

TONiC™ T20x1 RESM angle encoder system



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Legal notices

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Patents

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

EP0748436	US5861953	EP1173731	US6775008B2	JP4750998
CN100543424C	US7659992	JP4932706	CN100507454C	US7550710
EP1766335	CN101300463B	EP1946048	US7624513B2	JP5017275
CN101310165B	US7839296	EP1957943	US6481115	IL138995
EP1094302	CN1293983	GB2397040	JP4813018	US7723639
CN1314511	EP1469969	JP5002559	US2005045586	

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Product compliance

Renishaw plc declares that TONiC complies with the applicable standards and regulations.

A copy of the EU declaration of conformity is available from our website at

www.renishaw.com/productcompliance.

Compliance

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.

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.

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.

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

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). This can be downloaded from our website at www.renishaw.com/tonicdownloads and is also available from your local representative.

Packaging

Packaging 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.

WEEE recycling guidelines

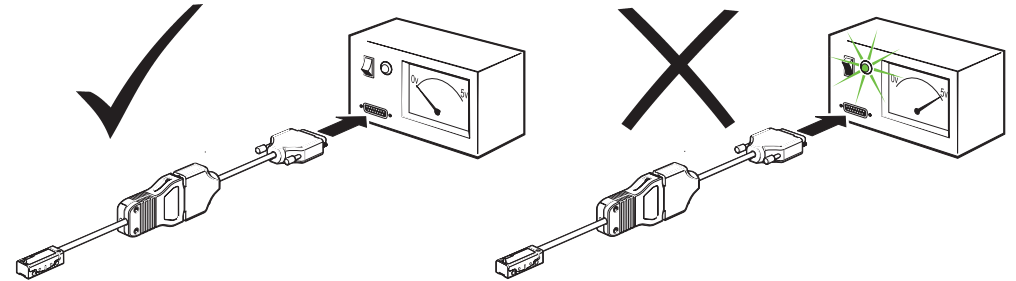
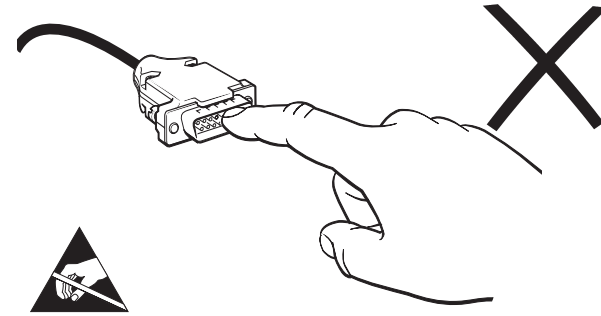
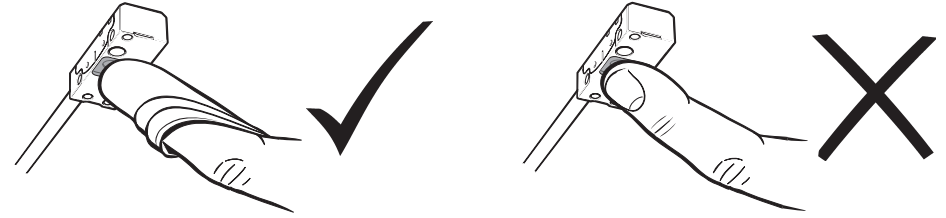
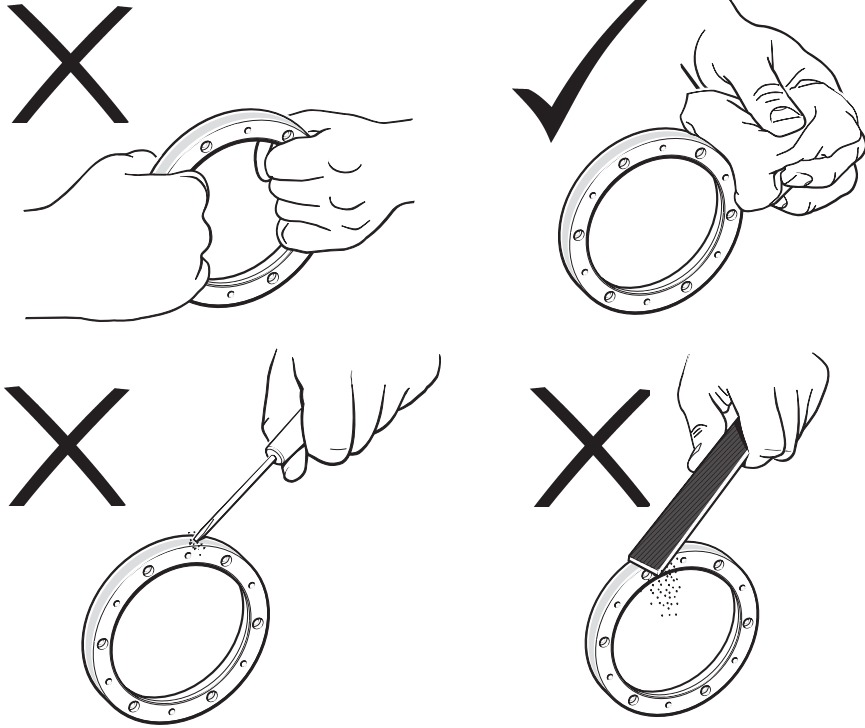


The use of this symbol on Renishaw products and/or accompanying documentation indicates that the product should not be mixed with general household waste upon disposal. It is the responsibility of the end user to dispose of this product at a designated collection point for waste electrical and electronic 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, please contact your local waste disposal service or Renishaw distributor.

Storage and handling

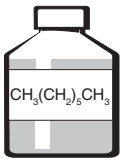
RESM20 is a non-contact optical encoder that provides good immunity against contaminants such as dust, fingerprints and light oils.

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

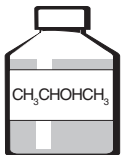


Ring and readhead

N-heptane

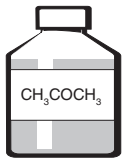


Propan-2-ol



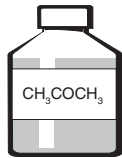
Ring only

Acetone



Readhead only

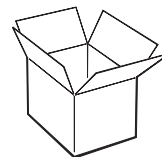
Acetone



Storage

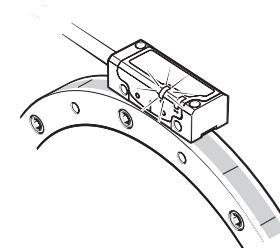
+70 °C
-20 °C

UHV readhead
Bakeout +120 °C



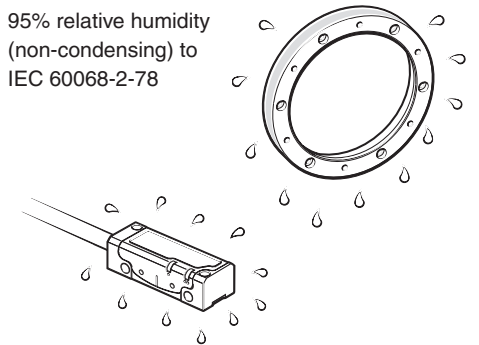
Operating

+70 °C
0 °C



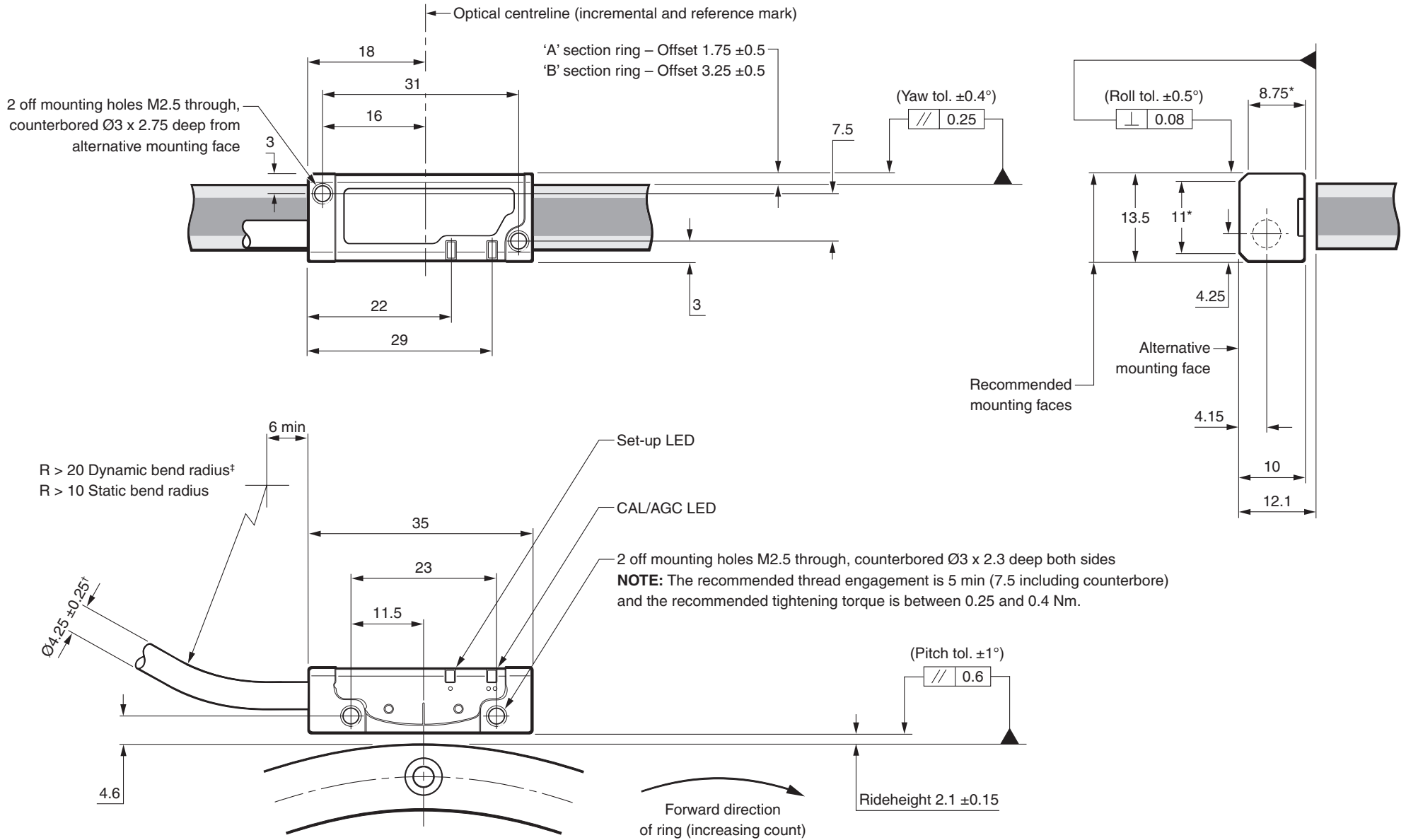
Humidity

95% relative humidity
(non-condensing) to
IEC 60068-2-78



TONiC T20x1 readhead installation drawing

Dimensions and tolerances in mm



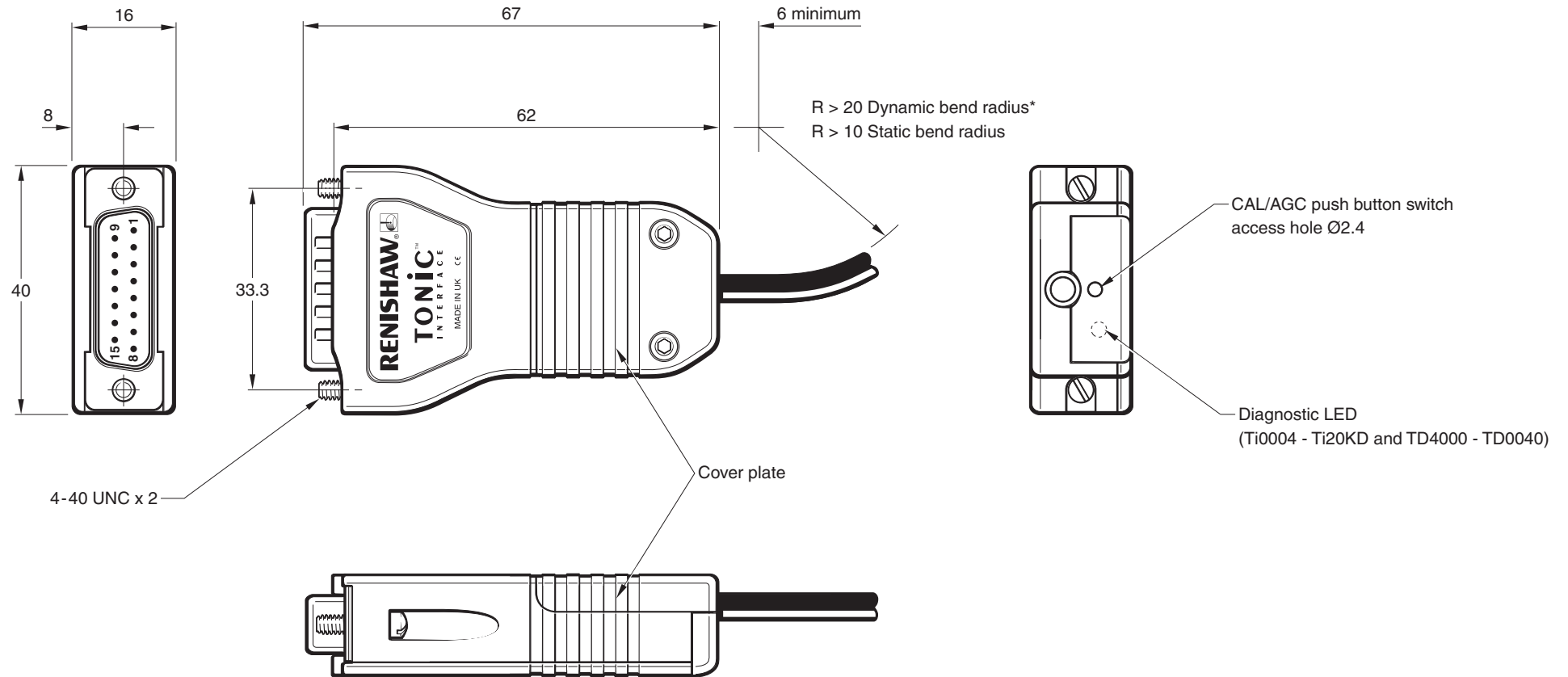
* Extent of mounting faces.

† UHV cable 3.0 approx.

‡ Dynamic bend radius not applicable for UHV cables.

Ti interface drawing

Dimensions and tolerances in mm



CAL button operation

Push and release (< 3 seconds) - Calibration (CAL) routine enable/disable

Push and release (> 3 seconds) - Automatic Gain Control (AGC) enable/disable

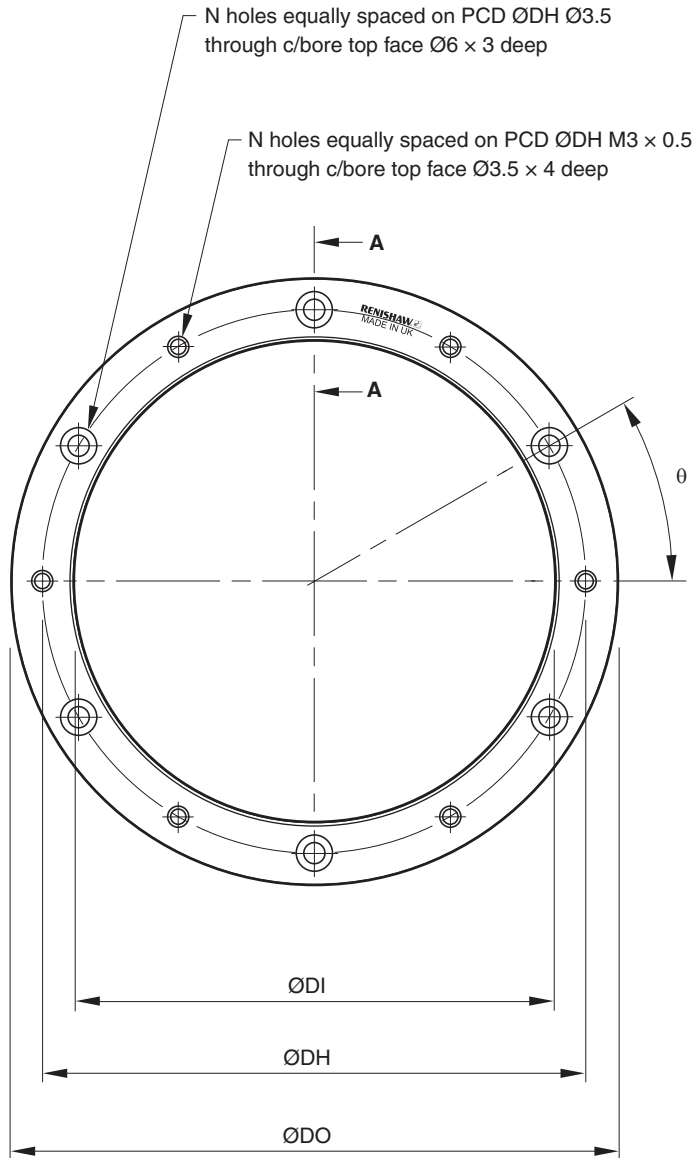
Push and hold during power 'Off/On' cycle - Restore factory defaults

Refer to readhead LED functionality chart for CAL LED indications

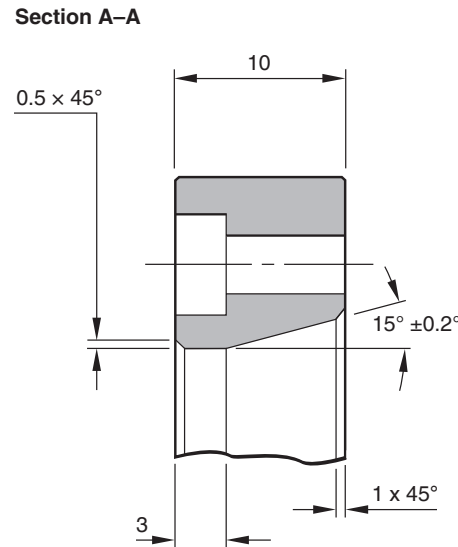
* Dynamic bend radius not applicable for UHV cables.

RESM20 installation drawing ('A' section)

Dimensions and tolerances in mm



NOTE: θ is the angle between one tapped hole and the adjacent clearance hole. The angle between two clearance holes is 2θ.

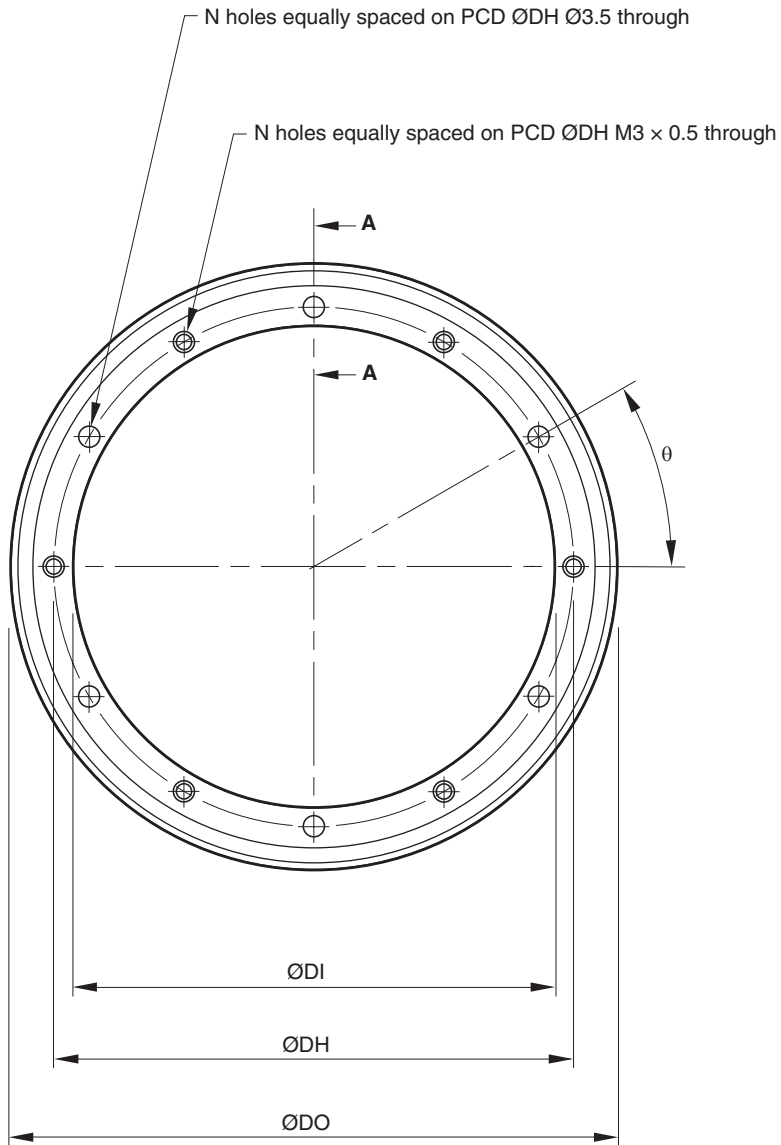


Nominal external diameter (mm)	Line count	DO (mm)	DI (mm)	Mounting holes			Readhead model
				DH (mm)	N	θ	
52	8 192	52.20	30.04	40	6	30°	T2021
		52.10	30.00				
57	9 000	57.35	37.04	47	6	30°	T2011
		57.25	37.00				
75	11 840	75.40 75.30	55.04 55.00	65	6	30°	T2011
100	15 744	100.30 100.20	80.04 80.00	90	6	30°	
103	16 200	103.20 103.00	80.04 80.00	90	6	30°	T2011
104	16 384	104.40 104.20	80.04 80.00	90	6	30°	
115	18 000	114.70 114.50	95.04 95.00	105	6	30°	T2001
150	23 600	150.40 150.20	130.04 130.00	140	9	20°	
200	31 488	200.40 200.20	180.04 180.00	190	12	15°	T2001
206	32 400	206.50 206.10	186.05 186.00	196	12	15°	
209	32 768	208.80 208.40	186.05 186.00	196	12	15°	T2001
229	36 000	229.40 229.00	209.05 209.00	219	12	15°	
255	40 000	254.80 254.40	235.06 235.00	245	12	15°	T2001
300	47 200	300.40 300.20	280.06 280.00	290	16	11.25°	
350	55 040	350.40 350.20	330.06 330.00	340	16	11.25°	T2001
413	64 800	412.70 412.30	392.08 392.00	402	18	10°	
417	65 536	417.40 417.00	380.10 380.00	390	18	10°	T2001
489	76 800	489.12 488.72	451.10 450.90	462	20	18°*	
550	86 400	550.20	510.10	520	20	9°	T2001
		549.80	510.00				

* There are no tapped holes on the 489 mm ring.

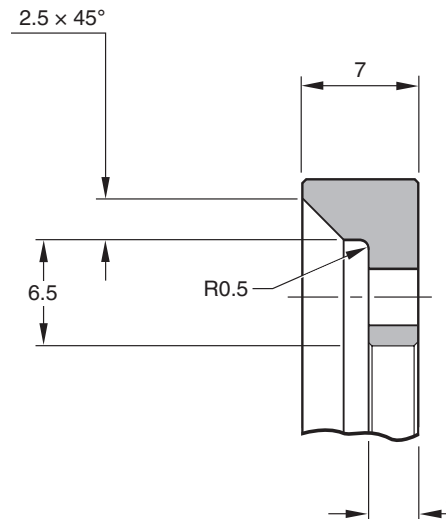
RESM20 installation drawing ('B' section)

Dimensions and tolerances in mm



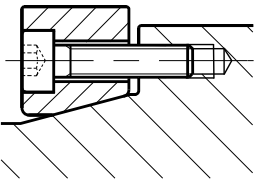
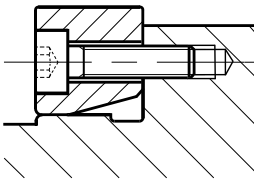
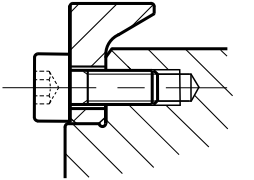
Nominal external diameter (mm)	Line count	DO (mm)	DI (mm)	Mounting holes			Readhead model
				DH (mm)	N	θ	
52	8 192	52.20 52.10	32.04 32.00	38	6	30°	T2021
75	11 840	75.40 75.30	55.04 55.00	61	6	30°	T2011
100	15 744	100.30 100.20	80.04 80.00	86	6	30°	
115	18 000	114.70 114.50	95.04 95.00	101	6	30°	
150	23 600	150.40 150.20	130.04 130.00	136	9	20°	T2001
200	31 488	200.40 200.20	180.04 180.00	186	12	15°	

Section A-A



NOTE: θ is the angle between one tapped hole and the adjacent clearance hole.
The angle between two clearance holes is 2θ .

Select a RESM20 ring mounting option

	Taper Mount	Interference fit
'A' Section		
'B' Section	Not applicable	
Notes	<p>Recommended for all installations</p> <ul style="list-style-type: none"> ▶ Enables simplest adjustment. ▶ Offers highest accuracy. ▶ Enables eccentricity to be compensated. ▶ Offers excellent mechanical stability against thermal cycling, shock and vibration. ▶ Minimises cost of substrate preparation. 	<p>Alternative installation</p> <ul style="list-style-type: none"> ▶ Will not correct eccentricity of the supporting shaft.

Equipment for taper mounting

Suitable for:

- ▶ RESM20 'A' section rings

Required parts:

- ▶ Appropriate RESM20 'A' section ring ('RESM20 installation drawing ('A' section)', page 5)
- ▶ Appropriate number of screws for ring size ('RESM20 installation drawing ('A' section)', page 5)
NOTE: Recommended screw type M3 × 0.5: ISO 4762/DIN 912 grade 10.9 minimum/ANSI B18.3.1M.
- ▶ Dial Test Indicator (DTI)
- ▶ Appropriate cleaning solvents ('Storage and handling', page 2)
- ▶ Hex key
- ▶ Green spacer (supplied with TONiC readhead)

Optional parts:

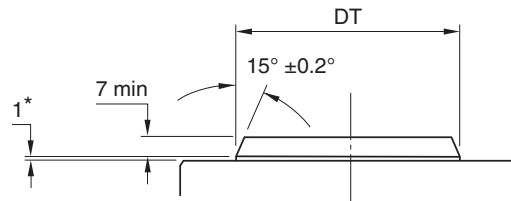
- ▶ Renishaw scale wipes (A-9523-4040)
- ▶ Lint-free cloth

Taper mount method

Step 1 Mounting shaft specifications

Recommended taper roundness:

Diameter (mm)	Roundness value (mm TIR)
≤ 115	0.025
150 to 225	0.050
≥ 300	0.075



* Allow 2 mm for 417 mm, 489 mm and 550 mm rings only.

Recommended taper roundness when using two heads and DSi:

Diameter (mm)	Roundness value (mm TIR)
≤ 115	0.0125
150 to 225	0.025
≥ 300	0.0375

Recommended taper diameter (DT):

DO (mm)	DT (mm)	DO (mm)	DT (mm)	DO (mm)	DT (mm)
52	33.85 33.65	150	133.85 133.65	350	333.85 333.65
57	40.85 40.65	200	183.85 183.65	413	395.85 395.65
75	58.85 58.65	206	189.85 189.65	417	383.85 383.65
100	83.85 83.65	209	189.85 189.65	489	454.85 454.65
103	83.85 83.65	229	212.85 212.65	550	513.85 513.65
104	83.85 83.65	255	238.85 238.65		
115	98.85 98.65	300	283.85 283.65		

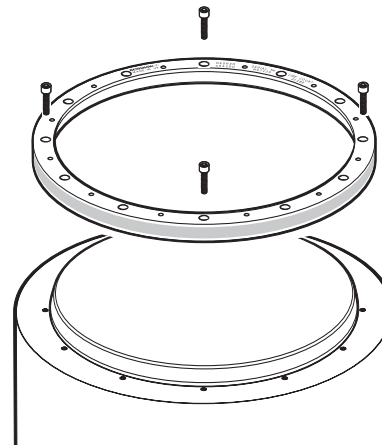
DO = Nominal external diameter.

Recommended surface finish ≤ Ra 1.2.

NOTE: It is recommended that the mounting surface is a turned, rather than ground finish.

TONiC RESM20 angle encoder system installation guide

Step 2

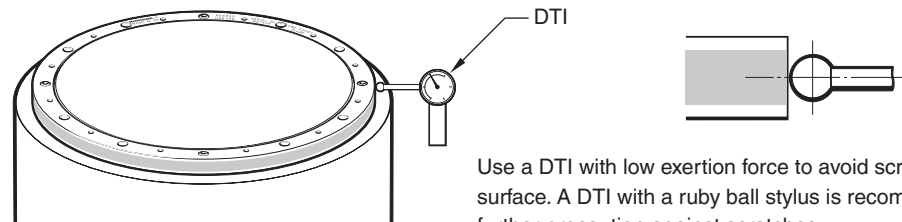


- ▶ Remove the protective film from the surface of the the RESM20 ring.
- ▶ Clean shaft taper and internal taper of RESM20 as recommended in 'Storage and handling', page 2
- ▶ Insert the first screws:
 - For RESM20 rings with 6, 9 or 18 mounting holes, use 3 equally spaced M3 screws.
 - For RESM20 rings with 12, 16 or 20 mounting holes, use 4 equally spaced M3 screws.

NOTE: Do not lubricate screws.

- ▶ Insert the screws so that the RESM20 is loosely connected to the shaft, then roughly align the ring by eye and touch.
- ▶ Lightly tighten the screws. Use a Dial Test Indicator (DTI) to check the radial displacement at the screw locations.

NOTE: Disregard the radial displacement between the screw locations.



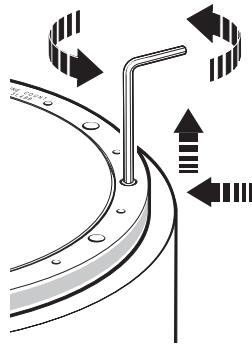
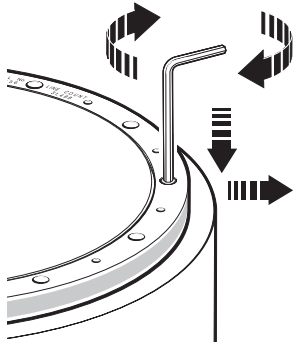
Use a DTI with low exertion force to avoid scratching the scale surface. A DTI with a ruby ball stylus is recommended as a further precaution against scratches.

Taper mount method (continued)

- ▶ Adjust the screws to reduce the range of radial displacement. When adjusting, identify the screw location with the lowest radial displacement and tighten that screw, aiming for the average of the highest and lowest indicator readings.

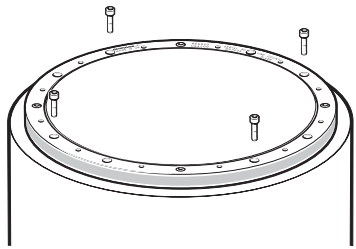
- ▶ Repeat this process until the DTI readings are within $\pm 5 \mu\text{m}$ at the screw locations.

NOTE: It may be necessary to loosen screws whilst tightening other screws.



NOTE: At this stage, the screws should only be lightly tightened (less than 0.5 Nm) to allow further final adjustment.

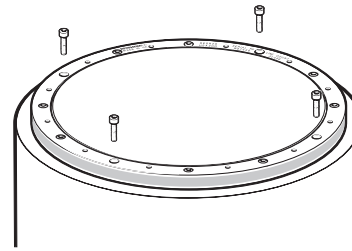
Step 3



- ▶ Insert the next screws:
 - For RESM20 rings with 6, 9 or 12 mounting holes, insert all the remaining M3 screws.
 - For RESM20 rings with 16 mounting holes, insert 4 equally spaced M3 screws.
 - For RESM20 rings with 18 mounting holes, insert 6 equally spaced M3 screws.
 - For RESM20 rings with 20 mounting holes, insert 8 equally spaced M3 screws (in four groups of two) between existing screws.
- ▶ As described in Step 2, adjust all the screws inserted thus far, so that the radial displacement at each screw location is within $\pm 5 \mu\text{m}$.
- ▶ Again, at this stage, the screws should only be lightly tightened (less than 0.5 Nm).

NOTE: You may notice that the torque required to achieve the radial displacement tolerance will be slightly higher during step 3 than during step 2. This is normal.

Step 4



- ▶ Insert screws into the remaining mounting holes.

Step 5

Diameter (mm)	Recommended torque range (Nm)
≤ 115	1.5 - 2.1
150 to 255	0.8 - 1.1
300 to 413	0.5 - 0.7
≥ 417	1.2 - 1.7

- ▶ Rotate the RESM20 ring, measuring the radial displacement at all of the screw locations.
- ▶ Tighten the screw with the lowest radial displacement so that it matches the average radial displacement, whilst ensuring the maximum torque specified in the table is not exceeded.
- ▶ Again, rotate the RESM20 ring and re-check the radial displacement at all of the screw locations, tightening the screw with the lowest radial displacement so that it matches the average.
- ▶ Repeat this process until the radial displacement at all of the screw locations is within $\pm 3 \mu\text{m}$ and that all screw torques are within the specified range.
- ▶ Excessive tightening of screws can have a small effect on accuracy. Please contact your local representative for more details.
- ▶ Clean ring using Renishaw scale cleaning wipes or a clean, dry, lint-free cloth.

Equipment for interference fit mounting

Suitable for:

- ▶ RESM20 'A' section rings
- ▶ RESM20 'B' section rings

Required parts:

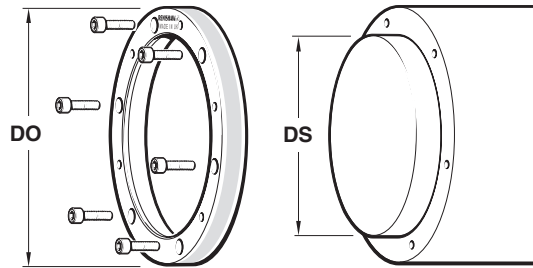
- ▶ Appropriate RESM20 'A' or 'B' section ring ('RESM20 installation drawing ('A' section)', page 5) or ('RESM20 installation drawing ('B' section)', page 6)
- ▶ Appropriate number of screws for ring size ('RESM20 installation drawing ('A' section)', page 5) or ('RESM20 installation drawing ('B' section)', page 6)
NOTE: Recommended screw type M3 × 0.5: ISO 4762/DIN 912 grade 10.9 minimum/ANSI B18.3.1M.
- ▶ Appropriate cleaning solvents ('Storage and handling', page 2)
- ▶ Hex key
- ▶ Green spacer (supplied with TONiC readhead)

Optional parts:

- ▶ Renishaw scale wipes (A-9523-4040)
- ▶ Lint-free cloth

Interference fit method

- ▶ Remove the protective film from the surface of the RESM20 ring.
- ▶ Clean the mounting faces for the shaft and the RESM20 as recommended in 'Storage and handling', page 2.
- ▶ Place RESM20 ring on shaft.



- ▶ Insert required number of screws into all mounting holes.
- ▶ Tighten all screws.
- ▶ Clean ring using Renishaw scale cleaning wipes or a clean, dry, lint-free cloth.

NOTES:

- ▶ Ensure that all screws are tightened to 1.6 Nm.
- ▶ The recommended thread engagement is 6 mm.
- ▶ 417, 489 and 550 mm rings should be taper mounted only.

DO (mm)	DS (mm)
52*	30.033 30.017
57	37.033 37.017
75	55.039 55.020
100	80.045 80.023
103	80.045 80.023
104	80.045 80.023
115	95.045 95.023
150	130.052 130.027
200	180.052 180.027
206	186.060 186.031
209	186.060 186.031
229	209.060 209.031
255	235.060 235.031
300	280.066 280.034
350	330.073 330.037
413	392.073 392.037

DO = Nominal external diameter.

DS = Recommended shaft diameter to enable interference fit.

* 52 mm 'B' section ring DS (mm) = $\frac{32.033}{32.017}$

This section is a quick-start guide to installing a TONiC system.
More detailed information on installing the TONiC system is contained on pages 14 to 18 of this installation guide.

INSTALLATION

Ensure RESM20 ring, readhead optical window and mounting faces are clean and free from obstructions.



Plug the readhead cable into the Ti/TD interface under the cover plate and reassemble interface.
Connect to receiving electronics and power-up.



Ensure 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).

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), ensuring the readhead does not pass a reference mark, until the CAL LED starts double flashing.



No reference mark

If a reference mark is not being used, the calibration routine should now be exited by pressing and releasing the CAL button.
The CAL LED will stop flashing.
(Incremental CAL values are automatically stored)

Reference mark

Move the readhead back and forth over the reference mark until the CAL LED stops flashing and remains 'off'.
(Incremental and reference mark CAL values are automatically stored)



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.

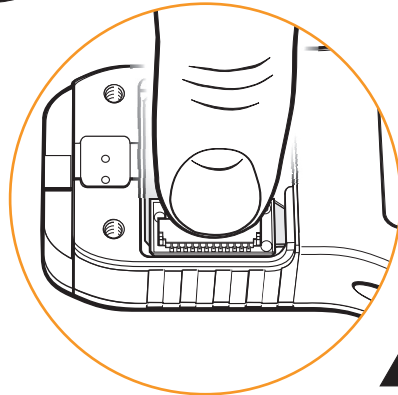
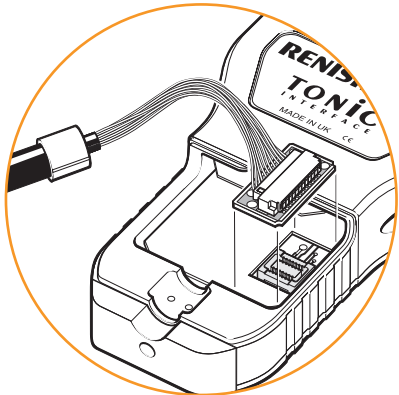
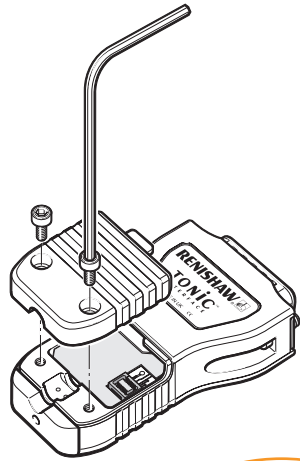
NOTE: If calibration fails, restore factory defaults by pressing and holding the CAL button whilst switching on ('Restoring factory defaults', page 18). Then repeat the installation and calibration routine.

System connection

Approved ESD precautions must be followed at all times during readhead and interface electrical connections. The readhead is connected to the Ti/TD interface via a small, rugged connector to allow for easy feed-through during installation.

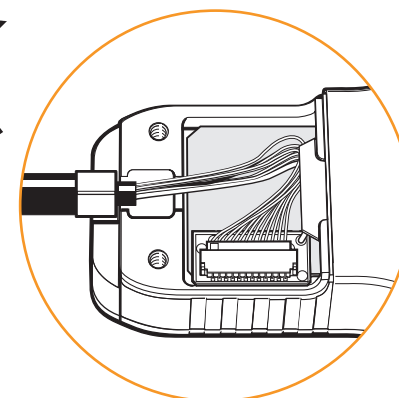
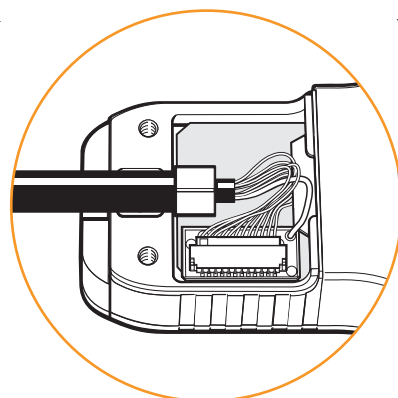
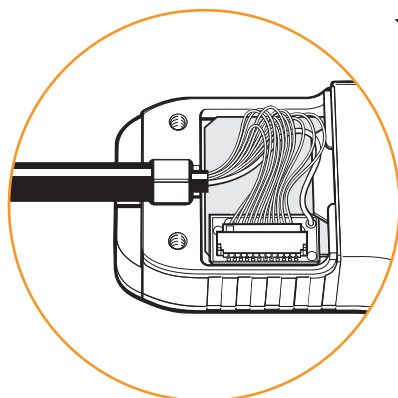
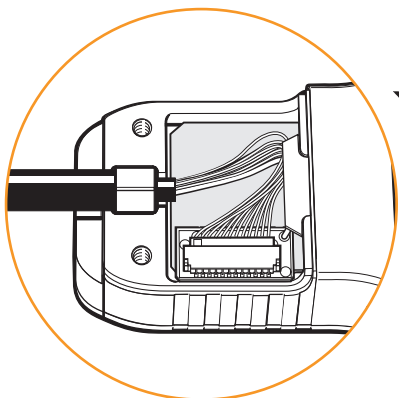
Connecting the readhead

- ▶ Remove the cover plate as shown (2 x M2.5 hex head screws).
- ▶ Taking care not to touch the pins, plug the connector into the socket in the interface, ensuring correct orientation as shown.



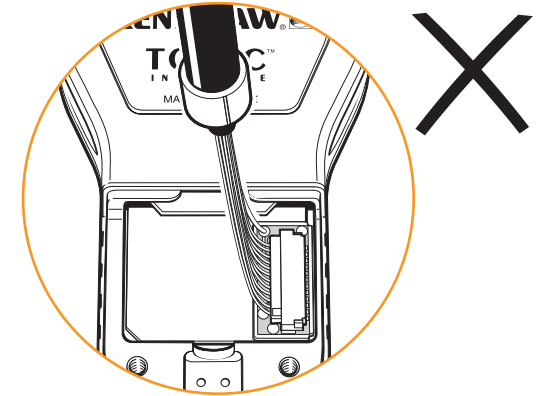
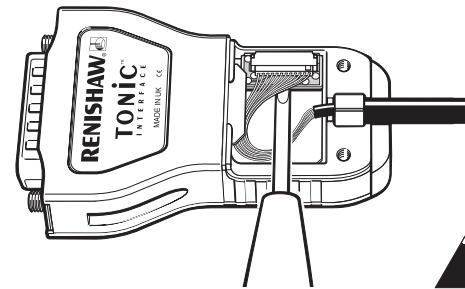
- ▶ Refit the cover plate ensuring the cable ferrule is located in the recess on the inside and no wires are trapped under the cover plate.

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



Disconnecting the readhead

- ▶ Remove the cover plate on the interface (2 x M2.5 hex head screws).
- ▶ Gently lever the connector PCB (on the end of the cable) out of the socket. Do not pull the cable to remove the connector.
- ▶ Place the connector in an anti-static bag.
- ▶ Refit the cover plate.



T20x1 readhead and RESM20 compatibility

T20x1 readhead models are compatible with a range of RESM20 ring sizes. The optical configuration is optimised for the following conditions:

Readhead model	RESM20 diameter range (mm)
T2001	> 136
T2011	60 to 136
T2021	< 60

Published performance specifications and operating tolerances only apply where the correct readhead model conforms to the RESM20 size range. Ensure readhead part number and RESM20 size range compatibility at the time of ordering and installation.

Reference mark position



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 adjustment are required.

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.

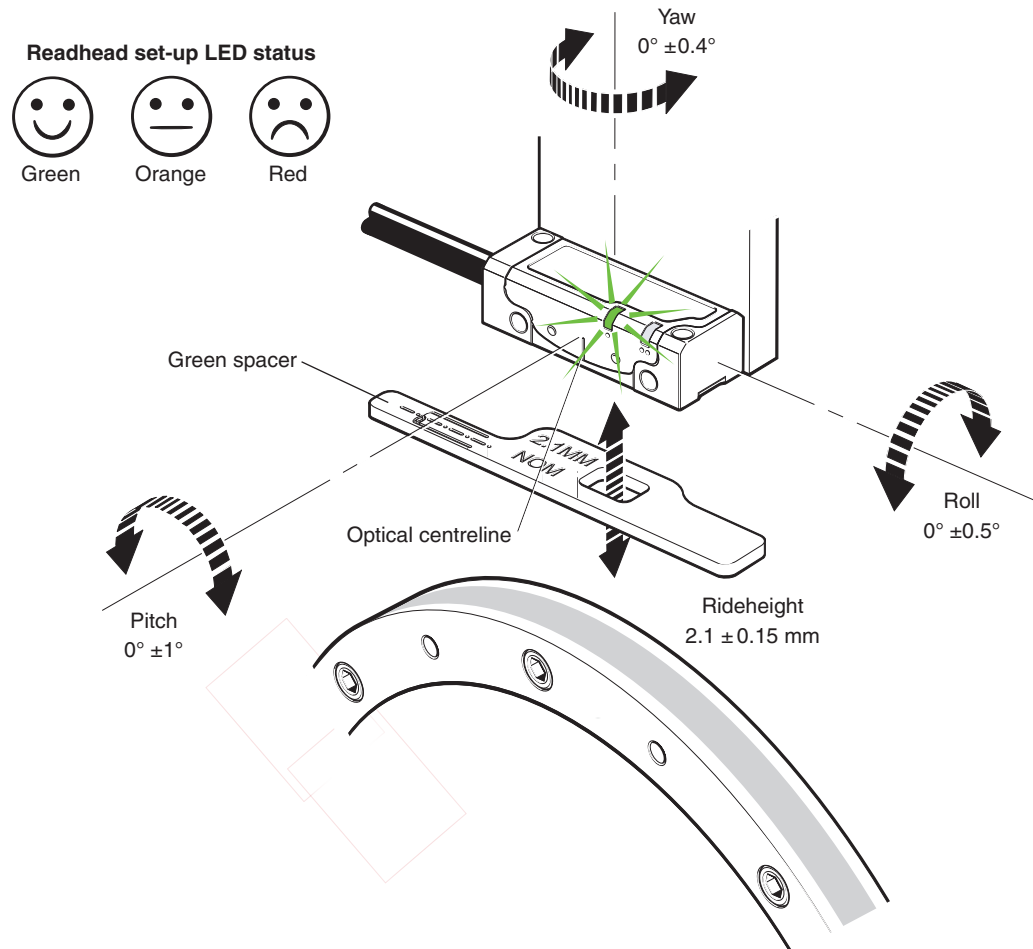
Readhead set-up

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

NOTE: When cleaning 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) for a complete rotation. If a digital Ti/TD interface is used, aim for a Blue LED on the interface.

NOTE: The readhead should be installed and set-up with the AGC switched off (CAL LED off). When re-installing, factory defaults should be restored ('Restoring factory defaults', page 18).



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)*	Normal phasing
		Orange (flash)	Acceptable phasing
		Red (flash)	Poor phasing; clean scale 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

* Flash will effectively be invisible when incremental signal is > 70% when passing reference mark.

Ti0004 to Ti20KD and TD4000 to TD0040 interface LED diagnostics

Signal	Indication	Status	Alarm output†
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	Over speed; 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)

† Alarm output will take the form of 3-state or line driven E- signal depending on interface configuration.

Also, some configurations do not output overspeed alarm.

- Momentary status only, while fault condition remains.
- Alarm may result in axis position error, re-datum to continue.

See the product nomenclature for interface configuration in the *TONiC encoder system Data sheet* (Renishaw part no. L-9517-9337). This can be downloaded from our website at www.renishaw.com/tonicdownloads and is also available from your local representative.

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.

Before system calibration:

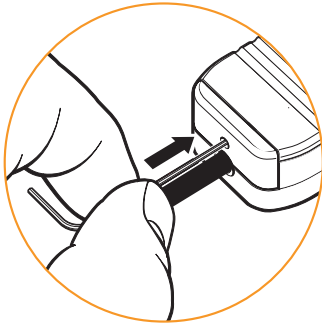
- ▶ Clean the scale and readhead optical window (contamination around the reference mark may result in reference mark dephasing).
- ▶ If reinstalling, restore factory defaults ('Restoring factory defaults', page 18).
- ▶ Ensure signal strength has been optimised over the full axis of rotation; the readhead LED will be Green.

NOTE: CAL routine maximum speed < 100 mm/s (all Ti/TD interface models).
TD interface can be calibrated in either resolution.

Step 1 – Incremental signal calibration

- ▶ Ensure Automatic Gain Control is switched off (CAL LED on readhead is not illuminated) before beginning calibration ('Switching Automatic Gain Control (AGC) on or off', page 18).
- ▶ 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.



- ▶ The CAL LED will now periodically single-flash to indicate that it is in incremental signal calibration mode.
- ▶ 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.
- ▶ The system is now ready for reference mark phasing.
- ▶ For systems without reference mark, go to 'Calibration routine - manual exit'
- ▶ 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. After ensuring failure is not due to overspeed (> 100 mm/s or exceeding the readhead maximum speed), exit the calibration routine, restore factory defaults ('Restoring factory defaults', page 18) and check the readhead installation and system cleanliness before repeating the calibration routine.

Step 2 – Reference mark phasing

- ▶ Move the readhead back and forth over the selected reference mark until the CAL LED stops flashing and remains off. The reference mark is now phased.
- ▶ The system automatically exits the CAL routine and is ready for operation.
- ▶ 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. Readheads can either output all reference marks or only output a reference mark where a reference selector magnet is fitted.

Calibration routine – manual exit

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

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 re-installing the system, or in the case of continued calibration failure, factory defaults should be restored.

To restore factory defaults:

- ▶ Switch system off.
- ▶ 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.
- ▶ Release CAL button.
- ▶ Check the [‘Readhead mounting and alignment’, page 16](#) and re-calibrate the system ([‘System calibration’, page 17](#)).

NOTE: System must be re-calibrated after restoring factory defaults.

Switching Automatic Gain Control (AGC) on or off

AGC can be switched on or off via the interface.

- ▶ Press and hold the CAL button on the interface for > 3 seconds to switch AGC on or off. The CAL LED on the readhead will be illuminated when AGC is active.

NOTE: The system must be calibrated before switching AGC on.

Output signals

Interface output (analogue) Ti0000 only				Interface Ti0000
Function	Output type		Signal	Pin
Power	-		5 V Power	4
			5 V Sense	5
			0 V Power	12
			0 V Sense	13
Incremental signals	Analogue	Cosine	V_1 +	9
			V_1 -	1
	Sine	V_2 +	10	
		V_2 -	2	
Reference mark	Analogue		V_0 +	3
			V_0 -	11
Limits	Open collector		V_p	7
			V_q	8
Set-up	-		V_x	6
Calibrate	-		CAL	14
Shield	-		Inner shield	Not connected
	-		Outer shield	Case

Readhead output

Function	Output type		Signal	Colour
Power	-		5 V Power	Brown
			0 V Power	White
Incremental signals	Analogue	Cosine	V_1 +	Red
			V_1 -	Blue
	Sine	V_2 +	Yellow	
		V_2 -	Green	
Reference mark	Analogue		V_0 +	Violet
			V_0 -	Grey
Limits	Open collector		V_p	Pink
			V_q	Black
Set-up	-		V_x	Clear
Calibrate	-		CAL	Orange
Shield	-		Inner shield*	Green/Yellow
	-		Outer shield	Outer screen

* No inner shield on UHV cables.

Interface output (digital) Ti0004 to Ti20KD and TD4000 to TD0040				Interface	
				Ti0004 - Ti20KD	TD4000 - TD0040
Function	Output type	Signal	Pin	Pin	
Power	-	5 V	7, 8	7, 8	
		0 V	2, 9	2, 9	
Incremental	RS422A digital	A	+	14	
			-	6	
		B	+	13	
			-	5	
Reference mark	RS422A digital	Z	+	12	
			-	4	
Limits	Open collector	P^\dagger	11	-	
		Q	10	-	
Set-up	RS422A digital	X	1	1	
Alarm [‡]	-	E	+	-	
			-	3	
Resolution switching [‡]	-	-	-	10	
Shield	-		Inner shield	-	
	-		Outer shield	Case	

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

[‡] The alarm signal can be output as a line driver signal or 3-state. Please select the preferred option at time of ordering.

[‡] On TD interfaces pin 10 should be connected to 0 V to switch to lower resolution.



Output connector for all interfaces;
15 way 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 (RESM) installation.

Limit switch signal detail is included here for information only.

Please contact your local Renishaw representative if you require limits on your rotary installation.

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
Analogue output	10 (-3dB)										

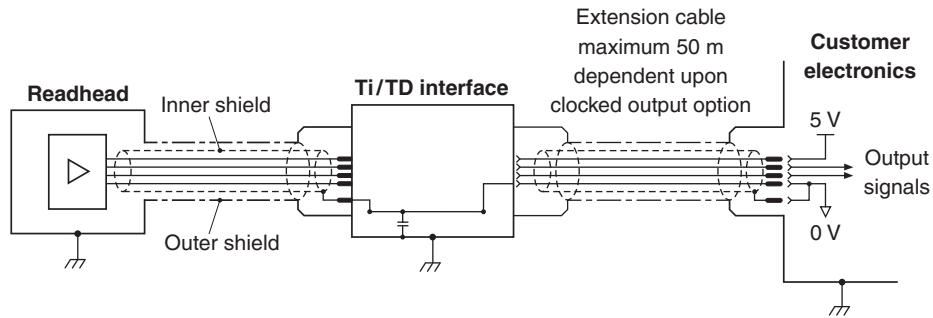
NOTE: TD maximum speeds are resolution dependent as defined above.

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

$$\text{Angular speed (rev/min)} = \frac{V \times 1000 \times 60}{\pi D} \quad \text{Where } V = \text{maximum linear speed (m/s) and } D = \text{external diameter of RESM20 ring (mm)}$$

Electrical connections

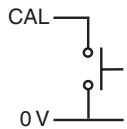
Grounding and shielding



IMPORTANT: The outer shield should be connected to the machine earth (Field Ground). The inner shield should be connected to 0 V at 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.

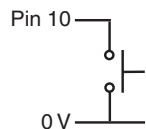
NOTE: Maximum cable length between readhead and Ti/TD interface is 10 m

Remote CAL operation (Analogue versions only)



All Ti/TD interfaces include a push button switch to enable CAL/AGC features. However, remote operation of the CAL /AGC is possible via pin 14 of analogue Ti0000 interfaces. For applications where no interface is used, remote operation of CAL/AGC is essential.

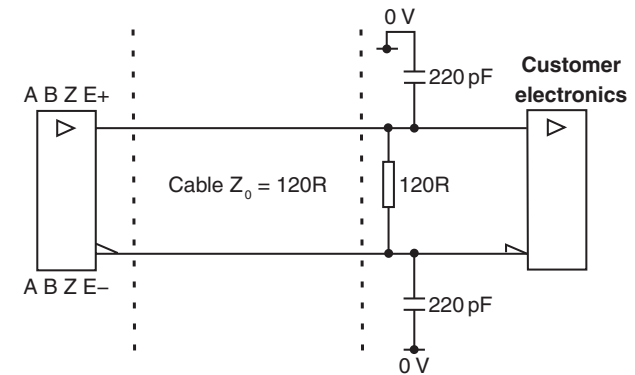
TD interface resolution switching



Connect pin 10 to 0 V to switch to lower resolution.

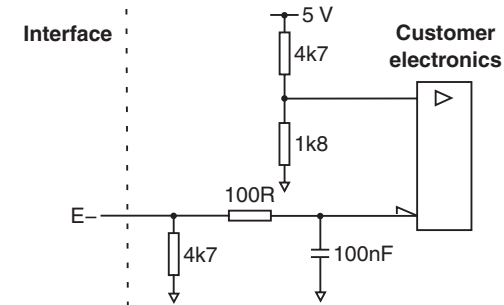
Recommended signal termination

Digital outputs

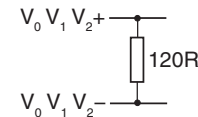


Standard RS422A line receiver circuitry
Capacitors recommended for improved noise immunity

Single ended alarm signal termination (Ti options A, B, C, D)



Analogue outputs

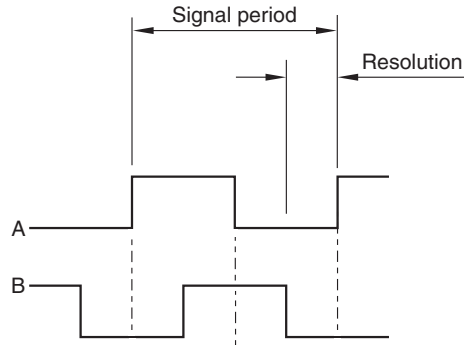


Output specifications

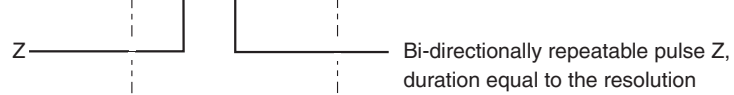
Digital output signals

Form – Square wave differential line driver to EIA RS422A (except limits P and Q)

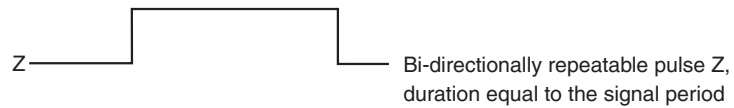
Incremental† 2 channels A and B in quadrature (90° phase shifted)



Reference†



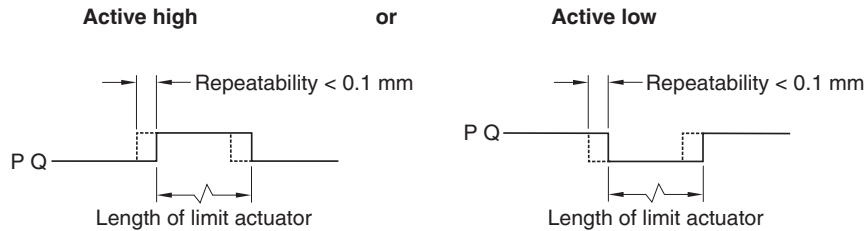
Wide reference†



NOTE: Select 'standard' or 'wide' reference at time of ordering, to match the requirements of the controller being used. Wide reference mark not available on Ti0004 interfaces.

Limits Open collector output, asynchronous pulse

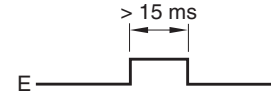
Digital Ti interfaces only



NOTE: No limits on TD interfaces. P limit becomes E+ for options E, F, G, H.

Alarm† Asynchronous pulse

Line driven



Alarm asserted when:

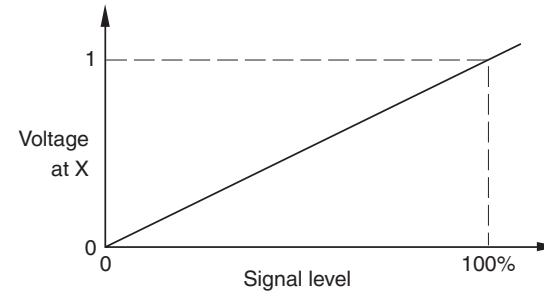
- Signal amplitude < 20% or > 135%
- Readhead speed too high for reliable operation

E– output only for Ti options A, B, C, D

or 3-state alarm

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

Set-up*



Set-up signal voltage proportional to incremental signal amplitude

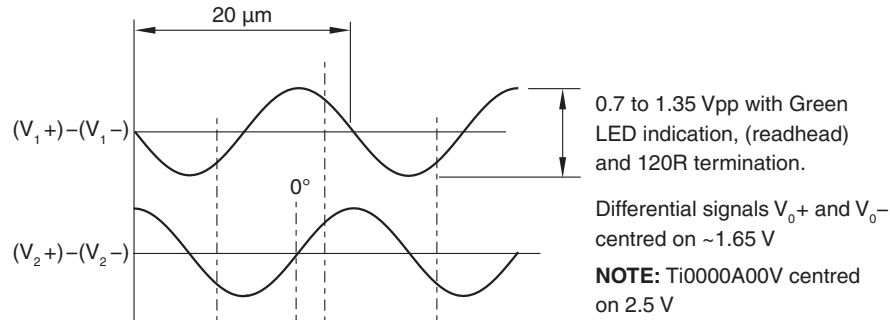
* Set-up signals as shown are not present during calibration routine.

† Inverse signals not shown for clarity

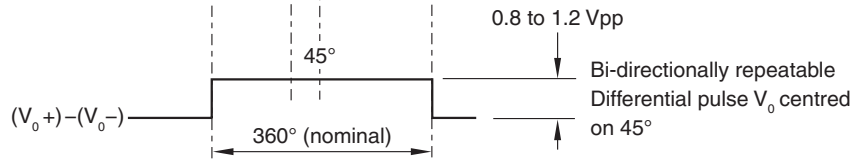
Output specifications (continued)

Analogue output signals

Incremental 2 channels V_1 and V_2 differential sinusoids in quadrature centred on 1.65 V (90° phase shifted)



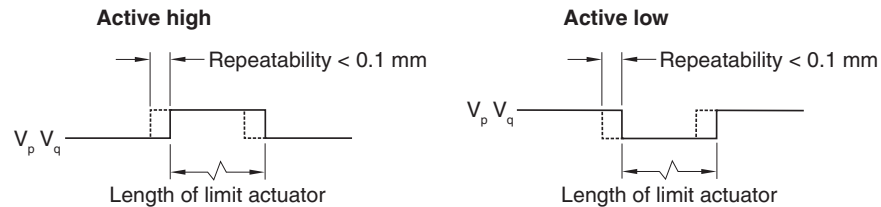
Reference



Limits Open collector output, asynchronous pulse

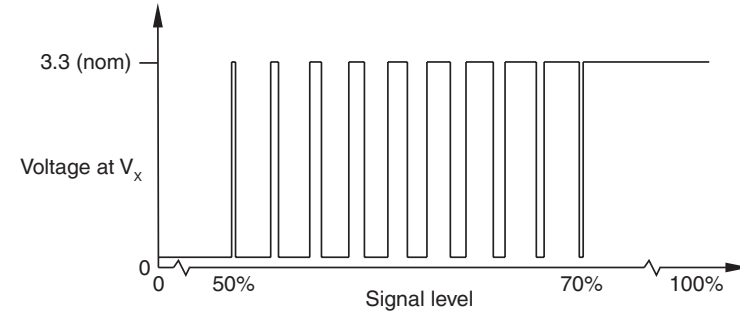
Ti0000 interfaces only

Readhead only



NOTE: Ti0000 interface contains a transistor to invert the readhead's 'active low' signal to give an 'active high' output.

Set-up*




Between 50% and 70% signal level, V_x is a duty cycle.

Time spent at 3.3 V increases with incremental signal level.

At > 70% signal level V_x is nominal 3.3 V.

* Set-up signals as shown are not present during calibration routine.

General specifications

Power supply		5 V ±10%	Readhead only < 100 mA T20x1 with Ti0000 < 100 mA T20x1 with Ti0004 – Ti20KD or TD4000 – TD0040 < 200 mA NOTE: Current consumption figures refer to unterminated systems. For digital outputs a further 25 mA per channel pair (eg A+, A-) will be drawn when terminated with 120R. For analogue outputs a further 20 mA in total will be drawn when terminated with 120R. 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	
Temperature	(System)	Storage	-20 °C to +70 °C	
		Operating	0 °C to +70 °C	
	(UHV readhead)	Bakeout	+120 °C	
Humidity	(System)		95% relative humidity (non-condensing) to EN 60068-2-78	
Sealing	(Readhead)		IP40	
	(Interface)		IP20	
Acceleration	(Readhead)	Operating	500 m/s ² , 3 axes	
Shock	(System)	Operating	500 m/s ² , 11 ms, ½ sine, 3 axes	
Vibration	(System)	Operating	100 m/s ² , 55 Hz to 2000 Hz, 3 axes	
Mass	(Readhead)		10 g	
	(Interface)		100 g	
	(Cable)		26 g/m	
	(UHV 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	Readhead to interface	10 m		
		Interface to controller		
			Clocked output option (MHz)	Maximum cable length (m)
			40 to 50	25
		< 40	50	
		analogue	50	

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.

RESM20 ring specifications

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

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