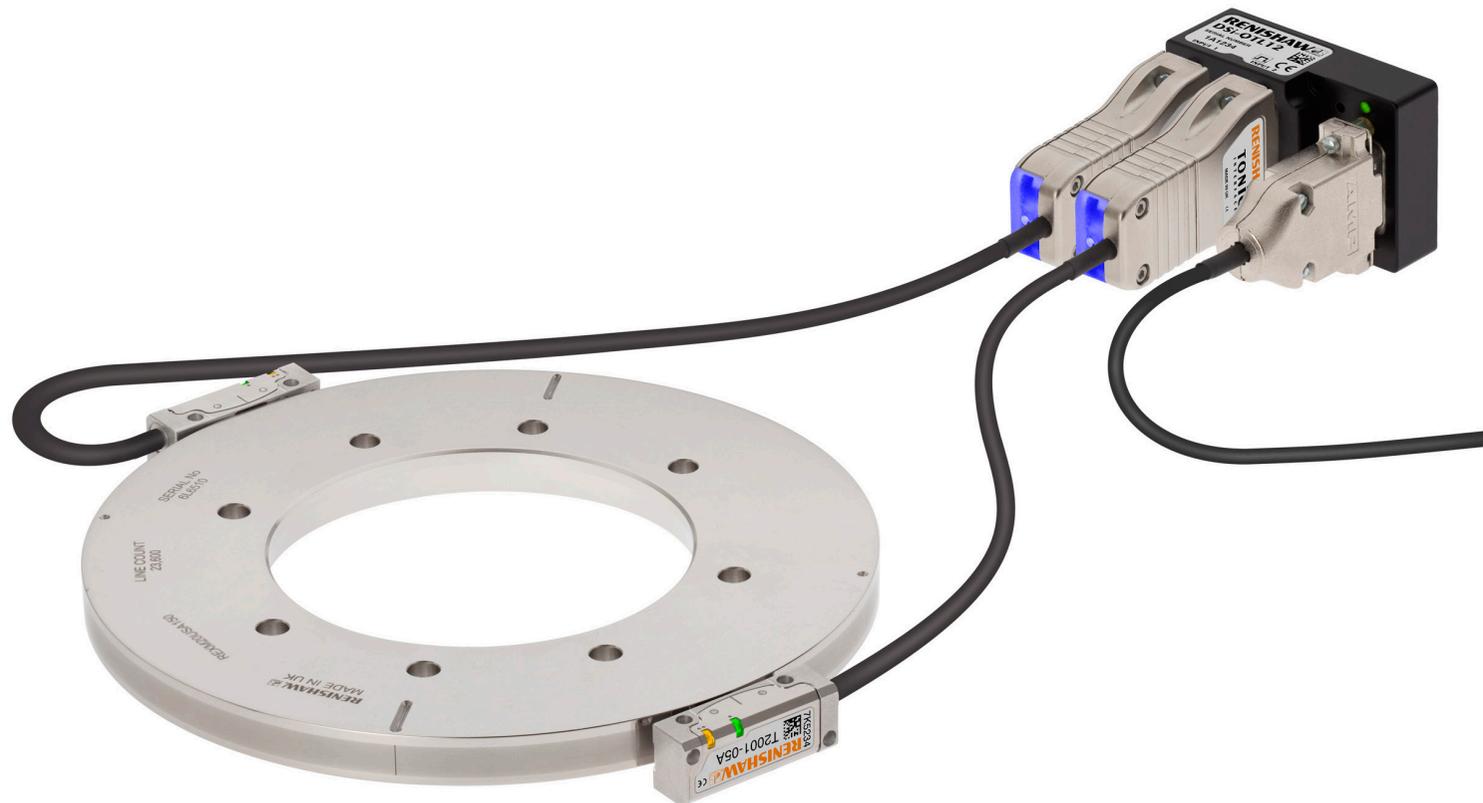**RENISHAW®**
apply innovation™

TONiC™ T20x1 REXM20/REXT20 ultra-high accuracy angle encoder system

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Contents

Legal notices

Patents

Features of Renishaw's encoder systems and similar products are the subjects of the following patents and patent applications:

CN100543424	EP1766334	JP4932706	US7659992	CN100507454
EP1766335	IN281839	JP5386081	US7550710	CN101300463
EP1946048	JP5017275	US7624513	IN317599	CN101310165
EP1957943	US7839296	CN1293983	DE10297440	GB2397040
JP4813018	US7723639	CN1314511	EP1469969	JP5002559
US8987633	US8466943	CN101371105	EP1974186	IN312608
JP5676850	US8017904			

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.

Declaration of Conformity

Renishaw plc hereby declares that the TONiC™ encoder system is in compliance with the essential requirements and other relevant provisions of:

- the applicable EU directives

- the relevant statutory instruments under UK law

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

Compliance

Federal Code Of Regulation (CFR) FCC Part 15 – RADIO FREQUENCY DEVICES

47 CFR Section 15.19

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (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 the instruction manual, 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 his own expense.

47 CFR Section 15.27

This unit was tested with shielded cables on the peripheral devices. Shielded cables must be used with the unit to ensure compliance.

Supplier's Declaration of Conformity

47 CFR § 2.1077 Compliance Information

Unique Identifier: TONiC

Responsible Party - U.S. Contact Information

Renishaw Inc.
1001 Wesemann Drive
West Dundee
Illinois
IL 60118
United States
Telephone number: +1 847 286 9953
Email: **usa@renishaw.com**

ICES-003 – Information Technology Equipment (including Digital Apparatus)

This ISM device complies with Canadian ICES-003(A).

Cet appareil ISM est conforme à la norme ICES-003(A).

Intended use

The TONiC encoder system is designed to measure position and provide that information to a drive or controller in applications requiring motion control. It must be installed, operated, and maintained as specified in Renishaw documentation and in accordance with the Standard Terms and Conditions of the Warranty and all other relevant legal requirements.

Further information

Further information relating to the TONiC encoder range can be found in the *TONiC encoder system* data sheet (Renishaw part no. L-9517-9337), *TONiC DSi dual readhead rotary encoder system* data sheet (Renishaw part no. L-9517-9466), and *REXM20 ultra-high accuracy angle encoder* data sheet (Renishaw part no. L-9517-9318). These can be downloaded from our website at **www.renishaw.com/tonicdownloads** and are also available from your local Renishaw representative.

Packaging

The packaging of our products contains the following materials and can be recycled.

Packing component	Material	ISO 11469	Recycling guidance
Outer box	Cardboard	Not applicable	Recyclable
	Polypropylene	PP	Recyclable
Inserts	Low density polyethylene foam	LDPE	Recyclable
	Cardboard	Not applicable	Recyclable
Bags	High density polyethylene bag	HDPE	Recyclable
	Metalised polyethylene	PE	Recyclable

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.

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.

TONiC software notices

Third party licences

US government notice

NOTICE TO UNITED STATES GOVERNMENT CONTRACT AND PRIME CONTRACT CUSTOMERS

This software is commercial computer software that has been developed by Renishaw exclusively at private expense. Notwithstanding any other lease or licence agreement that may pertain to, or accompany the delivery of, this computer software, the rights of the United States Government and/or its prime contractors regarding its use, reproduction and disclosure are as set forth in the terms of the contract or subcontract between Renishaw and the United States Government, civilian federal agency or prime contractor respectively. Please consult the applicable contract or subcontract and the software licence incorporated therein, if applicable, to determine your exact rights regarding use, reproduction and/or disclosure.

Renishaw End User Licence Agreement (EULA)

Renishaw software is licensed in accordance with the Renishaw licence at: **www.renishaw.com/legal/softwareterms**.

Storage and handling

TONiC non-contact optical encoder systems provide good immunity against contaminants such as dust, fingerprints and light oils.

However, in harsh environments such as machine tool applications, protection should be provided to prevent ingress of coolant or oil.

System

N-heptane

$CH_3(CH_2)_5CH_3$

Propan-2-ol

$CH_3CHOHCH_3$

✓

Ring only

Acetone

CH_3COCH_3

Chlorinated Solvents

Methylated Spirits

✓

Readhead only

Acetone

CH_3COCH_3
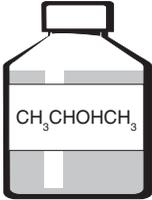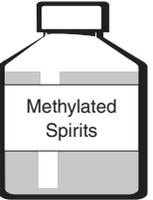
Chlorinated Solvents
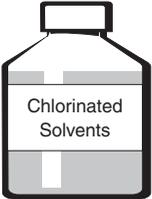
Methylated Spirits

✗
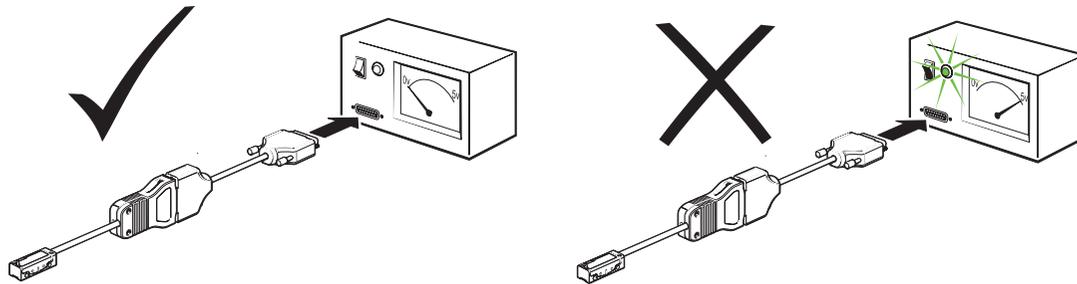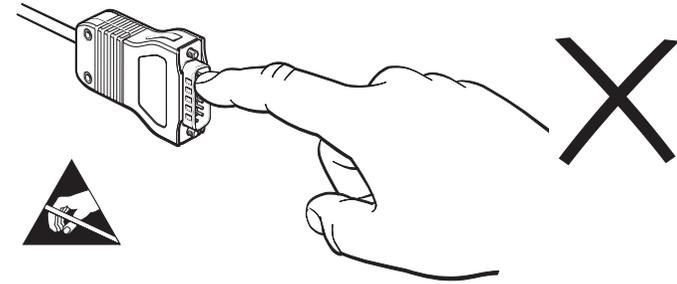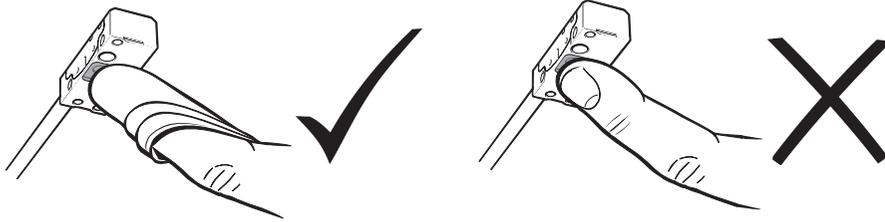
Temperature

Storage	
System	−20 °C to +70 °C

Bakeout	
UHV readhead	+120 °C

Operating	
System	0 °C to +70 °C
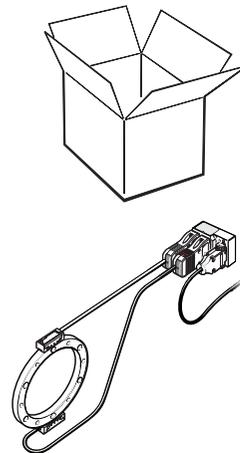
Humidity

95% relative humidity (non-condensing) to IEC 60068-2-78
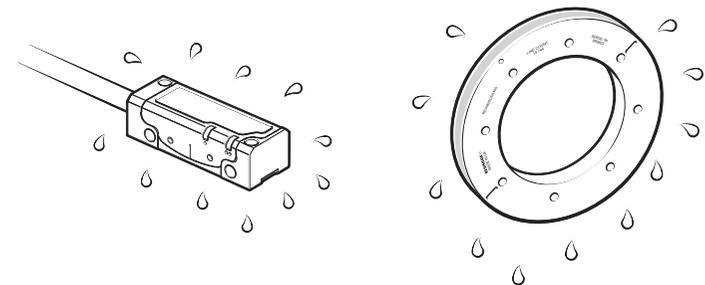
TONiC T20x1 readhead installation drawing

Dimensions and tolerances in mm

2 holes M2.5 through, counterbored top face
Ø3 × 2.75 deep from alternative mounting face

Optical centreline
(incremental and reference mark)

Offset 1.75 ±0.5

(Yaw tolerance ±0.4°)
// 0.25

Ring and readhead
optical centreline

18
31
16
3
7.5

6.75 ±0.5
22
29
3

(Roll tolerance ±0.5°)
⊥ 0.08

8.75 [1]
13.5   11 [1]
4.25

Recommended mounting faces

Alternative mounting face

4.15
10

6 minimum

R > 20 Dynamic bend radius [2]
R > 10 Static bend radius

Ø4.25 ±0.25 [3]

Set-up LED

CAL/AGC LED

2 holes M2.5 through, counterbored Ø3 × 2.3 deep both sides [4]

35
23
11.5

(Pitch tolerance ±1°)
// 0.6

4.6

Rideheight 2.1 ±0.15

Forward direction
of ring (increasing count)

[1]   Extent of mounting faces.
[2]   The dynamic bend radius is not applicable for UHV cables. UHV cables are for static use only.
[3]   UHV cable approximately Ø3.0 mm.
[4]   The recommended thread engagement is 5 mm (7.5 mm including counterbore) and the recommended tightening torque is between 0.25 Nm and 0.4 Nm.

NOTE: Ring centreline refers to the centre of the ring based on the full thickness, i.e., including the raised flat portion.

Ti interface drawing

Dimensions and tolerances in mm

R > 20 Dynamic bend radius [1]
R > 10 Static bend radius

CAL/AGC push button switch
access hole Ø2.4

Diagnostic LED

Cover plate

4-40 UNC × 2
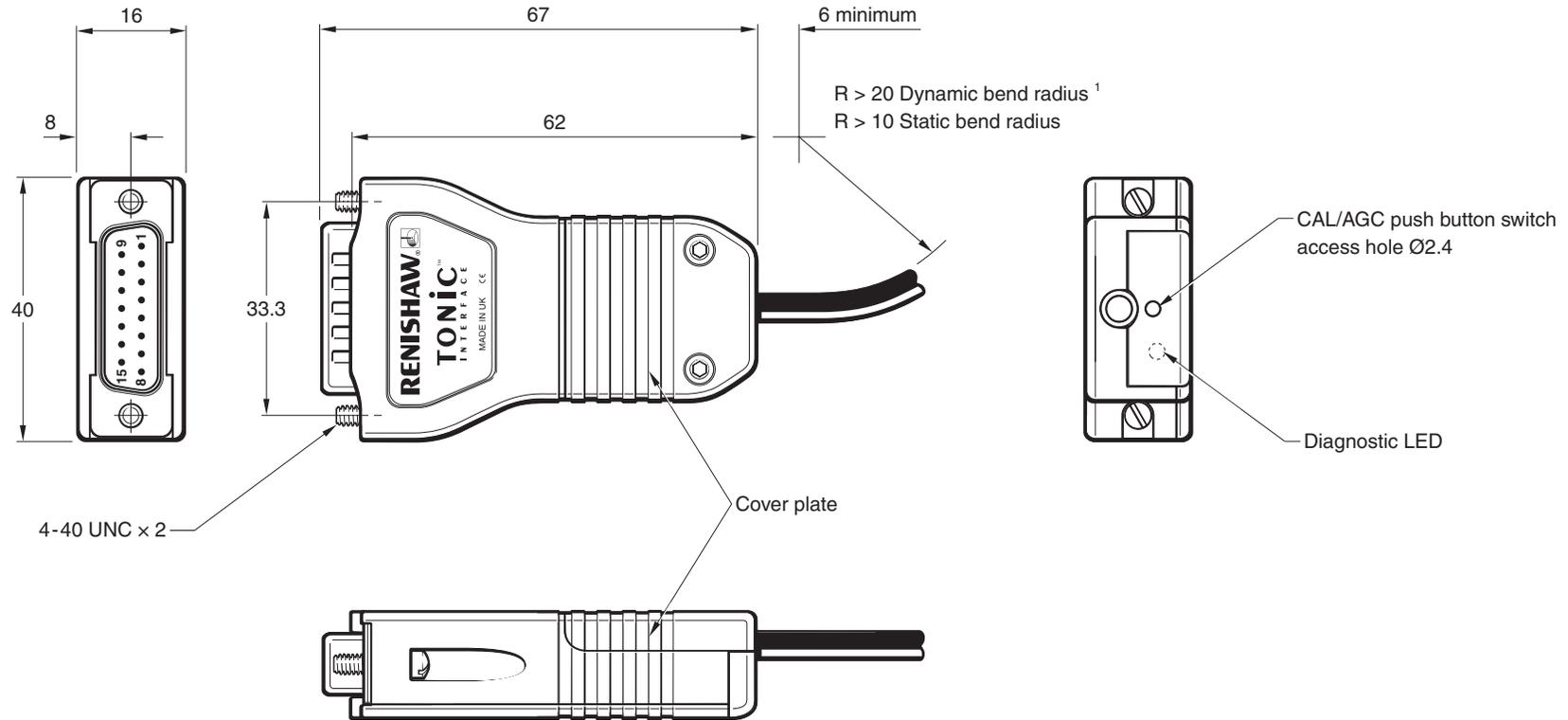
CAL button operation

Function	Operation
Calibration (CAL) routine enable/disable	Push and release (< 3 seconds)
Automatic Gain Control (AGC) enable/disable	Push and release (> 3 seconds)
Restore factory defaults	Push and hold during power 'Off/On' cycle

NOTES:

- For full readhead and interface LED diagnostics, see 'System LEDs' on page 34.

- Only the readhead is UHV compatible. The Ti interface must be kept outside of the vacuum chamber.

[1]   The dynamic bend radius is not applicable for UHV cables. UHV cables are for static use only.

DSi drawing

Dimensions and tolerances in mm

Ø3.5 through 2 positions

17.5

26.5

17.4

42.5

66

8.5

21.4

9.5

7

4

43

LED

Access to *propoZ* button

3

4.3

9.9

19.4

22

5.9

Ti interface
(plugged into DSi)

49

92.5
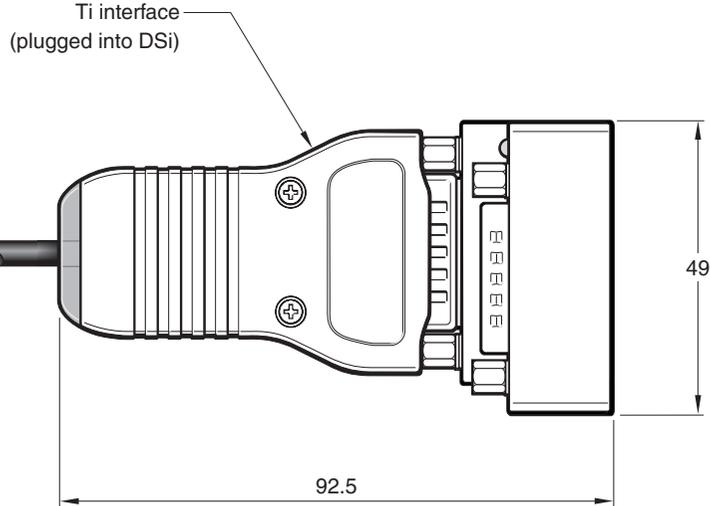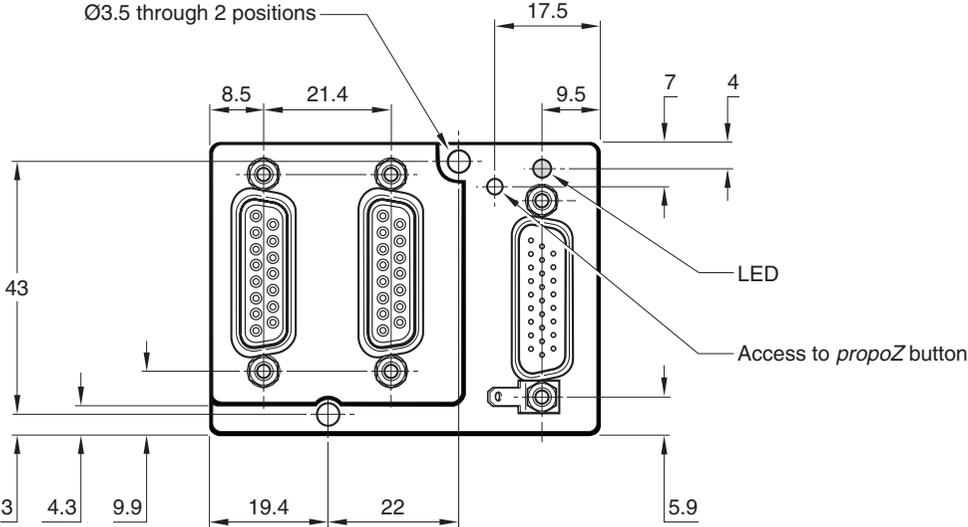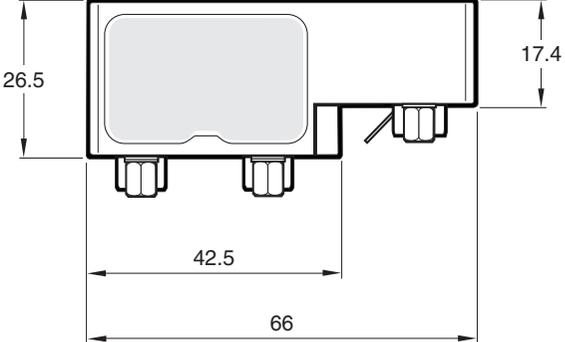
REXM20/REXT20 installation drawing

Dimensions and tolerances in mm

10 ±0.1 [1]

0.25

REXM20/REXT20 reference mark location

REXT20 second reference mark location

D2 [2] D1 [2] D3 [2]

Fiducial marks, 4 positions, to aid installation [3]

N holes Ø6 through equispaced [2]

D4 [2]

θ
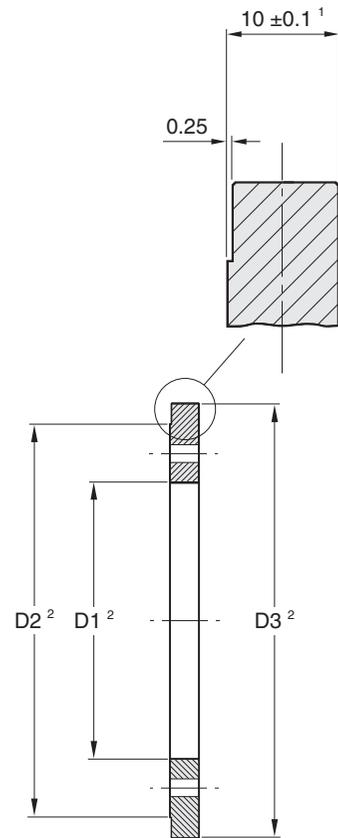
Section A-A
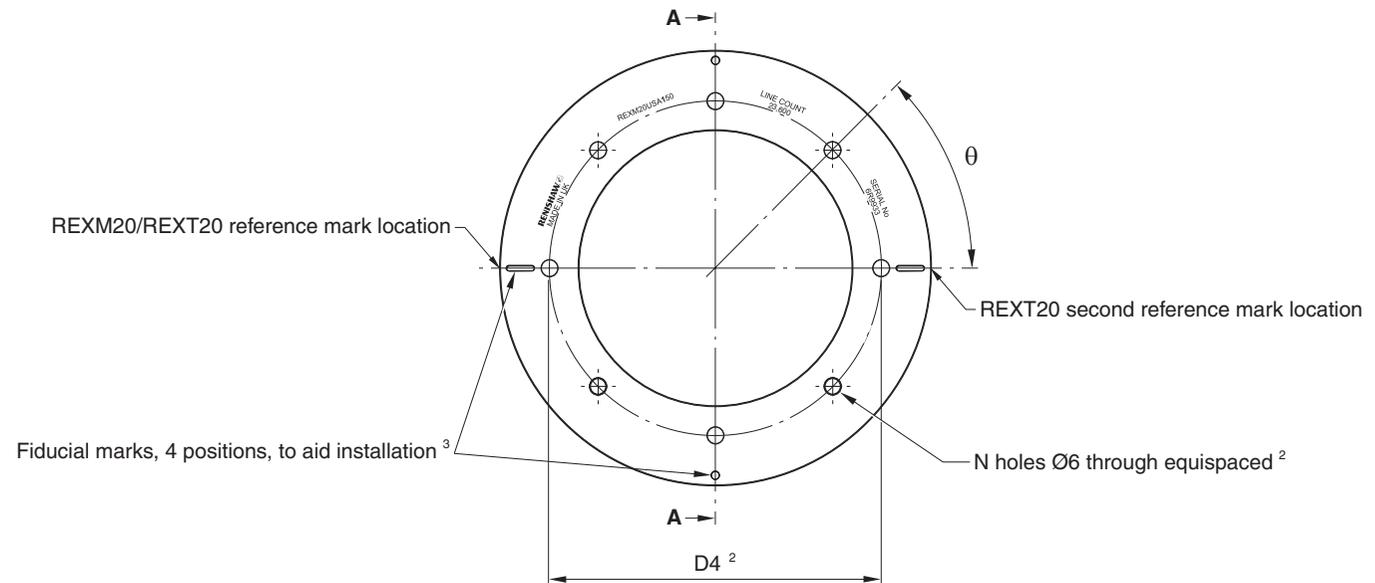
[1] Graduations are centred within this dimension.

[2] Refer to page 14 for dimension and hole information.

[3] 52 mm and 57 mm rings have dimple fiducial features and no slots.

NOTE: For partial rotation REXT refer to 'Mounting the REXT (partial rotation)' on page 18.

REXM20/REXT20 specifications

Nominal external diameter (mm)	Line count	Dimensions			Holes		
		D1 (mm)	D2 (mm)	D3 (mm)	D4 (mm)	N	θ
52	8 192	26	50	52.1 - 52.2	38	4	90°
57	9 000	26	50	57.25 - 57.35	38	4	90°
75	11 840	40.5	64.5	75.3 - 75.4	52.5	8	45°
100	15 744	57.5	97.5	100.2 - 100.3	77.5	8	45°
103	16 200	57.5	97.5	103.0 - 103.2	77.5	8	45°
104	16 384	57.5	97.5	104.2 - 104.4	77.5	8	45°
115	18 000	68	108	114.5 - 114.7	88	8	45°
150	23 600	96	136	150.2 - 150.4	116	8	45°
183	28 800	122.5	162.5	183.2 - 183.4	142.5	12	30°
200	31 488	136	176	200.3- 200.5	156	12	30°
206	32 400	140.5	180.5	206.1 - 206.5	160.5	12	30°
209	32 768	140.5	180.5	208.4 - 208.8	160.5	12	30°
229	36 000	160.5	200.5	229.0 - 229.4	180.5	12	30°
255	40 000	180.5	220.5	254.4 - 254.8	200.5	12	30°
300	47 200	216	256	300.4 - 300.6	236	12	30°
350	55 040	256	296	350.3 - 350.5	276	16	22.5°
417	65 536	305	345	417.0 - 417.4	325	16	22.5°

Equipment for REXM20/REXT20 mounting

Suitable for:

- REXM (full rotation)

- REXT (3° to 357° partial rotation). For partial rotation check the orientation of the ring before installation (see 'Mounting the REXT (partial rotation)' on page 18).

Required parts:

- Appropriate REXM/REXT ring (see 'REXM20/REXT20 specifications' on page 14)

- Appropriate number of screws for ring size (see 'REXM20/REXT20 specifications' on page 14) [1]

- Appropriate number of M5 flat washers for ring size (see 'REXM20/REXT20 specifications' on page 14)

- Dial Test Indicator (DTI) with a ruby ball stylus

- Rubber mallet

- Appropriate cleaning solvents (see 'Storage and handling' on page 8)

- 4 mm hex key

- Torque wrench

Optional parts:

- Renishaw scale wipes (A-9523-4040)

- Lint-free cloth

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[1] Recommended screw type M5 × 0.8: ISO 4762/DIN 912 grade 10.9 minimum / ANSI B18.3.1M.

REXM20/REXT20 ring mounting

- The REXM/REXT ring should be flange mounted onto a flat surface to minimise 2-per-rev distortion.

- Taper mounting is not suitable for thick cross-section REXM/REXT rings.

- To avoid distorting the ring, the REXM/REXT should not be interference fitted.

- Some eccentricity of the ring is acceptable because it will be compensated using two readheads.

Dimensions and tolerances in mm

≥ 0.375
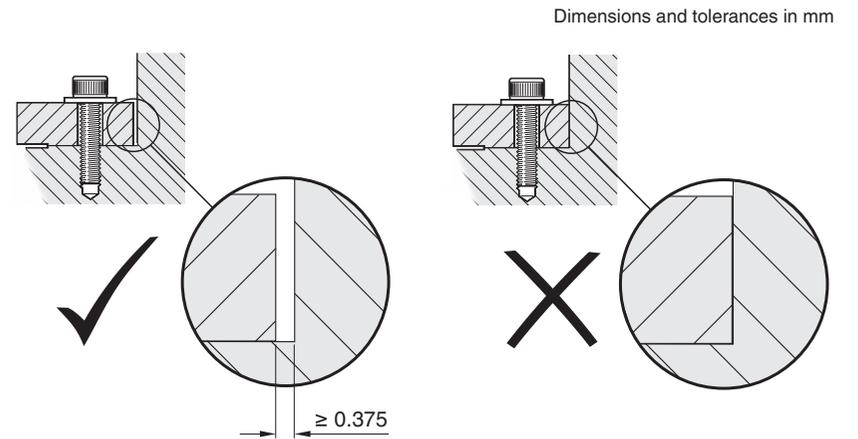
Mounting shaft geometry

The shaft must have a flat mounting surface to match the diameter of the mounting face (D2 [1]) on the lower side of the REXM20/REXT20.

The total axial run-out of the mounting surface should be within 10 µm.

$(< D1\ ^{1} - 0.75)$

N holes [1] × M5 × 10 deep equispaced

| ∠↗ | 0.01 | A |

A

D4 [1]

| ⊕ | Ø0.2 | A |

D2 [1]

D4 [1]

D1 [1]

D2 [1]

---
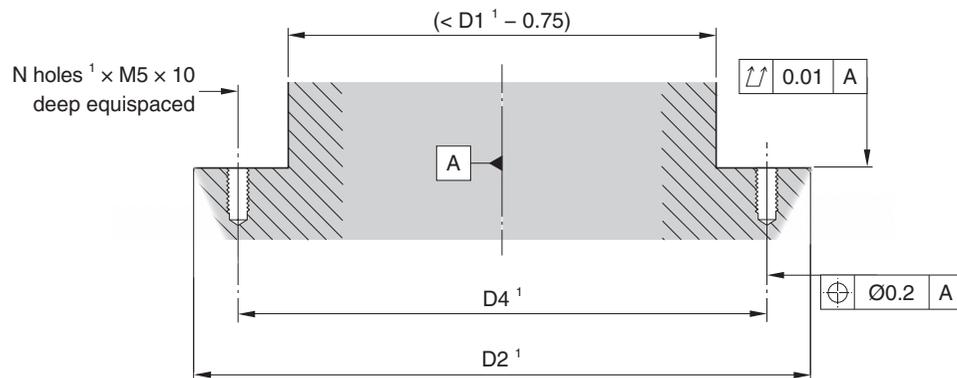
[1]   Refer to 'REXM20/REXT20 specifications' on page 14 for dimension and hole information.

Mounting the REXM (full rotation)

1. Clean the REXM mounting face as recommended in 'Storage and handling' on page 8.

2. Clean the mating surface on the mounting shaft / hub as recommended in 'Storage and handling' on page 8.

3. Place the REXM onto the mounting shaft.

4. Insert four M5 screws with flat washers into the four screw holes by the fiducial marks.

    IMPORTANT: Do not tighten the screws at this point; simply engage the threads ensuring that the screw heads do not touch the ring.

5. See 'Adjusting the REXM/REXT ring (full and partial rotation)' on page 20 for the next steps.

Dimple or slot indicates fiducial mark
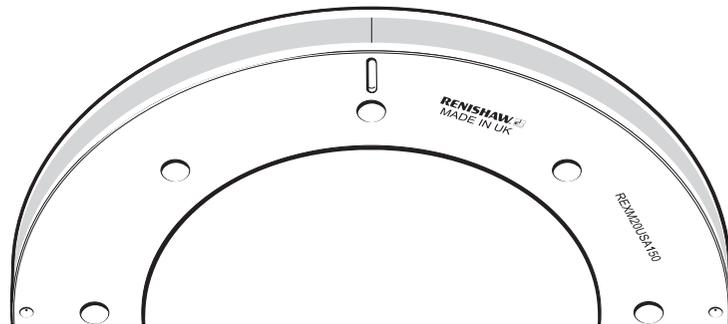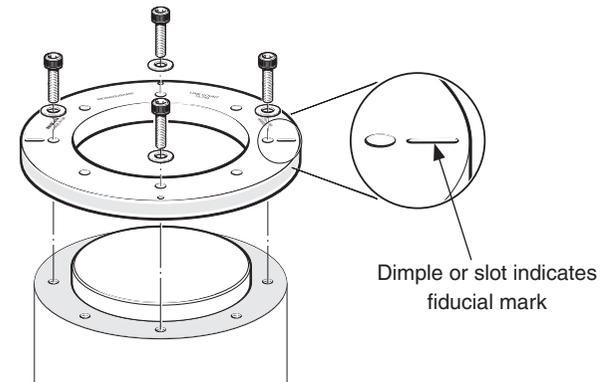
NOTE: The *IN-TRAC*™ reference mark is integrated in the scale, radially aligned with the centre of the mounting hole to the left of the 'Renishaw' logo within ±0.5 mm. No external actuators or physical adjustments are required. For REXT20, the second reference mark is 180° from the first.

Mounting the REXT (partial rotation)

IMPORTANT:

- For partial rotation applications using a DSi, a REXT ring (two reference marks opposite each other) is required.

- The ring must be installed so that, when the ring is rotated, each readhead only sees a single reference mark.

- Both readheads must see a single reference mark to complete the initialisation sequence, see 'Initialisation' on page 32.

- The maximum angle of rotation of the rotor / hub is 357° (Figure 1).

- The minimum angle of rotation of the rotor / hub is 3° (Figure 2).

- The reference mark is output at 0° and will be the average detected difference between readhead (H1) and readhead (H2).

- The position of the reference mark output can be set by the user; see 'Selecting a new reference mark output position (propoZ)' on page 33.

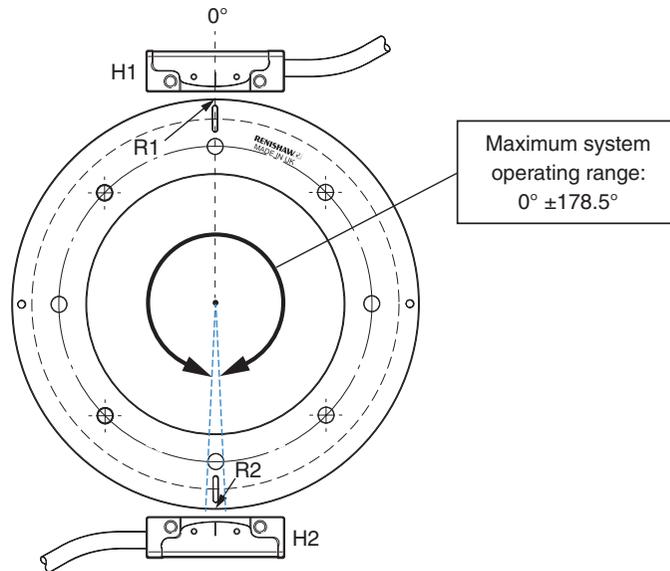**Figure 1: Maximum angle of rotation**

Maximum system
operating range:
0° ±178.5°

Figure 2: Minimum angle of rotation

Minimum system
operating range:
0° ±1.5°
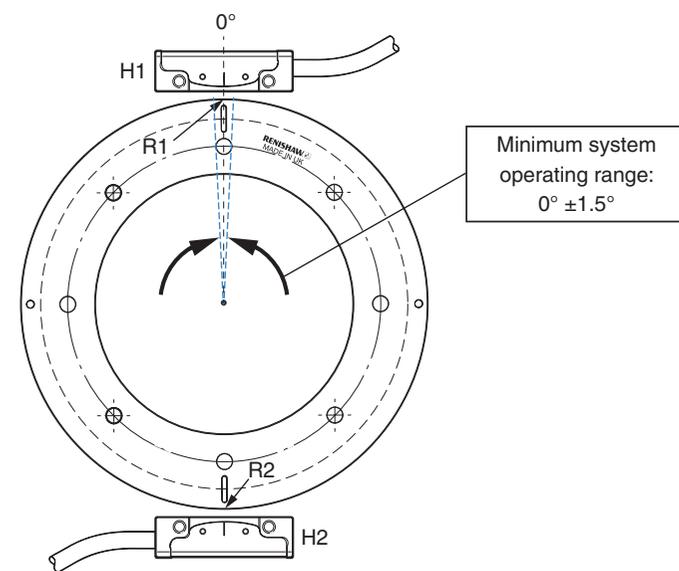
1. Clean the REXT mounting face as recommended in 'Storage and handling' on page 8.

2. Clean the mating surface of the mounting shaft/hub as recommended in 'Storage and handling' on page 8.

3. Move the axis to the mid-point of the required rotation, Φ.

4. Locate the ring so that the reference mark R1 is as close to possible to the centre of the readhead, H1 (see figure 1).

5. Rotate the axis to the full extent of required movement in the counter clockwise direction. Ensure that the readhead, H1, does not pass the other reference mark, R2 (see figure 2).

6. Rotate the axis to the full extent of required movement in the clockwise direction. Ensure that the readhead, H1, passes reference mark R1, but does not pass the other reference mark, R2 (see figure 3).

7. Insert four M5 screws with flat washers into the four screw holes by the fiducial marks.

   IMPORTANT: DO NOT tighten the screws at this point; simply engage the threads ensuring that the heads do not touch the ring.

8. The ring is positioned correctly and can be adjusted. See 'Adjusting the REXM/REXT ring (full and partial rotation)' on page 20.

Figure 1

Figure 2

Figure 3
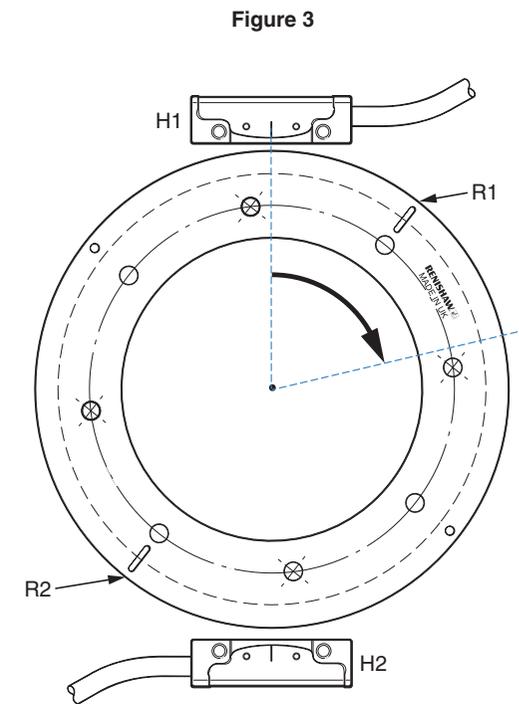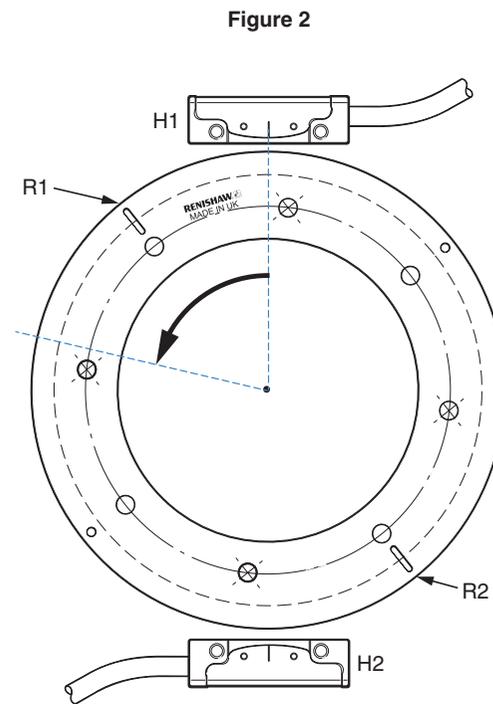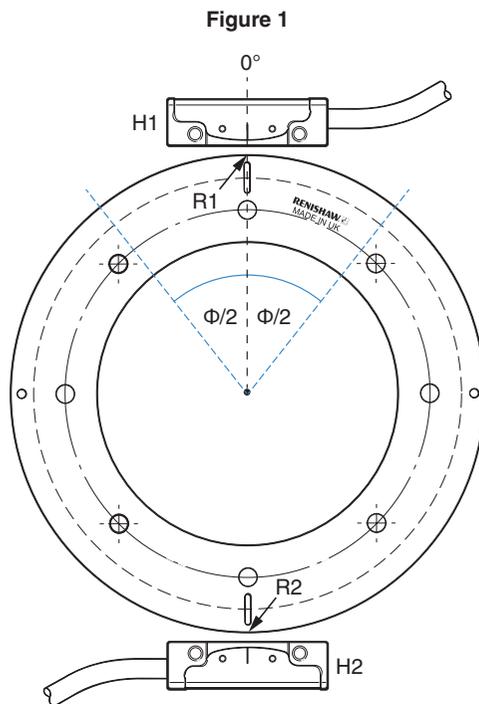
Adjusting the REXM/REXT ring (full and partial rotation)

1. Remove the protective film from the surface of the ring.

2. Measure the run-out on the ring using a Dial Test Indicator (DTI).

   CAUTION: Use a DTI with low exertion force to avoid scratching the ring surface. A DTI with a ruby ball stylus is recommended as a further precaution against scratches.

   NOTE: At this stage the ring is not firmly fixed so, to avoid causing the ring to shift position, rotate the ring slowly and smoothly.

3. Where the DTI shows the lowest radius reading, gently tap the opposite side of the ring on the edge using a rubber mallet, until the DTI reading is approximately at the 'mid-point' of the run-out.

4. Find the new lowest radius reading.

5. Tap the opposite side of the ring with a rubber mallet until the DTI reading is at the 'mid-point' of the run-out.

6. Repeat this process until the run-out of the ring is approximately 30 µm TIR.
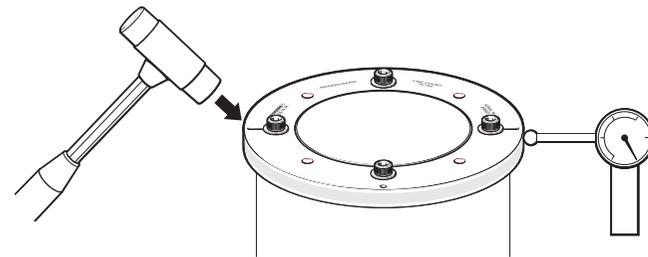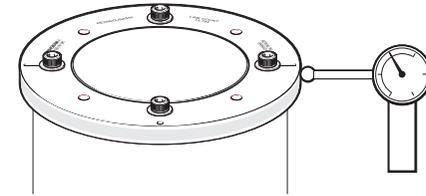
7. Adjust ring position until the DTI reading at these points agrees to 10 µm TIR.

    NOTE: 52 mm and 57 mm rings do not have 'slot' fiducials marked.

'Slot' fiducial
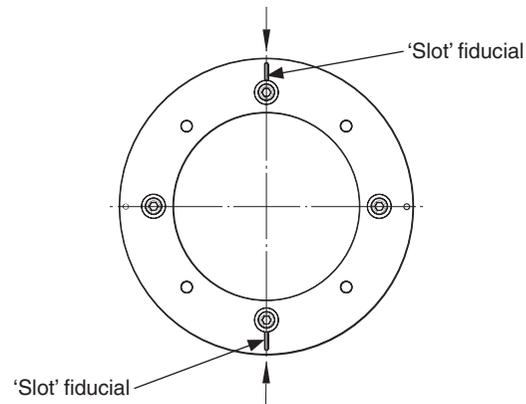
'Slot' fiducial

8. Rotate the ring by 90°.

9. Adjust the ring position until the DTI reading at these points agrees to 10 µm TIR.

'Dimple' fiducial

'Dimple' fiducial
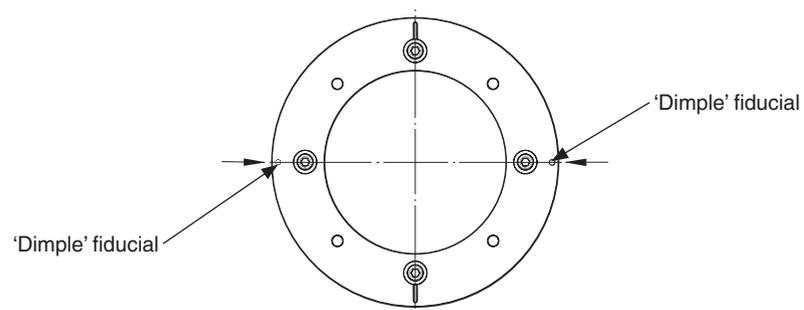
10. Recheck the run-out at the two 'slot' fiducial points, to ensure the run-out is still within 10 µm TIR. Adjust if necessary.

11. Gradually tighten the 4 screws in turn, enough to grip and lightly secure the ring so as to avoid moving the position of the ring.

12. Insert the remaining M5 screws and, in a sequential pattern, gradually tighten them to a torque of approximately 4 Nm.

13. Recheck the run-out at the two 'slot' fiducial points, then at the two 'dimple' fiducial points.

    NOTE: The run-out values at the 'slot' fiducial points do not have to match the run-out values at the 'dimple' fiducial points.

14. If the ring has moved position outside the 10 µm limit, the screws must be loosened and the ring adjusted.

15. Clean ring using Renishaw scale cleaning wipes or a clean, dry, lint-free cloth.

System compatibility

TONiC readhead and ring compatibility

T20x1 readhead models are compatible with a range of REXM/REXT ring sizes. The optical configuration is optimised for the following conditions:

Readhead model	REXM/REXT diameter range (mm)
T2001	> 135
T2011	60 to 135
T2021	< 60

Ensure readhead part number and REXM/REXT size range compatibility at the time of ordering and installation.

NOTE: Published accuracy specifications only apply when 2 readheads are used and the output combined and blended using either a DSi or with the customers own electronics. For optimum accuracy performance, the readheads should be mounted diametrically opposite each other so that the optical centrelines are 180 ±1° apart.

TONiC Ti interface and DSi compatibility

When connecting a DSi the TONiC Ti interfaces must:

• Be configured with line driven alarm outputs.

• Have the same interpolation factor/resolution.

• Have a clocked output option the same or lower than the connected DSi.

For details on readhead and interface configuration, refer to the *TONiC™ encoder system data sheet* (Renishaw part no. L-9517-9337).

TONiC encoder system quick-start guide

This section is a quick-start guide to installing a TONiC system. More detailed information on installing the TONiC system is contained on pages 24 to 28 of this installation guide.

NOTE: To meet accuracy specifications two readheads are required connected either to a DSi or to customers own electronics.

INSTALLATION

Ensure the ring, readhead optical window and mounting faces are clean and free from obstructions.

⬇

Plug the readhead cable into the Ti interface under the cover plate and reassemble the interface (see 'System connection' on page 24). Connect to receiving electronics and power-up.

⬇

Ensure Automatic Gain Control (AGC) is switched off - the CAL LED on the readhead should be off (if not press and hold the CAL button on the interface until the CAL LED on the readhead switches off).

⬇

Install and align the readhead to maximise signal strength over the full axis of rotation as indicated by the readhead and interface set-up LEDs (readhead - green; interface - ideally blue/purple).

⬇

Move to the CALIBRATION steps.

CALIBRATION

Press and release the CAL button on the interface. The CAL LED on the readhead will be single flashing.

⬇

Rotate the axis at slow speed (< 100 mm/s), without passing a reference mark, until the CAL LED starts double flashing.

⬇

Rotate the axis back and forth ensuring the reference mark passes the readhead until the CAL LED stops flashing and remains 'off'.

⬇

The system is now calibrated and ready for use. AGC can now be switched on if required by pressing and holding the CAL button until the CAL LED on the readhead switches on. CAL values and AGC status are stored in readhead non-volatile memory at power down.

NOTE: If calibration fails, restore factory defaults by pressing and holding the CAL button whilst switching on (see 'Restoring factory defaults' on page 28). Then repeat the installation and calibration routine.

⬇

Repeat the installation and calibration process for the second readhead.

⬇

Connect the interfaces to the DSi (see 'DSi quick-start guide' on page 29) or customers output blending electronics.

System connection

Approved ESD precautions must be followed at all times during readhead and interface electrical connections.

The readhead is connected to the Ti interface via a small, rugged connector to allow for easy feed-through during installation.

Connecting the readhead

1. Remove the cover plate as shown (2 × M2.5 hex head screws).
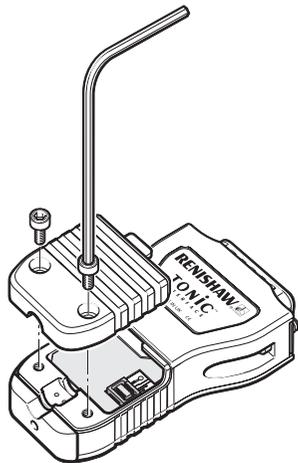
2. Taking care not to touch the pins, plug the connector into the socket in the interface, ensuring correct orientation as shown.
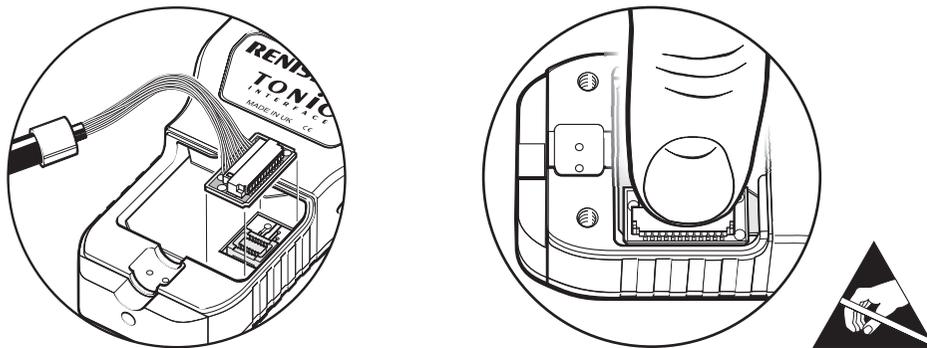
3. Refit the cover plate ensuring the cable ferrule is located in the recess on the inside and no wires are trapped under the cover plate.

NOTE: The tightening torque should be between 0.25 Nm and 0.4 Nm.
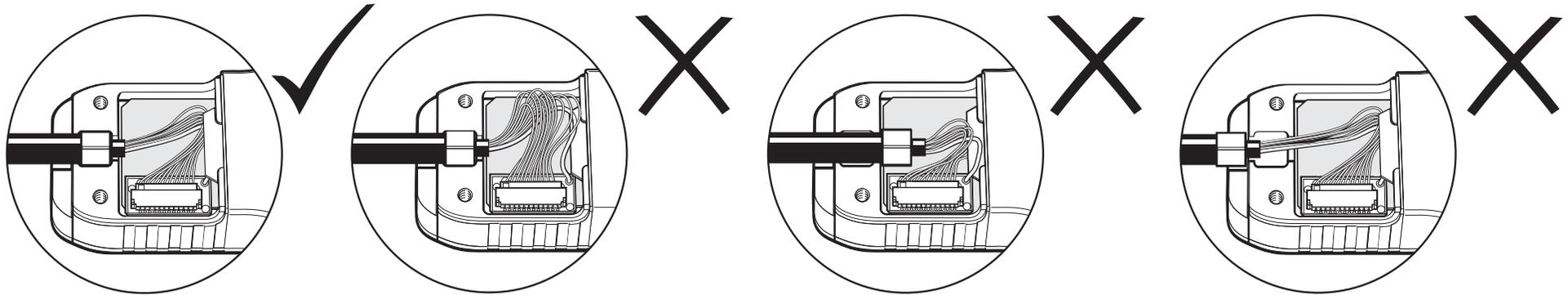
Disconnecting the readhead

1. Remove the cover plate on the interface (2 × M2.5 hex head screws).

2. Gently lever the connector PCB (on the end of the cable) out of the socket. Do not pull the cable to remove the connector.
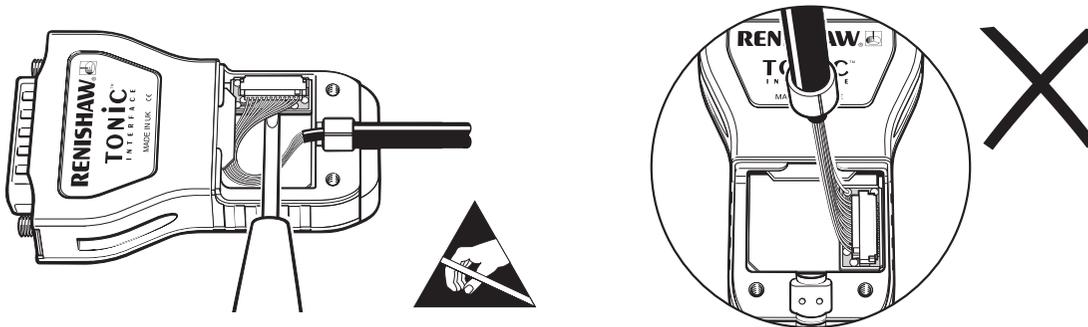
3. Place the connector in an anti-static bag.

4. Refit the cover plate.

Readhead mounting and alignment

Mounting brackets

The bracket must have a flat mounting surface and should enable conformance to the installation tolerances, allow adjustment to the rideheight of the readhead, and be sufficiently stiff to prevent deflection or vibration of the readhead during operation.

Readhead set-up

Ensure that the ring, readhead optical window and mounting face are clean and free from obstructions.

NOTES:

- Ensure that the protective film is removed from the ring before installing the readhead.

- When cleaning the readhead and ring apply cleaning fluid sparingly, do not soak.

To set nominal rideheight, place the green spacer with the aperture under the optical centre of the readhead to allow normal LED function during set-up procedure. Adjust the readhead to maximise the signal strength and achieve a green set-up LED on the readhead (> 70% signal) and a blue LED on the Ti interface for the full distance of rotation.

NOTE: The readhead should be installed and set-up with the AGC switched off (CAL LED off). When reinstalling, factory defaults should be restored (see 'Restoring factory defaults' on page 28).

Readhead set-up LED status

Green   Orange   Red

Yaw
0° ±0.4°

Roll
0° ±0.5°

Pitch
0° ±1.0°

Green spacer

Optical centreline

Rideheight
2.1 ±0.15 mm
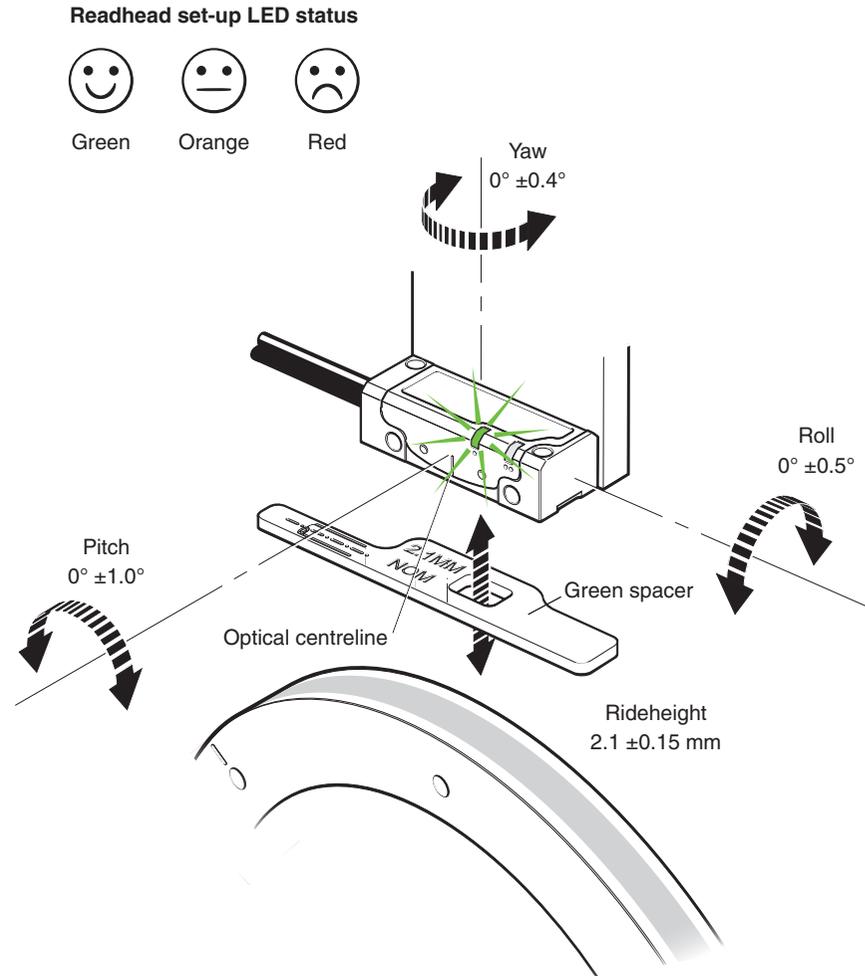
System calibration

Calibration is an essential operation that completes readhead set-up, with the optimum incremental and reference mark signal settings stored in the readhead's non-volatile memory.

Calibration must be carried out for both of the TONiC readheads before connecting them to the DSi.

Before system calibration:

- Ensure the ring and readhead optical window are clean.

- If reinstalling, restore factory defaults (see 'Restoring factory defaults' on page 28).

- Ensure Automatic Gain Control is switched off (CAL LED on readhead is not illuminated) before beginning calibration (see 'Switching Automatic Gain Control (AGC) on or off' on page 28).

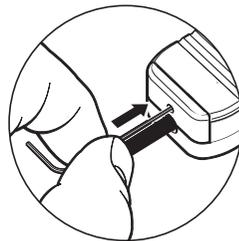- Ensure the signal strength has been optimised over the full axis of rotation; the readhead LED will be green.

Incremental signal calibration

1. Press and release the CAL button on the end of the interface using a 2 mm allen key or similar tool.

WARNING: Activating the CAL switch only requires 2.5 N force. Applying excess force may permanently damage the switch.

---

2. The CAL LED will now periodically single-flash to indicate that it is in incremental signal calibration mode.

3. Rotate the axis at slow speed (< 100 mm/s or less than the readhead maximum speed, whichever is slowest), ensuring the readhead does not pass a reference mark, until the CAL LED starts double-flashing. This indicates that the incremental signals are now calibrated and the new settings are stored in the readhead memory.

4. The system is now ready for reference mark phasing.

5. If the system does not automatically enter the reference mark phasing stage (no double-flashing of the CAL LED) the calibration of the incremental signals has failed.

   - Ensure the failure is not due to overspeed (> 100 mm/s or exceeding the readhead maximum speed)

   - Exit the calibration routine and restore factory defaults (see 'Restoring factory defaults' on page 28).

   - Check the readhead installation and system cleanliness and repeat the calibration routine.

Reference mark phasing

1. Rotate the axis back and forth ensuring the reference mark passes the readhead until the CAL LED stops flashing and remains off. The reference mark is now phased.

2. The system automatically exits the CAL routine and is ready for operation.

3. If the CAL LED continues double-flashing after passing the chosen reference mark many times, it is not detecting the reference mark.

   - Ensure that the correct readhead configuration is being used (T20x1).

Calibration routine manual exit

To exit the calibration routine at any stage press the CAL button. The CAL button will stop flashing.

LED status during system calibration

CAL LED	Settings stored
Single flashing	None, restore factory defaults and recalibrate
Double flashing	Incremental only
Off (auto-complete)	Incremental and reference mark

Restoring factory defaults

When realigning the readhead, reinstalling the system, or in the case of continued calibration failure, factory defaults should be restored.

To restore factory defaults:

1. Switch system off.

2. Press and hold the CAL button whilst switching the system on. The CAL LED on the readhead will flash several times, indicating that the factory defaults have been restored.

3. Release CAL button.

4. Check the 'Readhead mounting and alignment' on page 26 and recalibrate the system (see 'System calibration' on page 27).

   NOTE: The system must be recalibrated after restoring factory defaults.

Switching Automatic Gain Control (AGC) on or off

To switch the AGC on or off, press and hold the CAL button on the interface for > 3 seconds. The CAL LED on the readhead will be illuminated when AGC is active.

NOTE: The system must be calibrated before switching AGC on (see 'System calibration' on page 27).

DSi quick-start guide

This section is a quick-start guide to installing and calibrating a DSi system. More detailed information on installing, calibrating, and initialising a DSi is contained on pages 30 to 32 of this installation guide.

Complete rotation

Install and calibrate both of the TONiC encoder systems (see 'System calibration' on page 27).

⬇

Connect the TONiC encoder systems to the DSi (see 'DSi connection' on page 30).

⬇

Select the correct head orientation switch position on the DSi
(see 'Readhead orientation' on page 31).

⬇

Calibrate the DSi (see 'Calibration' on page 31).

⬇

Optional: Select a new *propoZ* reference (index) position if desired
(see 'Selecting a new reference mark output position (propoZ)' on page 33).

Initialisation

(see 'Initialisation' on page 32).
(Upon subsequent power-ups of the DSi)

⬇

Rotate the axis in one direction until the LED on the DSi goes solid green
(Initialisation status, 'K', goes 'high'). This may require up to 1 full turn.

⬇

The *propoZ* reference (index) output will now be given when the axis passes
the *propoZ* output position.

Partial rotation

IMPORTANT: Ensure the REXT ring is installed so that the reference marks are positioned correctly, relative to the readheads (see 'Mounting the REXT (partial rotation)' on page 18).

Install and calibrate each TONiC encoder system separately on their respective reference marks
(see 'System calibration' on page 27).

⬇

Connect the TONiC encoder systems to the DSi (see 'DSi connection' on page 30).

⬇

Select the correct head orientation switch position on the DSi (see 'Readhead orientation' on page 31).

⬇

Calibrate the DSi (see 'Calibration' on page 31).

⬇

Optional: Select a new *propoZ* reference (index) position if desired
(see 'Selecting a new reference mark output position (propoZ)' on page 33).

Initialisation

(see 'Initialisation' on page 32).
(Upon subsequent power-ups of the DSi)

⬇

Rotate the axis to its maximum travel in both directions.
The LED on the DSi will go solid green (Initialisation status, 'K', goes 'high') when initialized.

⬇

The *propoZ* reference (index) output will now be given when the axis passes
the *propoZ* output position.

DSi connection

Ensure that both TONiC readheads are calibrated before connecting them to the DSi.

NOTE: The DSi should be placed as close to the power supply as possible to minimise voltage drop.

Local mounting method

Plug the TONiC interfaces directly into the DSi.

Compatible DSi's	
Rotation	**DSi type** [1]
Full rotation	DSi-QTL
	DSi-QTM
Partial rotation	DSi-QUL
	DSi-QUM
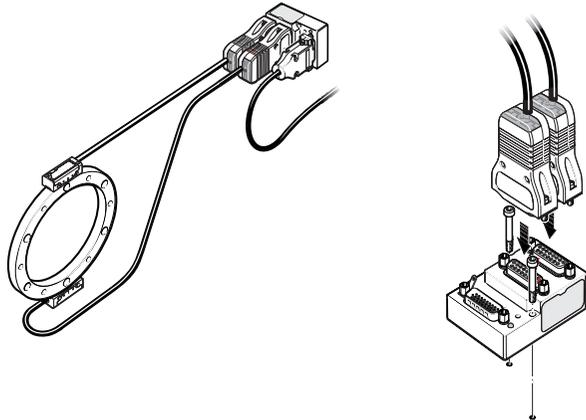
Remote mounting method

Extension cables between the TONiC interfaces and the DSi.

Compatible DSi's	
Rotation	**DSi type** [1]
Full rotation	DSi-QTR
	DSi-QTS
Partial rotation	DSi-QUR
	DSi-QUS
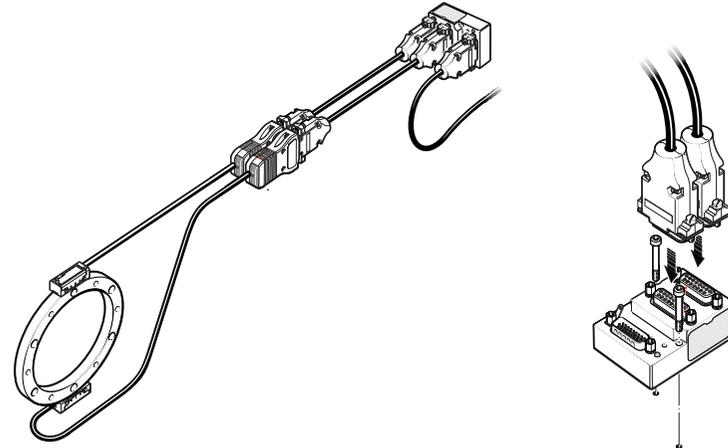
NOTE: The remote DSi has an additional 120 ohm termination resistor on the quadrature outputs.

[1]   See the *DSi dual readhead angle encoder system* data sheet (Renishaw part no. L-9517-9466) for more information.

Readhead orientation

IMPORTANT: Select the correct head orientation switch position.

This switch can be found on the rear of the DSi. The DSi must be recalibrated if the switch position is changed.

Encoder forward
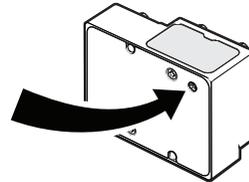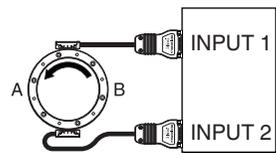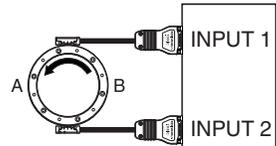rotation direction

Factory setting

Option 1: recommended

INPUT 1

A B

INPUT 2

	Factory setting			
Output count direction	FWD	-	-	REV
Factory default *propoZ* position	A	-	-	B

Option 2: alternative

INPUT 1

A B

INPUT 2

Output count direction	-	FWD	REV	-
Factory default *propoZ* position	-	A	B	-

Calibration

Calibration is an essential operation that completes system set-up. The system must be recalibrated if the installation is disturbed or if the DSi has been moved to a different axis.

Using a small hex-key (or other suitable implement) press and hold the recessed *propoZ* button on the front of the DSi as the power is switched on. The LED on the DSi will go red, release the button and the LED will go orange, then start to flash green. The initialisation status, 'K', will be 'low'.
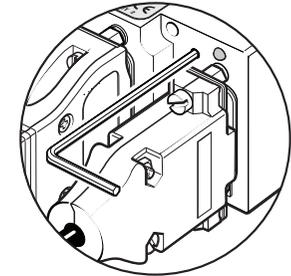
For complete rotation:

1. Rotate the axis in one direction until the LED on the DSi stops flashing (the initialisation status, 'K', will go 'high').

   NOTE: The axis may need up to two full rotations to achieve this.

2. The DSi has now memorised the number of counts per revolution and determined the factory default *propoZ* position.

For partial rotation:

1. Ensure the ring is installed so the reference marks are positioned correctly (see 'Mounting the REXT (partial rotation)' on page 18).

2. Rotate the axis in both directions to its maximum travel until the LED on the DSi stops flashing (the initialisation status, 'K', will go 'high').

3. The factory default *propoZ* position has now been determined.

NOTE: For optimum system accuracy and performance at higher speeds, ensure that the AGC is switched off (see 'Switching Automatic Gain Control (AGC) on or off' on page 28).

Initialisation

Initialisation is required at each power-up and after an error has occurred.

If an alarm occurs, the DSi will automatically re-enter initialisation mode when the alarm condition is removed.

For complete rotation:

1. Rotate the axis in one direction (either clockwise or anti-clockwise) until both readheads pass the reference mark. The LED on the DSi will then go solid green and the initialisation status, 'K', will go 'high'.

2. Initialisation is now complete. The reference mark will be output when the axis next passes the factory default *propoZ* position.
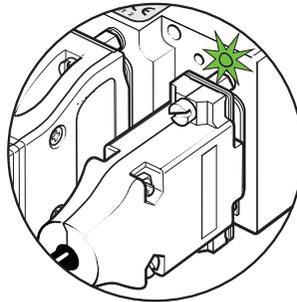
NOTE: For a complete rotation the default *propoZ* position is 90 degrees i.e. half way between the two readheads mounted opposite each other on the ring.

For partial rotation:

1. Ensure the ring is installed so the reference marks are positioned correctly (see 'Mounting the REXT (partial rotation)' on page 18).

2. Rotate the axis in both directions to its maximum travel. The LED on the DSi will then go solid green and the initialisation status, 'K', will go 'high'.

3. Initialisation is now complete. The reference mark will be output when the axis next passes the factory default *propoZ* position.

NOTE: For a partial rotation the default *propoZ* position is 0 degrees, i.e., inline with the two readheads mounted opposite each other on the ring.

Selecting a new reference mark output position (*propoZ*)

The position of the reference mark output (*propoZ*) can be set by the user and can be reprogrammed as many times as required.

Ensure the DSi is calibrated and has completed the initialisation routine before setting a new reference mark output position.

The LED on the DSi flashes 'blank' as it passes the last programmed *propoZ* position.

## Changing the *propoZ* position

1. Rotate the axis to the required reference (index) position.

2. Using a hex-key or other suitable tool, press the recessed *propoZ* button on the front of the DSi. The LED on the DSi will show orange while the button is pressed. The new *propoZ* position is stored as the button is released. If the axis remains at that position, the LED shows blank after the button is released, indicating that the axis is at the *propoZ* position.

   NOTE: You may find it useful to press and hold the *propoZ* button while you adjust the axis position slightly, then release the button at the optimum point.

3. The controller may now 'emergency stop' as the reference (index) is output at a new position. The controller should be restarted to ensure it is using the new reference (index) position.

4. After the controller has been restarted, the DSi will start the initialisation routine, indicated by a flashing green LED on the DSi and a 'low' initialisation status, 'K'. Rotate the axis in one direction (either clockwise or anti-clockwise) until the LED goes solid green and the initialisation status, 'K' goes 'high'. The new *propoZ* position will be indicated by a blank flash of the LED.

   NOTE: You can select a new *propoZ* position at any time when the LED is solid green, simply by pressing the *propoZ* button.

5. Small black adhesive covers are provided for the *propoZ* button and head orientation switch to reduce ingress of dust.
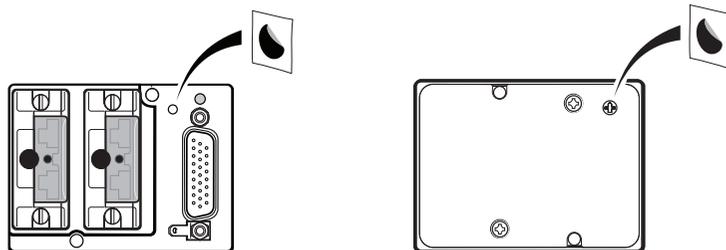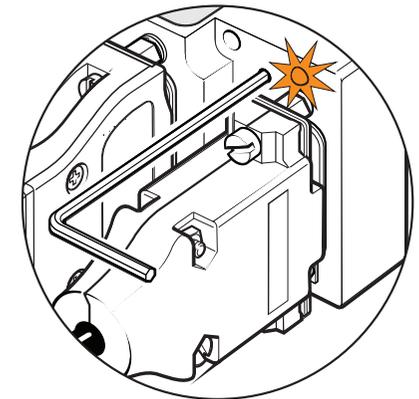
System LEDs

T20x1 readhead LED diagnostics

LED		Indication	Status
Set-up	Incremental	Green	Normal set-up: signal level > 70%
		Orange	Acceptable set-up; signal level 50% to 70%
		Red	Poor set-up; signal may be too low for reliable operation; signal level < 50%
	Reference mark	Green (flash) [1]	Normal phasing
		Orange (flash)	Acceptable phasing
		Red (flash)	Poor phasing; clean the ring and recalibrate if required
CAL	Operating	On	Automatic Gain Control – On
		Off	Automatic Gain Control – Off
	Calibration	Single-flashing	Calibrating incremental signals
		Double-flashing	Calibrating reference mark
	Reset	Flashing at power-up (< 2s)	Restore factory defaults

Ti interface LED diagnostics

Signal	Indication	Status	Alarm output [2]
Incremental	Purple	Normal setup; signal level 110% to 135%	No
	Blue	Optimum setup; signal level 90% to 110%	No
	Green	Normal set-up: signal level 70% to 90%	No
	Orange	Acceptable set-up; signal level 50% to 70%	No
	Red	Poor set-up; signal may be too low for reliable operation; signal level < 50%	No
	Red / blank - flashing	Poor set-up; signal level < 20%; system in error	Yes
	Blue / blank - flashing	Overspeed [3]; system in error	Yes
	Purple / blank - flashing	Over signal; system in error	Yes
Reference mark	Blank flash	Reference mark detected (speed < 100 mm/s only)	No

[1] The flash will effectively be invisible when passing the reference mark if the incremental signal is > 70%.

[2] The alarm output will take the form of 3-state or line driven E signal depending on DSi configuration. The Ti interfaces connected to the DSi must be configured with the line driven alarm format.

- The alarm output is a momentary status only. It is only present while the fault condition remains.

- The alarm may result in axis position error, redatum to continue.

[3] Some Ti interfaces do not output overspeed alarm. See the *TONiC encoder system* data sheet (Renishaw part no. L-9517-9337) for details of interface configuration. This can be downloaded from our website at **www.renishaw.com/tonicdownloads** and is also available from your local Renishaw representative.

DSi LED diagnostics

LED colour	Meaning
Green (flashing)	DSi is in initialisation mode. Rotate the axis in one direction until the LED turns solid green to exit initialisation mode. [1]
Green (solid)	DSi is in normal working mode.
Blank	Axis is at the *propoZ* reference (index) output position. [2]
Orange (*propoZ* button is being pressed)	A new *propoZ* position is being programmed. When the *propoZ* button is released, the LED will normally show blank unless the axis is moved from the *propoZ* position.
Red (solid)	Pulse count alarm has been asserted. The number of counts in the last revolution is different to the value stored during the automatic calibration routine when the DSi was first installed. This could be caused by a miscount from one of the TONiC encoders. If the pulse count alarm is asserted repeatedly, it is possible that an incorrect count is stored inside the DSi, in which case the DSi should be powered-up with the *propoZ* button pushed in to restore factory defaults. Recalibrate the DSi as per the initial installation. [3]
Red (flashing)	An alarm has occurred on one or both of the TONiC interfaces.
Red, then **orange**, then **flashing green**	The DSi has returned to factory default settings. This is triggered by pressing and holding the *propoZ* button while the DSi is being powered up.

[1] During high-speed rotation, the blank flash of the LED as the axis passes the *propoZ* position may appear like a flashing green LED. If the LED continues flashing green check for correct position of the orientation switch and press and hold the *propoZ* button on switch-on.

[2] If you drive the axis past the *propoZ* position, the blank LED will appear as a 0.25 second flash.

[3] On recalibration, the old *propoZ* position will be lost.

Output signals

Ti digital interface output

Function	Output type	Signal		Pin
Power	-	5 V		7, 8
		0 V		2, 9
Incremental	RS422A digital	A	+	14
			−	6
		B	+	13
			−	5
Reference mark	RS422A digital	Z	+	12
			−	4
Limits	Open collector	P [1]		11
		Q		10
Set-up	RS422A digital	X		1
Alarm [2]	-	E	+	-
			−	3
Shield	-	Inner shield		-
	-	Outer shield		Case
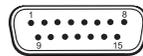
15-way D-type plug

DSi output

Function	Output type	Signal		Pin
Power	-	5 V power		26
		5 V sense		18
		0 V power		9
		0 V sense		8
Incremental signals	RS422A digital	A	+	24
			−	6
		B	+	7
			−	16
Reference mark	RS422A digital	Z	+	15
			−	23
Alarm [3]	RS422A digital	E+		25
		E−		17
Limits [4]	Open collector	P		4
		Q		13
Initialisation status	Open collector	K		3
Shield	-	Inner		Not connected
	-	Outer		Case
Do not connect	-	-		1, 2, 5, 10, 11, 12, 14, 19, 20, 21, 22
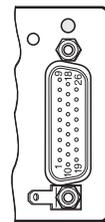
26-way high-density
D-type plug

NOTE: T2000 series readheads are fitted with P and Q 'end of travel' limit switch sensors, typically used for linear motion applications. P and Q limit actuators are not suitable for ring encoder installations. Limit switch signal detail is included here for information only. Please contact your local Renishaw representative if you require limits on your rotary installation.

[1] Becomes alarm (E+) for Ti options E, F, G, H

[2] The TONiC interface must be configured for line driven alarm.

[3] DSi alarm formats can be 3-state or line driven. Please specifiy at time of ordering.

[4] Limit switch outputs are taken directly from the readhead connected to input 1.

Speed

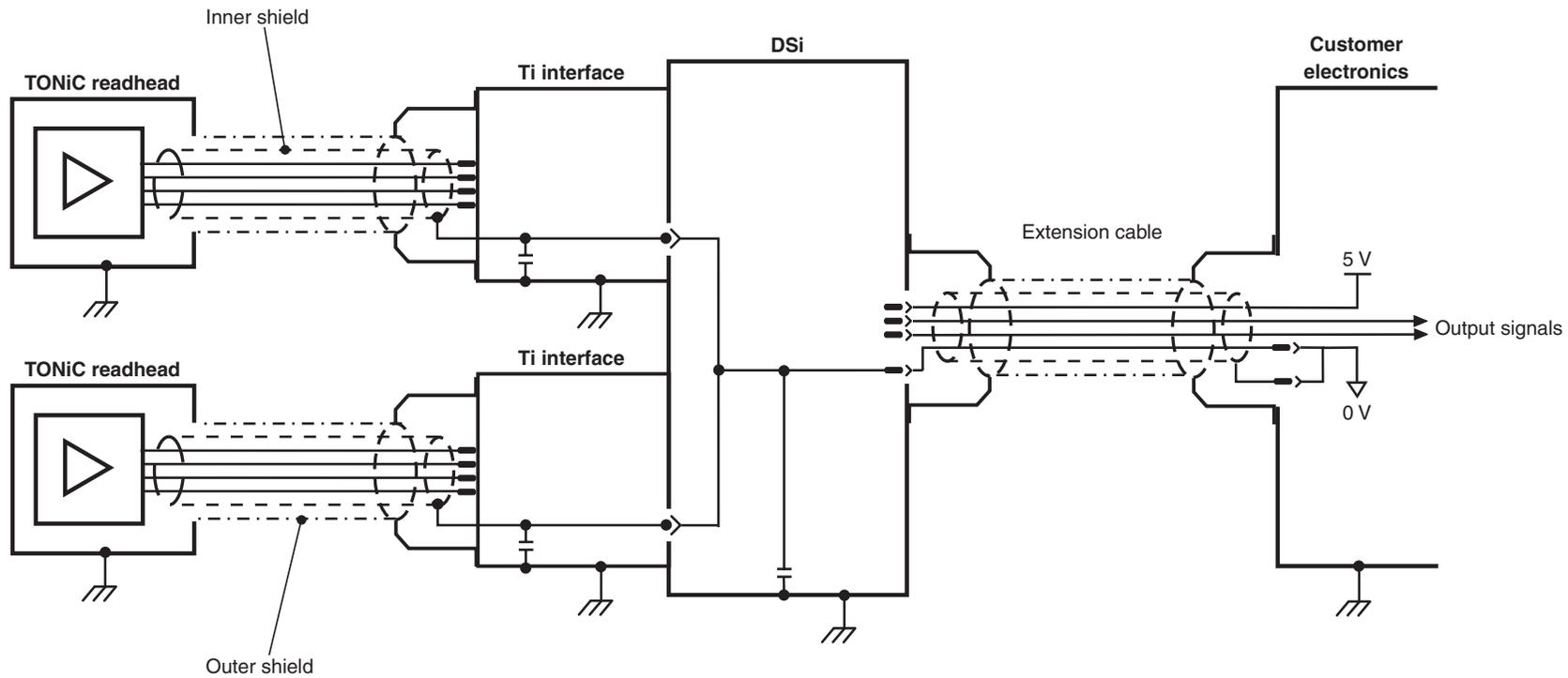| Clocked output option (MHz)	Maximum speed (m/s)										
	Ti0004 5 µm	Ti0020 1 µm	Ti0040 0.5 µm	Ti0100 0.2 µm	Ti0200 0.1 µm	Ti0400 50 nm	Ti1000 20 nm	Ti2000 10 nm	Ti4000 5 nm	Ti10KD 2 nm	Ti20KD 1 nm
50	10	10	10	6.48	3.24	1.62	0.648	0.324	0.162	0.0654	0.032
40	10	10	10	5.40	2.70	1.35	0.540	0.270	0.135	0.054	0.027
25	10	10	8.10	3.24	1.62	0.810	0.324	0.162	0.081	0.032	0.016
20	10	10	6.75	2.70	1.35	0.675	0.270	0.135	0.068	0.027	0.013
12	10	9	4.50	1.80	0.900	0.450	0.180	0.090	0.045	0.018	0.009
10	10	8.10	4.05	1.62	0.810	0.405	0.162	0.081	0.041	0.016	0.0081
08	10	6.48	3.24	1.29	0.648	0.324	0.130	0.065	0.032	0.013	0.0065
06	10	4.50	2.25	0.90	0.450	0.225	0.090	0.045	0.023	0.009	0.0045
04	10	3.37	1.68	0.67	0.338	0.169	0.068	0.034	0.017	0.0068	0.0034
01	4.2	0.84	0.42	0.16	0.084	0.042	0.017	0.008	0.004	0.0017	0.0008

Angular speed depends on ring diameter. Use the following equation to convert to rev/min.

$$\text{Angular speed (rev/min)} = \frac{V \times 1000 \times 60}{\pi D}$$

Where V = maximum linear speed (m/s) and D = external diameter of REXM/REXT ring (mm)

Electrical connections

Grounding and shielding

TONiC system and local DSi

Diagram labels: Inner shield, TONiC readhead, Ti interface, DSi, Customer electronics, Extension cable, 5 V, Output signals, 0 V, TONiC readhead, Ti interface, Outer shield

IMPORTANT: The outer shield should be connected to the machine earth (Field Ground). The inner shield should be connected to 0 V at the receiving electronics only. Care should be taken to ensure that the inner and outer shields are insulated from each other. If the inner and outer shields are connected together, this will cause a short between 0 V and earth, which could cause electrical noise issues

**NOTE:** Maximum cable lengths as detailed in 'General specifications' on page 43.

TONiC system and remote DSi
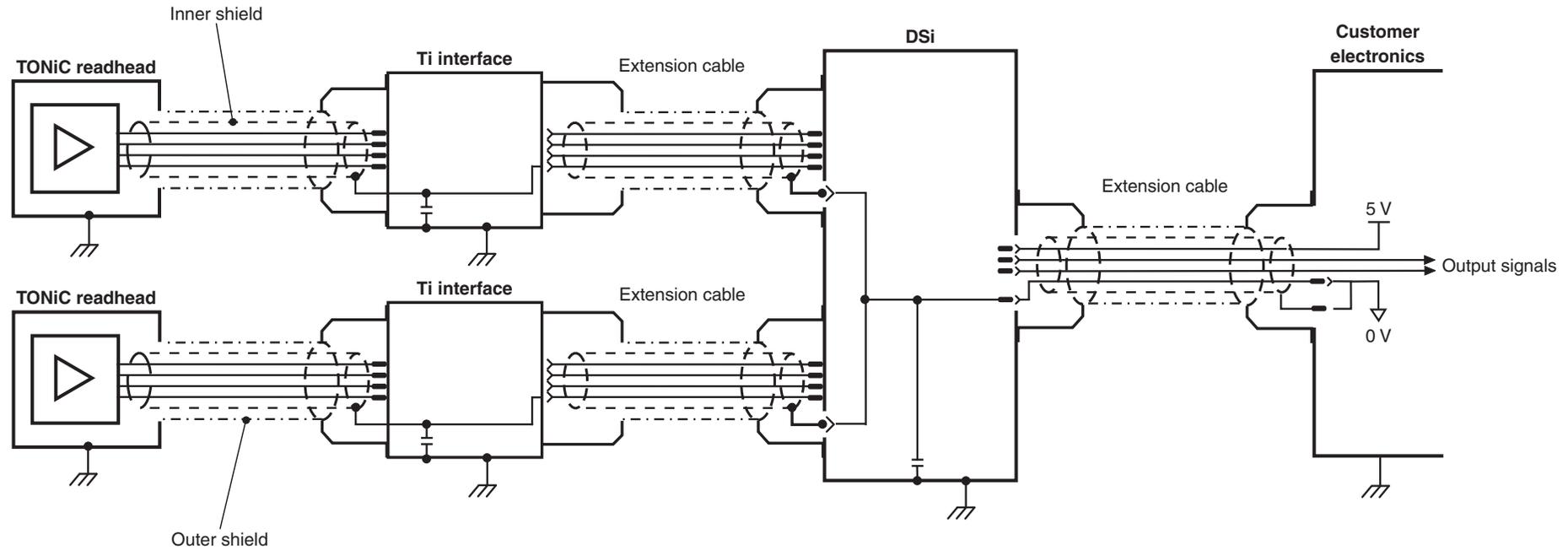
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IMPORTANT: The outer shield should be connected to the machine earth (Field Ground). The inner shield should be connected to 0 V at the receiving electronics only. Care should be taken to ensure that the inner and outer shields are insulated from each other. If the inner and outer shields are connected together, this will cause a short between 0 V and earth, which could cause electrical noise issues

NOTE: Maximum cable lengths as detailed in 'General specifications' on page 43.

Recommended signal termination

Digital outputs
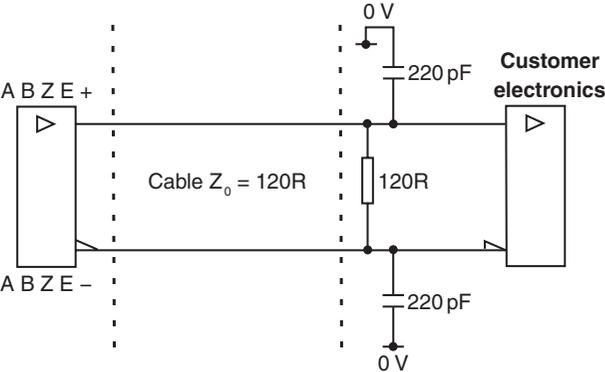
Standard RS422A line receiver circuitry
The capacitors are recommended for improved noise immunity

Initialisation status output
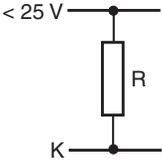
NOTE: Select the resistor R so that the maximum current does not exceed 20 mA.

Alternatively, use a suitable relay or opto-isolator.

Connecting a separate power supply

Many controllers cannot supply 1 amp at 5 volts, so it may be necessary to connect a separate power supply. To ensure correct operation, the separate power supply should be connected as per the diagram below. The 0 V of the separate power supply should be connected to the 0 V of the controller to ensure that the line driver in the DSi and line receiver in the controller are using the same reference voltage. The 10 ohm resistor minimises current flow due to different 0 V potentials.
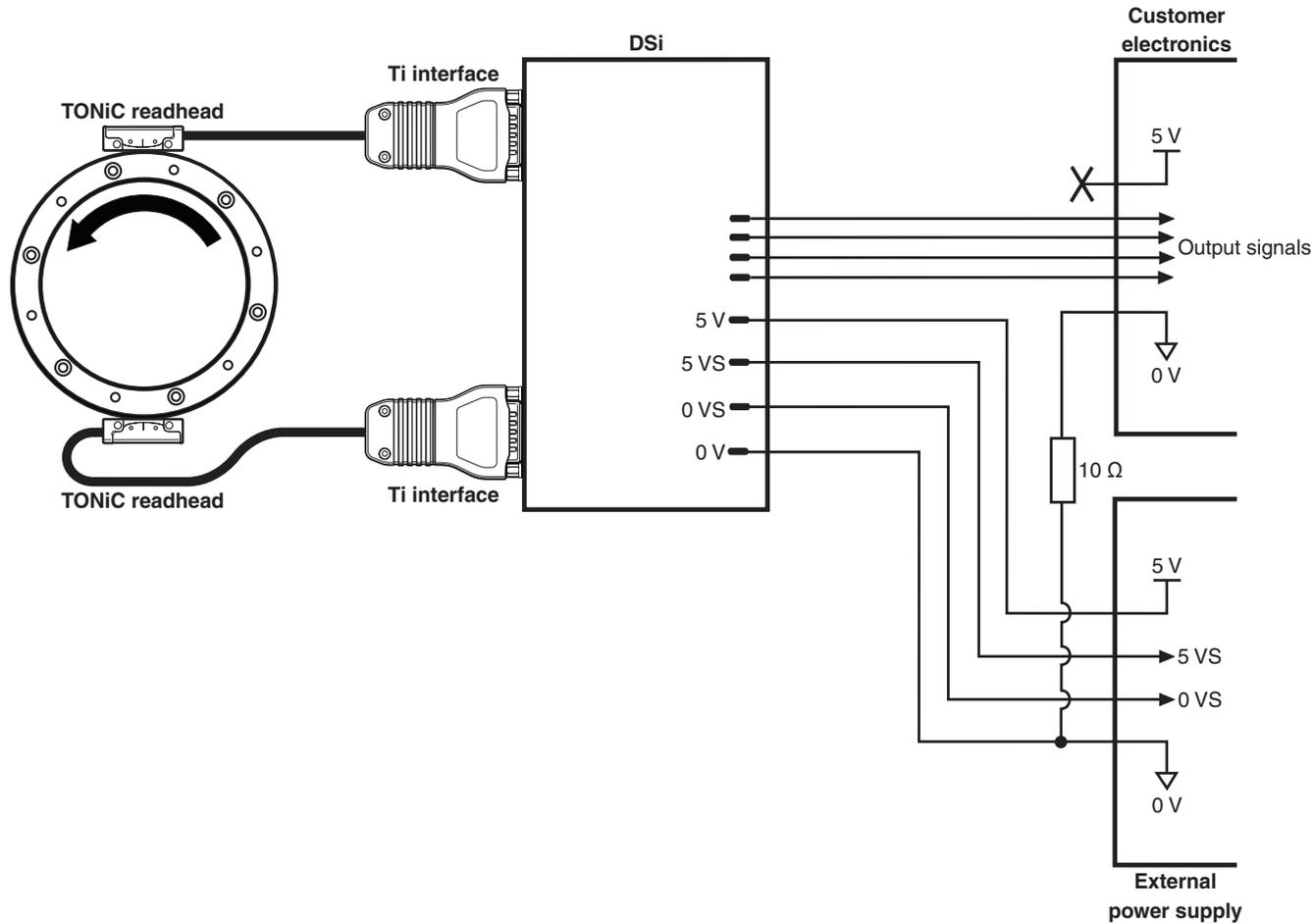
DSi output specifications

Digital output signals

Form - Square wave differential line driver to EIA RS422A

Incremental [1]

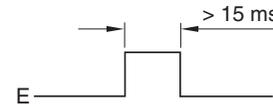2 channels A and B in quadrature (90° phase shifted)
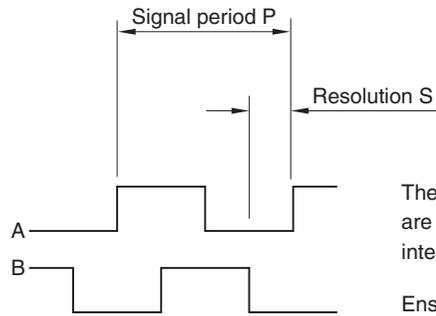
The resolution and retiming frequency are determined by the TONiC Ti interfaces connected to the DSi.

Ensure that the two Ti interfaces have the same part numbers.

Alarm [1]

Line driven (Asynchronous pulse)

An alarm is asserted when either TONiC encoder goes into an alarm condition, or when the DSi detects that a miscount has occurred.

The miscount alarm will be cleared when the DSi detects the correct count.

or 3-state alarm [2]

Differentially transmitted signals forced open circuit for > 15 ms when alarm conditions valid.
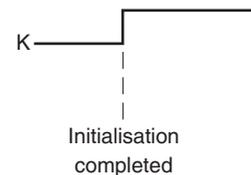
---

propoz reference [1]

Duration as resolution S.

Customer-positionable.

NOTE: The *propoz* reference mark is resynchronised at power-up and can be output in any quadrature state.

Initialisation status

Open collector output

The initialisation status goes low when the DSi is in initialisation mode (occurs when the DSi is powered-up or when an alarm condition has been cleared). When initialization is complete, the signal will go high.

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[1]   For clarity, the inverse signals are not shown.

[2]   Connected encoders must be configured with line dirven alarm output.

General specifications

Power supply	5 V ±10%	1 Amp maximum when terminated with 120 Ohms.
		Power from a 5 Vdc supply complying with the requirements for SELV of standard IEC 60950-1.
	Ripple	200 mVpp maximum @ frequency up to 500 kHz
Sealing	(Standard TONiC readhead)	IP40
	(UHV TONiC readhead)	IP20
	(Ti interface)	IP20
	(DSi)	IP20
Acceleration	Operating (TONiC readhead)	500 m/s^2, 3 axes
Shock	Non-operating (DSi)	1000 m/s^2, 6 ms, ½ sine, 3 axes
Vibration	Operating (TONiC readhead)	50 m/s^2, 55 Hz to 2000 Hz, 3 axes
Mass	(TONiC readhead)	10 g
	(Ti interface)	100 g
	(DSi)	85 g
	(Standard TONiC readhead cable)	26 g/m
	(UHV TONiC readhead cable)	14 g/m
Readhead cable	(Standard)	Double shielded, outside diameter 4.25 ±0.25 mm
		Flex life > 20×10^6 cycles at 20 mm bend radius
		UL recognised component ⓤⓁ
	(UHV)	Tin coated braided single screen FEP core insulation
Maximum cable length [1]	Readhead to Ti interface	10 m
	Ti interface to DSi (remote version) and DSi to controller	25 m (with 15 to 20 MHz clocked output)
		30 m (with ≤ 14 MHz clocked output)

CAUTION: Renishaw encoder systems have been designed to the relevant EMC standards, but must be correctly integrated to achieve EMC compliance. In particular, attention to shielding arrangements is essential.

[1]   When using extension cables customers should ensure correct voltage at DSi unit and also correct voltage at Ti interface for remote versions.

REXM20/REXT20 ring specifications

Pitch	20 µm
Material	303/304 stainless steel
Coefficient of thermal expansion (at 20 °C)	15.5 ±0.5 µm/m/°C

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