not happen within a few seconds, set the *Triggering* mode to **Triggering Off**, click **Set Trigger**, revert the *Triggering* mode to **Soft trigger, trigger immediately** and click on **Set Trigger** again.



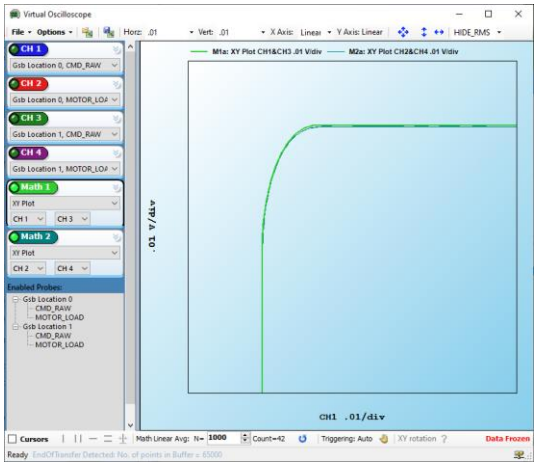
12. With the probe channels set up and active, the *Virtual Oscilloscope* now needs to be configured, as shown in the figure below.



13. Now run the scan job from *ScanMaster Designer*, allowing enough repetitions to give enough time to capture the trace in the *Virtual Oscilloscope* as shown in the figure below.

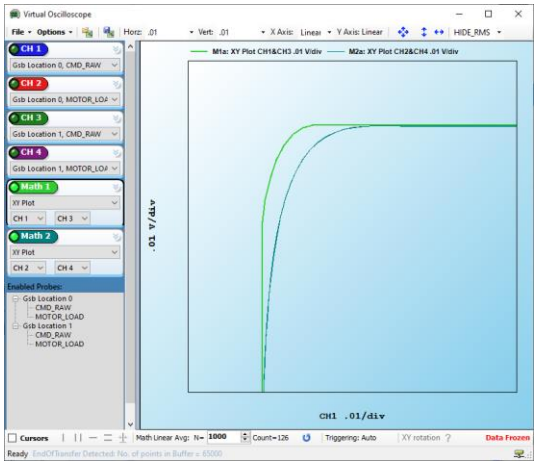


14. Zoom into the upper left corner and note the effect shown in the figure below.

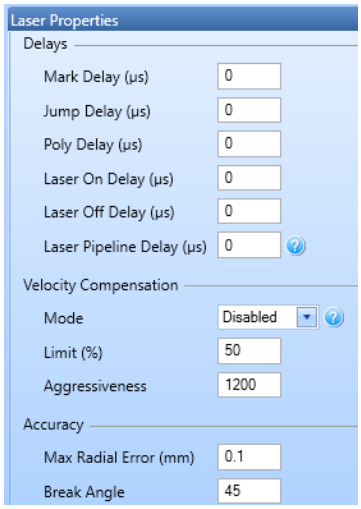


15. In *ScanMaster Designer* stop the scan job and increase the *Mark Speed* of the shape to a higher speed such as **5000** mm/s.

    Note how the error increases as the system needs to cut the corner of the geometry to maintain as much speed as possible as shown in the figure below.

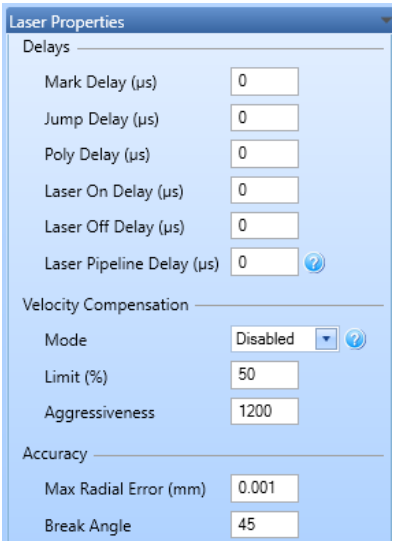


    Note the quality settings in the figure below. We have set all the *Delays* to *zero*. Eventually these will be replaced in part by system parameters. Key to note here is the *Max Radial Error* is quite large at 0.1 mm. This allows *ScanPack* to soften the corner.

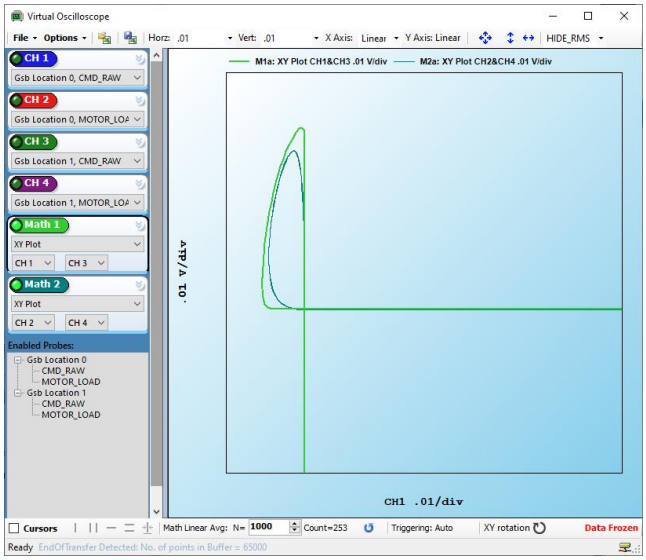


16. Now, let's tighten up the *Accuracy* criteria to **0.001** as shown in the figure below.

    Given this tighter accuracy criteria, *ScanPack* will execute a repositioning trajectory automatically to attempt to comply with the accuracy target set.



    The behavior shown in the figure below is typical behavior of a *ScanPack* configured system.


Virtual Oscilloscope
File Options
Horz: .01
Vert: .01
X Axis: Linear
Y Axis: Linear
HIDE_RMS
CH 1
Gsb Location 0, CMD_RAW
CH 2
Gsb Location 0, MOTOR_LOA
CH 3
Gsb Location 1, CMD_RAW
CH 4
Gsb Location 1, MOTOR_LOA
Math 1
XY Plot
CH 1
CH 3
Math 2
XY Plot
CH 2
CH 4
Enabled Probes:
Gsb Location 0
CMD_RAW
MOTOR_LOAD
Gsb Location 1
CMD_RAW
MOTOR_LOAD
M1a: XY Plot CH1&CH3 .01 V/div
M2a: XY Plot CH2&CH4 .01 V/div
.01 V/div
CH1 .01/div
Cursors
Math Linear Avg: N= 1000
Count=253
Triggering: Auto
XY rotation
Data Frozen
Ready
EndOfTransfer Detected: No. of points in Buffer = 65000

5 OPERATING

5.1 OPERATIONAL PROCEDURES

Firefly3D cannot be directly controlled.

Target audience and qualification

Operators and experts

Requirements

- ☐ You have successfully finished all necessary commissioning procedures.
- ☐ The laser unit, where the scan head is incorporated, complies with the standards and directives that are required by the declarations of incorporation of all laser unit components.

Procedure

- Control the scan head and the laser via the controlling system.

  Please find further reading in the documentation of the installed hardware and software components.

5.2 OBSERVABLE SIGNALS

Firefly3D does not provide any visual or audible means to indicate whether the product is operational.

5.3 TROUBLESHOOTING

Target audience and qualification

Experts

Safety precautions

Firefly3D does not provide any visual of audible means to indicate whether the product is operational.

Firefly3D contains a high-performance beam steering system, precision optical chain which is designed to emit:

- high power laser beams wavelength of 1070 nm at powers exceeding 1 kW
- red pointing laser light at 633 nm

During normal operation high power laser emission is expected and exposure must be avoided.

⚠ WARNING

Visible or invisible laser radiation can cause severe retinal and corneal burns, burns to the skin, and may pose a fire risk.

- DO NOT look through the exit window to view the mirrors and determine whether the mirrors move under command. Instead follow the procedure given below.
- Switch off the laser emission.
- Wear appropriate laser safety glasses.
- Restrict access to the area where the alignment is done, to the persons who perform the adjustment and who wear appropriate laser safety glasses.
- To avoid injury and reduce risk of fire, follow the control measures and safety guidelines provided by the laser's manufacturer, and those established by your Laser Safety Officer (LSO), Radiation Safety Officer (RSO), or safety department of your business or institution.

The scan head contains beryllium mirrors.

WARNING

Beryllium is classified as carcinogenic substance of category 1B and hazard class STOT RE1. This applies especially to beryllium as dust or vapor, i.e., if the beryllium mirrors are damaged. Beryllium causes eczema, berylliosis and cancer when getting in contact with skin or inhaled.

- DO NOT open the scan head. DO NOT remove the protective windows.
- If the housing is not sealed according to degree of protection IP65 AND if the beryllium mirrors are damaged, then immediately follow the response procedure in section 8.2 on page 127.

IMPORTANT

DO NOT attempt to remove any covers or dissemble any part of the scan head. There are no user serviceable parts inside, and the warranty will be invalidated.

Procedure

1. Read and follow all sections within this manual, especially the steps and actions described within chapter 4 on page 22 ff.
2. If Firefly3D still does not function as expected, then check the following:
    a. Check fuses and circuit breakers in any mains power supply.
    b. Check if all cables are connected correctly, especially that the PHOENIX CONTACT cables are correctly and fully screwed in place to ensure a good connection is attained.
    c. Check for any damage to cables and connections.

d. Check if the protective covers are removed from the main exit window on the base of the scanner and from monitoring ports that are in use.

⚠ WARNING

Protective covers removed from unused monitoring ports can expose the user to laser radiation.

- If you do not use a monitoring port, then leave the respective protective cover in place.

e. Confirm that after the ScanMaster Controller (SMC) is powered for more than 1 minute there are only 7 green LEDs and no red LEDs lit on the SMC, see Figure 48 on page 115.

This step might not be feasible as the SMC might be incorporated in a machine, so the LEDs are not visible.

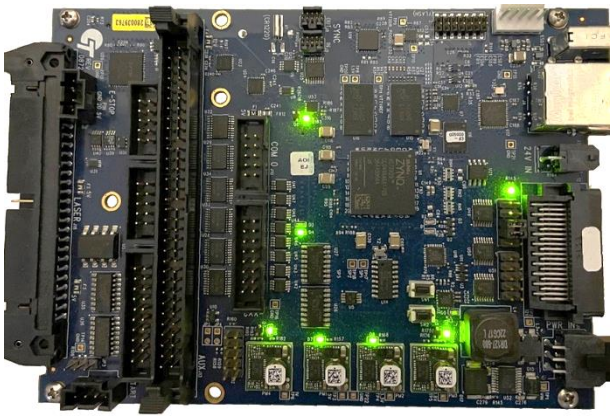


Figure 48: 7 green LEDs if the ScanMaster Controller is powered

f. Confirm that the SMC is powered. This is detectable using the *Broadcast Monitor* software. A screen similar to that shown in Figure 49 on page 116 should be seen if the SMC is powered and connected correctly.

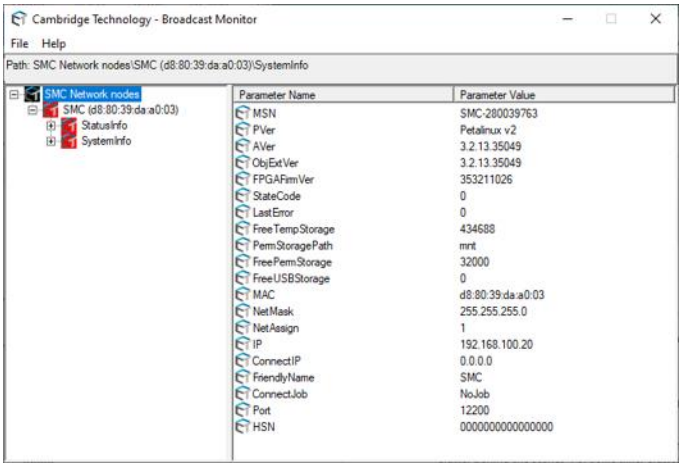


Figure 49: Example: Broadcast Monitor screen

g. Often the Ethernet IP settings of the computer connected to the SMC are configured incorrectly. This gives the impression that Firefly3D is not functional. The Ethernet adapter properties shown below reflect a correct configuration for an SMC that is set to its default IP address of 192.168.100.20.

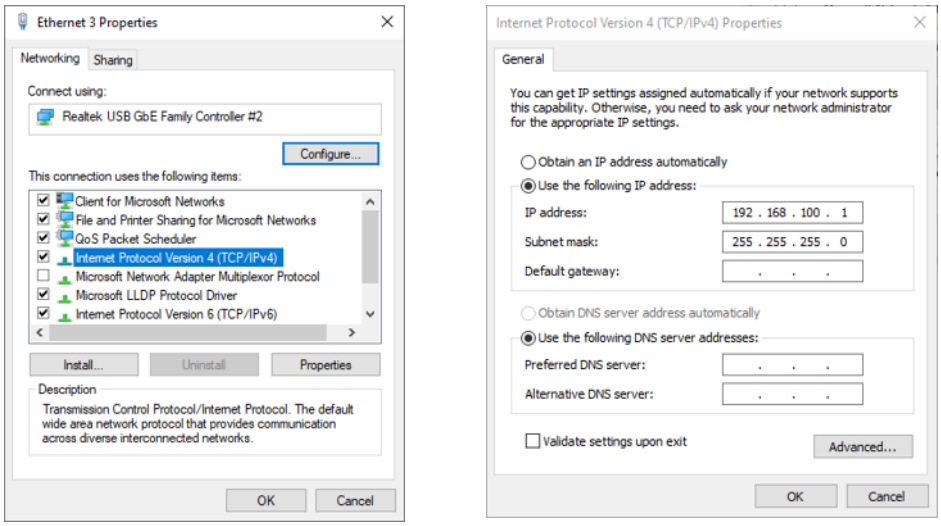


Figure 50: Example: Ethernet properties

3. If, after checking the points listed above no defects have been found then proceed with the additional diagnostic steps descried below:

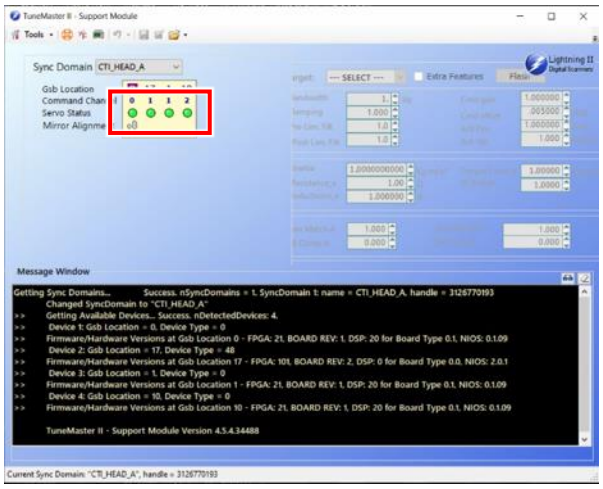
a. Connect Firefly3D to a ScanMaster Controller (SMC) as shown in the diagram in section 4.3.12 on page 55.

   Note once again, the laser emission should be switched off before starting to undertake these diagnostic tests.

b. If the TuneMaster II software is not already installed, then install it by following the procedure described in section 4.5.1 on page 78.

c. In the TuneMaster II software, there must be 4 green LEDs lit as shown in the figure below.

   If this is the case, the product is ready to receive positioning commands.



TuneMaster II Support Module main screen

d. Should the TuneMaster II screen indicate any LEDs colored red or yellow then switch off the power to FRIEFLY 3D and contact your local Novanta representative for further guidance and support; see page 2.

e. Should performance or dynamic operation be a concern, continue with the procedure to obtain Bode and Friction plots on page 83.

If no issues are identified whilst working through the procedure above, functionally the product should be operational. However, if this guide does not address the specific issue experienced, please contact your local Novanta representative for further guidance and support; see page 2.

6 CLEANING, MAINTAINING, AND REPAIRING

Cleaning, maintaining, and repairing are limited to the procedures described in this chapter. If other measures become needed, please contact our customer support; see page 2.

6.1 CLEANING

The protective windows at the laser beam entrance and exit may require cleaning from time to time. The necessity for cleaning depends on how contaminated the protective windows are, i.e., when the work results become unacceptable. It is good practice to clean the protective windows only if it really is necessary, as each cleaning degrades the quality of the optical coating.

Target audience and qualification

Experts

Safety precautions

- ☐ Switch off the laser unit, where the scan head is incorporated. Switch off the laser device, power supply, cooling and particularly disable moving parts.

Procedure

The scan head contains beryllium mirrors.

⚠ WARNING

Beryllium is classified as carcinogenic substance of category 1B and hazard class STOT RE1. This applies especially to beryllium as dust or vapor, i.e., if the beryllium mirrors are damaged. Beryllium causes eczema, berylliosis and cancer when getting in contact with skin or inhaled.

- Clean the protective windows only from the outside.

  DO NOT open the scan head. DO NOT remove the protective windows.
- If the housing is not sealed according to degree of protection IP65 AND if the beryllium mirrors are damaged, then immediately follow the response procedure in section 8.2 on page 127.

6.2 MAINTAINING

We recommend creating a maintenance plan. The maintenance intervals depend on the degree of contamination in the work environment.

Table 16: Maintenance plan

Interval	Measure	See section	On page
Annually	• Check the laser unit and the incorporated scan head according to standard EN 60204. Check the electrical safety of all connecting cables and particularly the mains cable.	–	–

6.3 REPAIRING

There are no user serviceable parts inside the scan head. Opening or disassembly of the scan head could risk your safety and safe operation of the scan head and will invalidate the warranty.

Please contact our customer support team for assistance; see page 2.

7 DECOMMISSIONING, RETURNING, AND DISPOSAL

7.1 DECOMMISSIONING

Target audience and qualification

Experts

Requirements

☐ Decommission the scan head only if you want to return it, were instructed to do so, or if you want to dispose of it.

Have ready

☐ Suitable screwdriver for the mounting screws

☐ Tissues or similar, to absorb leaking coolant immediately

☐ Original protective covers for the laser beam entrance and exit

Safety precautions

- Switch off the laser unit, where the scan head is incorporated. Switch off the laser device, power supply, cooling and particularly disable moving parts.

Procedure

1. Disconnect the power supply line from the scan head.
2. Disconnect the remaining electrical lines from the scan head.
3. Turn off the coolant supply line first and then the return line.

4. Relieve the pressure from the hose.

IMPORTANT

Leaking coolant can cause a short circuit and/or damage optics.

- Get some tissues or similar ready to absorb leaking coolant immediately.
- Deposit the open hose tips in a way that coolant cannot leak or contain the coolant in a tank.

5. Disconnect the cooling supply lines from the scan head.
6. Dismount the scan head from the laser unit.
7. Fix the protective covers over the laser beam entrance and exit.

   If you cannot find the original protective covers then we recommend Polyamide tape.

IMPORTANT

Temperatures lower than 0 °C (273 K) can cause frost damage to the cooling loop.

8. Blow-dry the scan head's cooling loop.

   The scan head is equipped with self-sealing couplings. Therefore, it is required opening the coupling's sealings. This can be done by connecting open-ended counterparts to the couplings.

   Blowing the cooling loop dry prevents the destruction of the self-sealing couplings when accidently transporting the scan head at temperatures lower than 0 °C (273 K).

9. Clear the scan head of contamination with any dangerous materials prior to further handling.
10. Dispose of the coolant according to its material safety data sheet.

7.2 RETURNING

This section describes how to prepare the scan head if you want to return it.

Target audience and qualification

Laymen, operators, and experts

Requirements

- ☐ The scan head has been decommissioned; see section 7.1 on page 121.
- ☐ The scan head has been cleared of contamination with any dangerous materials prior to return to Novanta.

Have ready

- ☐ Original packaging or an equivalent packaging
- ☐ Parcel tape

Procedure

1. Find the contact information for customer support, see page 2, and contact us.

   You will receive instructions about how to proceed.

   IMPORTANT

   The scan head contains beryllium mirrors; consider section 2.4.3 on page 14.

2. If you are instructed to return the scan head, then package it in its original or equivalent packaging to prevent damage during transport.

   As memory aid use the documentation that you may have taken during unpacking.

3. Arrange for return consignment.

7.3 DISPOSAL

This scan head is designed to be integrated into large-scale stationary industrial tools, therefore 2012/19/EU (WEEE) does not apply.

By ensuring the scan head is disposed correctly, you will help prevent potential negative consequences to the environment and human health, which could otherwise be caused by

inappropriate waste handling of the scan head. The recycling of materials will help to conserve natural resources.

Target audience and qualification

Laymen, operators, and experts

Requirements

- ☐ The scan head has been decommissioned; see section 7.1 on page 121
- ☐ The scan head has been cleared of contamination with any dangerous materials prior to disposal

Procedure

The scan head contains beryllium mirrors.

⚠ WARNING

Beryllium is classified as carcinogenic substance of category 1B and hazard class STOT RE1. This applies especially to beryllium as dust or vapor, i.e., if the beryllium mirrors are damaged. Beryllium causes eczema, berylliosis and cancer when getting in contact with skin or inhaled.

- DO NOT open the scan head. DO NOT remove the protective windows.
- If the housing is not sealed according to degree of protection IP65 AND if the beryllium mirrors are damaged, then immediately follow the response procedure in section 8.2 on page 127.

- Dispose of the scan head as hazardous waste and hand it over to the applicable collection point or to the manufacturer as described in section 7.2 on page 122.

  For more detailed information, please contact your local city office, your disposal service, or our customer service; see page 2.

8 APPENDIX

8.1 INTERFACING EQUIPMENT

The given part numbers are the manufacturer's part numbers.

Table 17: Required interfacing equipment

Figure	Description
	**ScanMaster Controller** The following part numbers are compatible with Firefly3D. Call for part number SMC-04-5-1-01-00-007 – OR – SMC-04-5-1-01-00-81F – OR – SMC-04-5-1-01-01-007 – OR – SMC-04-5-1-01-01-81F Part number code: **SMC - XX - X - X - XX - XX - XXX O** **007** SM API **81F** ScanMaster Designer license in addition to SM API **00** No expansion board **01** Expansion board **01** Power cable **5 - 1** Firefly3D connection kit **04** High power laser adapter

Figure	Description
	**Mating connector for cooling at the scan head** by Rectus/Parker Part number 21SBK006RVX
	**Mating connector for cooling at the laser interface adapter** by Rectus/Parker Part number 20SBK006RVX
	**PU tubing** by Parker/Legris Outer Ø 6 mm, inner Ø 4 mm, length 25 m, color clear, max. pressure 12 bar (12000 hPa), max. temperature 70 °C (343 K), part number 1025U06R08
	**HSSO interconnecting cable** by PHOENIX CONTACT Length 1 m, male – male, part number 1407434; Length 2 m, male – male, part number 1407435; Length 5 m, male – male, part number 1407436; Length 5 m, male – unterminated, part number 1408743; Length 10 m, male – unterminated, part number 1408744
	**Process monitoring sensor interconnecting connector** by PHOENIX CONTACT Straight male connector, part number 1424662; Straight male data (500 kBit/s) connector, part number 1424674 Angled male connector, part number 1424663; Angled male data (500 kBit/s) connector, part number 1424675
	**GSBus interconnecting cable** by PHOENIX CONTACT Length 5 m, part number 1402421; Length 10 m, part number 1402422

Figure	Description
	**Power supply interconnecting cable** by PHOENIX CONTACT Length 2 m, female – unterminated, part number 1558360; Length 5 m, female – unterminated, part number 1558373
–	**Mating product for thermopile connector** by binder-connector On website, set filter for: subminiature connector, number of contacts 2, lock M9, degree of protection IP67, version connector male angled – OR – straight

8.2 BERYLLIUM RESPONSE PROCEDURE

Firefly3D contains beryllium mirrors. Under normal circumstances, i.e., if the housing and protective windows and the beryllium mirrors are undamaged and if the product is handled and used properly then the beryllium mirrors present no danger. Danger may only arise if the beryllium mirrors are damaged and the housing is not sealed according to degree of protection IP65, as the damage may have produced small quantities of beryllium dust that may not be visible.

Minimizing staff exposure and limiting the spread of any contamination can be achieved through the following simple containment procedure.

IMPORTANT

- Be prepared for an incident, prepare a response pack, and have it near the product. This enables a smooth response.

Response pack

We suggest a response pack containing the following simple equipment:

- ☐ Wet wipes
- ☐ Disposable coveralls, gloves, and overshoes

- ☐ Dust mask P2 (FFP3-4)
- ☐ Various warning signs
- ☐ Tape
- ☐ Pre-labelled heavy-duty disposal bags

Response procedure

1. Ensure that any nearby electrical supplies are isolated.
2. Locate the response pack, see above, and have it nearby.
3. Take a wet wipe and gently lay it over the damage area without disturbing it.
4. Put on the dust mask, gloves, overshoes, and coverall.
5. Envelop the damaged part into the wet wipe and place it into the disposal bag.
6. Clean the immediate area with clean wet wipes several times, until all contamination is removed. Used wipes go in a second disposal bag.
7. Remove your coverall, overshoes, gloves, and dust mask and place them into the second disposal bag.
8. Seal both disposal bags immediately, but do not squeeze out the air.
9. Label the disposal bags as hazardous waste.
10. Wash your hands.
11. Report the incident to your health and safety officer and to your company management.
12. Arrange for disposal and return consignment.

8.3 FURTHER READING

Please find further reading in the documentation of the installed hardware and software components.

8.4 DECLARATION OF INCORPORATION

Please turn the page.

Novanta

Declaration of incorporation within the meaning of the Machinery Directive 2006/42/EC Annex II 1B

Product	Firefly3D		
Manufacturer	Novanta Europe GmbH Werk 4 92442 Wackersdorf Germany	The person authorized to compile the relevant technical documentation	Martin Hartmann (Director Engineering), manufacturer's address

The manufacturer declares that the above-named product is an incomplete machine within the meaning of the Machinery Directive. The product is exclusively intended to be incorporated into a machine or an incomplete machine and therefore does not comply with all the requirements of the Machinery Directive.

A list of the essential requirements of the Machinery Directive that apply to this product and with which it complies can be found in the Annex to this declaration.

Commissioning of the product is prohibited until it has been established that the machine into which the above-named product is incorporated complies with all essential requirements of the Machinery Directive.

The person authorized to compile the technical documentation undertakes to send the documentation to the national authorities in response to a reasoned request. The documentation is sent by post in paper format or by electronic media.

The above-named product fulfills the requirements of the following EC Directives:

- RoHS Directive 2011/65/EU
- EMC Directive 2014/30/EU

The following harmonized European standards have been applied:

- DIN EN ISO 12100:2010 Safety of machinery – General principles for design – Risk assessment and risk reduction
- DIN EN 60204-1:2018 Safety of machinery – Electrical equipment of machines
- DIN EN 60825-1:2014 Safety of laser products
- DIN EN IEC 61000-6-4:2020 Electromagnetic compatibility (EMC)
- DIN EN 61000-4-2:2009 Electromagnetic compatibility (EMC)
- DIN EN 61000-4-3:2006 Electromagnetic compatibility (EMC)
- DIN EN 61000-4-4:2012 Electromagnetic compatibility (EMC)

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- DIN EN 61000-4-5:2014 Electromagnetic compatibility (EMC)
- DIN EN 61000-4-6:2014 Electromagnetic compatibility (EMC)
- DIN EN ISO 60529:2014 Degrees of protection provided by enclosures (IP code)

Other standards and regulations have been applied as follows:

- ISTA-3A packaging testing

Wackersdorf, 2023-07-06

Martin Hartmann (Director Engineering)

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Annex to the declaration of incorporation

List of the essential health and safety requirements for the design and construction of machinery that apply to the product specified on page 1 and with which it complies.

Number Annex I	Heading	applicable	complied with	Comment
1	**ESSENTIAL HEALTH AND SAFETY REQUIREMENTS**	–	–	–
1.1.2	Principles of safety integration	yes	yes	–
1.1.3	Materials and products	yes	yes	The scan head contains beryllium-mirrors. **DO NOT** open the scan head. **DO NOT** remove the protective windows. For more information, see the manual.
1.1.4	Lighting	no	–	–
1.1.5	Design of machinery to facilitate its handling	yes	yes	–
1.1.6	Ergonomics	no	–	–
1.1.7	Operating positions	no	–	–
1.1.8	Seating	no	–	–
1.2	CONTROL SYSTEMS	–	–	–
1.2.1	Safety and reliability of control systems	no	–	–
1.2.2	Control devices	no	–	–
1.2.3	Starting	no	–	–
1.2.4	Stopping	–	–	–
1.2.4.1	Normal stop	no	–	–
1.2.4.2	Operational stop	no	–	–
1.2.4.3	Emergency stop	no	–	–
1.2.4.4	Assembly of machinery	no	–	–
1.2.5	Selection of control or operating modes	no	–	–
1.2.6	Failure of the power supply	no	–	–
1.3	PROTECTION AGAINST MECHANICAL HAZARDS	–	–	–
1.3.1	Risk of loss of stability	no	–	–
1.3.2	Risk of break-up during operation	no	no	–
1.3.3	Risks due to falling or ejected objects	no	–	–
1.3.4	Risks due to surfaces, edges, or angles	yes	yes	–
1.3.5	Risks related to combined machinery	no	–	–
1.3.6	Risks related to variations in operating conditions	yes	yes	–
1.3.7	Risks related to moving parts	no	–	–
1.3.8	Choice of protection against risks arising from moving parts	–	–	–
1.3.8.1	Moving transmission parts	no	–	–
1.3.8.2	Moving parts involved in the process	no	–	–
1.3.9	Risks of uncontrolled movements	no	–	–
1.4	REQUIRED CHARACTERISTICS OF GUARDS AND PROTECTIVE DEVICES	–	–	–
1.4.1	General requirements	no	–	–
1.4.2	Special requirements for guards	–	–	–
1.4.2.1	Fixed guards	no	–	–
1.4.2.2	Interlocking movable guards	no	–	–
1.4.2.3	Adjustable guards restricting access	no	–	–

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Number Annex I	Heading	applicable	complied with	Comment
1.4.3	Special requirements for protective devices	no	–	–
1.5	RISKS DUE TO OTHER HAZARDS	–	–	–
1.5.1	Electricity supply	yes	yes	–
1.5.2	Static electricity	yes	yes	–
1.5.3	Energy supply other than electricity	no	–	–
1.5.4	Errors of fitting	yes	yes	–
1.5.5	Extreme temperatures	yes	yes	–
1.5.6	Fire	yes	yes	–
1.5.7	Explosion	no	–	–
1.5.8	Noise	no	–	–
1.5.9	Vibrations	no	–	–
1.5.10	Radiation	yes	no	The integrator must consider X-rays and UV radiation during material processing, which can occur when using ultra-short-pulsed lasers.
1.5.11	External radiation	no	–	–
1.5.12	Laser radiation	yes	no	Device contains laser pointer Class 2. The integrator must consider appropriate measures.
1.5.13	Emissions of hazardous materials and substances	yes	no	The integrator must consider dust and particle emission during material processing.
1.5.14	Risk of being trapped in a machine	no	–	–
1.5.15	Risk of slipping, tripping, or falling	no	–	–
1.5.16	Lightning	no	–	–
1.6	MAINTENANCE	–	–	–
1.6.1	Machinery maintenance	no	–	–
1.6.2	Access to operating positions and servicing points	no	–	–
1.6.3	Isolation of energy sources	no	–	–
1.6.4	Operator intervention	no	–	–
1.6.5	Cleaning of internal parts	no	–	–
1.7	INFORMATION	–	–	–
1.7.1	Information and warnings on the machinery	yes	no	Device contains laser pointer Class 2. The integrator must apply appropriate information on the machine.
1.7.1.1	Information and information devices	no	–	–
1.7.1.2	Warning devices	no	–	–
1.7.2	Warning of residual risks	no	–	–
1.7.3	Marking of machinery	yes	no	Device contains laser pointer Class 2. The integrator must apply appropriate marking on the machine.
1.7.4	Instructions	–	–	–
1.7.4.1	General principles for the drafting of instructions	yes	yes	
1.7.4.2	Contents of the instructions	yes	yes	

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Number Annex I	Heading	applicable	complied with	Comment
1.7.4.3	Sales literature	yes	yes	–
2	**SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS FOR CERTAIN CATEGORIES OF MACHINERY**	no	–	Numbers 2 to 6 are collapsed as their sections are not applicable.
3	**SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS TO OFFSET HAZARDS DUE TO THE MOBILITY OF MACHINERY**	no	–	
4	**SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS TO OFFSET HAZARDS DUE TO LIFTING OPERATIONS**	no	–	
5	**SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS FOR MACHINERY INTENDED FOR UNDERGROUND WORK**	no	–	
6	**SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS FOR MACHINERY PRESENTING PARTICULAR HAZARDS DUE TO THE LIFTING OF PERSONS**	no	–	

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Novanta Corporation

125 Middlesex Turnpike
Bedford, MA 01730, USA

Phone: +1-781-266-5700
Email: Photonics@Novanta.com
Website: www.NovantaPhotonics.com

Firefly3D Scan Head
User Manual
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