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XR20 rotary axis calibrator

www.renishaw.com/xr20

#renishaw

NOTE: This user guide is also applicable to the XR20-W rotary axis calibrator.

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Contents

Legal information

Terms and conditions and warranty

Unless you and Renishaw have agreed and signed a separate written agreement, the equipment and/or software are sold subject to the Renishaw Standard Terms and Conditions supplied with such equipment and/or software, or available on request from your local Renishaw office.

Renishaw warrants its equipment and software for a limited period (as set out in the Standard Terms and Conditions), provided that they are installed and used exactly as defined in associated Renishaw documentation. You should consult these Standard Terms and Conditions to find out the full details of your warranty.

Equipment and/or software purchased by you from a third-party supplier is subject to separate terms and conditions supplied with such equipment and/or software. You should contact your third-party supplier for details.

Legal information

International regulations and conformance

EC and UKCA compliance for XR20

Renishaw plc hereby declares that the radio equipment type XR20 is in compliance with:

- EU directive 2014/53/EU.
- The relevant statutory instruments under UK radio law.

The full text of the declaration of conformity is available at: **www.renishaw.com/calcompliance**

In compliance with EN 61010-1:2010+A1:2019, the product is safe to use in the following minimum environmental conditions:

- Indoor use only
- Altitude up to 2000 m
- Maximum relative humidity (non-condensing) of 80% for temperatures up to 31 °C, decreasing linearly to 50% relative humidity at 40 °C
- Pollution degree 2

EC compliance for XR20-W

Renishaw plc declares that the XR20-W system complies with the applicable directives, standard and regulations. The full text of the declaration of conformity is available at: **www.renishaw.com/calcompliance**

In compliance with BS EN 61010-1:2010, the product is safe to use in the following environmental conditions:

- Indoor use only
- Altitude up to 2000 m
- Maximum relative humidity (non-condensing) of 80% for temperatures up to 31 °C, decreasing linearly to 50% relative humidity at 40 °C
- Pollution degree 2

Legal information

USA and Canadian regulations

FCC notice

47 CFR section 15.19

This device complies with Part 15 of the FCC rules. Operation is subject to the following conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

47 CFR section 15.21

The user is cautioned that any changes or modifications not expressly approved by Renishaw plc or authorised representative could void the user's authority to operate the equipment.

47 CFR section 15.105

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with this user guide, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at their own expense.

Canada – Innovation, Science and Economic Development Canada (ISEC)

IC: 11306A-ISP1507

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

REACH regulation

Information required by Article 33(1) of Regulation (EC) No. 1907/2006 ("REACH") relating to products containing substances of very high concern (SVHCs) is available at: **www.renishaw.com/REACH**

China RoHS

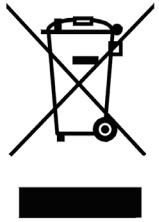
For more information on China RoHS, visit:
www.renishaw.com/calcompliance

Legal information

Packaging

Packaging components	Material	Material abbreviation	Material numerical code
Internal box	Cardboard – 70 % recycled material	PAP	20
Outer box	Cardboard – 70 % recycled material	PAP	20
Insert	Cardboard	PAP	20
Bag	Low density polyethylene	LDPE	4

Disposal of waste electrical and electronic equipment



The use of this symbol on Renishaw products and/or accompanying documentation indicates that the product should not be mixed with general household waste upon disposal. It is the responsibility of the end user to dispose of this product at a designated collection point for waste electrical and electronic equipment (WEEE) to enable reuse or recycling. Correct disposal of this product will help to save valuable resources and prevent potential negative effects on the environment. For more information, contact your local waste disposal service or Renishaw distributor.

Disposal of batteries

The use of this symbol on the batteries, packaging or accompanying documents indicates that used batteries should not be mixed with general household waste. Dispose of the used batteries at a designated collection point. This will prevent potential negative effects on the environment and human health which could otherwise arise from inappropriate waste handling. Contact your local authority or waste disposal service concerning the separate collection and disposal of batteries. All lithium and rechargeable batteries must be fully discharged or protected from short circuiting prior to disposal.

Legal information

XR20 radio communications

Bluetooth® LE 5.0 device

Output power: 0 dBm nominal; 4 dBm maximum

Frequency band: 2.402 GHz to 2.480 GHz

Bluetooth® transmission range: 10m typical operation

For details of national radio approvals for this device, see the Compliance with radio device regulations document on the Calibration product quality and conformance web pages.

Further radio approval country-specific statements can be found below:

Japan

This equipment contains a radio module, approved for use in the Japanese market.

Radio model	Name	Certificate number
ISP1507	Bluetooth low-energy module	207-161SP5

R 207-16ISP5

Recognized by
The Ministry of Internal Affairs and Communications (MIC)
CAB ID: 207

Mexico

La operación de este equipo está sujeta a las siguientes dos condiciones:

(1) es posible que este equipo o dispositivo no cause interferencia perjudicial y (2) este equipo o dispositivo debe aceptar cualquier interferencia, incluyendo la que pueda causar su operación no deseada.

Brazil

Renishaw Latino Americana Ltda. XR20

ANATEL
11423-23-02812

Para maiores informações, consulte o site da Anatel – **www.gov.br/anatel/pt-br**

Este equipamento não tem direito à proteção contra interferência prejudicial e não pode causar interferência em sistemas devidamente autorizados.

Este produto não é apropriado para uso em ambientes domésticos, pois poderá causar interferências eletromagnéticas que obrigam o usuário a tomar medidas necessárias para minimizar estas interferências.

Taiwan

低功率電波輻性電機管理辦法
第十二條經型式認證合格之低功率射頻電機，非經許可，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。
第十四條低功率射頻電機之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。前項合法通信，指依電信規定作業之無線電信。低功率射頻電機須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

Legal information

XR20-W radio communications

Class 2 Bluetooth® device

Output power:	0 dBm maximum; 3 dBm maximum
Frequency band:	2.402 GHz to 2.480 GHz
Bluetooth® transmission range:	10 m typical operation

For details of national radio approvals for this device, see the Compliance with radio device regulations document on the Calibration product quality and conformance **web pages**.

Further radio approval country specific statements can be found below:

Brazil

Frequency bandwidth (MHz):	2400 Mhz to 2483 MHz
Modulation:	GFSK
Output power (W):	0.0676 W

Renishaw Latino Americana Ltda, XR20W

ANATEL

00740-13-02812

Para maiores informações, consulte o site da Anatel – **www.gov.br/anatel/pt-br**

Este equipamento não tem direito à proteção contra interferência prejudicial e não pode causar interferência em sistemas devidamente autorizados.

Mexico

La operación de este equipo está sujeta a las siguientes dos condiciones:

(1) es posible que este equipo o dispositivo no cause interferencia perjudicial y (2) este equipo o dispositivo debe aceptar cualquier interferencia, incluyendo la que pueda causar su operación no deseada.

Taiwan

低功率電波輻性電機管理辦法

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Safety information

WARNING: Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Ensure that you read and understand the XR20 user guide before using any XR20 system.

The XR20 rotary axis calibrator can be used in a variety of environments and applications. To ensure the safety of the user and other personnel in the vicinity, it is therefore paramount that a comprehensive risk assessment is carried out for the machine under test before using the XR20 rotary axis calibrator.

This should be carried out by qualified users (requiring machine competency, applicable technical knowledge and a trained risk assessor) with consideration for the safety of all personnel. The risks identified must be mitigated prior to using the product. The risk assessment should pay particular attention to machine, manual handling, mechanical, laser, electrical, power and fibre optic safety.

Based on current research, the wireless devices used in this product would not seem to pose a significant health risk for the vast majority of pacemaker wearers. However, people with pacemakers may want to ensure a minimum distance of 3 cm between the product and pacemaker.

Safety warnings

The XR20 rotary axis calibrator system is designed to be used to test machine tools. As such, the user will need to prepare and run a part program which moves the machine as required. It is assumed therefore that the user is thoroughly familiar with the operation of the machine tool and its controller and knows the location of all emergency stop switches. Also, if it is necessary to operate the machine with the guards or any safety feature removed or disabled, it is the responsibility of the operator to ensure that alternative safety measures are taken in line with the machine manufacturer's operating instructions or relevant codes of practice. Safety procedures should be in accordance with the user's risk assessment.

The XR20 device works in conjunction with a Renishaw laser system. Before using the laser system, read the safety section of the relevant laser user guide.

The XR20 can reflect the laser beam from the laser around the room as it rotates. Consideration should be given to other users working in the area.

Do not spin the optics on the XR20 as this can cause damage to the hardware.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Mechanical safety

- When setting up and mounting Renishaw laser calibration equipment, beware of pinch and/or crush hazards that may be created; for example, due to magnetic mounting bases.
- Beware of trip hazards that may be created when using Renishaw equipment; for example, due to trailing cables.
- Exercise caution if components are to be mounted to moving or rotating machinery. Beware of cables becoming entangled.
- Exercise extreme caution if Renishaw equipment is to be mounted to machinery that may accelerate rapidly or move at high speed, which could lead to items colliding or being ejected.
- If it is necessary to operate the machine with the guards or any safety feature removed or disabled, it is the responsibility of the operator to ensure that alternative safety measures are taken in line with the machine manufacturer's operating instructions or relevant codes of practice.
- If you are using a part program or error-correction parameters generated by Renishaw software, it is the responsibility of the user to validate these at low feedrate and be prepared to operate the emergency stop button if necessary.



Laser optical safety

- In accordance with (IEC) EN60825-1, Renishaw XL-80 and XM systems used to provide a laser source for XR20 are class 2M lasers and safety goggles are not required (under normal circumstances the eye will blink and look away before damage can occur).
- Do not stare directly into the laser beams or view them with optical equipment such as telescopes, convergent mirrors or binoculars, as permanent retinal damage could occur.
- Do not direct the beam at other people or into areas where people unconnected with the laser might be present. It is safe to view a diffuse-reflected beam during system alignment..

Battery safety

This product is supplied with rechargeable lithium ion batteries. Refer to the battery manufacturer's literature for specific battery operating, safety and disposal guidelines.

- Use only the charger supplied with the product to recharge the batteries.
- Replace the batteries only with the specified type.
- Do not mix batteries with different states of charge in the product.
- Do not mix different types or brands of batteries within the product.
- Ensure that all batteries are always inserted with the correct polarity in accordance with the instructions in this manual and indicated on the product.
- Do not store the batteries in direct sunlight
- Do not expose the batteries to water.
- Do not expose the batteries to heat or dispose of the batteries in a fire.
- Avoid forced discharge of the batteries.
- Do not short circuit the batteries.
- Do not disassemble, apply excessive pressure, pierce, deform or subject the batteries to impact.
- Do not swallow the batteries.
- Keep the batteries out of the reach of children.
- If the batteries are swollen or damaged do not use them in the product and exercise caution when handling them.
- Dispose of waste batteries in accordance with your local environmental and safety laws.

Ensure that you comply with international and national battery transport regulations when transporting batteries or this product with the batteries inserted. Lithium ion batteries are classified as dangerous goods for transportation and require labelling and packaging in accordance with the dangerous goods regulations before being offered for transportation. To reduce the risk of shipment delays, should you need to return this product to Renishaw for any reason, do not return any batteries.

System overview

XR20 is a rotary axis calibrator designed for measuring rotary axes.
Key features include:

- Compatible with Renishaw XL-80 or XM systems.
- Compact and lightweight.
- Quick and simple mounting system.
- Easy alignment with built-in alignment aid.
- Wireless operation by utilising Bluetooth communication.
- Battery-powered (can be powered by external USB if required).

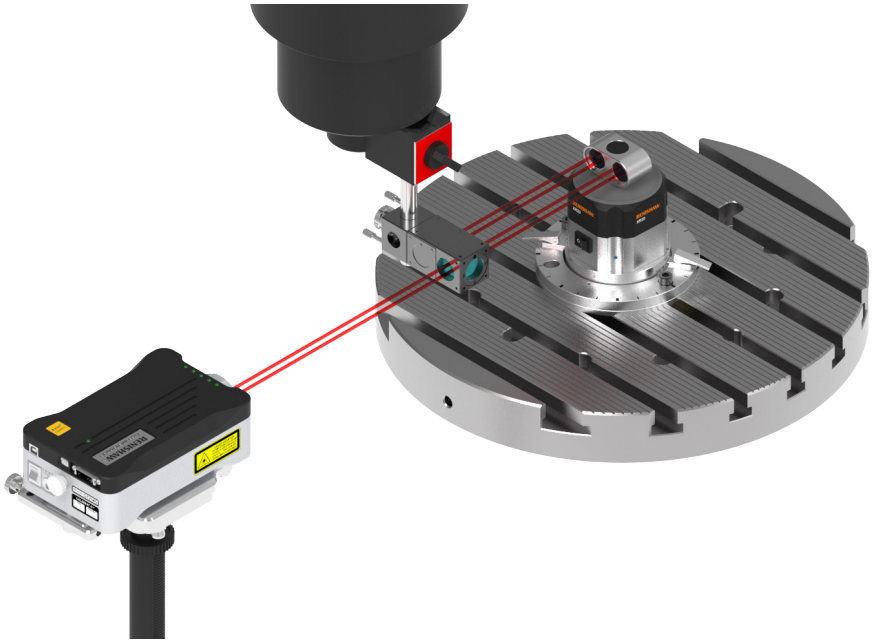

Figure 1 Typical set-up for calibrating a rotary axis using XL-80 as the laser reference

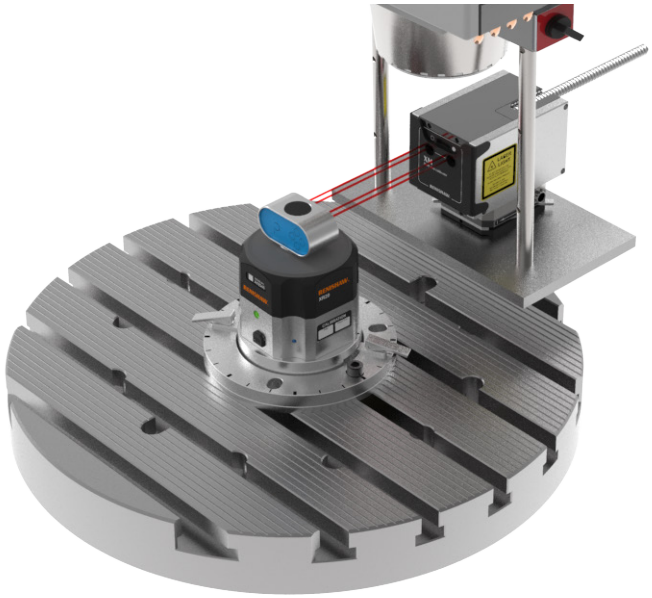

Figure 2 Typical set-up for calibrating a rotary axis using XM as the laser reference

The CARTO data capture software uses both the measured angle and the position from the XR20 internal encoder scale to very accurately measure the positioning performance of the table under test. The rotation of an axis is calibrated by rotating it sequentially through a number of angular targets, pausing at each defined target to capture a reading. As the axis rotates, the software counter-rotates the XR20 to ensure that the laser beam is returned to the laser, maintaining signal strength.

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System components

1	XR20
2	Chuck adaptor
3	Centration aid
4	Mounting ring
5	Mounting ring adaptor
6	Battery Li-Polymer × 3
7	Dock

Mounting ring

The mounting ring bolts or clamps directly to the surface of the machine and locks the XR20 in position.

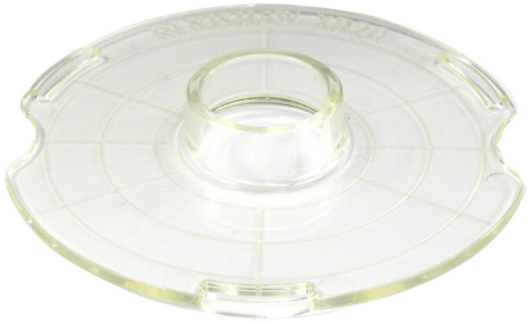
Mounting ring adaptor plate

The mounting ring adaptor plate enables the XR20 to be fitted to rotary tables with unsuitable centre recesses. It can also be used to secure the XR20 rotary axis calibrator to the chuck adaptor and custom mounts.

Chuck adaptor

The chuck (lathe) adaptor has a 40 mm diameter to fit most chuck sizes. It can also be used to secure the XR20 to custom mounts.

Centration aid



The centration aid allows the mounting ring to be easily centred to the axis of rotation of the machine under test before the XR20 rotary axis calibrator is mounted to the machine.

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CARTO software suite

The XR20 rotary axis calibrator is used with the CARTO software suite. This is made up of three applications:

Capture	collects laser interferometry data
Explore	enables powerful analysis to international standards
Compensate	generates compensation files for precision applications

www.renishaw.com/carto

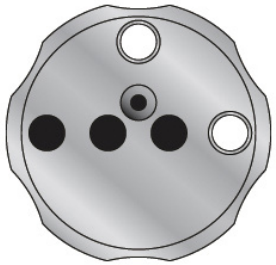
Setting up a test

Setting up the hardware

CAUTION: Before proceeding, read the **safety** section.

1. Prepare the machine for calibration. Remove all tools from the spindle of the machine and retract them into the tool holder.
2. Ensure surfaces are clean and free of swarf, debris and burrs.
3. Ensure that the laser beam can reach the rotary table without obstruction.
4. The XR20 requires a defined test method to be entered into the machine tool controller via a part program. The test method and part program can be generated from the CARTO software.
5. Ensure that the PC is Bluetooth-enabled and that the CARTO software is installed. See the **Bluetooth set-up** section for more information.
6. For XL-80 use, mount the laser head on the stage and tripod. Turn on the laser to begin stabilisation.

CAUTION: For safety, the shutter of the laser must be rotated to its closed position before commencing.



6a. For XM system use, suspend the XM launch unit within the machine environment and switch on the laser unit to begin stabilisation.

CAUTION: For safety, the shutter of the XM launch must be rotated to its closed position before commencing.

WARNING: Both XL-80 and XM laser systems are classified as Class 2 and safety goggles are not required (under normal circumstance the eye will blink and look away before damage can occur).

Refer to the relevant laser system manual.

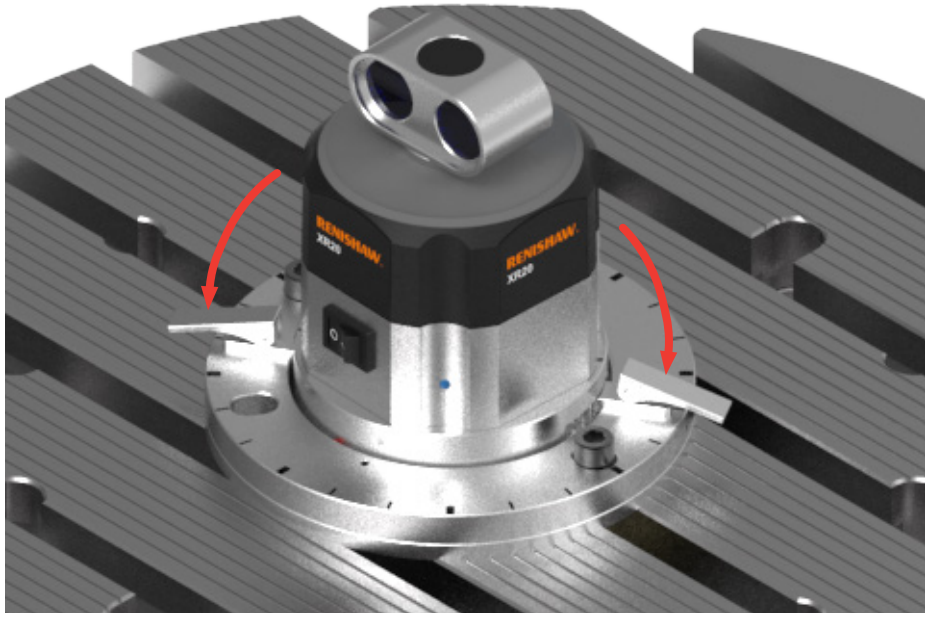
7. Connect the laser to the PC. To monitor the environment during calibration, plug the environmental compensator in to the PC. Place the temperature sensors in suitable positions on or around the machine and connect them to the environmental compensator. For more information on setting up the laser and environmental compensator, refer to the relevant laser system user guide.
8. Before mounting the XR20 to the rotary axis, ensure the mounting ring and XR20 facing ring are clean and free of swarf, debris and burrs. See the **Care and handling section** for more information.
9. Alignment of the rotary table can be carried out visually with the centration aid from the XR20 kit or by using a dial test indicator (DTI). The centration of the mounting ring should be aligned to the following specification:

XL-80 laser use < ±1 mm:

XM laser system use < ±0.25 mm:

10. Once aligned, fix the mounting to the axis using bolts mounted through the mounting holes into the machine's T-slots. If the T-slots do not pass under the mounting holes, toe clamps may need to be used. Remove the centration aid.

11. Switch on the XR20 to check the battery power: a green LED indicates sufficient battery power. Switch off the XR20 to conserve battery power. If the LED is amber, change the battery. See the **power supply: rechargeable battery** section for more details and the **Diagnostics and trouble shooting** section for a full list of LED states.
12. Attach the XR20 to the mounting ring. Ensure the clamp levers are released (in the up position). Align the red spot on the facing ring with the red spot on the mounting ring so that the slots in the facing ring are aligned with the clamps. Lower the facing ring onto the table surface, then rotate the XR20 clockwise until the clamps are aligned above the clamping surfaces.



13. Lock the clamp levers down to secure the XR20.

For XL-80, proceed to page 21.

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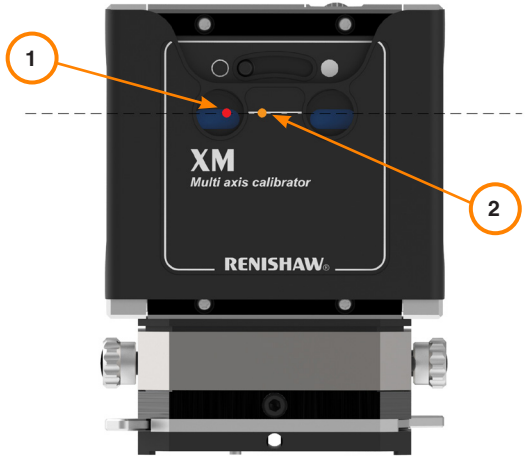
XM system set-up

1. Attach the beam blocker to the front of the XM launch unit.

1	Beam blocker

2. Translate the laser launch horizontally and vertically so that the laser beam hits the target on the alignment aid as shown:

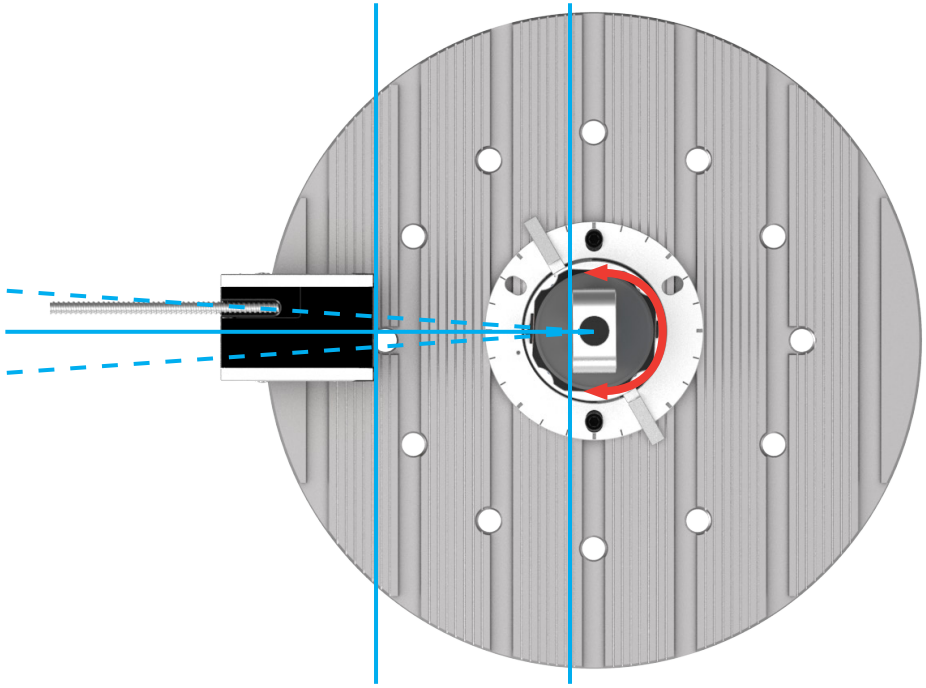
3. Observe the reflected beam on the launch beam blocker. Adjust the pitch of the launch so that the reflected beam is on the centre line.



1	Beam aperture
2	Reflected beam

4. Translate vertically to align the beam again as shown in step 2.

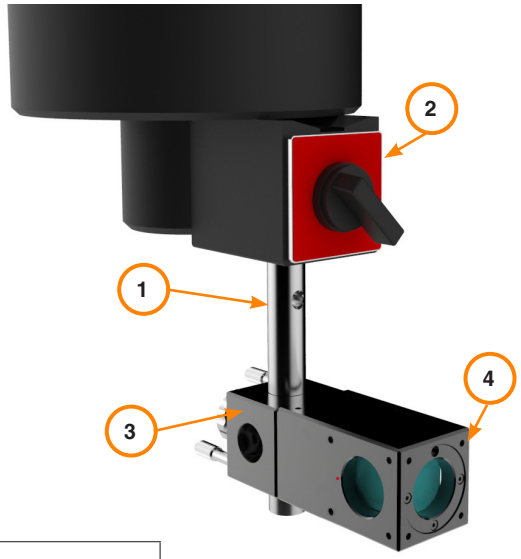
5. Rotate the XR20 optic so that it is parallel to the face of the XM-60 launch unit to within +/- 3 degrees.



XM system set-up is complete; proceed to page 24.

XL system set-up

1. For XL-80 use, assemble the magnetic base, optics mounting kit and angular interferometer optic and attach to the machine spindle as shown. In this example, the input aperture of the angular interferometer is on the right-hand side. See the **Optical set-up** section for alternative mounting schemes. Refer to the *XL laser system* user guide (Renishaw part number F-9908-0683) for more information on the optics mounting kit and angular interferometer.

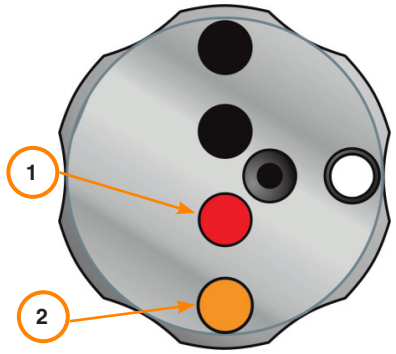


1	Mounting pillar
2	Magnetic mount
3	Clamp block
4	Angular interferometer

2. Move the machine in X, Y and Z using the handwheel to provisionally position the angular interferometer between the laser and the XR20. The angular interferometer should be relatively close to the XR20 angular reflector to optimise measurement performance, but ensure that it cannot collide during the test. Ensure that the angular interferometer's input aperture is aligned with the right-hand retroreflector in the angular reflector.
3. Using the machine's handwheel, raise the interferometer, attached to the spindle, in Z only. To maintain alignment between the XR20 and the angular interferometer, do not move it in X or Y.
4. Rotate the alignment aid on the back of the angular reflector so that it faces the laser.

NOTE: If it is difficult to access the angular reflector, it can be moved using the jog functions in CARTO Capture.

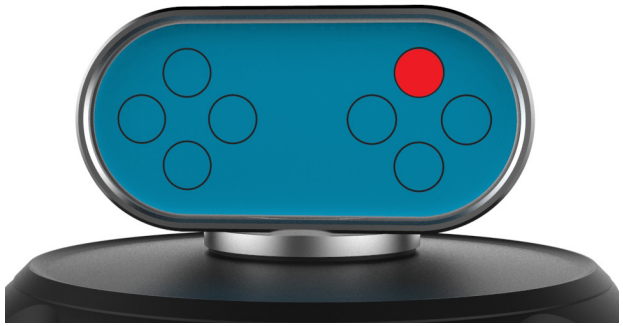
5. Position the laser and tripod in front of the machine. To simplify set-up, use a level on the top of the laser to ensure that the laser is level and so nominally perpendicular to the machine's axis of rotation.
6. Rotate the laser shutter to the 6 mm beam alignment position.



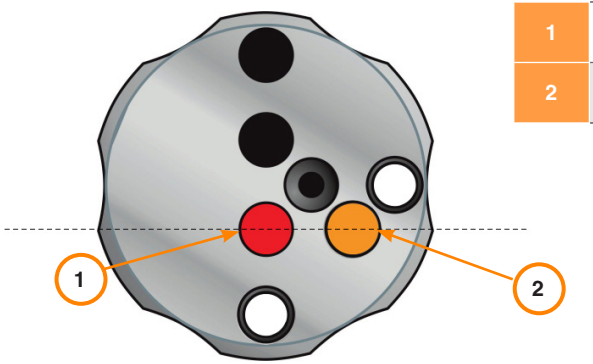
1	Beam aperture
2	Target

7. Adjust the laser so that the beam hits the alignment aid. For more information on laser alignment controls, refer to the relevant laser user guide.

8. Translate the XL-80 horizontally and vertically so that the laser beam hits the target on the alignment aid as shown:



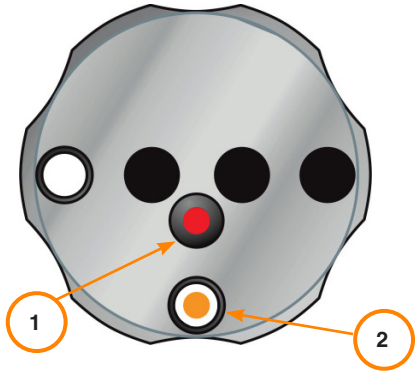
9. To minimise measurement errors, the laser beam must be aligned perpendicular to the machine's axis of rotation. Refer to the **set-up errors section** for more information. Adjust the pitch of the laser so that the beam reflects onto an imaginary horizontal line which passes through the centre of the shutter's output aperture as shown.



1	Beam aperture
2	Reflected beam

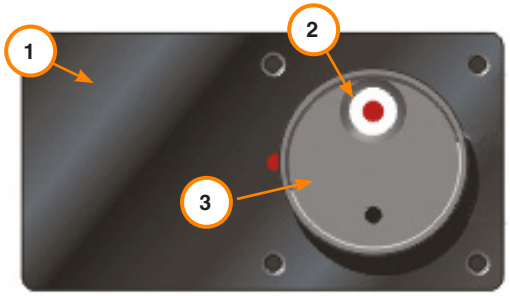
NOTE: The laser may become destabilised; this is not a problem.

10. Turn the laser shutter so that the 3 mm aperture is set. Check that the beam returning from the retroreflectors is concentric inside the white target. Make translation adjustments to the laser and tripod, if required.



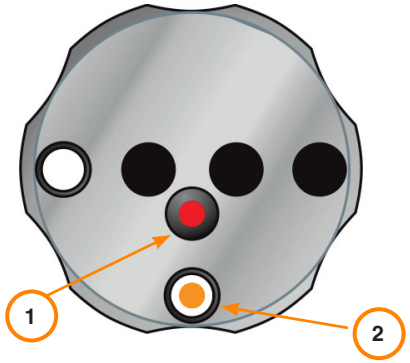
1	Reduced beam aperture
2	Target

11. Fix a target into the input aperture of the angular interferometer and lower the interferometer back into position using the Z control on the handwheel. Ensure that the beam from the laser is concentric with the white target.



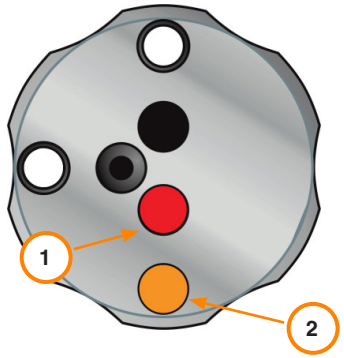
1	Angular interferometer
2	Reduced laser beam
3	Target

12. Remove the target from the angular interferometer. Ensure that the beams pass through the angular interferometer, and that both beams returned from the XR20's angular reflector overlap on the middle of the laser shutter's target.



1	Reduced beam aperture
2	Target

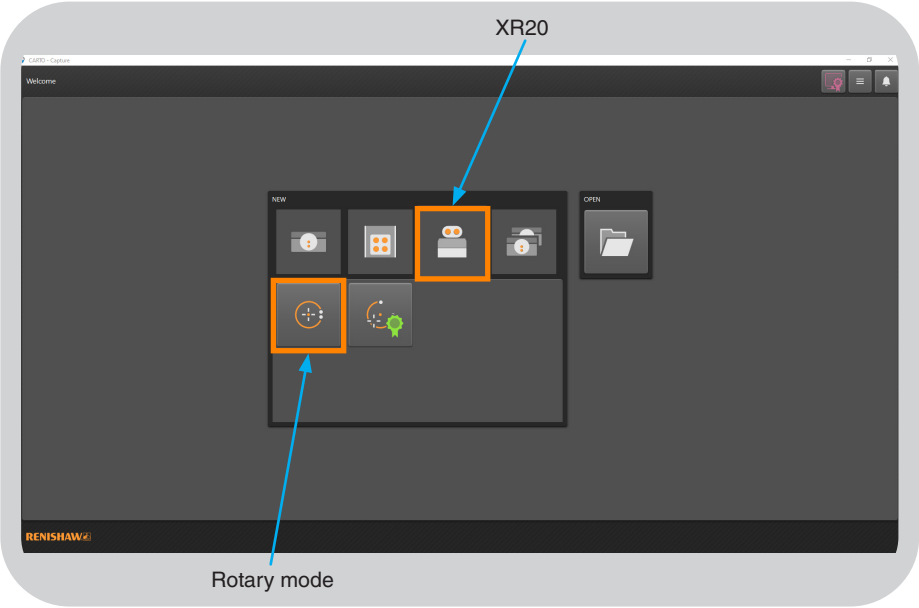
13. Turn the shutter to 6 mm aperture and check that good signal strength is obtained.



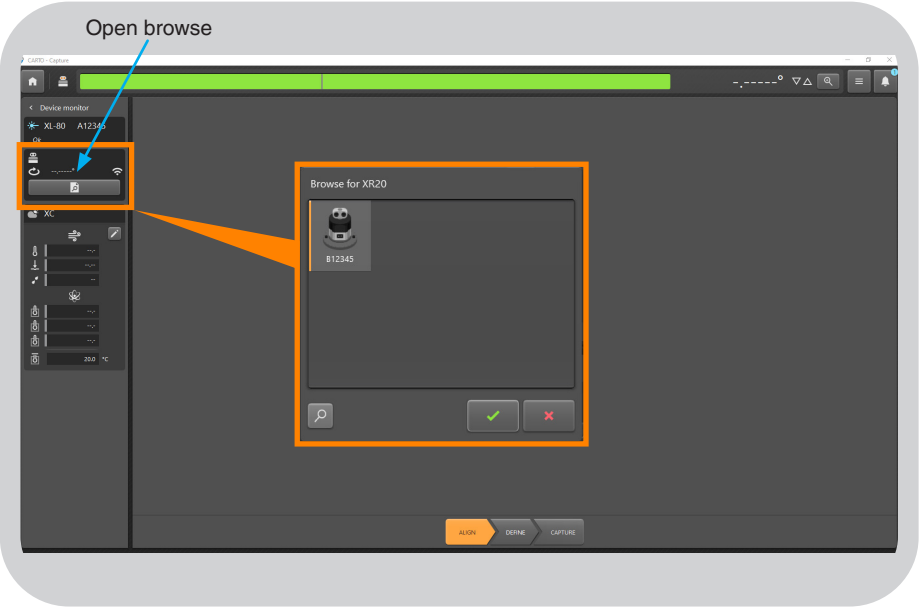
1	Beam aperture
2	Detector aperture

14. Switch on the XR20 and check that the status LEDs go green.

On axis rotary



Run the Capture application and select ‘Rotary mode’.



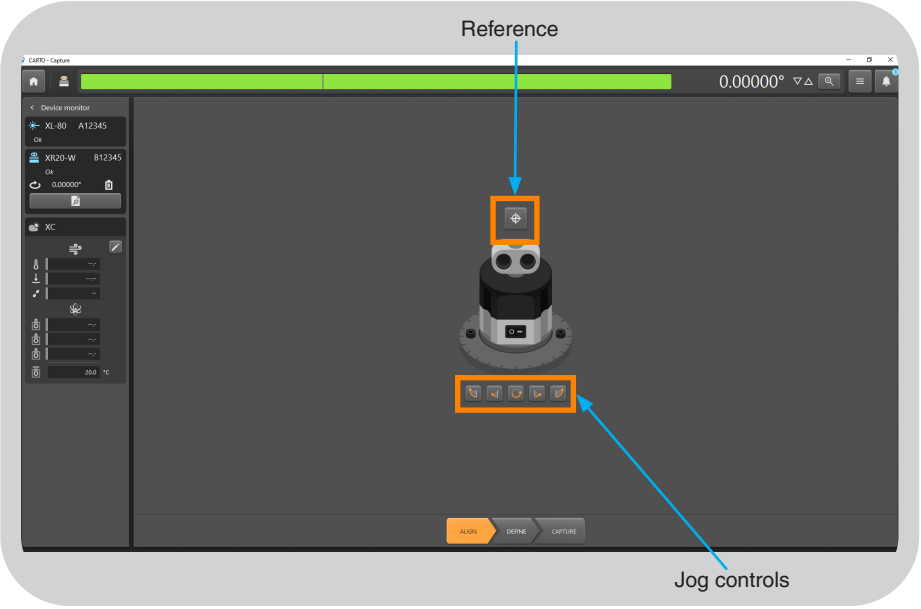
To connect the XR20, select ‘Open browse’.

In the browse box, select search. XR20’s within range will appear in the list.

Select the correct XR20 serial number and press ‘OK’.

If the XR20 is not found then see the setup pages for XR20 (Appendix E) or XR20-W (Appendix F) as applicable.

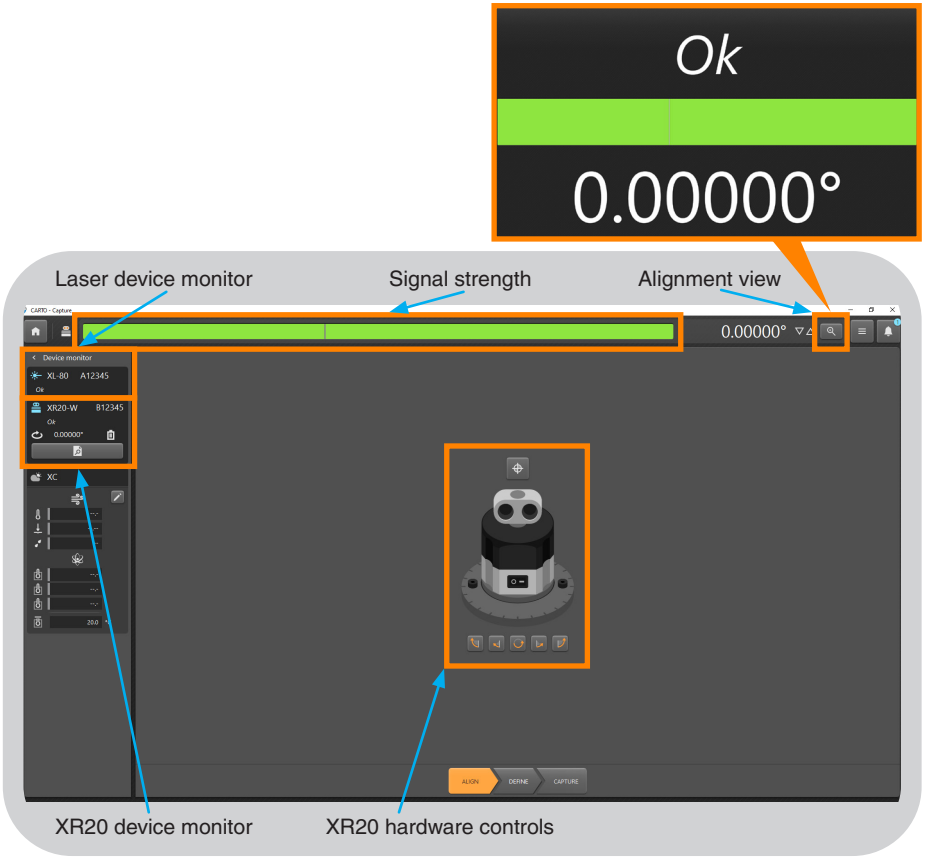
On axis rotary



Alignment of the XR20 can be carried out by manually rotating the optic by hand, or using the built in jog controls.

To use the built in jog controls, the XR20 must be referenced.

NOTE: When using the jog controls the optic must not be rotated by hand.

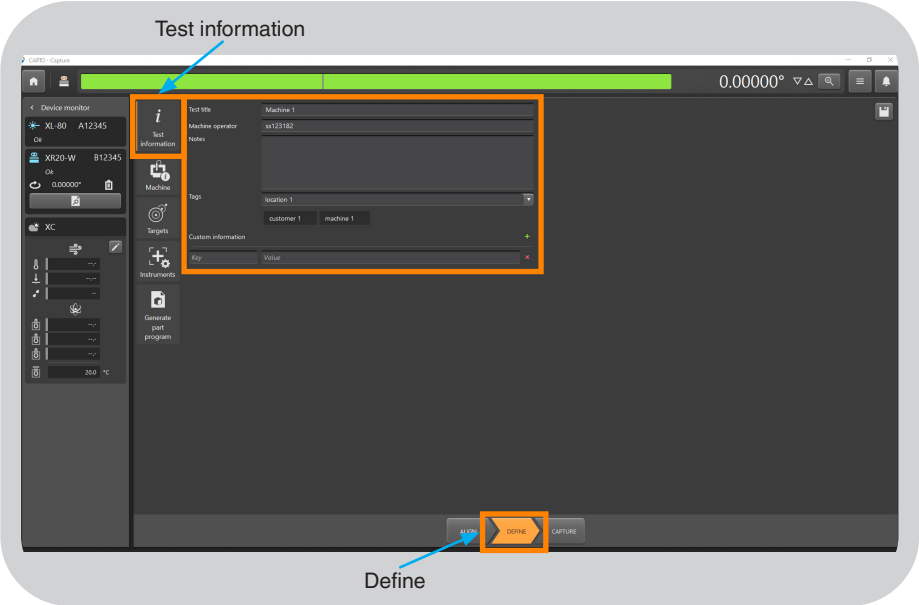


When the hardware is connected the application will be in the view shown. Ensure that the laser is connected to the laptop.

- **Device monitors** – show the status of connected hardware.
- **Signal strength** – gives an indication of alignment.
- **Alignment view** – gives a simple full screen view of signal strength and current laser reading to aid alignment.
- **XR20 hardware controls** – allow the XR20 to be rotated for alignment using the software.

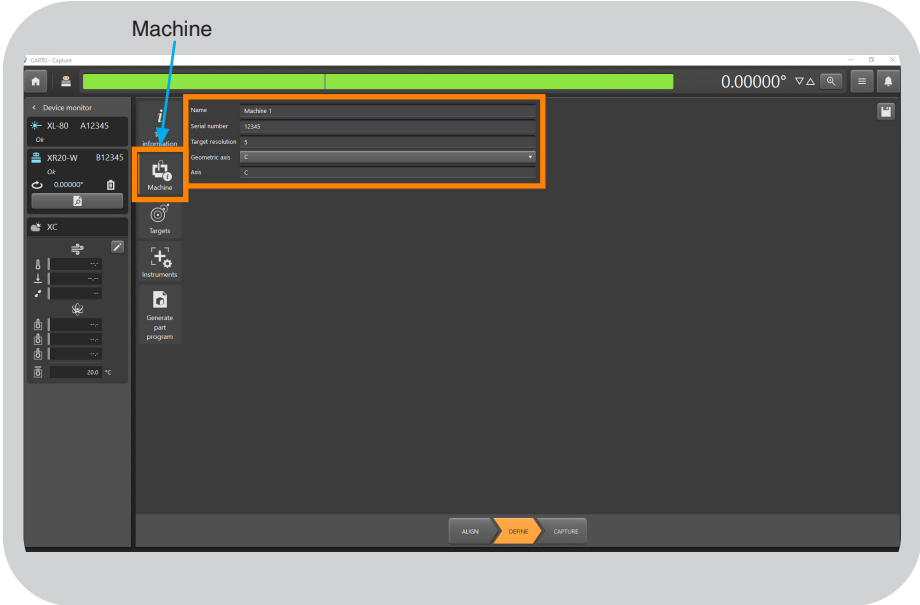
On axis rotary

Select the ‘Define’ tab. The ‘Test information’ tab is a place to enter general information for test identification within the CARTO database.



- **Test title** – title to be used when referring to the test.
- **Machine operator** – name of operator conducting the test.
- **Notes** –information which may be useful about the test.
- **Tags** – apply tags to aid filtering of data in Explore.
- **Custom information** – allows customised fields to be created and included in the test record.

In the ‘Machine’ tab enter information which is specific to the machine and axis under test.

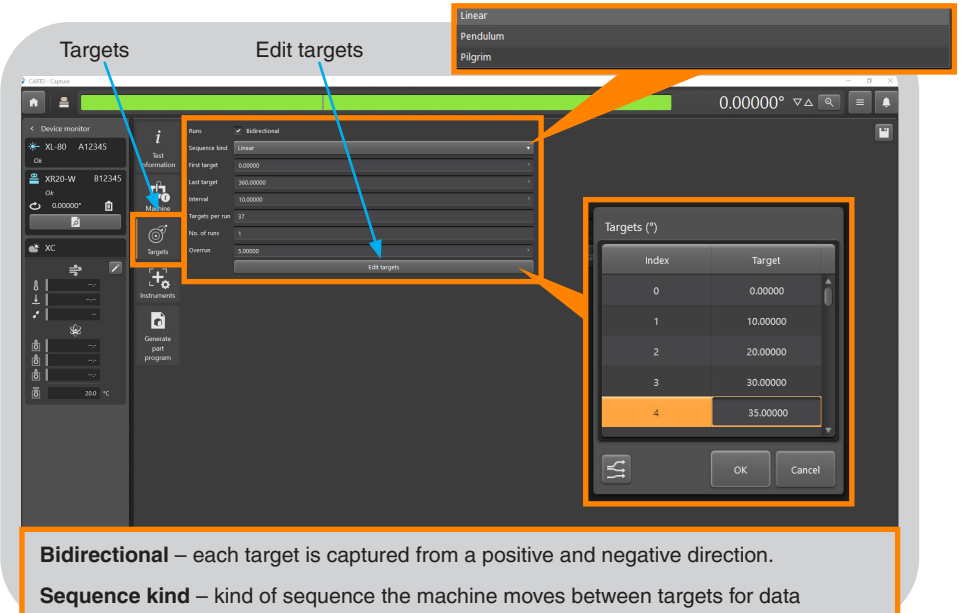


- **Name** – name of the machine under test.
- **Serial number** – serial number of machine under test.
- **Target resolution** – number of decimal places for targets. This must not be higher than the machine resolution.
- **Geometric axis** – select the axis under test to match the set-up.
- **Axis** – allows a custom axis name to be used.

On axis rotary

In the ‘Targets’ tab, enter the positions to capture data and the sequence required to capture them.

Targets can be manually edited or randomised using the ‘Edit targets’ button.



Bidirectional – each target is captured from a positive and negative direction.

Sequence kind – kind of sequence the machine moves between targets for data capture. See appendix in *CARTO Capture* user guide (Renishaw part no. F-9930-1007) for more information.

First target – input the first position for data capture.

Last target – input the last position for data capture.

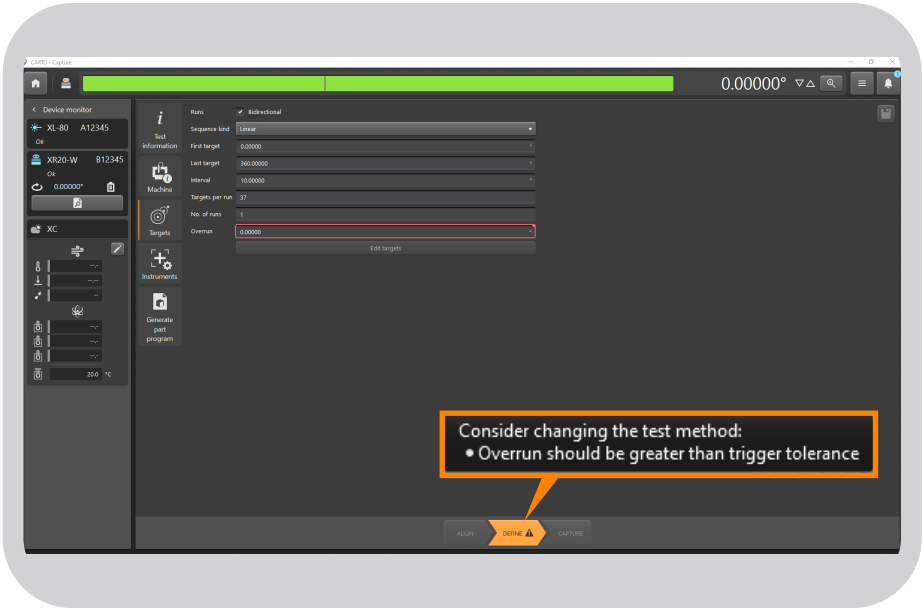
Interval – distance between targets.

Targets per run – if the interval value has been entered this will be updated accordingly.

Number of runs – determine the number of times the target sequence is repeated.

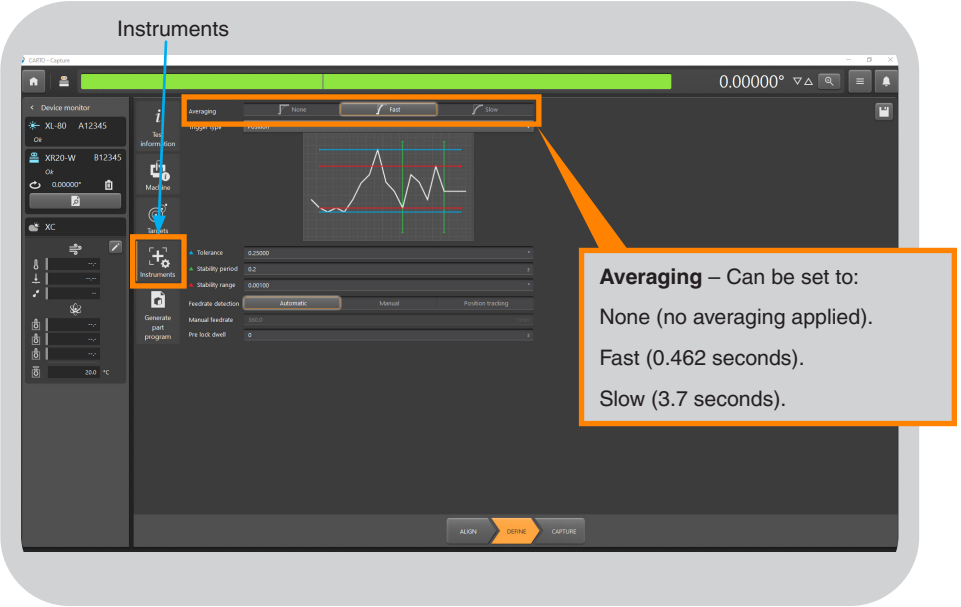
Overrun – distance required for turn around at end of the axis (including first target and last target).

Edit targets – targets can be individually edited or randomised.



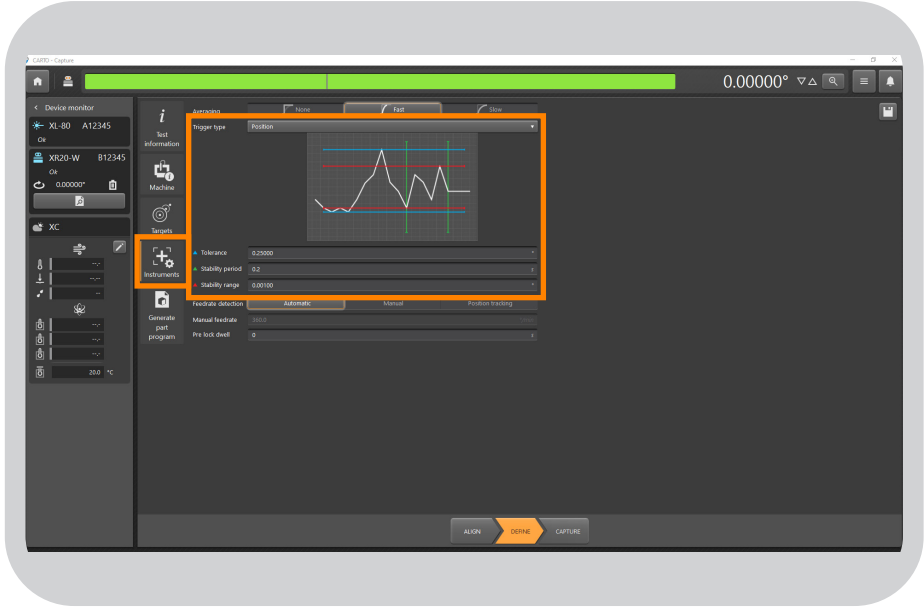
Any **red** highlighted box or warning triangles highlight potential problems with the test method. Hover the mouse over the area for a tooltip with more information on how to correct the issue.

On axis rotary



In the ‘Instruments’ tab, select the averaging type required.

When using position trigger type, the trigger parameters must be set correctly to ensure that the software recognises when data should be captured.

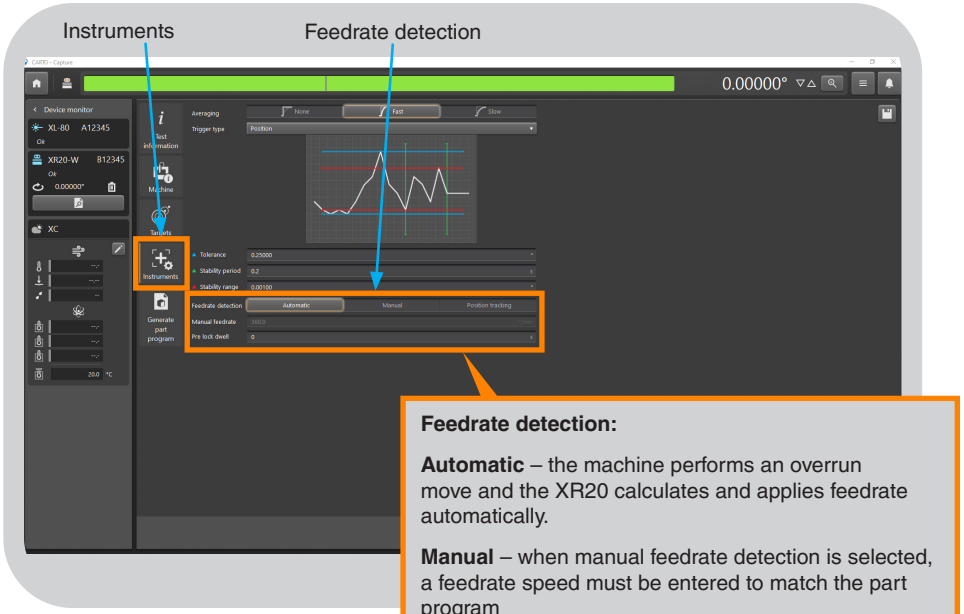


- **Tolerance** – the distance either side of the set target value considered to be acceptable.
- **Stability period** – the period of time that the machine must stay within the set stability range.
- **Stability range** – the maximum position variation considered to be acceptable.

If the machine is outside of any of the trigger parameters, data will *not* be captured.

On axis rotary

Set the ‘Feedrate detection’ as required.



Feedrate detection:

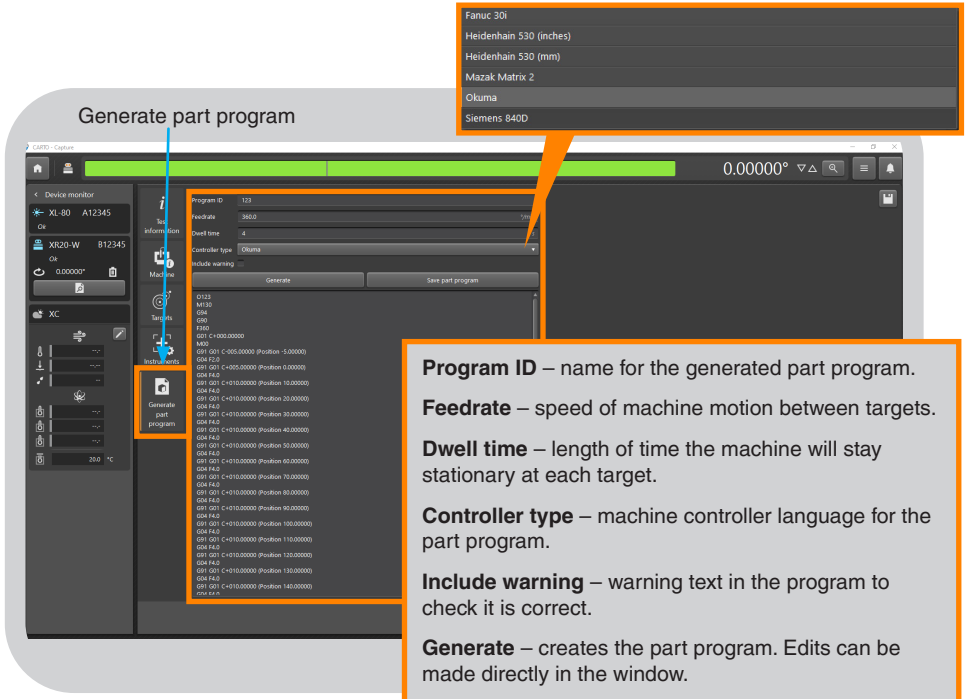
Automatic – the machine performs an overrun move and the XR20 calculates and applies feedrate automatically.

Manual – when manual feedrate detection is selected, a feedrate speed must be entered to match the part program

Position tracking – this setting allows the user to perform data capture in situations such as manual motion of the axis under test where the feedrate is not constant. It works by monitoring the signal strength of the laser and indexing the optic to optimise the signal.

Manual feedrate – requires a speed to be entered in degrees per minute only when feedrate is set to ‘manual’.

Pre-lock dwell – is used for applications such as machine tools with a mechanical brake. This is a time delay for the XR20 to capture data allowing the brake to be applied.



Program ID – name for the generated part program.

Feedrate – speed of machine motion between targets.

Dwell time – length of time the machine will stay stationary at each target.

Controller type – machine controller language for the part program.

Include warning – warning text in the program to check it is correct.

Generate – creates the part program. Edits can be made directly in the window.

Save part program – launches a browser to save to a suitable location for transfer to the controller.

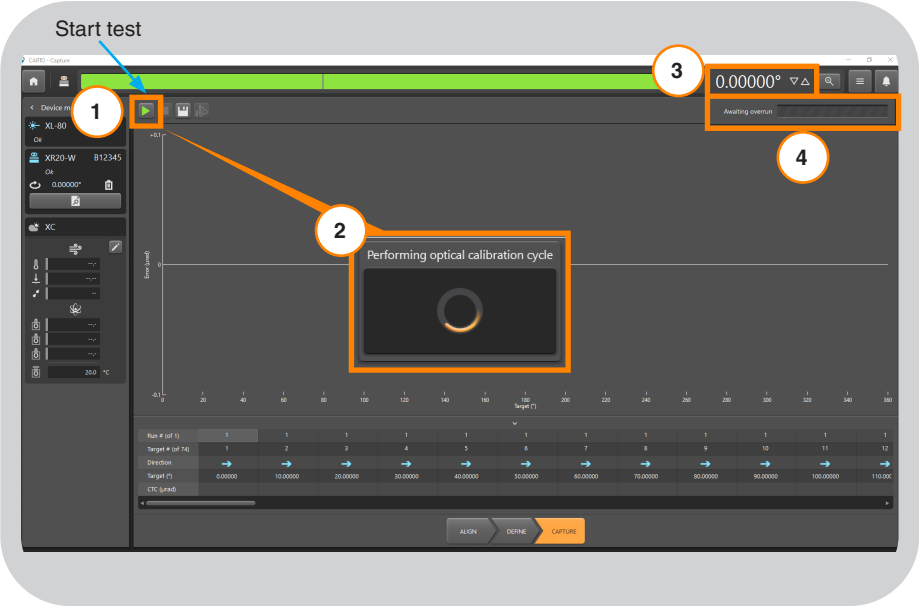
To create a machine part program use the ‘Generate part program’ tab, enter a program name and feedrate.

Dwell time will be modified based upon previous selections such as averaging and trigger parameters, however this can be modified if required.

Select a supported control type, generate the program and save to a suitable location for transfer to the machine.

On axis rotary

Select the ‘Rotary’ tab.



There is no requirement to set sign direction for rotary tests. The software monitors the targets and compares them to the overrun move to set them automatically.

1. Press ‘Start test’.
2. The XR20 will then start the optical calibration cycle.
3. The read-out will be set to the value of the first target.
4. The test status bar advises the next steps.

Press start on the machine controller. Using position trigger type data will be collected automatically.

The test status is displayed in the top right of the screen.

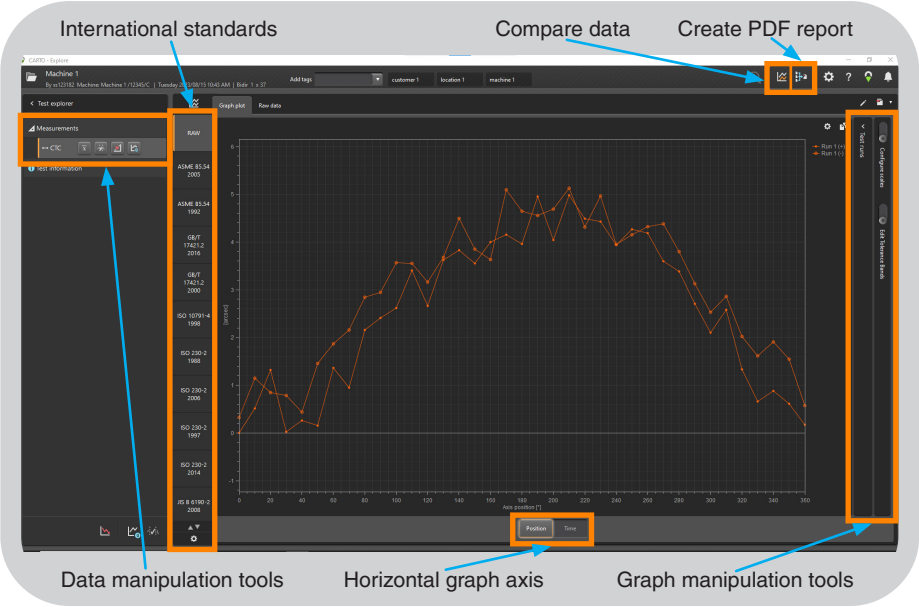
On axis rotary

The test status will indicate when the test is complete. ‘Save’ the test.

A dialogue box will appear to allow further detail or amendments to be added to the test record.

Select ‘Analyse’ to launch the Explore application.

On axis rotary



The application will open in the view shown.

Different mounting configurations

The XR20 rotary axis calibrator can be mounted to many different types of rotary axis. Set-ups 1 to 3 show typical set-up using the fittings supplied with the standard XR20 kit. Always ensure the mounting surface of the table under test and the XR20 facing ring are clean and free of swarf, debris and burrs.

Mounting set-up 1 (default configuration)

In most applications, the facing ring of the XR20 can be mounted directly to the surface of the axis under test (as shown) using the mounting ring.

The mounting ring is fixed to the table using bolts secured through the mounting holes into the machine's T-slots.

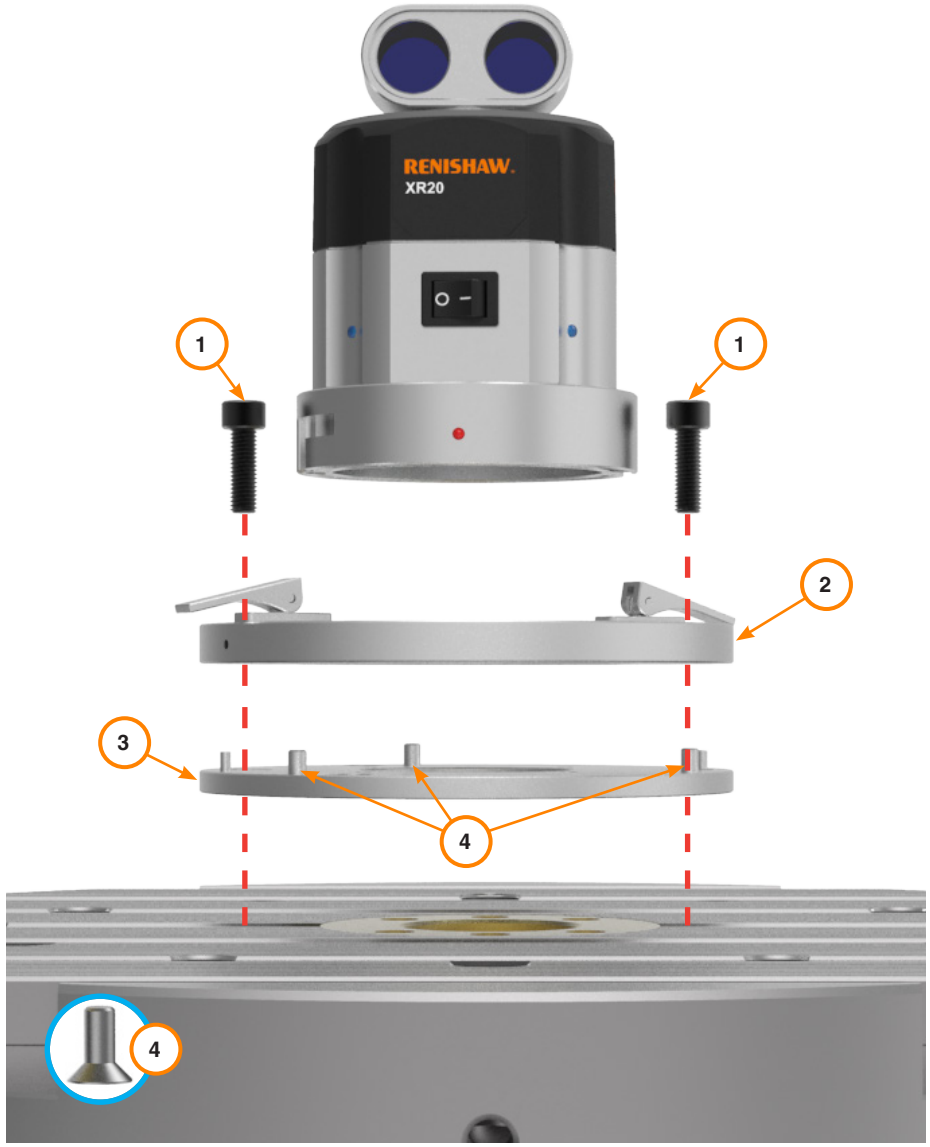
1	Mounting bolt
2	Mounting ring

Mounting set-up 2 (machine with large centre bore)

The mounting ring adaptor plate should be used if the axis under test has a centre bore or recess that prevents the XR20 mounting ring being mounted securely and parallel to the rotary axis. Mount the XR20 to the axis under test as shown.

Mount the mounting ring adaptor plate to the mounting ring using three M5 × 12 mm countersunk screws.

1	Mounting bolt
2	Mounting ring
3	Mounting ring adaptor plate
4	M5 × 12 mm countersunk screws



Mounting set-up 3 (lathes)

When calibrating lathes, the chuck adaptor should be used.

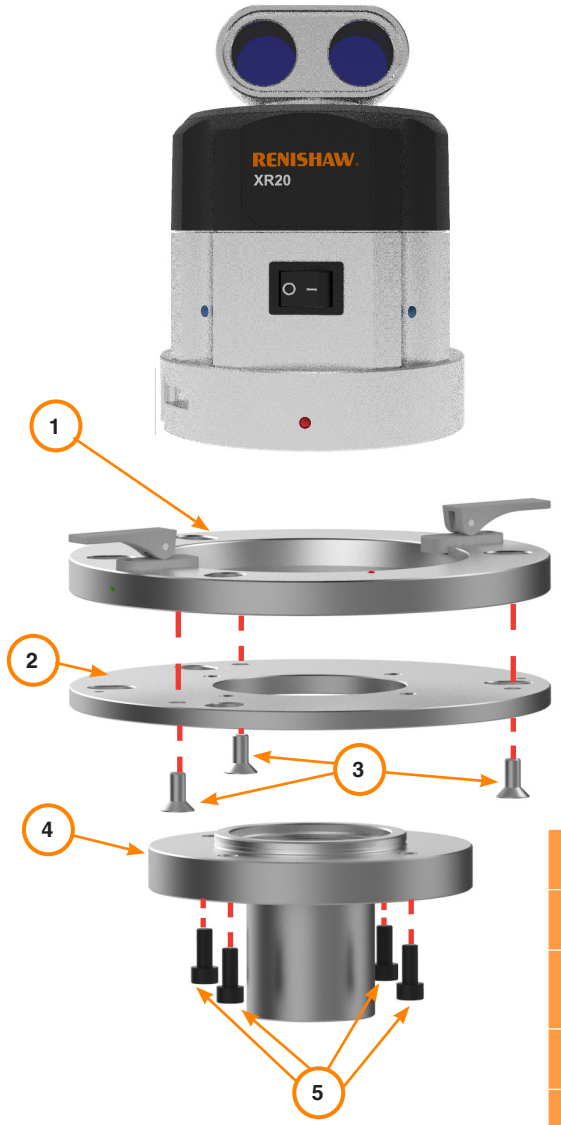
Fix the chuck adaptor to the mounting ring adaptor plate using four M4 × 12 mm cap head screws.

NOTE: When mounted to the chuck adaptor, each of the components must be screwed in the locations indicated in the image using the correct screws. Refer to the **specification section** for more information. To ensure optimum measurement performance, it is recommended that the Total Indicator Run-out (TIR) of the top surface of the mounting ring adaptor plate is checked using a digital gauge. Refer to the **set-up errors** section for more information.

Machine set-up 4

A variation of the chuck adaptor can be used for mounting to small or partially concealed axes (for example, behind access corners). This uses a through bolthole to secure to the test axis.

NOTE: The orthogonality of the adaptor to the test axis is crucial to capturing 'clean' data.

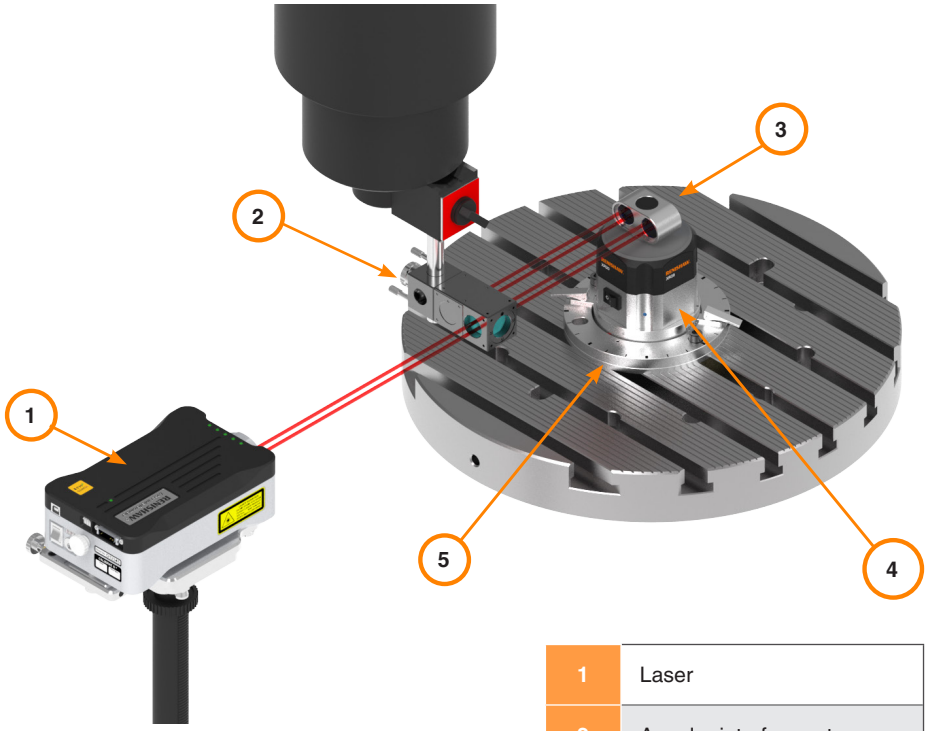


1	Mounting ring
2	Mounting ring adaptor plate
3	M5 × 12 mm countersunk screws
4	Chuck adaptor
5	M4 × 12 mm cap head screws

Optical set-ups using XL-80

Optical set-up 1

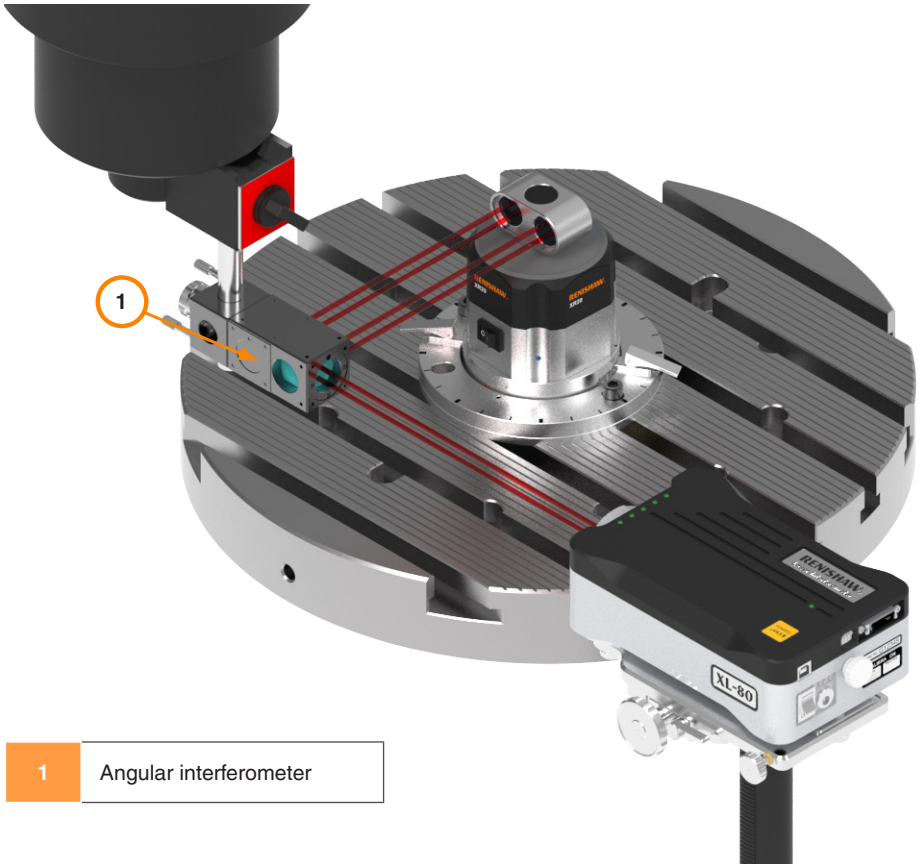
This optical set-up is used when the axis under test has a vertical axis of rotation. See the **setting up the hardware** section for more details.



1	Laser
2	Angular interferometer
3	Angular retroreflector
4	XR20
5	Mounting ring

Optical set-up 2

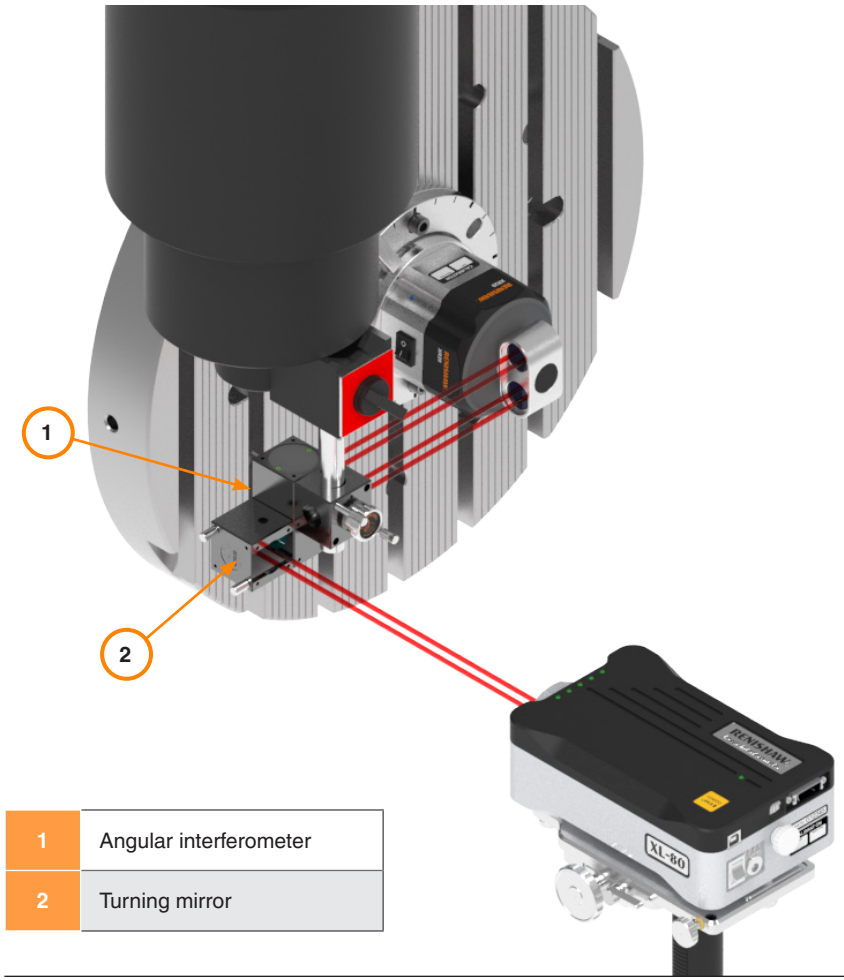
This set-up may be required if it is not possible to mount the laser directly in front of the XR20 rotary axis calibrator due to machining guarding. In this example, the beam enters the angular interferometer through the side aperture rather than the front aperture.



1	Angular interferometer

Optical set-up 3

If the beam emerging from the laser is parallel to the machine axis of rotation, an additional turning mirror is required. The turning mirror turns the beam through 90 degree into the angular interferometer's input aperture as shown. Refer to the *XL laser system* user guide (Renishaw part no. F-9908-0683) for more information.



1	Angular interferometer
2	Turning mirror

Optical set-up using the XM laser system

If using the XM system laser source, use custom fixturing to suspend the launch unit from the spindle.

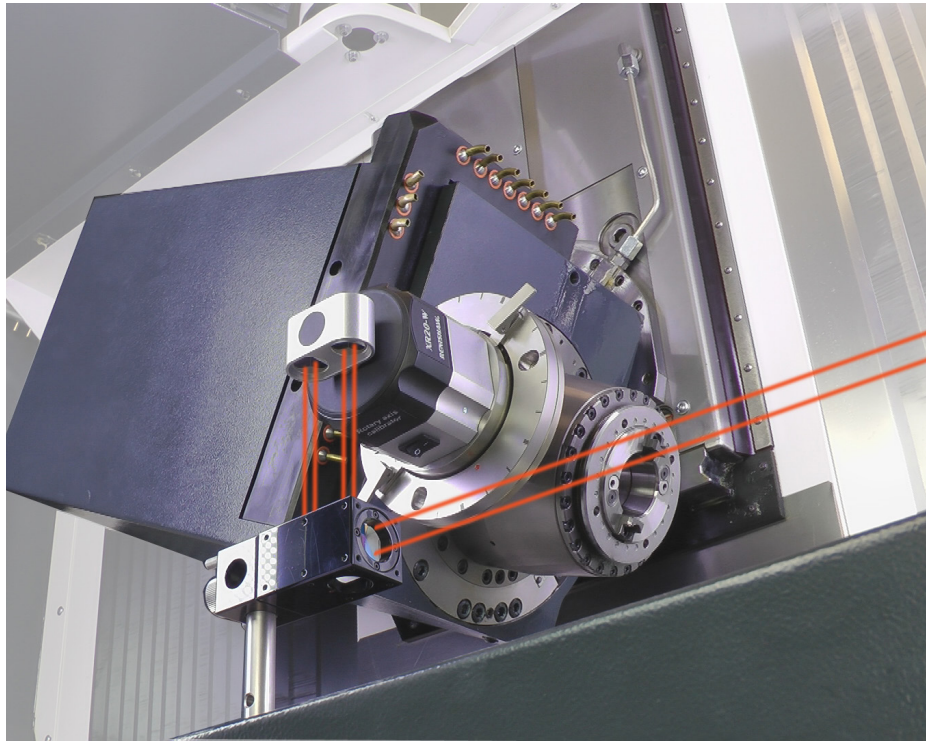
CAUTION: Mounting the XM launch to a tripod may result in measurement error.

Off axis rotary measurement

Off axis rotary measurement simplifies hardware set-up where the XR20 cannot be mounted to the centre of rotation (pivot point) of the axis. Typical applications which can benefit from this method are machine configurations such as trunnions and swivel heads.

Off axis rotary measurement can be carried out using either a XL-80 laser system or an XM laser system in combination with CARTO software suite. If using the XM laser system, custom fixturing may be required for your application.

This section explains the set up of XR20 hardware for off axis rotary measurements.



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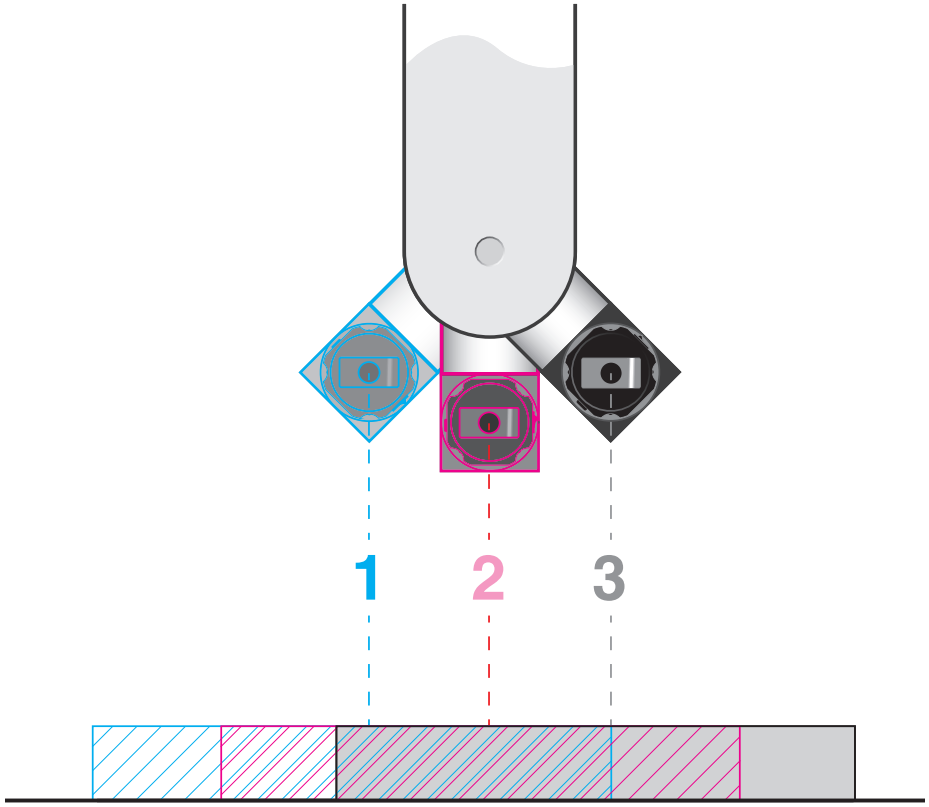
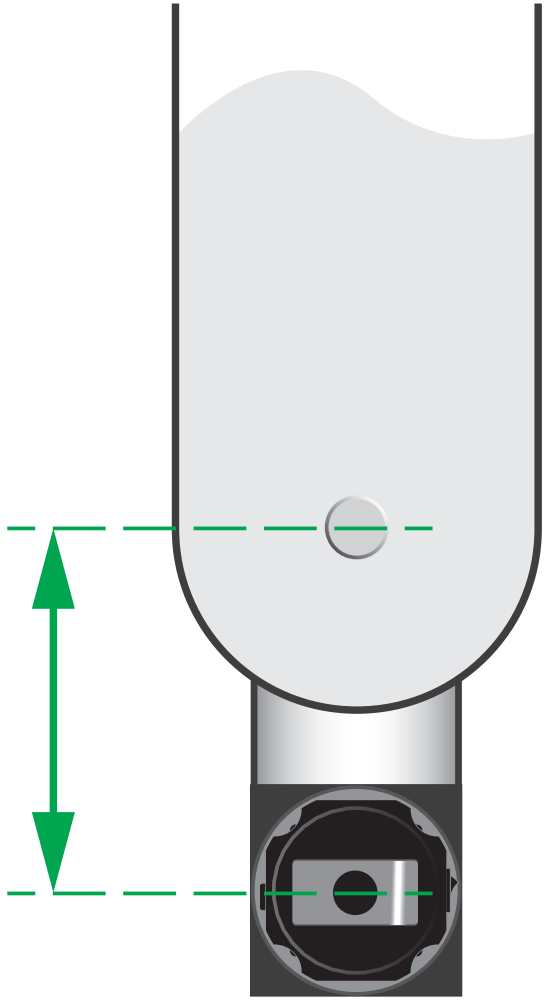
Principles of operation

Off axis rotary measurement uses synchronised movement of linear and rotary axes to ensure beam alignment throughout the test.

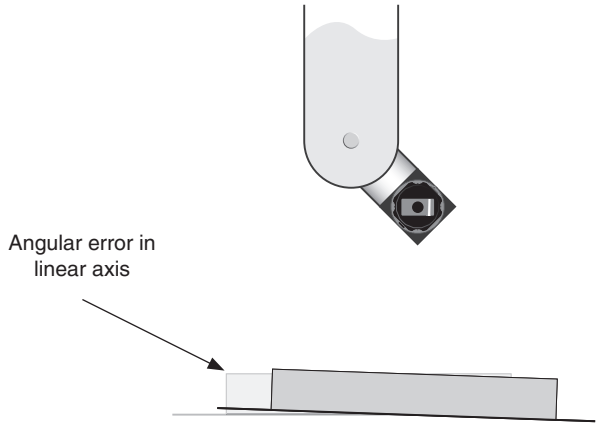


The software produces part programs with synchronised rotary and linear axis movements by calculating the offset distance between the centre of rotation of the XR20 and the rotary axis.



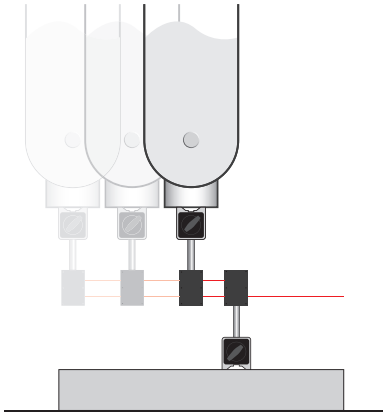
During the rotary test, one of the optics is mounted to a moving linear axis, as shown below.

Any angular error in the linear axis will be included in the rotary data.



Following measurement of the rotary axis, the linear axis angular error must also be measured.

The two data sets are combined in the software to remove the linear axis error from the rotary axis.



Getting started

To complete a calibration using the 'off-axis' method, the following steps are necessary:

Set up the hardware

Identify the rotary and linear axes to be moved, then mount and align the hardware.

Calculate the offset (Capture)

Enter rotary and linear positions into the software using the XR20 and the laser to calculate the offset between the XR20 and the rotary axis.

Generate part programs (Capture)

Program 1: Synchronised rotary and linear commands.

Program 2: Linear only commands.

Capture rotary data (Capture)

Measure the performance of the rotary axis.

Capture angular data (Capture)

Measure the angular performance of the linear axis.

Produce axis analysis (Explore)

The displayed data is the true rotary positioning error with the linear axis error removed from the rotary axis.

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Mounting the XR20

Attach the XR20 90 degree bracket to the machine using the three magnet assemblies supplied ...

... or source fasteners and T-nuts to suit the machine.

NOTE: Do not attach the bracket with the XR20 attached.

It is important to ensure the axis under test is parallel with the axis of the XR20. Parallelism of the axis under test and the XR20 axis is controlled by two factors:

1. The design and tolerance of any bracket used to mount the XR20.
2. The alignment of the bracket with respect to the axis under test.

Align the bracket using a 'dial-type indicator' (DTI) to minimise the run out of the mounting face against the linear axis.

To minimise the test errors relating to the misalignment ensure that the DTI reading is less than 60 µm across the bracket (from A-B) and down the face of the bracket (B-C).

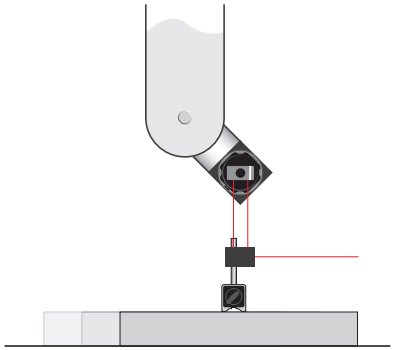
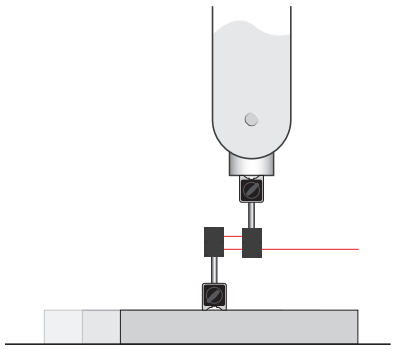
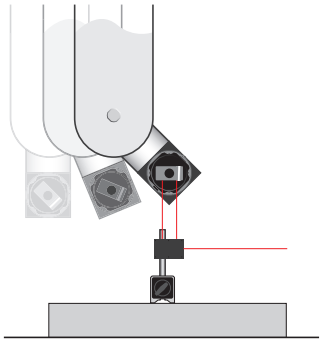
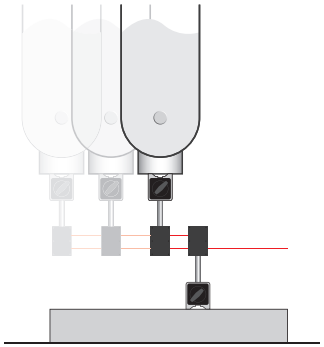
If it is not possible to achieve <60 µm, there will be an induced test error. See **Appendix A** for further details.

Attach the XR20 to the bracket using the three M5 x 12 mm cap head screws and 4 mm hex key supplied.

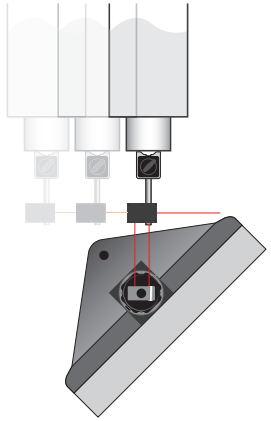
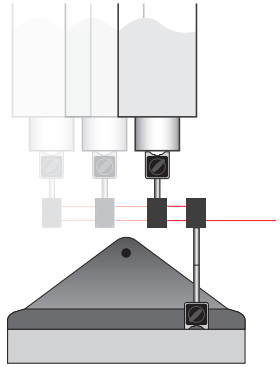
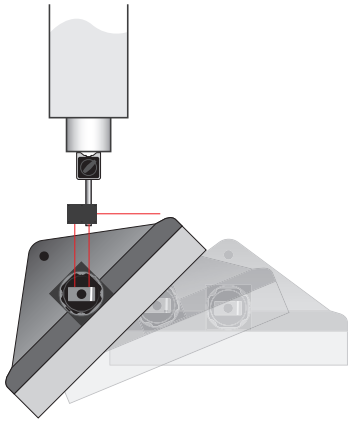
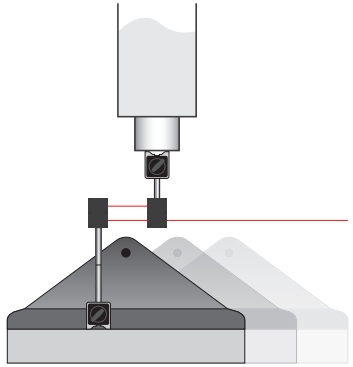
For XM-60, go to page 45.

XL-80 optical set-ups

The optical setup will depend upon the machine type being tested. The following table shows the optical configurations for the most common machine applications. **For XM-60, go to page 45.**

	Off-axis set-up	Angular measurement set-up
Head machine type 1		
Head machine type 2		

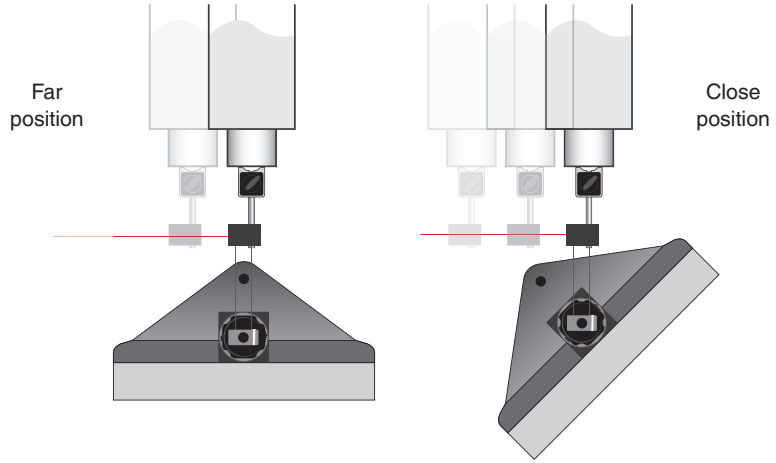
NOTE: In the angular measurement setup, the retroreflector is always mounted to the moving linear axis of the machine.

	Off-axis set-up	Angular measurement set-up
Table machine type 1		
Table machine type 2		

XL-80 laser alignment (rotary axis)

1. Mount the magnetic base, pillar and interferometer on to the spindle/ machine bed as required for the type of machine under test.
2. Nominally position the laser, XR20 and interferometer.
3. Place the bubble level onto the laser and adjust the tripod to ensure it is level.
4. Move the rotary and linear axes to the position where the XR20 comes closest to the interferometer as shown below.

WARNING: Observe caution when moving the components to the close position. Ensure there is sufficient clearance to avoid the potential for collisions when running the tests.



5. If necessary, adjust the positions of the components and the axes to ensure a collision cannot occur.
6. Align the laser to the linear axis across the full range of travel for the test setup.
7. Hold a plane mirror against the face of the interferometer and rotate the interferometer so the beam returns into the output aperture of the laser.

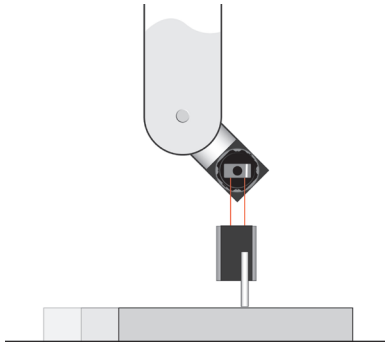
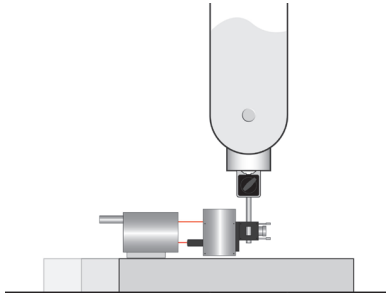
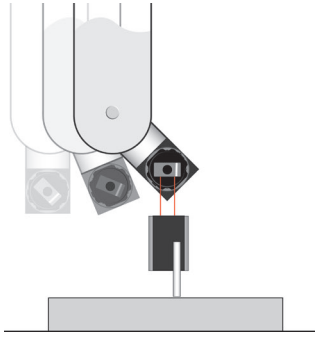
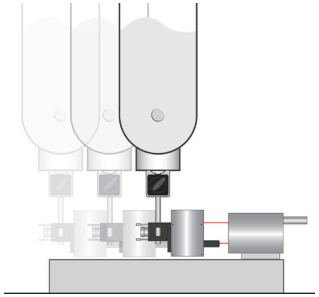
NOTE: the laser may go unstable at this point.

8. Recheck the alignment across the linear axis and translate the laser or interferometer to correct any misalignment caused during the previous step.
9. Position the rotary axis at one extreme of rotary travel for the test to be run.
10. Move the linear axis so the interferometer is in line with the XR20 and check full signal strength is achieved.
11. Move the machine to the opposite extreme of travel for the test set-up and repeat the two steps above.

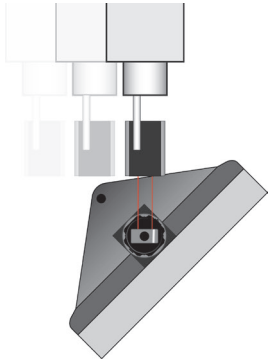
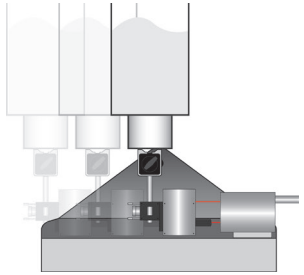
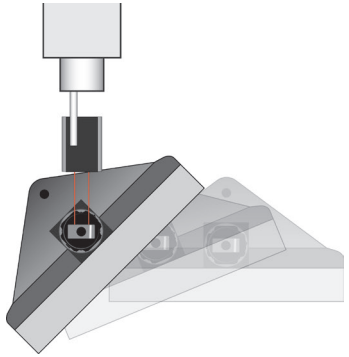
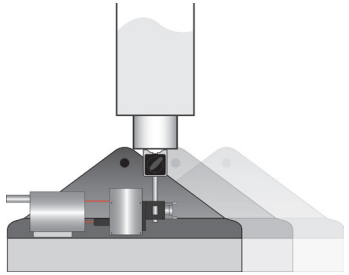
XL-80 alignment complete, go to page 48.

XM-60 optical set-ups

The optical setup will depend upon the machine type being tested. The following table shows the optical configurations for the most common machine applications.

	Off-axis set-up	Angular measurement set-up
Head machine type 1		
Head machine type 2		

NOTE: In the angular measurement setup, the receiver is always mounted to the spindle.

	Off-axis set-up	Angular measurement set-up
Table machine type 1	 **NOTE:** Custom fixturing may be required for this set-up.	
Table machine type 2	 **NOTE:** Custom fixturing may be required for this set-up.	

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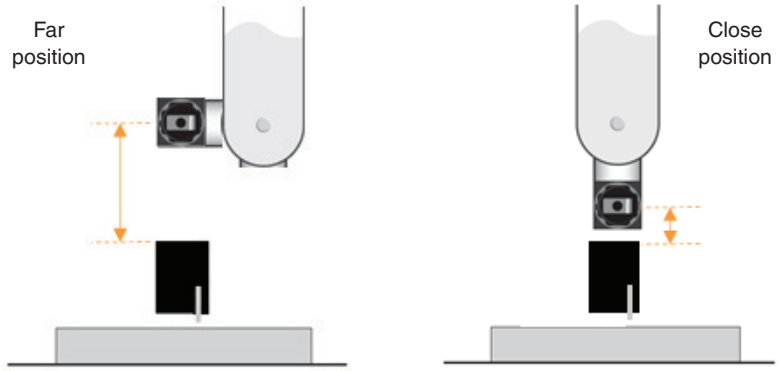
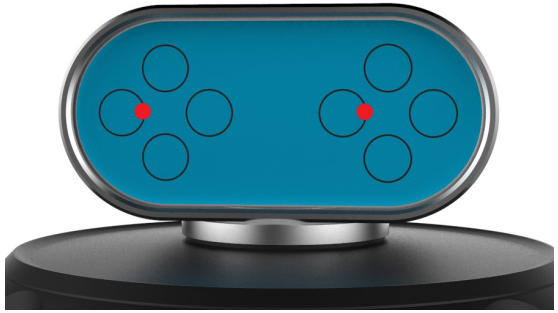
XM-60 laser alignment (rotary axis)

1. Mount the launch unit on to the spindle/machine bed as required for the type of machine under test.
2. Place the bubble level onto the front or rear face of the launch unit as appropriate, then adjust the yaw screw to ensure that it is level.
3. Attach the beam blocker to the face of the launch unit.
4. Nominally align the launch unit and XR20.
5. Move the rotary and linear axes to the position where the XR20 comes closest to the launch unit as shown below.

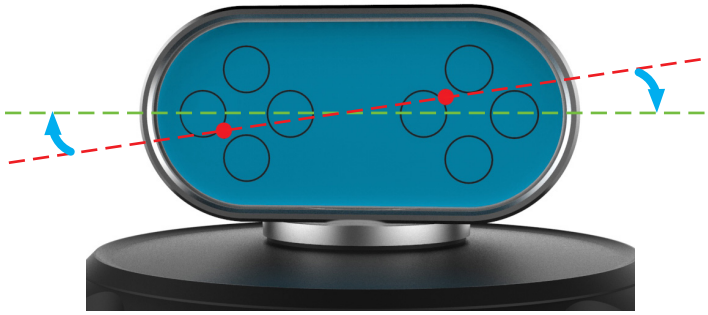
WARNING: Observe caution when moving the components to the close position. ensure there is sufficient clearance to avoid the potential for collisions when running the tests.



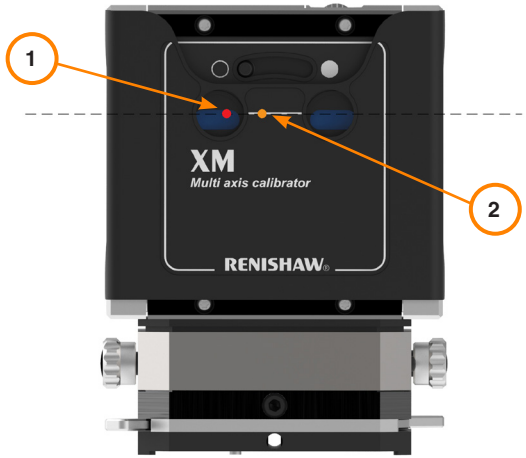
6. If necessary, adjust the positions of the components and the axes to ensure a collusion cannot occur.
7. Rotate the machine head to the far position. Move the linear axis until the XR20 is directly above the launch unit.
8. Translate the laser launch so that the laser beam hits the target on the alignment aid as shown:



9. If required, rotate the launch unit to until the beams are level on the blue target.



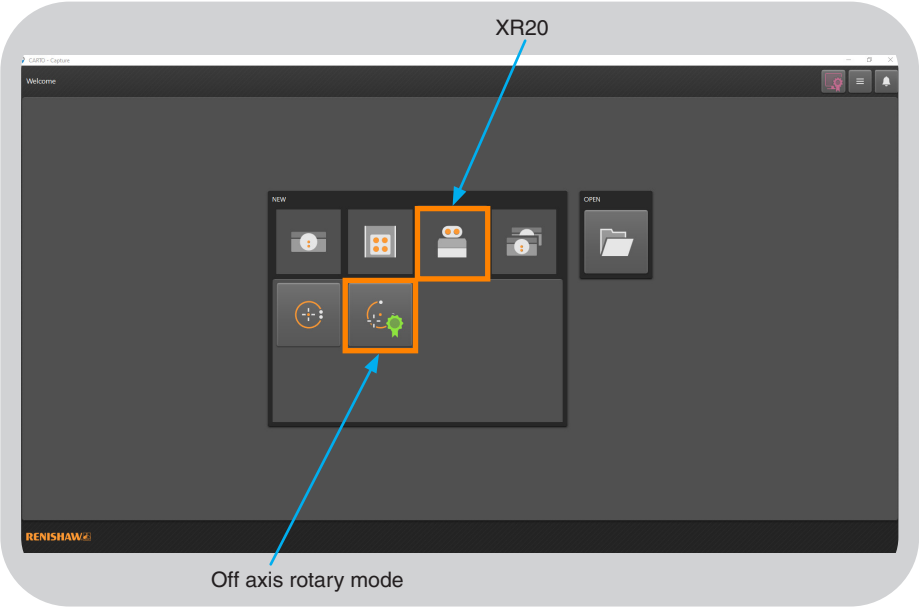
10. Observe the reflected beam on the launch beam blocker. Adjust the pitch of the launch so that the reflected beam is on the centreline.



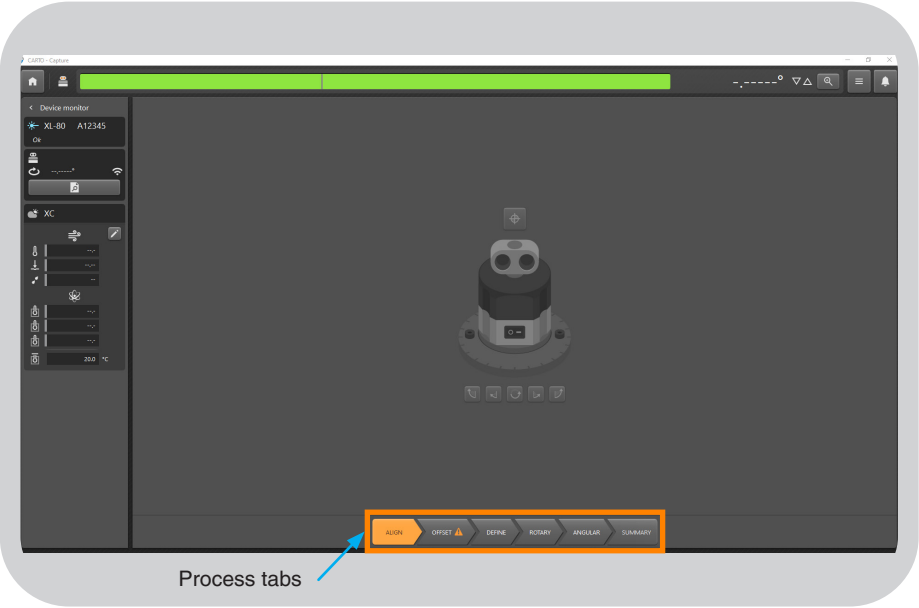
1	Beam aperture
2	Reflected beam

11. Translate the machine to align the beam again as per step 8.
12. Rotate the XR20 optic back around so that the retroreflectors are pointing back towards the laser within +/- 2 deg.
13. Position the rotary axis at one extreme of rotary travel for the test to be run.
14. Move the linear axis so the interferometer is in line with the XR20 and check full signal strength is achieved.
15. Move the machine to the opposite extreme of travel for the test set-up and repeat the two steps above to check good signal strength is achieved.

Rotary axis data capture

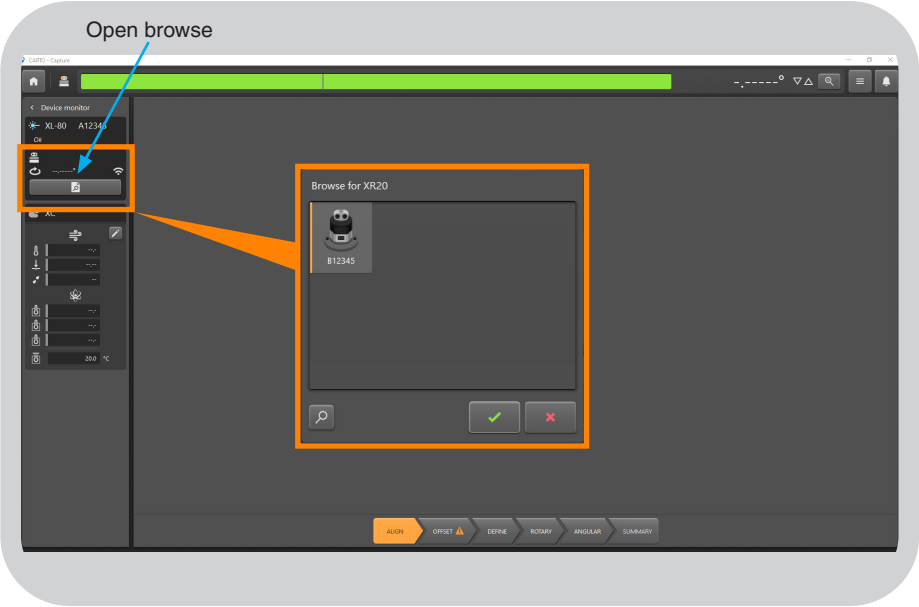


Run the Capture application and select ‘Off axis rotary mode’.



The Process tabs will change depending upon which laser device is connected.

Rotary axis data capture

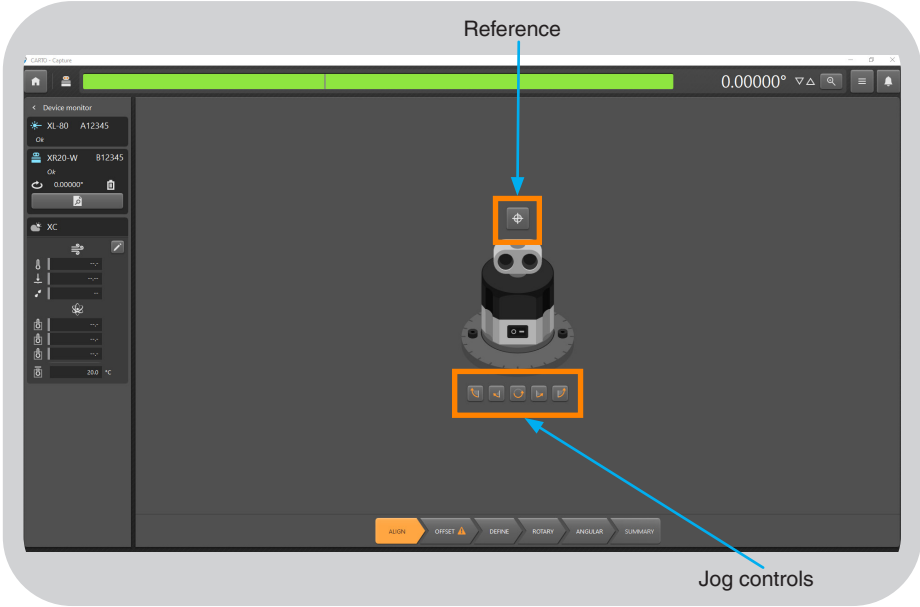


To connect the XR20, select ‘Open browse’.

In the browse box, select search. XR20’s within range will appear in the list.

Select the correct XR20 serial number and press ‘OK’.

If the XR20 is not found then see the setup pages for XR20 (Appendix E) or XR20-W (Appendix F) as applicable.



Alignment of the XR20 can be carried out by manually rotating the optic by hand, or using the built in jog controls.

To use the built in jog controls, the XR20 must be referenced.

NOTE: When using the jog controls the optic must not be rotated by hand.

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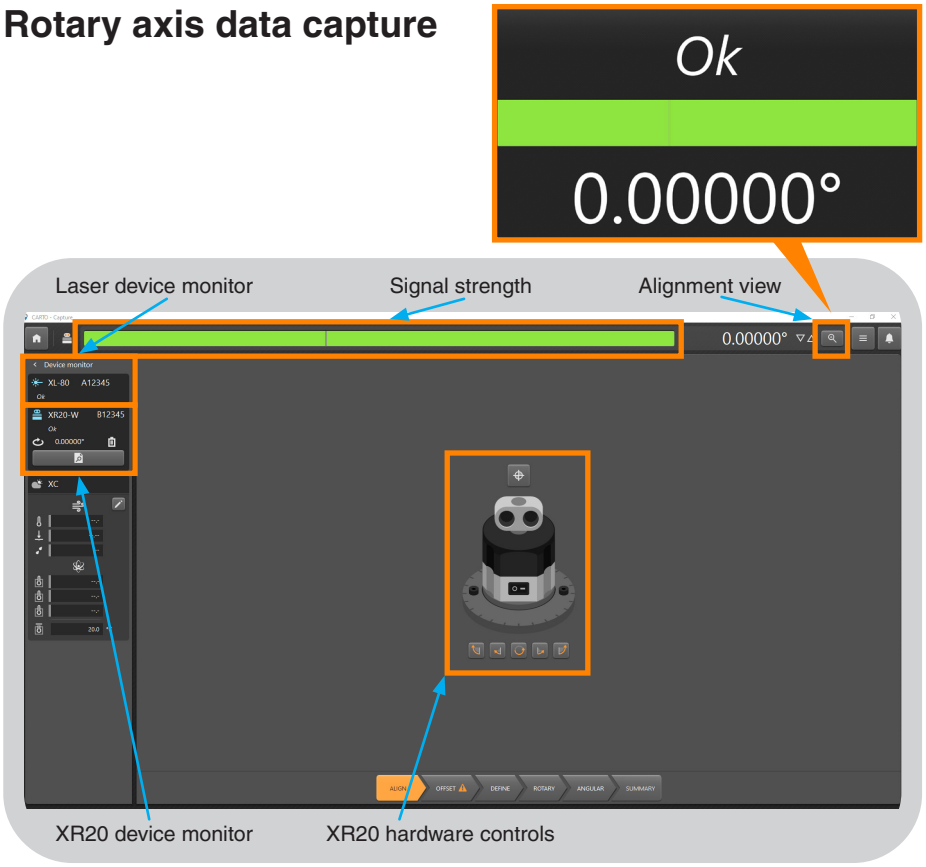
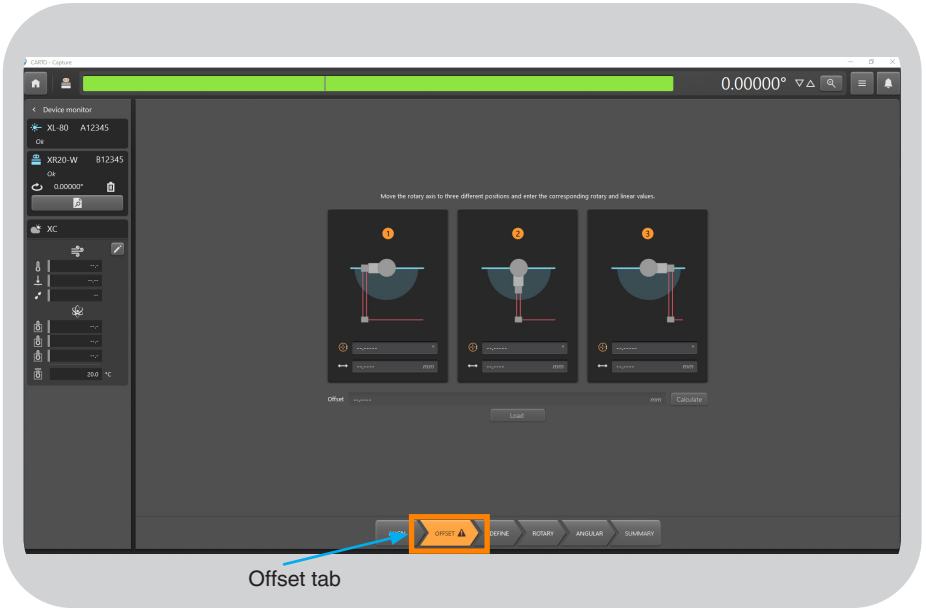
Rotary axis data capture



When the hardware is connected the application will be in the view shown. Ensure that the laser is connected to the laptop.

- **Device monitors** – show the status of connected hardware.
- **Signal strength** – gives an indication of alignment.
- **Alignment view** – gives a simple full screen view of signal strength and current laser reading to aid alignment.
- **XR20 hardware controls** – allows the XR20 to be rotated for alignment using the software.



Select the 'Offset' tab to calculate the offset between the XR20 and machine centre of rotations.

Offset calculation

The ‘offset’ is the distance between the XR20 and the rotary axis. It must be calculated accurately for synchronised movement of the rotary and linear axes.

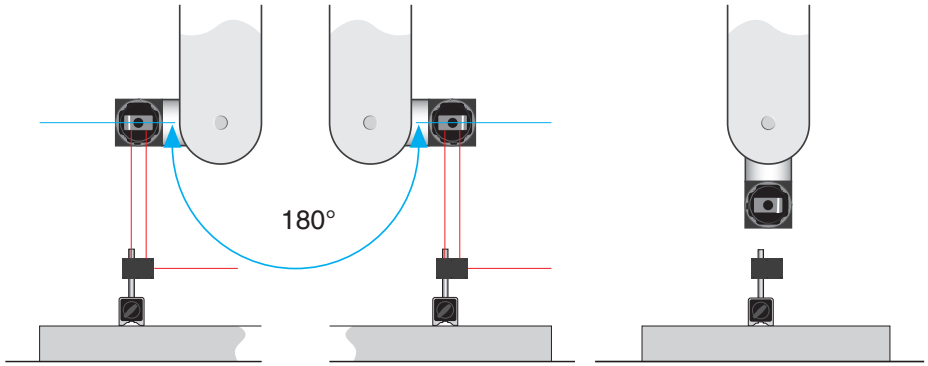
Calculating the offset relies on moving the machine to three positions, ensuring laser alignment and recording the machine positions.

WARNING: Incorrect offset calculation could result in a machine crash.

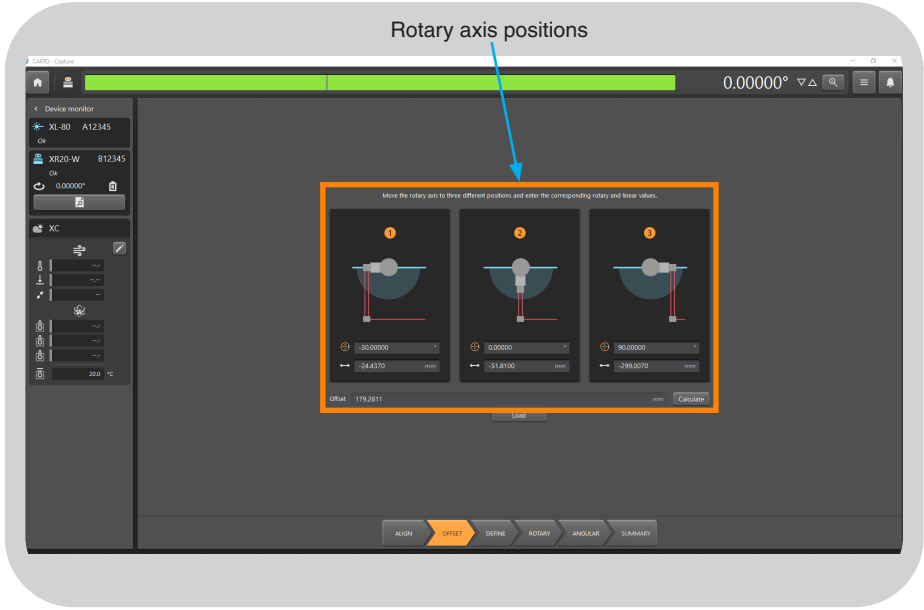
The images below show the positions to achieve the most accurate offset calculation.

At the 180 degree rotary positions the linear axis will be at the maximum and minimum extremes of travel for the test.

The third position should be midway between them.



For more information, see **Appendix G.**



1. Drive the rotary axis to position
2. Rotate the XR20 optic so that the retro-reflectors are facing the XL-80 beam splitter or XM-60 launch to +/-2 degrees.
3. Drive the linear axis so that the laser beams return to the laser source.
4. Adjust the linear axis until the signal strength is maximised.
5. Record the rotary and linear machine co-ordinate positions into the software.

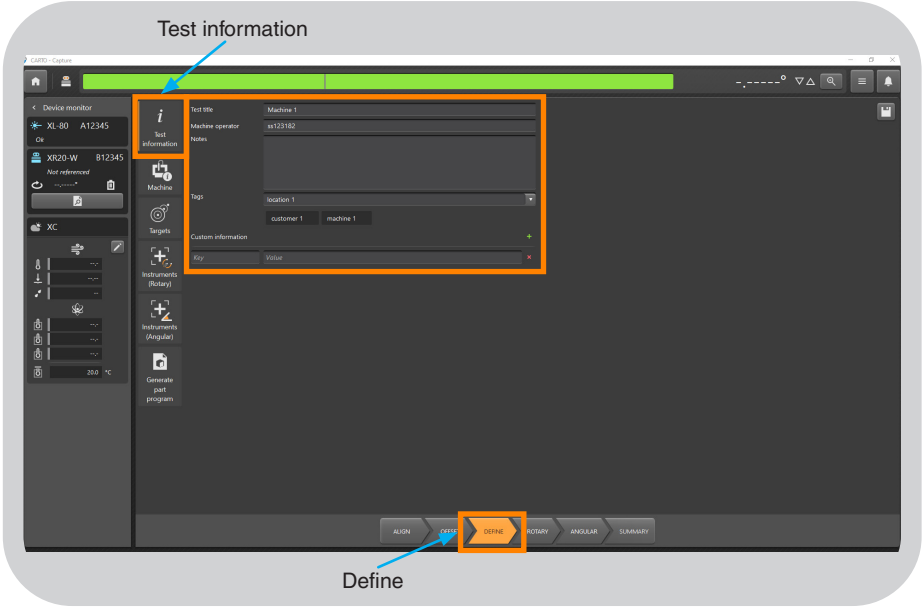
Repeat the process for a further two positions, then select calculate.

WARNING: Care should be taken to ensure recording machine positions are taken with the same work offset applied that will be used when the program is run.

Rotary axis data capture

If the test has been carried out previously in the same position, it is possible to load previously used offset values using the ‘Load’ button.

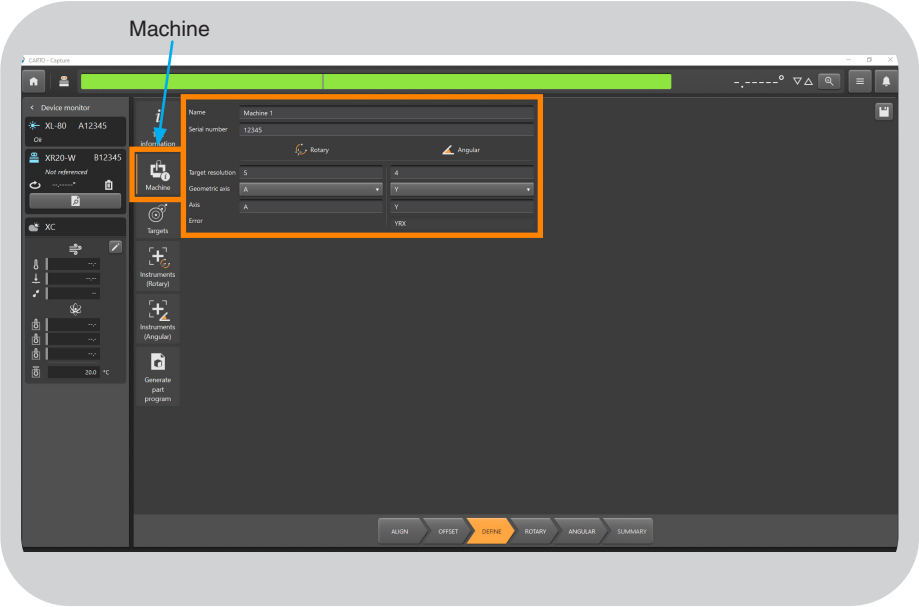
Select the ‘Define’ tab. The ‘Test information’ tab is a place to enter general information for test identification within the CARTO database.



- **Test title** – title to be used when referring to the test.
- **Machine operator** – name of operator conducting the test.
- **Notes** – information which may be useful about the test.
- **Tags** – apply tags to aid filtering of data in Explore.
- **Custom information** – allows customised fields to be created and included in the test record.

Rotary axis data capture

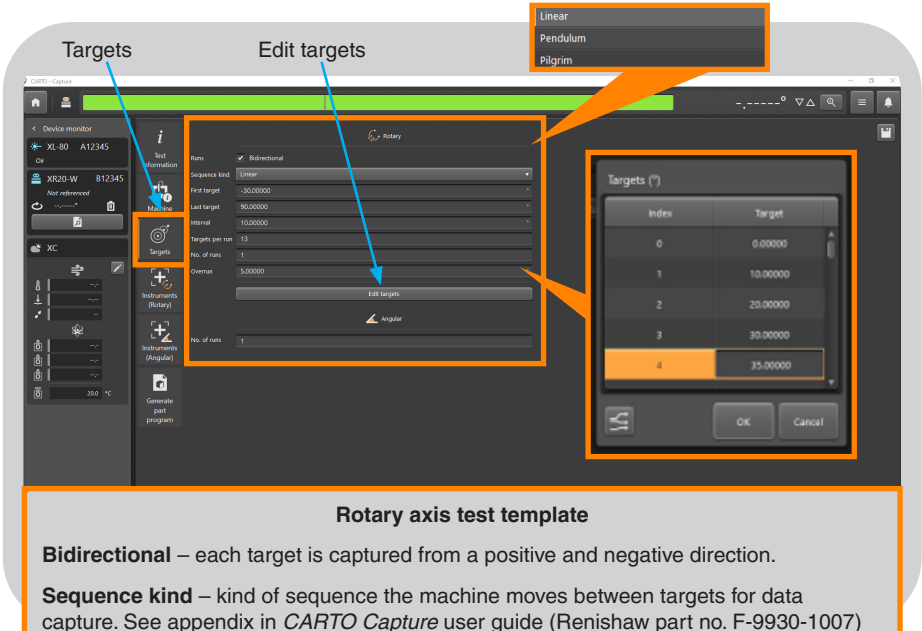
In the ‘Machine’ tab enter information which is specific to the machine and axis under test.



- **Name** – name of the machine under test.
- **Serial number** – serial number of machine under test.
- **Target resolution** – number of decimal places for targets. This must not be higher than the machine resolution.
- **Geometric axis** – select the axis under test to match the set-up.
- **Axis** – allows a custom axis name to be used.
- **Error** – identifies the angular error measured along the linear axis.

In the ‘Targets’ tab, enter the positions to capture data and the sequence required to capture them.

Targets can be manually edited or randomised using the ‘Edit targets’ button.



Rotary axis test template

Bidirectional – each target is captured from a positive and negative direction.

Sequence kind – kind of sequence the machine moves between targets for data capture. See appendix in *CARTO Capture* user guide (Renishaw part no. F-9930-1007) for more information.

First target – input the first position for data capture.

Last target – input the last position for data capture.

Interval – distance between targets.

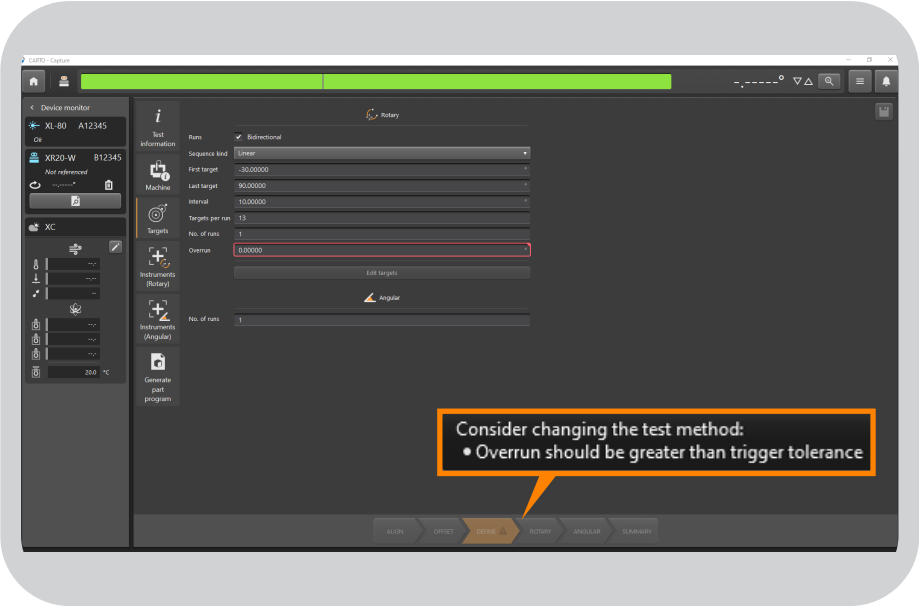
Targets per run – if the interval value has been entered this will be updated accordingly.

Number of runs – determine the number of times the target sequence is repeated.

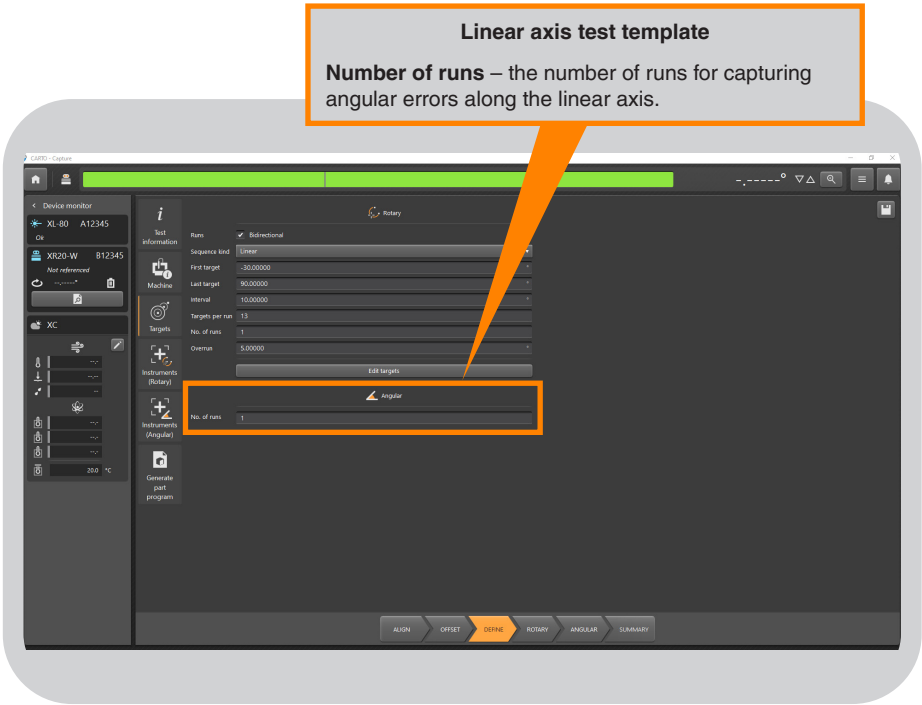
Overrun – distance required for turn around at end of the axis (including first target and last target).

Edit targets – targets can be individually edited or randomised.

Rotary axis data capture



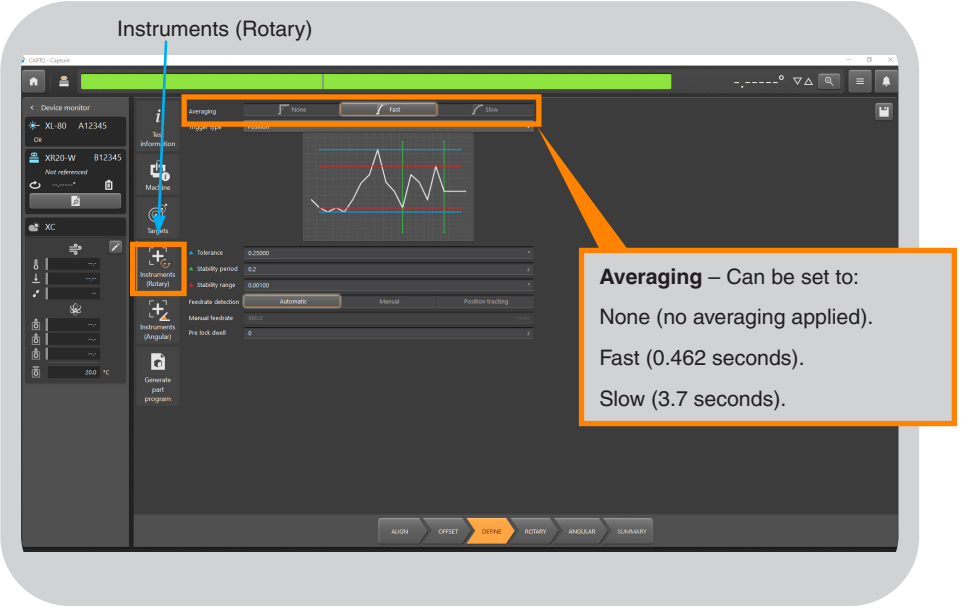
Any highlighted box or warning triangles highlight potential problems with the test method. Place the mouse over the text field for more information.



Enter the quantity of runs for the linear axis test.

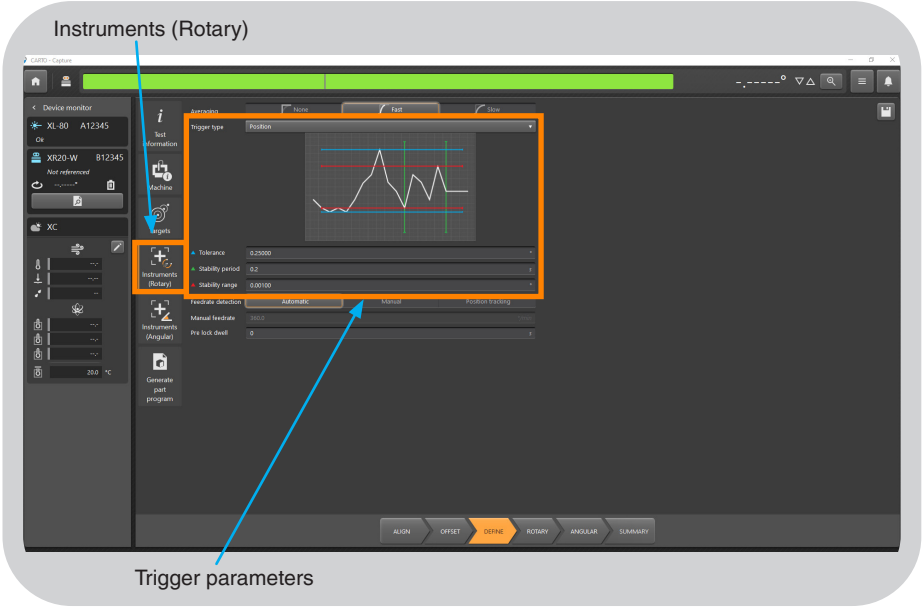
- A minimum of 1 run is recommended.
- If more than 1 run is carried out, the data is averaged to correct the rotary axis.

Rotary axis data capture



In the ‘Instruments (Rotary)’ tab, select the averaging type required.

When using position trigger type, the trigger parameters must be set correctly to ensure that the software recognises when data should be captured.

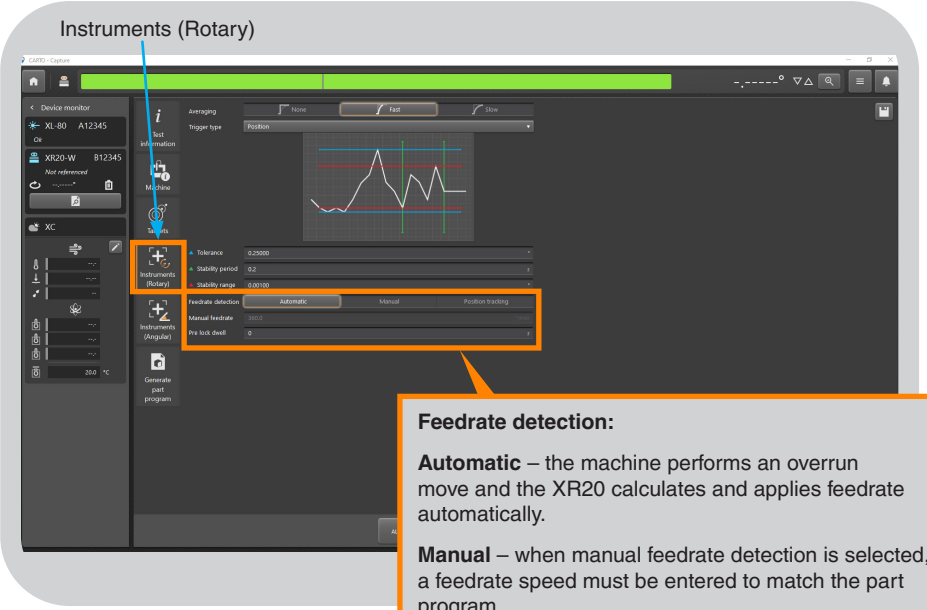


- **Tolerance** – the distance either side of the set target value considered to be acceptable.
- **Stability period** – the period of time that the machine must stay within the set stability range.
- **Stability range** – the maximum position variation considered to be acceptable.

If the machine is outside of any of the trigger parameters, data will not be captured.

Rotary axis data capture

Set the ‘Feedrate detection’ as required.



Feedrate detection:

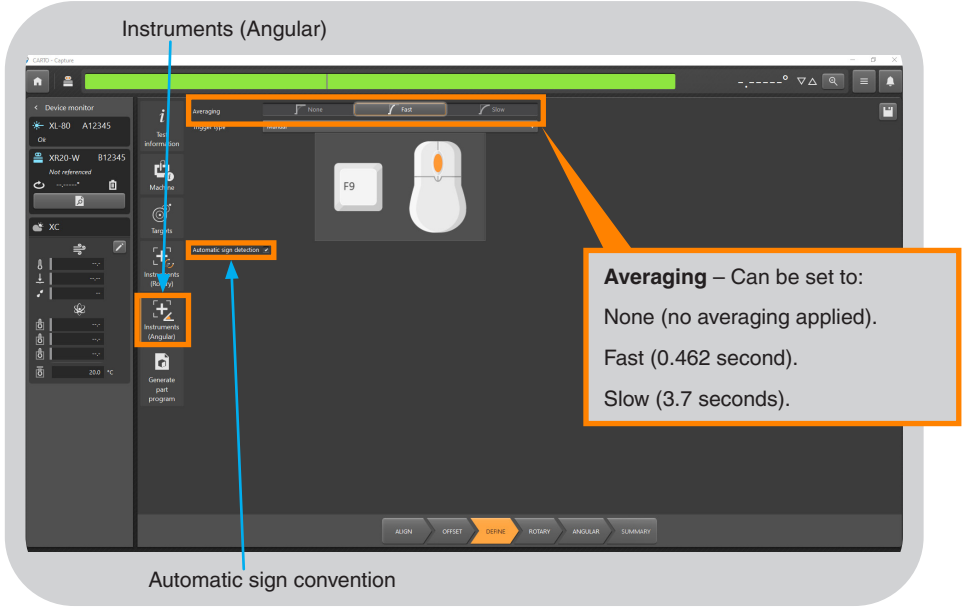
Automatic – the machine performs an overrun move and the XR20 calculates and applies feedrate automatically.

Manual – when manual feedrate detection is selected, a feedrate speed must be entered to match the part program

Position tracking – this setting allows the user to perform data capture in situations such as manual motion of the axis under test where the feedrate is not constant. It works by monitoring the signal strength of the laser and indexing the optic to optimise the signal.

Manual feedrate – requires a speed to be entered in degrees per minute only when feedrate is set to ‘manual’.

Pre-lock dwell – is used for applications such as machine tools with a mechanical brake. This is a time delay for the XR20 to capture data allowing the brake to be applied.



Averaging – Can be set to:

None (no averaging applied).

Fast (0.462 second).

Slow (3.7 seconds).

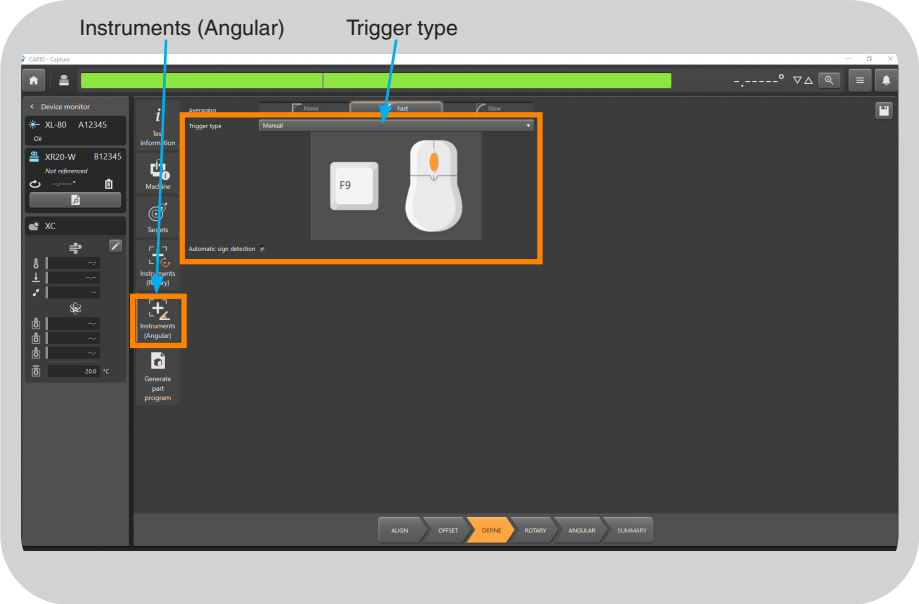
In the ‘Instruments (Angular)’ tab, select the averaging type required.

Automatic sign convention can be enabled or disabled. This puts an entry into the part program to toggle the rotary axis.

If automatic sign convention is disabled refer to **Appendix C**.

Rotary axis data capture

XL-80 only

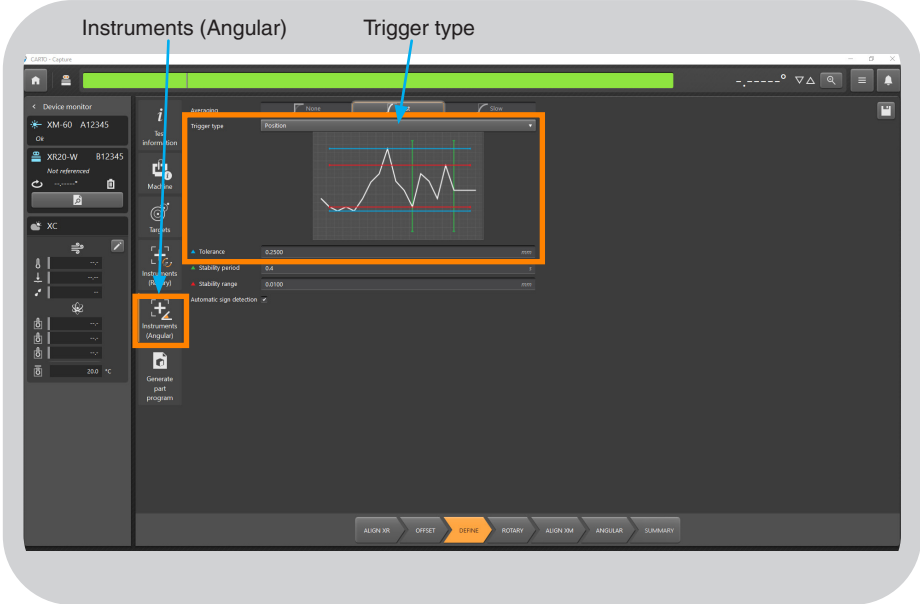


Set the trigger type to capture the data along the linear axis.
When using XL-80 ‘manual’ or ‘TPin’

- **Manual** – uses the F9 key or middle mouse button
- **TPin** – uses an external source to trigger through he Aux I/O input on the XL-80. See **Appendix B.**

Position triggering is unavailable because the laser does not feedback the current linear position.

XM-60 only

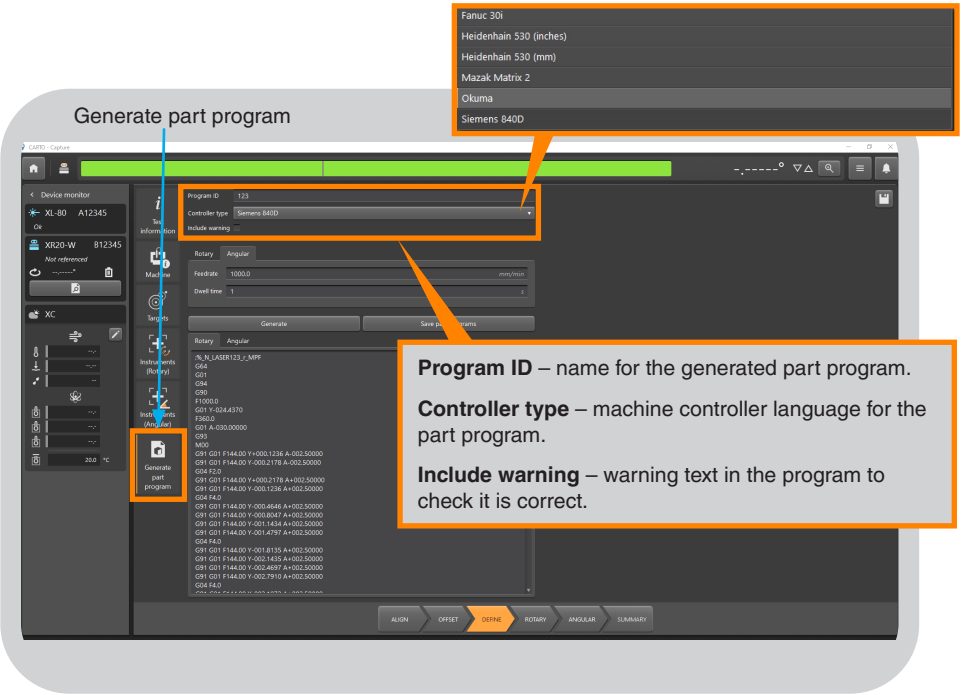


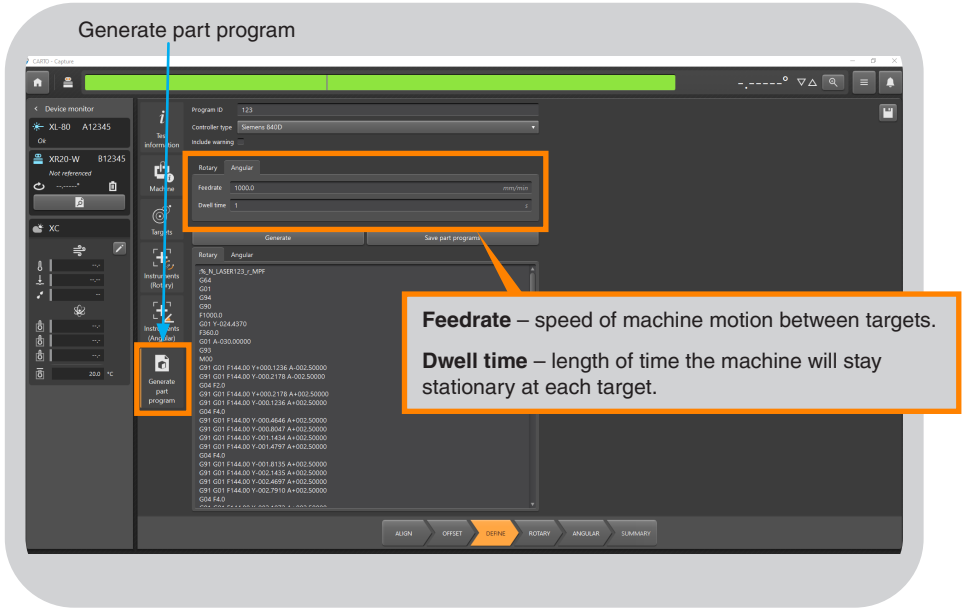
Set the trigger type to capture the data along the linear axis.
When using XM-60 ‘position’ or ‘manual’ options are available.

- **Position** – provides automated data capture.
- **Manual** – uses the F9 key or middle mouse button

XM-60 uses the linear position feedback to know when it has arrived at the required target position, but linear data is not recorded.

Rotary axis data capture





To create a machine part program use the ‘Generate part program’ tab.

Enter a program ID and select the required machine controller type.

In the ‘Rotary’ and ‘Angular’ tabs, enter the feedrate and dwell time for each test.

Dwell time is automatically populated based upon previous selections such as averaging and trigger parameters, however this can be modified if required.

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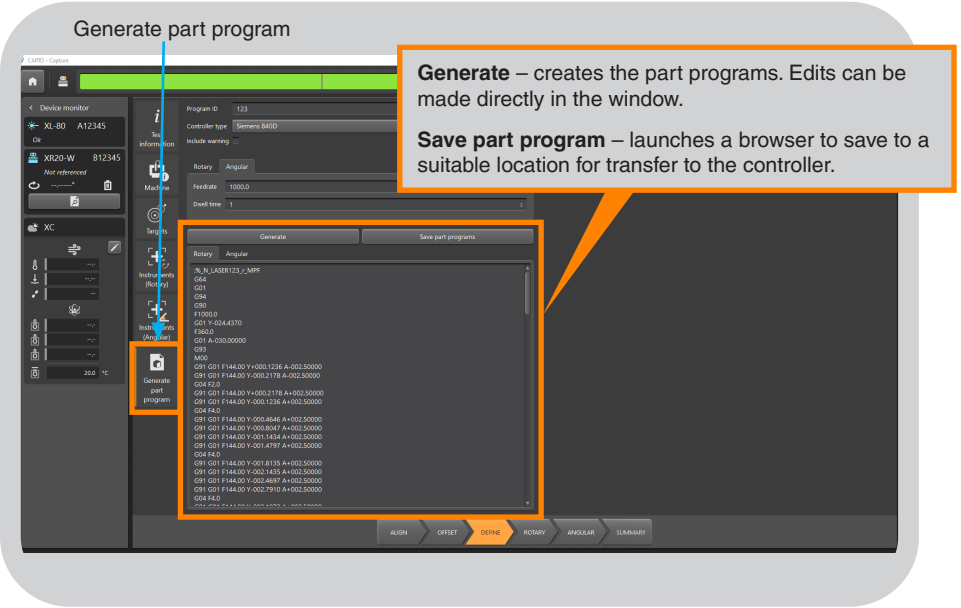
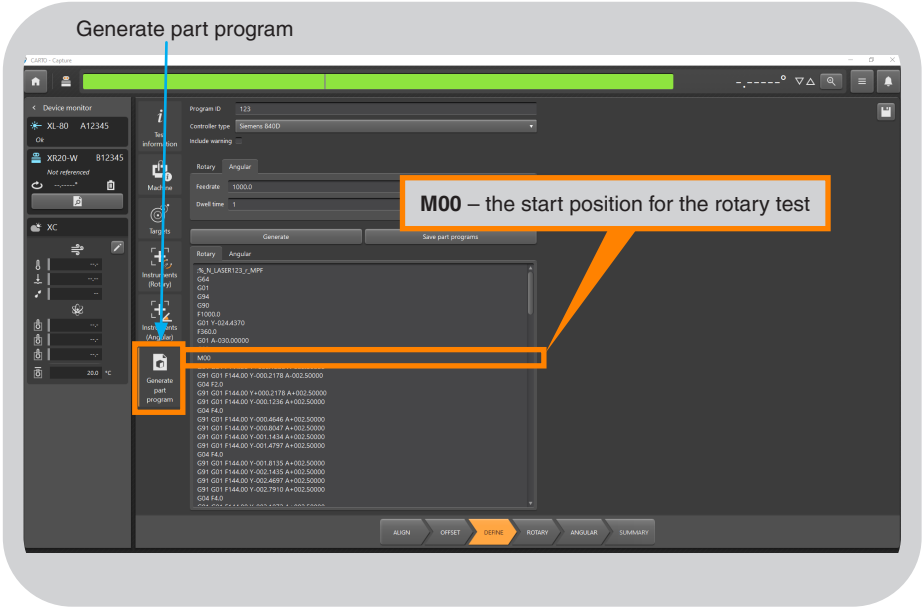
Rotary axis data capture





Generate the part programs. There are two tabs, rotary and angular which contain the programs required for off axis testing.

- **Rotary** – contains rotary axis moves with synchronised linear axis moves.
- **Angular** – contains linear axis moves only.

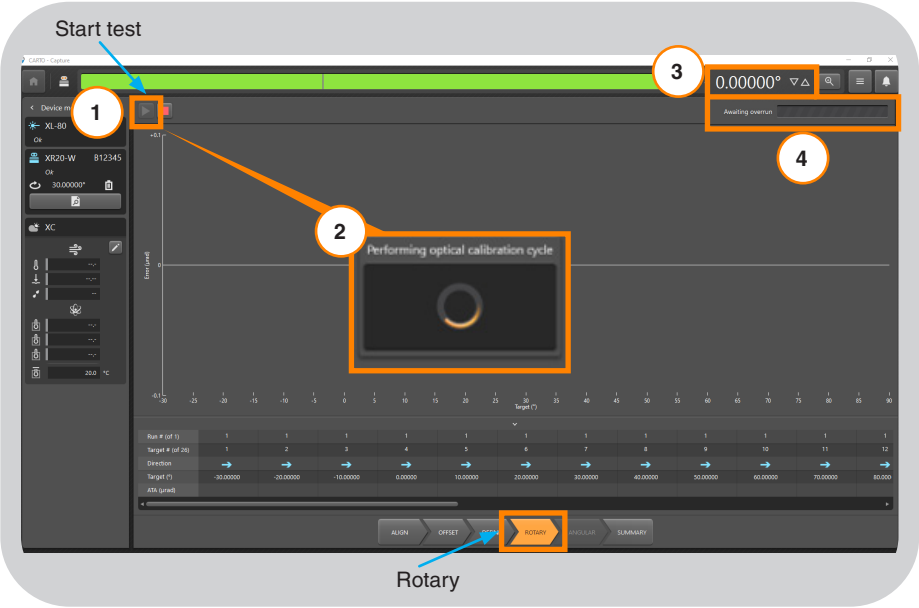
Save to a suitable location for transfer to the machine.

Activate the rotary part program in the machine controller and run to the start ‘M00’ position.

Ensure that the XR20 optic is aligned and full signal is achieved.

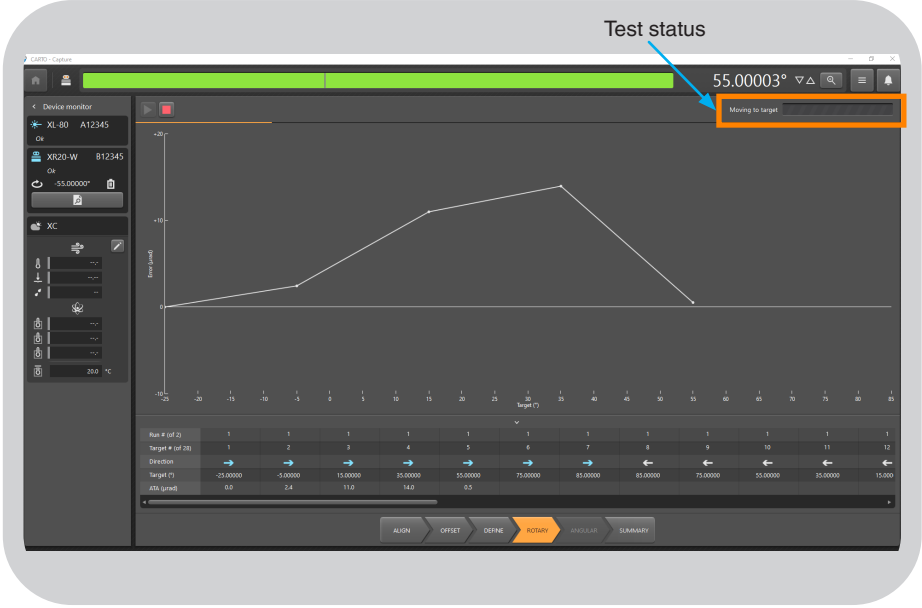
Rotary axis data capture

Select the ‘Rotary’ tab.



There is no requirement to set sign direction for rotary tests. The software monitors the targets and compares them to the overrun move to set them automatically.

1. Press ‘Start test’.
2. The XR20 will then start the optical calibration cycle.
3. The read-out will be set to the value of the first target.
4. The test status bar advises the next steps.



Press start on the machine controller. Using position trigger type, data will be collected automatically.

The test status is displayed in the top right of the screen.

Rotary axis data capture

The test status will indicate when the test is complete.

Setup the hardware (linear axis)

When using XL-80, in most cases there is no need to move the laser as this will already be aligned to the moving linear axis.

When using XM-60, the orientation and position of the launch unit will need to be changed.

1. Remove the XR20 from the rotary axis.

XL-80

2. Mount the retroreflector to the moving linear axis of the machine.
3. Mount the Interferometer to the stationary element of the machine.

XM-60

2. Mount the receiver to the spindle of the machine.
3. Mount the launch unit to the bed of the machine.

XL-80 and XM-60

4. Move to the minimum and maximum travel positions in the linear part program to ensure that the optics do not collide.
5. Adjust the optics as necessary.
6. Ensure good signal strength along the range of travel covered by the part program.

NOTE: If alignment is required then refer to the angular section of the **XL-80 manual.**

7. Capture the linear axis data.

Sign convention

When measuring the angular error in the linear axis the sign convention can be determined in the Capture software application with one of two methods:

- Automatic sign convention
- Manual sign convention

The method chosen is a user configurable setting in the software application.

Automatic sign convention

Automatic sign convention requires optical hardware to be mounted to the rotary axis of the machine which was previously measured with the XR20.

- For XL-80, it can be the angular interferometer or the angular reflector.
- For XM-60, it can be the launch unit or the receiver.

The part program generated in the Capture software must be used as it contains a small 'directional jog' of the rotary axis. The direction of the machine is observed by the laser and the software sign convention is set to match the machine.

Manual sign convention

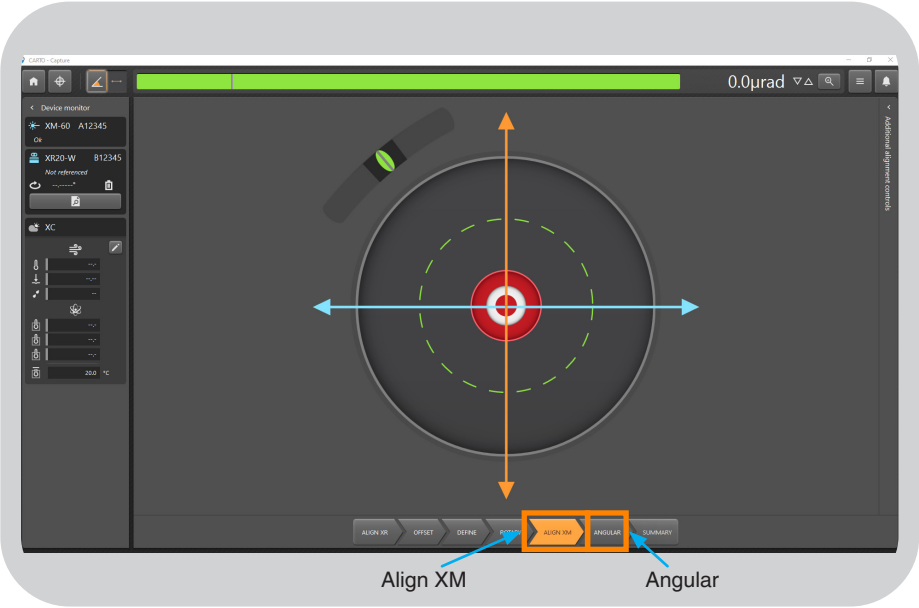
Manual sign convention requires you to determine the direction manually. The method to determine the sign convention depends on the optical set up in the linear axis.

The laser has a determined sign convention; therefore, a rotation of the angular reflector is not the same as a rotation of the angular interferometer if they are rotated in the same direction.

Appendix C provides more details for determining sign convention manually.

Linear axis data capture

XM-60 only



Select the ‘Align XM’ tab to align the XM-60 hardware to the linear axis.

Once aligned switch to the ‘Angular’ tab.

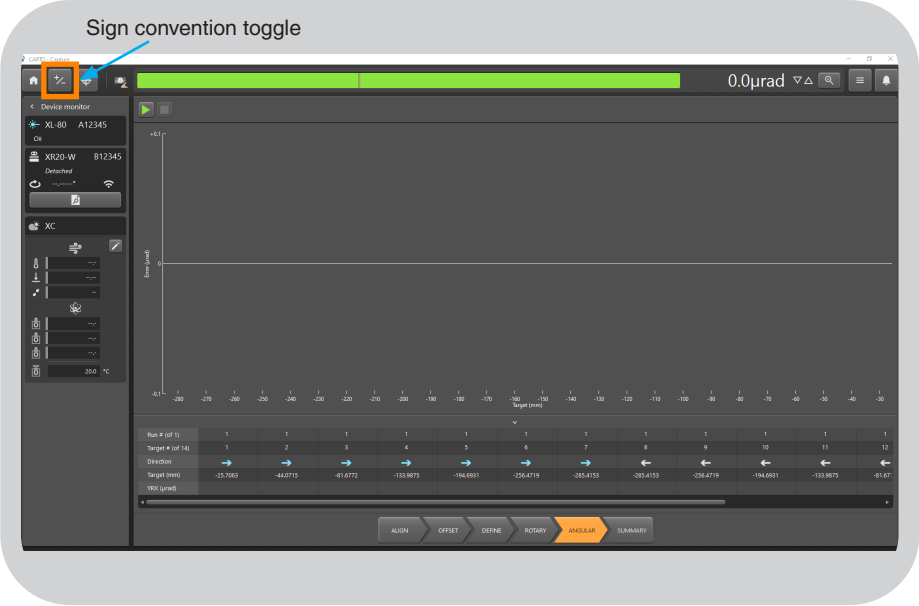
Ensure that good signal strength is achieved across the full length of travel.

XL-80 only

Select the ‘Angular’ tab and align the hardware along the linear axis.

Ensure that good signal strength is achieved across the full length of travel.

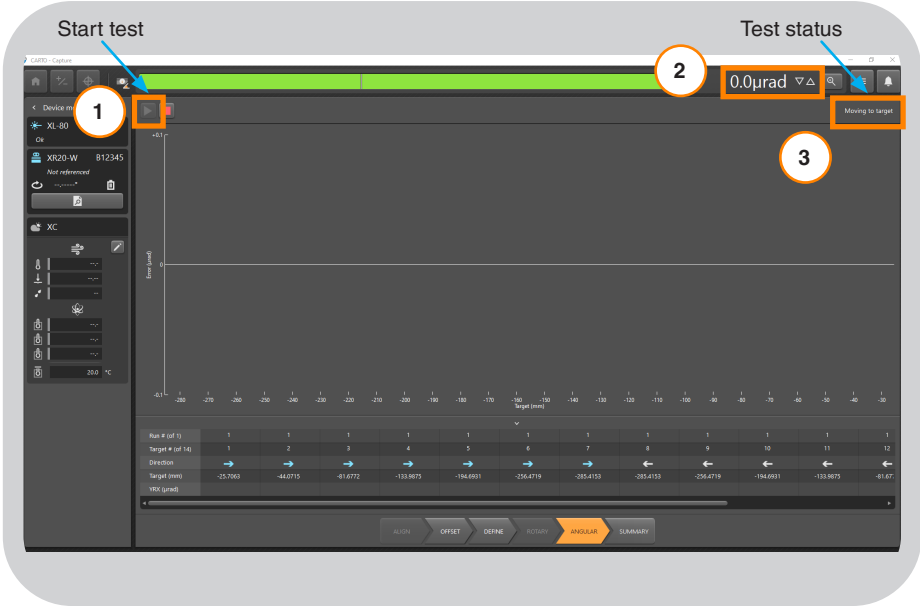
Linear axis data capture



Sign convention for the linear axis is automatic unless manual sign convention has been set in the test method.

If manual sign convention has been set for the linear axis test, confirm and set using the toggle button.

See **Appendix C** for further details.



1. Drive the machine to the first target position and press ‘Start test’.
2. ‘Start test’ will datum the error value to zero.
3. The test status bar advises the next steps.

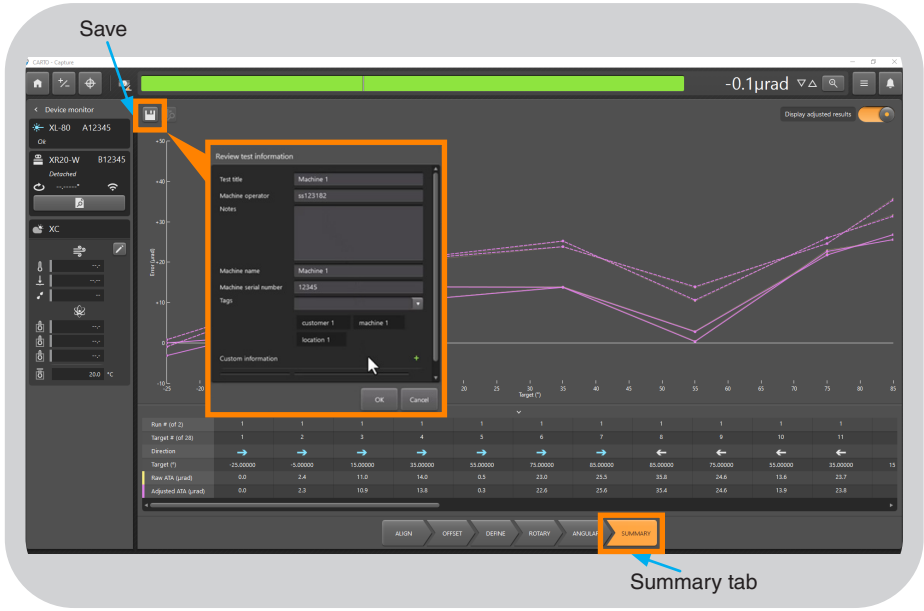
Linear axis data capture

Press start on the machine controller and capture test data.

- **Position trigger type** (XM-60 only) – data will be collected automatically.
- **Manual triggering** (XL-80 and XM-60) – press F9 or middle mouse button at each target when the machine stops.
- **TPin** (XL-80 only) – data will be collected automatically.

The test status will confirm when the test is complete.

NOTE: Overrun positions do not need to be captured.



When the test is complete, switch to the ‘Summary’ tab and ‘Save’ the test.

A dialogue box will appear to allow further detail or amendments to be added to the test record.

Linear axis data capture

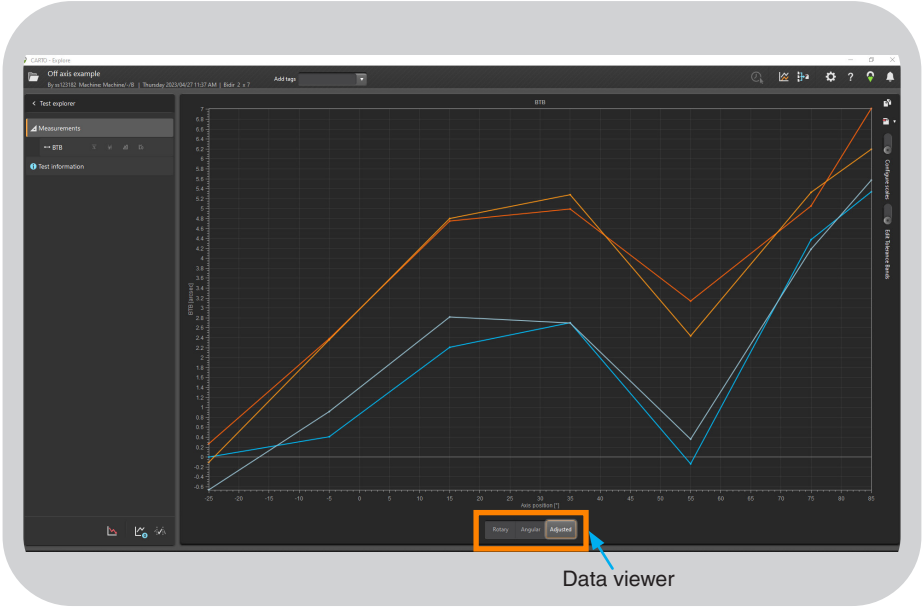
When rotary and linear axis data capture is complete, both data sets can be viewed using the display adjusted results toggle.

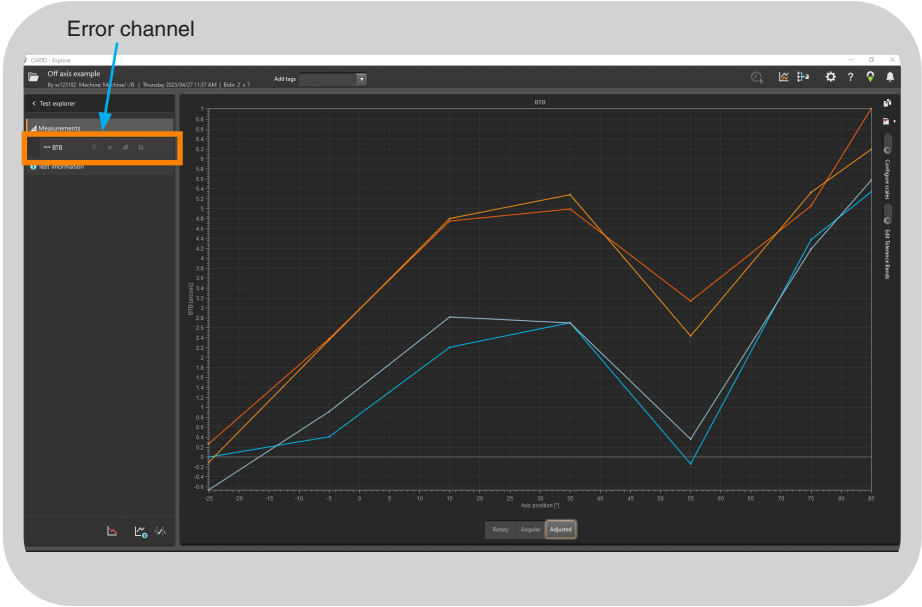
- **Switched on** – data shows rotary axis errors with linear axis angular errors removed
- **Switched off** – data shows angular errors in the rotary and linear axis.

Select ‘Analyse’ to launch the Explore application.

Linear axis data capture

The application will open in the view shown.



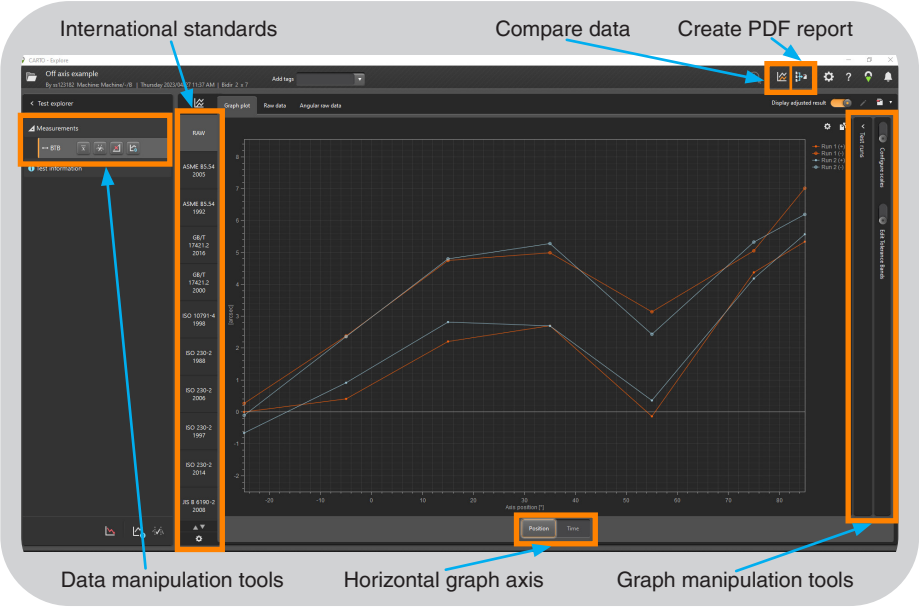


Using the tabs at the bottom, data sets can be filtered.

- **Rotary** – rotary axis test data. Shows combined rotary and linear axis angular errors.
- **Angular** – linear axis test data. Shows linear axis angular errors only.
- **Adjusted** – Shows true rotary axis errors. Linear axis angular errors are removed from the rotary axis errors.

Select the error channel to launch data manipulation tools and analyse data to international standards.

Linear axis data capture



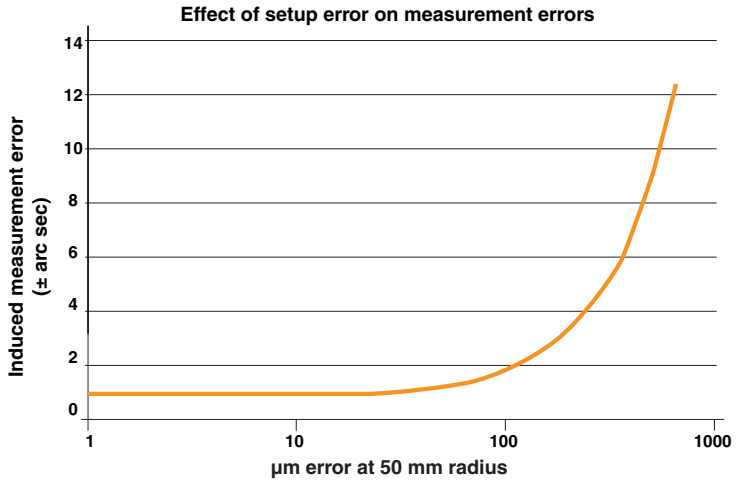
The error channel view provides functionality as shown.

Appendix A: Off axis induced error

In some cases it may not be possible to achieve the mounting tolerance specified due to mounting set-ups. As the error increases, the induced error in the XR20 measurement also increases.

The chart below shows the error from the XR20 measurement that will be induced for a given parallelism tolerance.

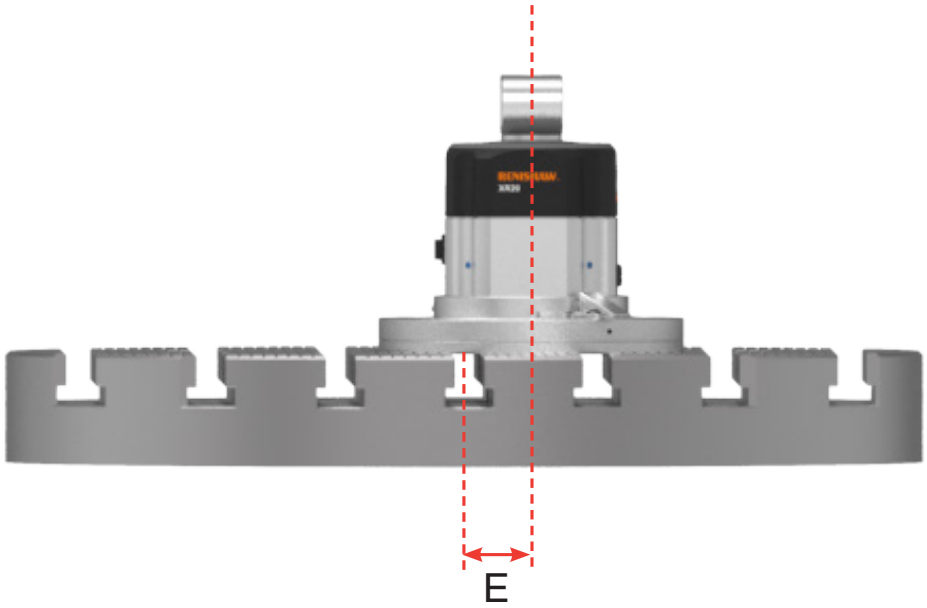
NOTE: Depending upon the sign of this error, the measurement may make an axis appear worse or better than in reality.



Appendix B: Set-up errors

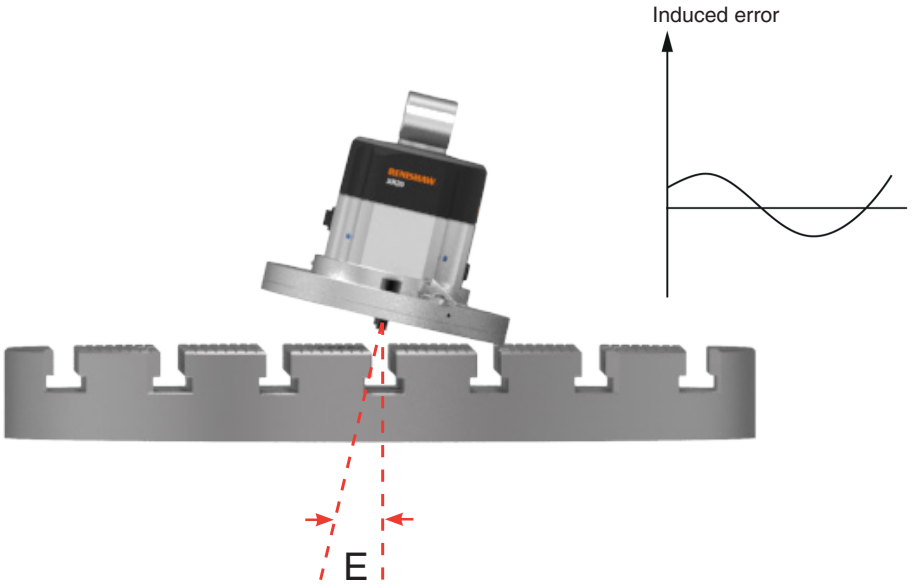
When mounting the XR20 rotary axis calibrator and setting up the optics, it is important to align them as accurately as possible. Small misalignments are expected to exist. This section indicates how tolerant the software is at minimising or eliminating them, and the effect they have on captured data.

Axes of rotation parallel but not coincident



- Optics translate during rotation
- To avoid signal strength loss, ensure:
  - For XL-80, E = < ±1 mm
  - For XM system, E = < ±0.25 mm

Axes of rotation coincident but not parallel



Sinusoidal component measurement error induced into the captured data over 360 degree rotation.

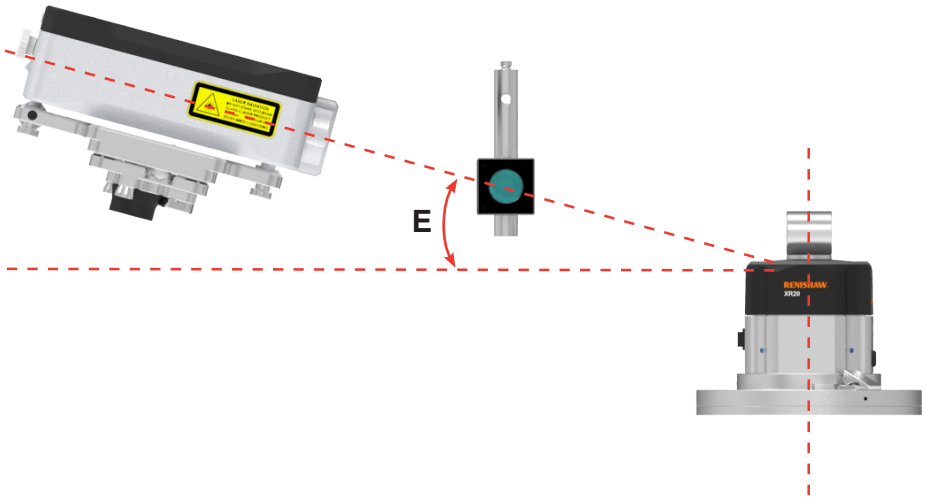
Size of error is dependent on E and shows one cycle in 360 degree.

- For induced error to be less than ±1 arcsecond, ensure E < 0.025 degrees or the TIR is < 0.04 mm at a radius of 50 mm from the centre of rotation of the machine under test.
- For induced error to be less than ±10 arcseconds, ensure E < 0.23 degrees, or the TIR is < 0.4 mm at a radius of 50 mm from the centre of rotation of the machine under test.

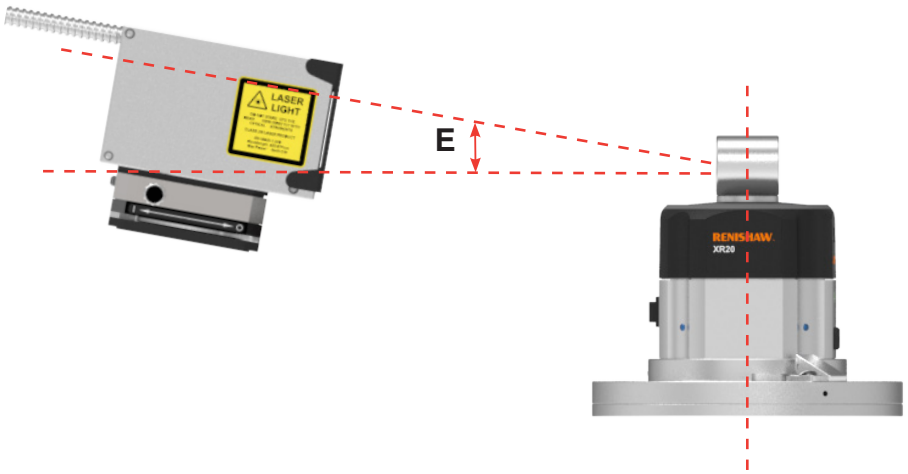
NOTE: It is relatively easy to achieve the alignment tolerances quoted when calibrating a rotary table with a mounting surface perpendicular to the axis of rotation. Ensure the rotary tables and XR20 mounting surface are clean and free from debris, swarf and burrs. Care must be taken when calibrating rotating axes if the mounting surface is not perpendicular to the axis of rotation. In this case, it is recommended that the TIR of the surface the XR20 is to be mounted to is checked (whilst rotating the axis under test) using a dial gauge. This allows alignment to be verified before the test starts.

Laser beam not perpendicular to reflector, axes of rotation coincident

- Use the XR20 alignment aid to align the laser beam to be perpendicular to the shutter.
- E is the angle between the normal of the XR20 alignment aid and the beam from the XL-80/XM system. For XM system/XL-80, E < 0.115 degrees.

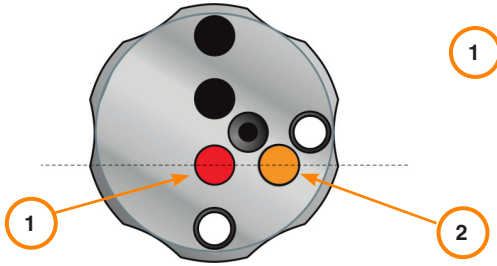


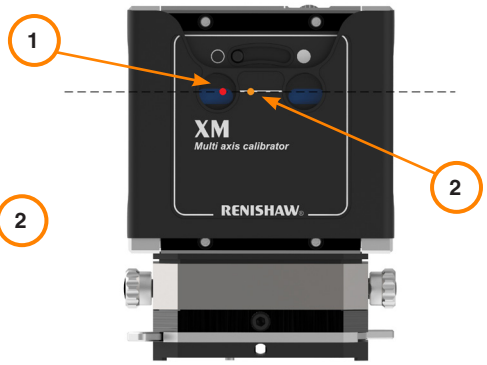
Refer to the **XL system set-up** for more information.



Refer to the **XM system set-up** for more information.

The angle of E can be calculated within the set-up by measuring the vertical position of beam 2 relative to 1 and then using the comparison table below.



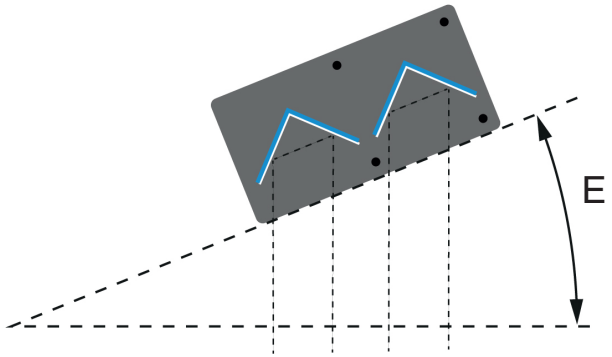


1	Beam aperture
2	Reflected beam

Distance between XL80/XM and XR20 (m)	Maximum vertical offset (mm)
0.1	0.4
0.2	0.8
0.5	2
1	4
2	8
3	12
4	16

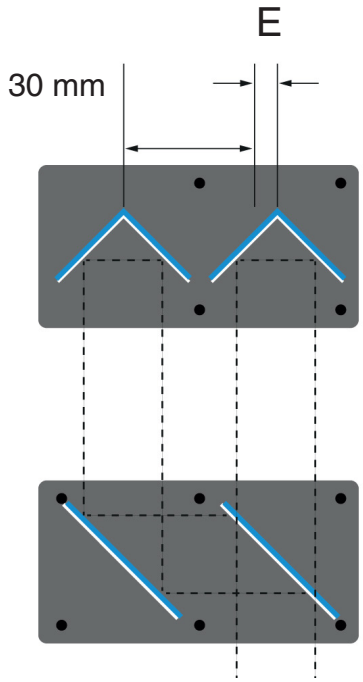
RENISHAW apply innovation™

Reflector not perpendicular to laser beam when laser is datumed at start of optical set-up calibration cycle



- Limited danger of beam obstruction (only if E > 10 degrees). To avoid signal strength loss, ensure E < 2 degrees.
- Use alignment aid to align optics perpendicular to laser beam.
- Error eliminated by optical set-up calibration cycle.

Reflector separation not exactly 30 mm

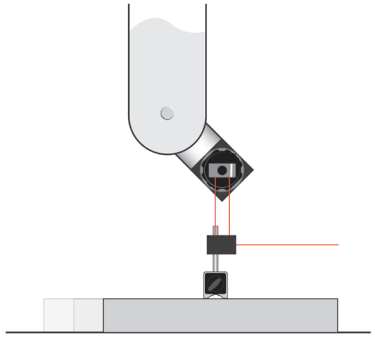


- Caused by thermal expansion and manufacturing tolerances.
- Error eliminated by optical set-up calibration cycle.
- No danger of beam obstruction.

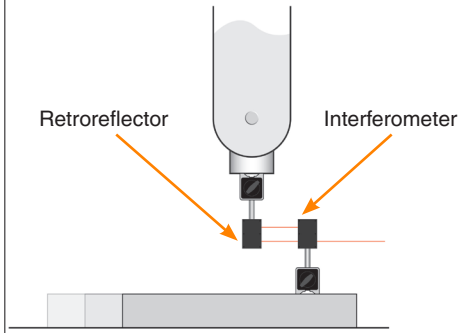
Appendix C: Sign Convention

The example given is for XL-80 and determines sign convention depending on optical arrangement.

To simplify this process it helps to replace the XR20 with the retroreflector. If this is done, the rule is straightforward.

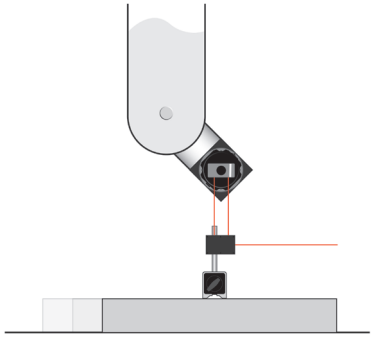


Move the rotary axis in the positive direction

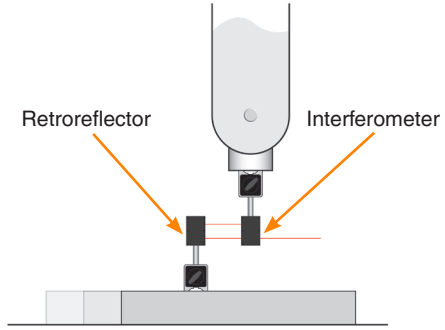


Set the sign of angular error positive

If the XR20 is replaced by the interferometer the rule is reversed. In the example below the interferometer has replaced the XR20 which was mounted to the machine spindle.



Move the rotary axis in the positive direction



Set the angular error negative

Appendix D: Feedrate

If the target interval is greater than 10 degrees, the XR20 rotary axis calibrator will automatically track the movement of the machine under test. The laser's beam remains unbroken, as the XR20 angular reflector continues to face the laser as the machine moves.

The feedrate of the test can be determined automatically or entered into the software manually via the test menu.

The XR20 system can determine the velocity of the machine under test automatically, during the machine overrun move at the beginning of the test. To allow the feedrate to be automatically determined, an overrun move of 5 degrees should be programmed. If, during this move, the software cannot determine the velocity of the machine, it will display a warning message. If a warning message is displayed, try the following:

- Decrease the programmed machine feedrate by modifying the part program. Refer to the part program section in the *CARTO Capture* user guide (Renishaw part no. F-9930-1007) for more details.
- Increase the angle of the overrun move to allow the machine to reach the programmed feedrate.
- Manually enter the feedrate into the software.

Enter the feedrate set in the part program. Alternatively, for optimum performance, enter the feedrate displayed by the machine controller during a move.

Appendix E: Bluetooth® set-up for XR20 rotary axis calibrator

The XR20 rotary axis calibrator communicates with the PC using Bluetooth wireless technology.

Before connecting the XR20, Bluetooth capability must be provided on your PC. This can be done either by enabling the PC's internal Bluetooth device (if available) or by using a proprietary USB Bluetooth dongle recommended by Renishaw.

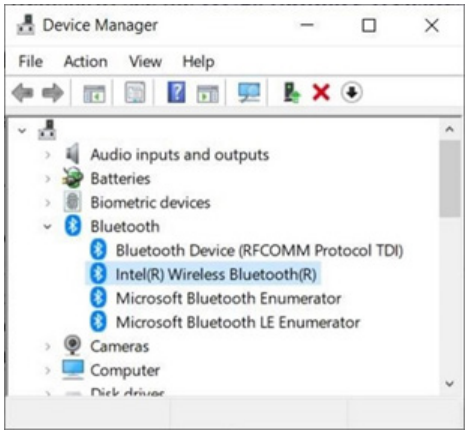
The CARTO software will only work with Bluetooth devices which use the Microsoft stack (software which enables communication between a PC and a Bluetooth device).

Set-up for a Windows 10 PC version 1803 and above with a built-in Bluetooth LE 5.0 device

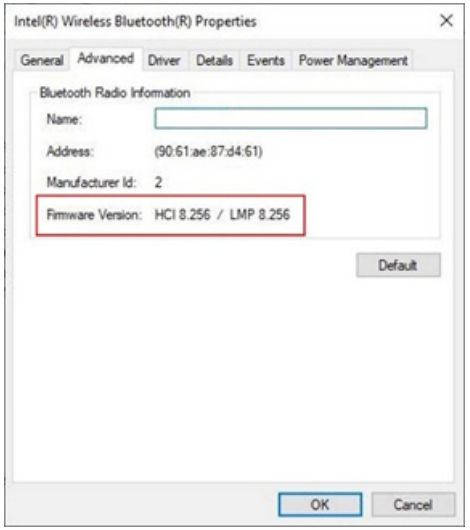
1. Right-click on the start button and select 'Device Manager'.
2. Ensure the 'view' is set on the menu bar as 'devices by type'. If the device list shows a Bluetooth tree, expand it; if not, refer to section **Set-up for a PC without a built-in Bluetooth device**.
3. If, in the Bluetooth tree, you see 'Generic Bluetooth Radio' and 'Microsoft Bluetooth Enumerator', the PC is Bluetooth capable and has the Microsoft stack installed. If you also see 'Microsoft Bluetooth LE Enumerator', the PC is Bluetooth LE capable.

NOTE: Bluetooth radio names (in the figure below called 'Intel(R) Wireless Bluetooth(R)') can vary between manufacturers and models.

4. Select the Bluetooth radio listing (it may simply be listed as a wireless device).



5. Select the Advanced tab, then look for the LMP (Link Manager Protocol) listing in the Firmware or Firmware version area. This number tells you what LMP version you have on your device. LMP 8 is the minimum required stack version.



6. Run the CARTO software and connect the XR20 to establish communication.

Appendix F: Bluetooth® set-up for XR20-W rotary axis calibrator

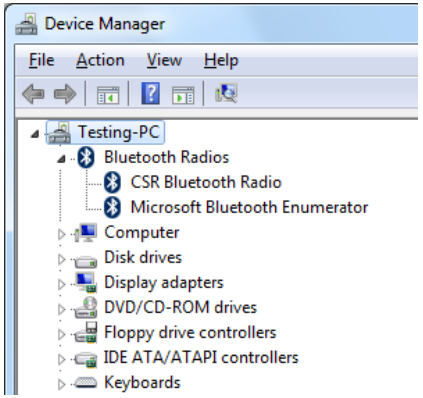
The XR20-W rotary axis calibrator communicates with the PC using Bluetooth wireless technology.

Before connecting the XR20-W, Bluetooth capability must be provided on the PC. This can be done either by enabling the PC's internal Bluetooth device (if available) or by using a proprietary USB Bluetooth dongle recommended by Renishaw.

The CARTO software will only work with Bluetooth devices which use the Microsoft stack (software which enables communication between a PC and a Bluetooth device).

Set-up for a PC with a built-in Bluetooth device

1. Right-click on the start menu.
2. Select 'Device Manager'.
3. If the device list shows 'Generic Bluetooth Radio' and 'Microsoft Bluetooth Enumerator', the PC is Bluetooth capable and has the Microsoft stack installed.



4. Ensure that Bluetooth functionality is switched on (see PC user instructions).
5. Run the CARTO software and connect the XR20-W to establish communication.

If your PC does not have the Microsoft stack installed, refer to the Calibration service, support and training website for further instructions.

Set-up for a PC without a built-in Bluetooth device

If you do not have built-in Bluetooth capacity on your PC, obtain a USB Bluetooth dongle.

CAUTION: When first using the USB Bluetooth dongle, do not install the software provided with the device. Plug the dongle in to a spare USB port, run the CARTO software, and connect the XR20-W to establish communication.

NOTE: Some USB Bluetooth dongle software provides Bluetooth stacks (other than the Microsoft version) which are not compatible with CARTO software.

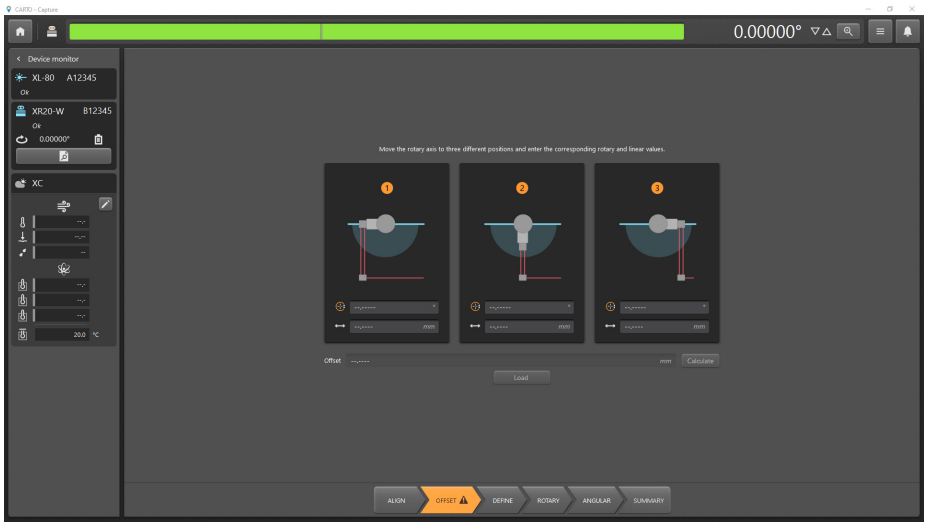
Appendix G: Measuring the rotary offset

CARTO software requires three rotary and linear positions to be entered.

It shows these in ascending numerical order.

The order of positions captured is not important and does not need to match the images.

The images show a machine the has a rotation of 180 degrees. If the machine under test does not have 180 degree rotation, the **linear axis** becomes the more important factor when measuring the offset, not the rotary axis.

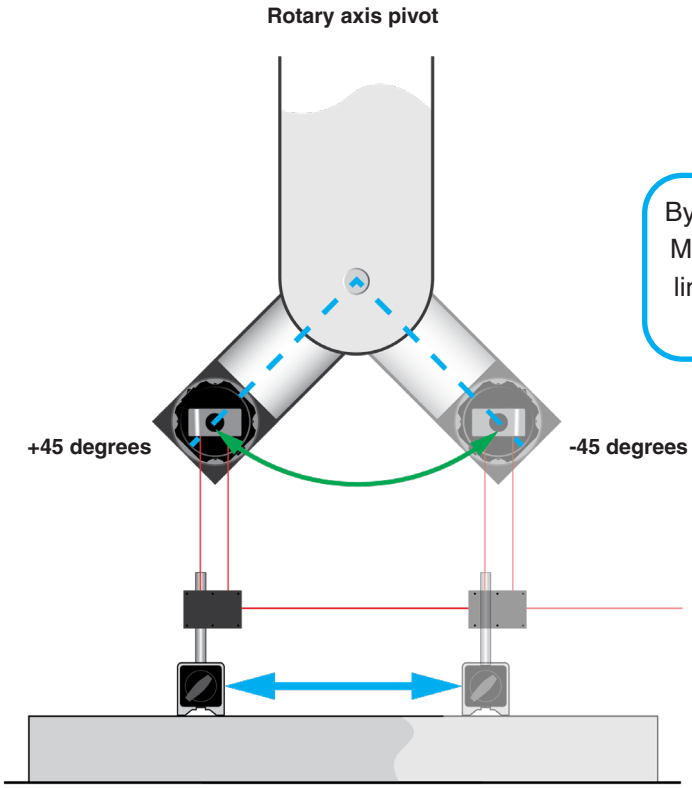


Appendix G: Measuring the rotary offset (2 example machines)

The rotary axis in both machines show the maximum and minimum travel limits.

Machine 1

Total rotary angle range = 90 degrees

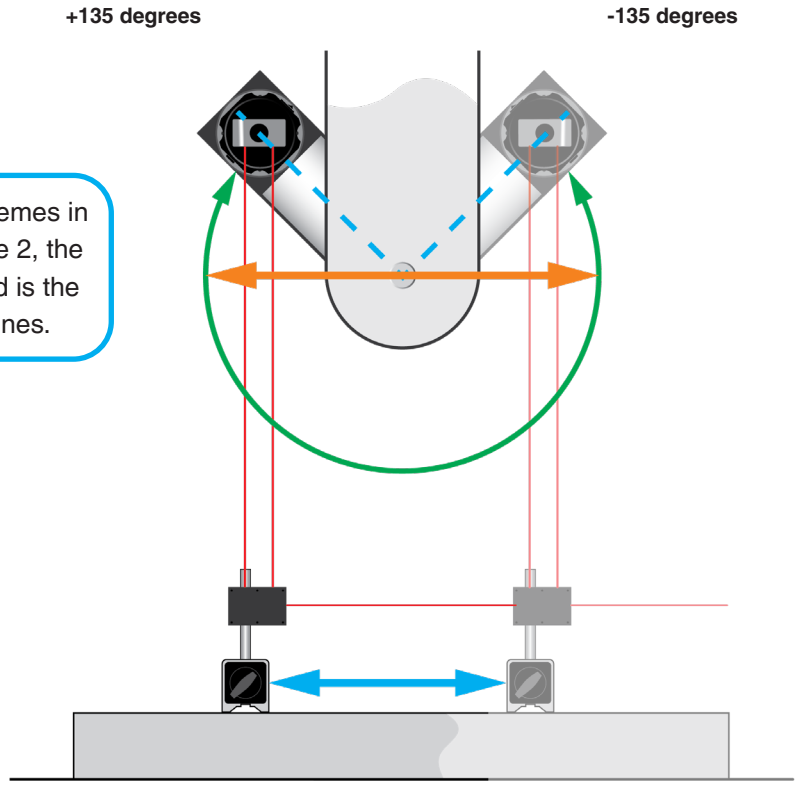


The linear distance indicated by the blue arrow is the total distance travelled during the test.

By using the rotary extremes in Machine 1 and Machine 2, the linear distance travelled is the same for both machines.

Machine 2

Total rotary angle range = 270 degrees

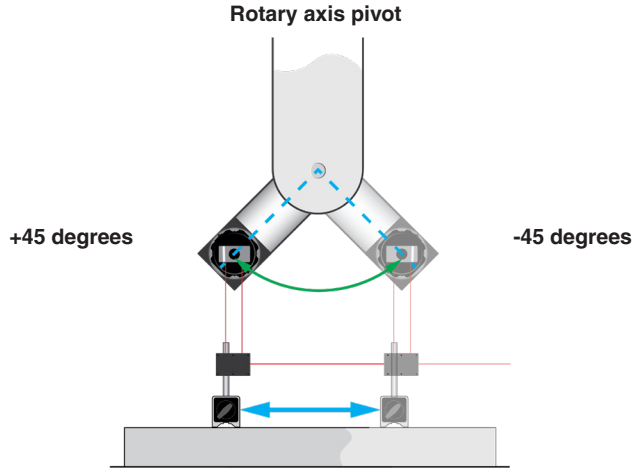


The linear distance indicated by the blue arrow is not the total distance travelled during the test. This is indicated by the orange arrow.

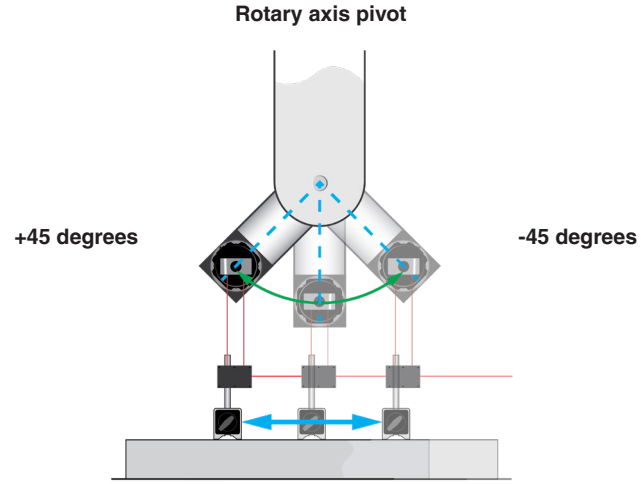
Appendix G: Measuring the rotary offset – best practice

Make sure that the maximum range of linear movement is included for the range of the machine arc.

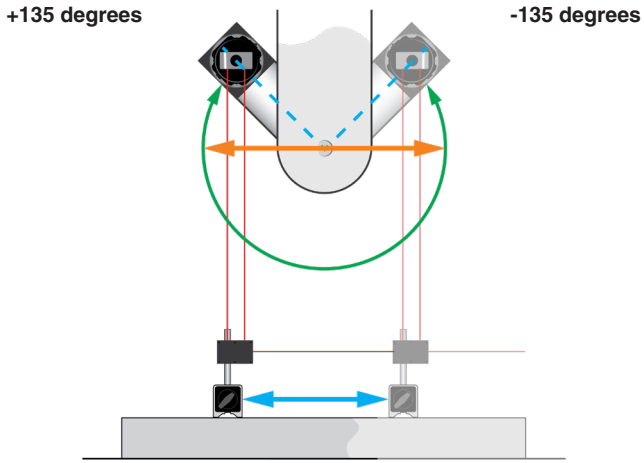
Machine 1 – measurement range



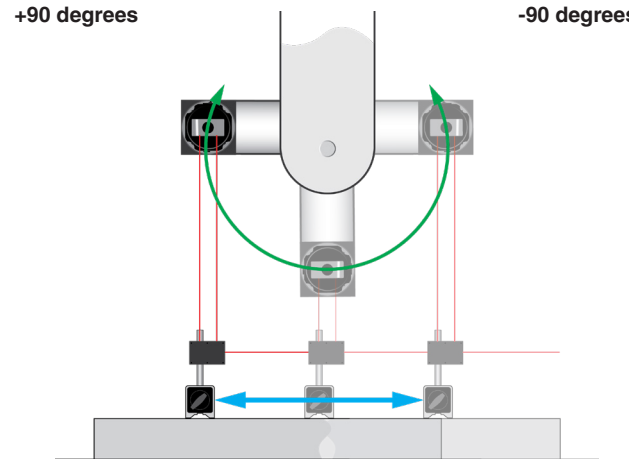
Machine 1 – best practice



Machine 2 – measurement range



Machine 2 – best practice



Diagnostics and troubleshooting

XR20 fault-finding

The following table should be used for fault-finding. If you experience further difficulties, see the **Calibration service, support and training website**, or contact your local Renishaw office.

Problem	Possible cause	Action
XR20 will not connect to the PC	PC is not running the correct version of Windows 10	• Check the PC specification as per the **Bluetooth set-up** page • Update the PC or use an external USB dongle
Bluetooth communication cannot be established (XR20 status LED stays green)	PC Bluetooth is not activated or PC is out of range	• Check Bluetooth is enabled on PC (or presence of USB Bluetooth dongle) • Ensure the Bluetooth is set up correctly on PC • Move PC closer to XR20
Intermittent Bluetooth communication	Machine enclosure preventing communication	• Attach Bluetooth dongle to USB extension lead and position inside of machine enclosure
XR20 status LED off	XR20 switched off No battery fitted Battery flat Battery fault Environment is outside XR20 operational temperature range	• Ensure XR20 is switched on • Switch the XR20 off and then on • Replace the **battery** • Ensure the USB cable is disconnected and reinsert battery • Connect USB power supply
XR20 status LED red	XR20 fault	• Switch the XR20 off then on • Replace the battery • If problems persist, contact your local Renishaw office
XR20 status LED is slow flashing blue and CARTO software DRO (Digital Read Out) is dim	XR20 and software in power-saving mode	• Click on DRO to resume live reading
Software has not installed in the required language of operation	The PC's regional settings are not set to the user's preference	• Change the 'regional settings' in the PC's control panel to the required language
Battery life is too short	Dirt/contamination on battery contact in the battery cap	• Clean the battery contact • Clean the inside of the cap using a soft cloth and appropriate solvent, for example, isopropyl alcohol (IPA).

Status LEDs

LED status		Description
OFF		Off, no power or power-down mode.
Solid green		On, communication has not been established.
Solid blue		Communication established and drive disabled.
Flashing blue		Communication established and drive enabled.
Slow flashing blue		Power saving; see below.
Solid amber		Battery low and drive disabled. Change battery.
Flashing amber		Battery low and drive enabled. Change battery.
Red		Fault; **see fault-finding section.**

Power saving

If the system is idle for 2 minutes, the DRO in the CARTO software dims and the XR20 status LEDs slowly flash blue as the system goes into power-saving mode. To exit power-saving mode, click on the DRO. The XR20 must be re-referenced before testing can continue.

If the XR20 is idle for 5 minutes, it switches off and the status LED goes off. The unit must be switched off, then on again, and re-referenced before testing can continue.

Care and handling

Recalibration

Why recalibrate?

As with any calibration equipment, it is recommended that the Renishaw XR20 rotary axis calibrator is periodically recalibrated to give confidence that the system:

- is currently still within its original specified (or required) performance
- is likely to remain within its specified (or required) performance until its next recalibration

This is why the recalibration of calibration test equipment is a mandatory requirement of most quality management/assurance systems.

An added benefit of periodic calibration is that the inspection Renishaw carries out when recalibrating your XR20 can also reveal any otherwise unidentified accidental damage. The recalibration procedure includes general cleaning.

Compared to your investment in the measurement system, staff and procedures, periodic recalibration is a modest additional cost and could prevent far more serious and costly problems arising.

Recalibration periods

The Renishaw recommended recalibration period for an XR20 is three years.

NOTE: This is 3 years from sale by Renishaw rather than from factory calibration date as stated on the calibration certificates supplied with the new equipment, since the units are stored under controlled conditions by Renishaw prior to sale.

Renishaw recommended recalibration periods are only a recommendation and are based on typical use of the equipment in a typical environment. Under such conditions your XR20 system should still be performing within Renishaw's specification at the end of this period.

However, there are several factors that may generate the need for more frequent calibration, including:

- Environmental conditions
- Frequency and duration of use
- Harsh treatment of the equipment during storage, transportation or use
- Level of accuracy required by the user
- The requirements of company QA procedures and/or local regulations

Ultimately it is for you to determine the appropriate recalibration period after taking into account your own operational environment and performance requirements.

Recalibration reminders

Evidence of calibration is important for users and their customers. Several reminders are built into the main system hardware and system software.

Hardware reminder

The recommended recalibration date is indicated on a label on the side of the XR20 unit.

Software reminders

Further reminders are built into the CARTO software. If an XR20 is out of calibration, the date of last recalibration and the recommended date for recalibration will be displayed on-screen.

Recalibration facilities

Recalibration of the XR20 requires specialist test rigs and software to give results comparable to the original factory calibration. Renishaw therefore recommends that items are returned to our specialist facilities via your local Renishaw office.

Periodic recalibrations and recalibrations following repairs (if required) are carried out in accordance with the same procedures used for new systems and an identical format certificate will be issued.

Calibration certificate

Each Renishaw XR20 rotary axis calibrator is delivered with a calibration certificate. This demonstrates that the system has been calibrated at the Renishaw factory against reference systems with traceability to National Standards. It is proof of the equipment's performance as tested before delivery.

The certificate is a valuable document, and may be required to satisfy your own or your customer's quality assurance requirements.

Duplicate documents can be supplied at an additional charge.

Certificate content

Each certificate is unique and is identified by a certificate number. All XR20 certificates provide the following key information:

- Serial number of calibrated XR20
- Specific test results and graph
- Statement of accuracy
- Test conditions and methodology
- Traceability data (calibration details: see below)

The first page gives graphical representation of test results and specification limits, as well as tabulated details of the specific test results and uncertainty of measurement. Users can visually verify whether or not the unit meets published specifications and/or their own requirements. To enable traceability, details of the test equipment used are given. The date of testing and the date of printing the certificate are separately noted and the results are signed by a Renishaw-authorised engineer.

The second page gives generic details of the test procedure, test environment, and applicable standards, in accordance with ISO 17025.

Care and maintenance

The Renishaw XR20 rotary axis calibrator is precision-engineered to ensure very high levels of measurement accuracy and repeatability when correctly used and handled.

- To ensure optimum measurement performance, ensure the XR20 facing ring, mounting ring and mounting ring adaptor plate are clean and free from debris, swarf and burrs before use.
- Place the XR20 mounting ring and mounting ring adaptor plate into the case when not in use.
- Switch off the unit before transporting it.

Care should be taken to avoid extremes of environment (heat, humidity etc.) and to avoid any sharp blows or violent vibration. Do not attempt to clean using water or any other fluids. The system must not be exposed to dusty or misty environments, as particles could enter housings and cause damage, preventing correct operation and affecting accuracy. Renishaw system cases provide secure storage for the equipment when not in use.

Storage and environmental specification

The equipment should always be inspected before use to check for any signs of damage on all system components (including optics and tripods) such as cracks, dents or other evidence of physical damage, loose joints, cracked or pinched cables.

Damaged equipment may still function, but the accuracy of the reading may have been affected.

If in doubt, contact your local Renishaw office for advice and guidance. Defective products should be returned to Renishaw for repair.

There are no user-serviceable parts inside the main calibration system equipment. Never remove housings, as doing so may invalidate the warranty and cause additional damage. If in doubt, contact your local Renishaw office for advice and guidance.

Cleanliness of optics

The optics must be kept as clean as possible. Dirty optical surfaces are likely to result in a loss of signal strength, making calibration more difficult.

Clean the optics only when necessary. Care should be taken when handling or storing to ensure optical components do not become dirty or smeared. Frequent cleaning is not required.

- Do not touch the optical surfaces.
- Do not use in contaminated atmospheres.
- Store securely when not in use.

Cleaning recommendations

- Wipe only with non-abrasive lens tissue or cloth, for example spectacle cleaning cloths.
- Use cleaning fluid suitable for spectacles or similar (do not use acetone).
- Clean the optics using a gentle wiping action.
  Never use a scrubbing action.

Failure to follow these recommendations may lead to damage to the coatings and glass elements of the optics.

System specification

XR20 system	
Recommended recalibration period	3 years or less (typical use)
Maximum feedrate	10 r/min

Performance specifications

Rotary (with XL-80)	
Accuracy	±1 arcsec (at 20 °C)
Resolution	0.1 arcsec
Range	0° to 360°

Rotary (with XM system)	
Accuracy	±1.2 arcsec (at 20 °C)
Resolution	0.1 arcsec
Range	0° to 360°

Operating and storage environment

Operating environment		
Pressure	600 mbar to 1150 mbar	Normal atmospheric
Humidity	0% to 95% RH	Non-condensing
Temperature	0 °C to 40 °C	

Storage environment		
Pressure	550 mbar to 1200 mbar	Normal atmospheric
Humidity	0% to 95% RH	Non-condensing
Temperature	–20 °C to 60 °C	

NOTE: To protect against battery damage, the XR20 rotary axis calibrator will not power up when operated below 0 °C and above 40 °C.

Radio communication for XR20

Bluetooth® LE 5.0 device	
Output power	0 dBm nominal; 4 dBm maximum
Frequency band	2.402 GHz to 2.480 GHz
Communication distance	10 m typical operation

Dock, power supply, cables and battery

Dock

Technical data			
Input voltage	5 V nom.	Output voltage	4.2 VDC Tolerance: ±1 % max
Input current	2 A nom.	Output current	1 A max. Tolerance: ±10 % max. @1.00 A
Input power	10.00 W	Output protection	Short circuit, Battery over/ under temperature, Charger over temperature, Charger timer
Charge Time	3 hours nominal		
Safety and EMC (*In combination with included external AC/DC power supply and USB cable)*			

General product specifications	
Indicator	Multi-color LED (green, red, orange) (see **Battery charging LED status** details)
Battery types	Standard battery Varta EasyPack EZPack XL
Green procurement	RoHS 2011/65/EU, 2015/863/EU WEEE 2012/19/EU Chinese RoHS
Humidity	10 % to 90 % r.H., non-condensing

Environmental product specifications		
Cooling	Convection cooled	
Temperature	Operating: 0 °C to 40 °C	Storage: -20 °C to 80 °C
Pressure and Altitude	Operating: 1060 hPa to 795 hPa (-382 m to 2000 m) Storage: 1060 hPa to 572 hPA (-382 m to 4570 m)	
Humidity	10 % to 90 % r.H., non-condensing	

Micro USB cable (Power cable)	
Shielded USB2	High speed
Gauge (AWG)	30 AWG (for data) and 20 AWG (for power)

USB Plug & Go (Power supply)	
Minimum current	2 A
Output voltage	5 V
Rated input voltage	100 Vac to 240 Vac

Replacement USB power supply and USB cables (A-B and micro USB) are available from Renishaw.

CAUTION: To ensure correct operation only use the USB power supply supplied and USB cables with the correct power rating (see specifications).

USB (A-B) cable	
Shielded USB2	Full or high speed
For cable length less than 3 m	28 AWG/2C (for data) 24 AWG/2C (for power)
For cable length more than 3 m	28 AWG/2C (for data) 20 AWG/2C (for power)

Power supply: XR20

The USB power supply can be used to power the XR20 rotary axis calibrator. The USB power supply should be used if no charged batteries are available or you are performing a long test.

Ensure the plug adaptor that is compatible with your country or region is attached to the USB power supply. Push the plug adaptor firmly until it is securely held in place. Connect the USB power supply to the XR20 USB port via the supplied USB (A-B) cable. Connect the USB power supply to the electrical outlet.

Do not connect the USB power supply to the XR20 during a test, or measurement errors may result.

NOTE: There is no need to remove the battery when using the USB power supply.

Do not connect the XR20 to a standard PC's USB port, as the XR20 will not recognise the PC as a suitable power supply and therefore will not turn on.

Care must be taken that the USB (A-B) cable does not snag inside the machine as the rotary axis rotates, as this may cause damage to the XR20.

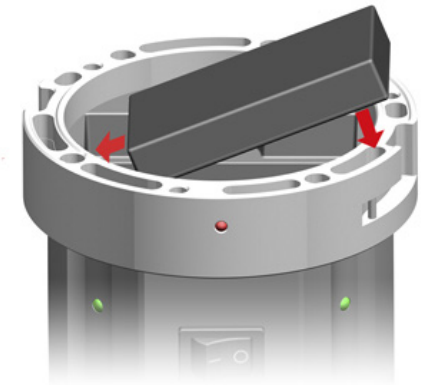
Rechargeable battery

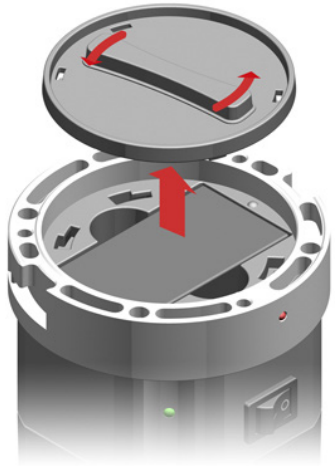
Technical data		
Battery type	Varta EasyPack XL part no. 56456 702 099 (rechargeable Li-Polymer), 3.7 V 2400 mAh 8.9 Wh	MSDS Ref LPP 503562 S
Nominal voltage	3.7 Vdc	
Battery life	3 hours typical operation (for new batteries)	

The XR20 rotary axis calibrator kit contains Li-Polymer Varta Easypack batteries and dock. These batteries are the only type which should be used with the XR20 unit.

Before charging or using the battery, read the **battery safety** section of this manual.

To remove a battery, turn the battery cover on the bottom of the XR20 anticlockwise and remove it to reveal the battery compartment.





When fitting a battery, ensure the terminals of the battery sit over the terminals inside the battery compartment.

Battery charging LED status

To recharge the battery, remove it from the unit and place it into the slot in the dock. Ensure the battery is inserted into the dock in the correction orientation.

The colour status for the LED on the current dock and previous battery charger are shown below:

Dock (BTA-001)		Description
Flashing green and amber		The inserted battery is currently being charged.
Solid green		The battery is charged and can be removed for use.
Solid amber		Failure or no battery connected.
Solid red		Battery detected but no external power supplied.

Battery Charger (RRC-SCC-EZP)		Description
Solid amber		The inserted battery is currently being charged.
Solid green		The battery is charged and can be removed for use.
Flashing red		Battery detection phase.
Solid red		Failure.

Dock (BTA-001)

Battery Charger (RRC-SCC-EZP)

NOTE: To maintain optimum battery performance, batteries should be recharged every 6 months irrespective of use.

Battery life

Battery life in use will depend on many variables including age and condition of battery, initial charge, and test cycle and duration. The published specification is for a new battery and with the XR20 used in a typical configuration.

For optimum battery performance, only fit fully-charged batteries.

A battery should continue to be used until battery low is indicated by the XR20 status LEDs. Once battery low is indicated, replace the battery with a fully-charged one as soon as possible.

The battery contact inside the battery cap must be kept clean. Dirt build-up on the contact can cause a high resistance circuit which can give false battery flat indication. The inside of the cap should be cleaned with a soft cloth and appropriate solvent, for example, IPA (isopropyl alcohol).

NOTE: Batteries should be removed during transportation.

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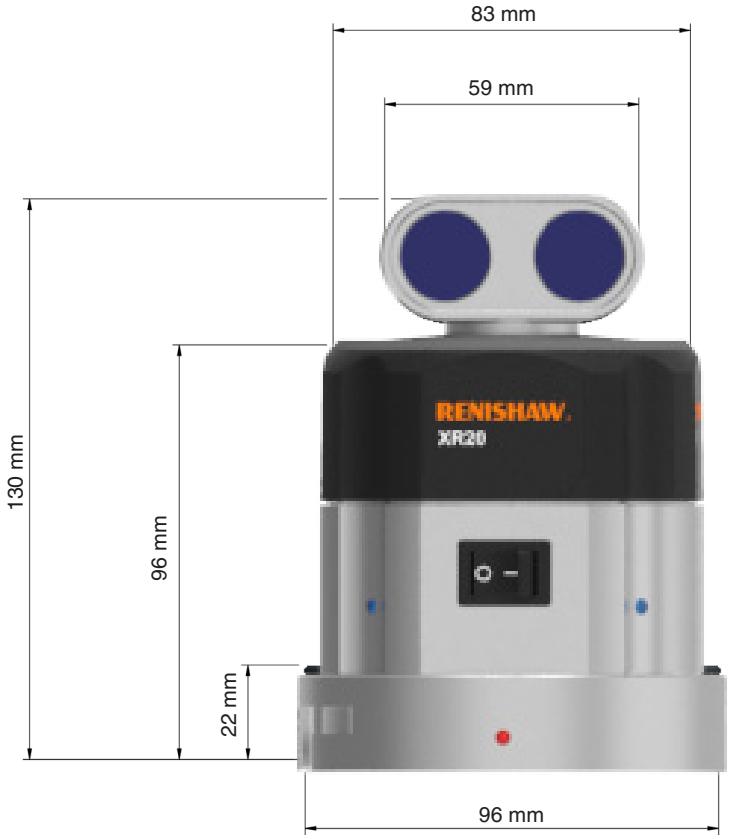
Weights and dimensions

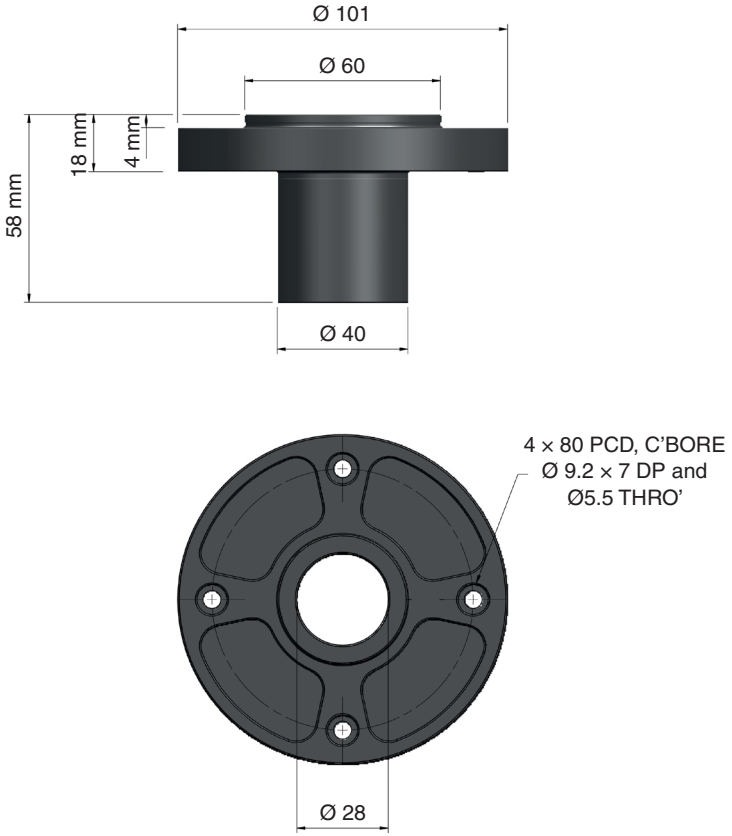
Description	Weight
XR20 weight (including battery)	1.2 kg
XR20 system weight in case	6.5 kg

Dock	
Housing dimensions (LxWxH)	102.3 x 42.3 x 12.5 mm
Battery dock	21 g (excluding power supply)

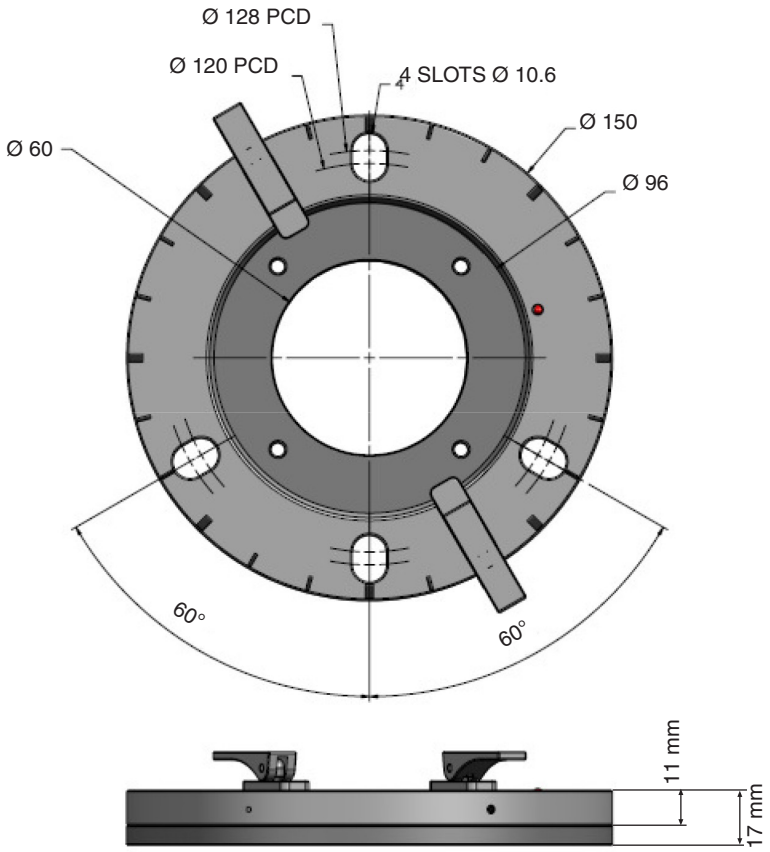
XR20



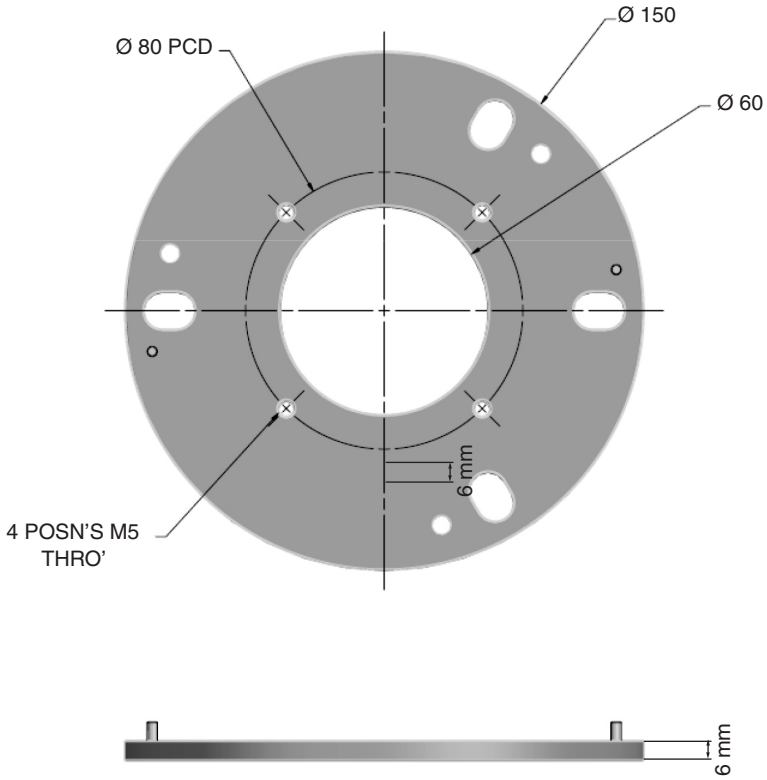
Chuck adaptor



Mounting ring



Mounting ring adaptor



Description	Weight
Mounting ring	0.85 kg
Mounting 'ring' adaptor	0.65 kg

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Part no.: F-9950-0400-07-A
Issued: 05.2024