Data sheet
L-9517-9337-07-H

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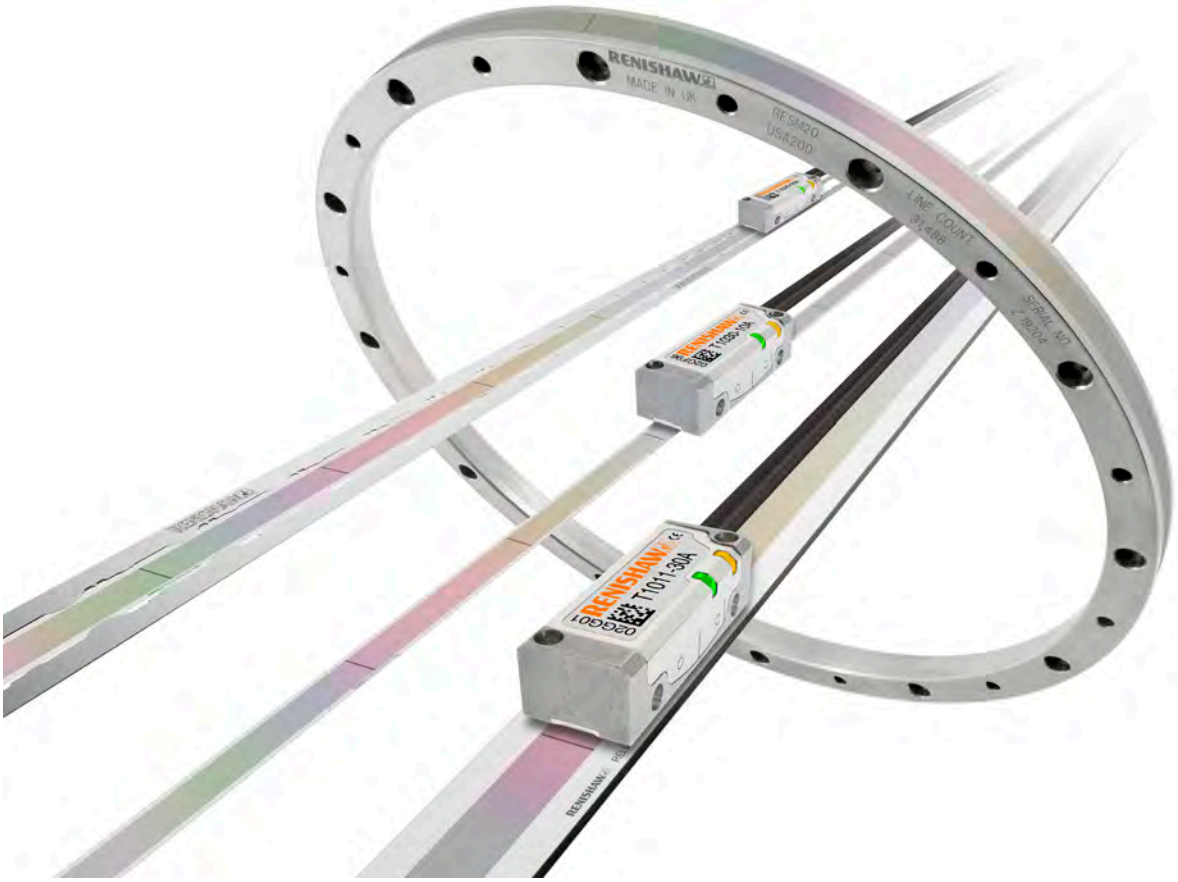
TONiC™ encoder system



Renishaw's TONiC encoder series is designed for highly-dynamic precision motion systems, bringing higher accuracy, speed and greater reliability to a wide variety of demanding industry sectors.

The readhead is compatible with a wide range of linear, partial arc and rotary scales with bi-directional optical *IN-TRAC*™ reference marks.

For ultimate reliability and high dirt immunity, TONiC encoder system readheads incorporate Renishaw's market proven filtering optics, tuned for even lower noise (jitter), further enhanced by dynamic signal processing including Auto Gain Control (AGC) and Auto Offset Control (AOC). The result is ultra-low sub-divisional error (SDE) giving smoother velocity control for improved scanning performance and increased positional stability.

TONiC encoder system readheads also feature a detachable analogue or digital interface in the form of a robust, convenient connector that can be located up to 10 m from the readhead. The interface offers digital interpolation to 1 nm resolution, with clocked outputs for optimised speed performance at all resolutions for industry-standard controllers.

- Compact readhead (35 mm × 13.5 mm × 10 mm)
- Compatible with a wide range of linear, partial arc and rotary scales with customer-selectable *IN-TRAC* auto-phase optical reference mark (datum)
- Optimised filtering optics for even lower noise (jitter)
- Dynamic signal processing provides ultra-low SDE of typically ±30 nm
- Auto Gain Control (AGC) ensures consistent signal strength for long-term reliability
- Integrated set-up LED for ease of installation
- Maximum speed to 10 m/s (3.24 m/s at 0.1 µm resolution)
- Detachable analogue or digital connector with integral interpolation to 1 nm resolution (0.00075 arc seconds)
- Integral dual limits (linear only)
- Operating temperature to 70 °C
- Dual resolution version available

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Compatible scales

Linear scales

	RTLC20-S	RTLC20/*FASTRACK*™	RKLC20-S†
	Self-adhesive mounted stainless steel tape scale	Stainless steel tape scale and self-adhesive mounted carrier	Self-adhesive mounted stainless steel tape scale
			
Form (H × W)	0.4 mm × 8 mm including adhesive	RTLC20 scale: 0.2 mm × 8 mm *FASTRACK* carrier: 0.4 mm × 18 mm including adhesive	0.15 mm × 6 mm including adhesive
Accuracy (includes slope and linearity)	±5 µm/m	±5 µm/m	±5 µm/m
Linearity (Figures achievable with two-point error correction)	±2.5 µm/m	±2.5 µm/m	±2.5 µm/m
Maximum length	10 m* (> 10 m available on request)	10 m (> 10 m available on request)	20 m (> 20 m on available request)
Coefficient of thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C	10.1 ±0.2 µm/m/°C	Matches that of substrate material when scale ends fixed by epoxy mounted end clamps

* For RTLC20-S axis lengths > 2 m, *FASTRACK* with RTLC20 is recommended.

† Suitable for partial arc applications. For more information refer to *RKL scale for partial arc applications* data sheet (Renishaw part no. L-9517-9897).

	RSLM20	RELM20
	Self-adhesive or clip/clamp mounted stainless steel spar scale	Self-adhesive or clip/clamp mounted low-expansion ZeroMet™ spar scale
		
Form (H × W)	1.5 mm × 14.9 mm	1.6 mm × 14.9 mm
Accuracy (includes slope and linearity)	±4 µm (Total accuracy over a complete 5 m length)	±1 µm (Total accuracy up to 1 m)
Linearity (Figures achievable with two-point error correction)	N/A	N/A
Maximum length	5 m	1.5 m
Coefficient of thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C	0.75 ±0.35 µm/m/°C

For more information about the scales refer to the relevant scale data sheet which can be downloaded from **www.renishaw.com/tonicdownloads**

Rotary scales	RESM20	REXM20
	Stainless steel ring	Ultra-high accuracy stainless steel ring
		
Accuracy	±1.9 arc second (Typical installed accuracy for a 550 mm diameter RESM20 ring)*	±1 arc second † (Total installed accuracy for a 417 mm diameter REXM20 ring)
Ring diameters	52 mm to 550 mm	52 mm to 417 mm
Coefficient of thermal expansion (at 20 °C)	15.5 ±0.5 µm/m/°C	15.5 ±0.5 µm/m/°C

*'Typical' installations are a result of graduation and installation errors combining and, to some magnitude, cancelling.

† When using two readheads and an additional DSi interface.

For more information about the scales refer to the relevant scale data sheet which can be downloaded from **www.renishaw.com/tonicdownloads**

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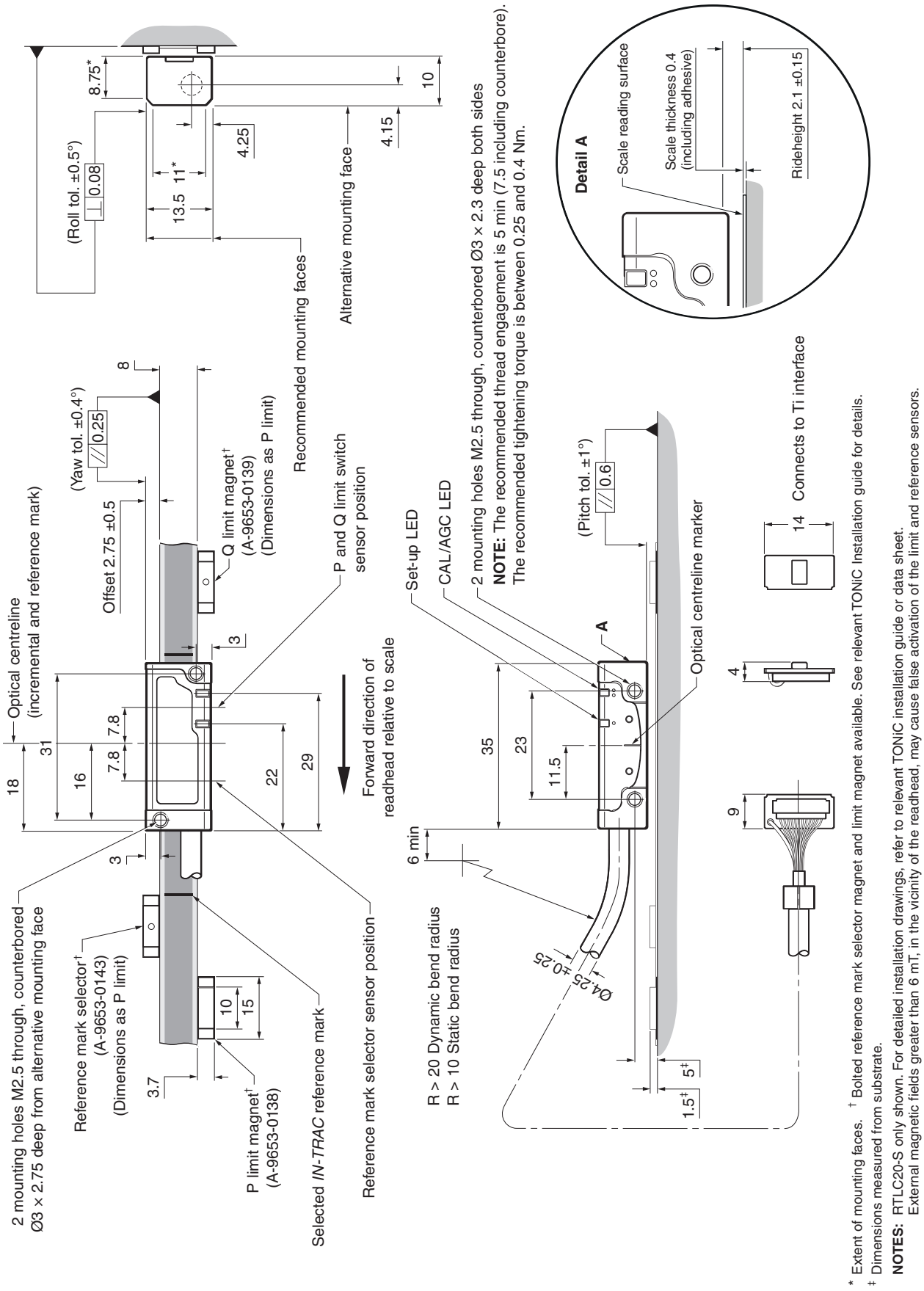
TONiC readhead installation drawing (on RTLC20-S scale)

Dimensions and tolerances in mm



* Extent of mounting faces. † Bolted reference mark selector magnet and limit magnet available. See relevant TONiC Installation guide for details.
‡ Dimensions measured from substrate.

NOTES: RTLC20-S only shown. For detailed installation drawings, refer to relevant TONiC installation guide or data sheet.
External magnetic fields greater than 6 mT, in the vicinity of the readhead, may cause false activation of the limit and reference sensors.

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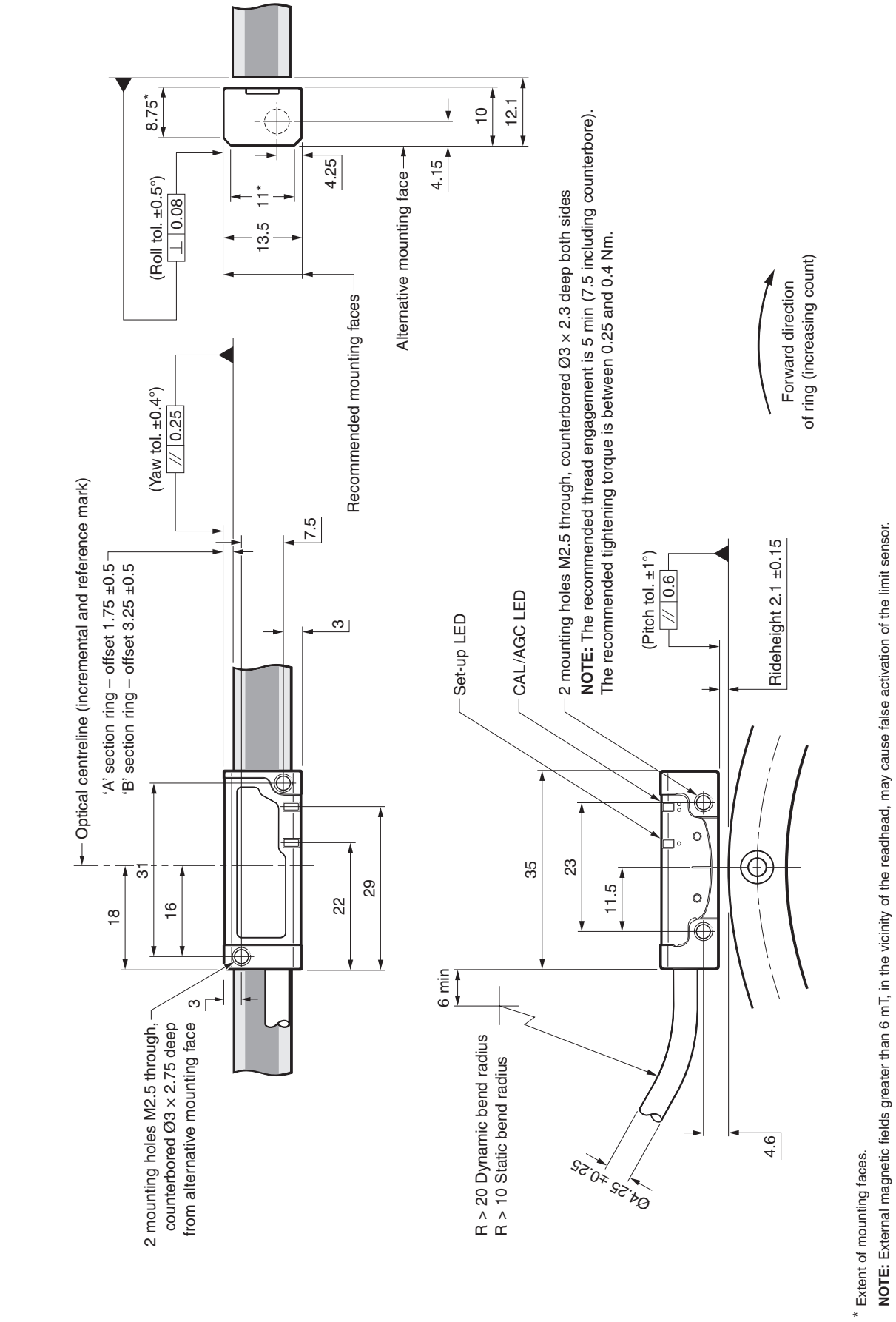
TONiC readhead installation drawing (on RESM20 ring)

Dimensions and tolerances in mm

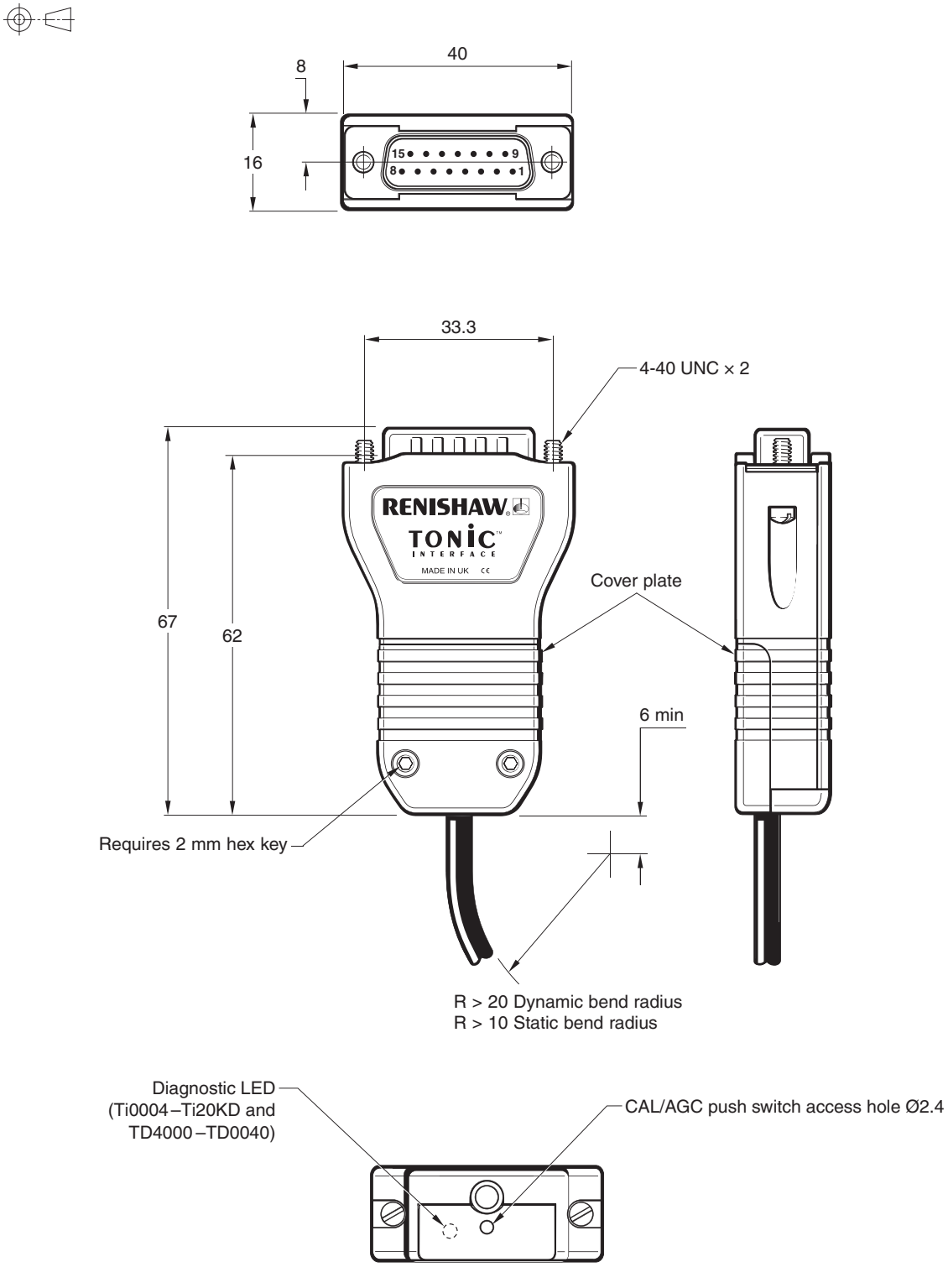


* Extent of mounting faces.

NOTE: External magnetic fields greater than 6 mT, in the vicinity of the readhead, may cause false activation of the limit sensor.

Ti/TD interface dimension drawing

Dimensions and tolerances in mm



TD dual resolution interface

Allows output to be switched between two resolutions. See TD interface part number section for details of available resolutions.

NOTES:

- It is recommended that movement should be halted before switching resolutions.
- No limit outputs.

General specifications

Power supply	5V ±10%	Readhead only < 100 mA
		T1xxx/T2xxx with Ti0000 < 100 mA
		T1xxx/T2xxx 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
Humidity (system)		95% relative humidity (non-condensing) to IEC 60068-2-78
Sealing (readhead)		IP40
(interface)		IP20
Acceleration (readhead)	Operating	500 m/s², 3 axes
Shock (system)	Operating	500 m/s², 11 ms, ½ sine, 3 axes
Vibration (system)	Operating	100 m/s² max @ 55 Hz to 2000 Hz, 3 axes
Mass	Readhead	10 g
	Interface	100 g
	Cable	26 g/m
EMC compliance (system)		IEC 61326-1
Readhead cable		Double-shielded, outside diameter 4.25 ±0.25 mm
		Flex life > 20 × 10^6 cycles at 20 mm bend radius
		UL recognised component
Typical sub-divisional error (SDE)		±30 nm

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	3.240	1.625	0.648	0.324	0.162	0.065	0.032
40	10	10	10	5.40	2.700	1.350	0.540	0.270	0.135	0.054	0.027
25	10	10	8.10	3.24	1.620	0.810	0.324	0.162	0.081	0.032	0.016
20	10	10	6.75	2.70	1.350	0.670	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	0.400	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 interface maximum speeds are resolution dependent as defined above.

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

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

Where V = maximum linear speed (m/s) and
D = external diameter of RESM20 or REXM20 ring (mm).

Output signals

Digital outputs

			Interface	
			Ti0004 – Ti20KD	TD4000 – TD0040
Function	**Signal**		**Pin**	**Pin**
Power	5 V		7, 8	7, 8
	0 V		2, 9	2, 9
Incremental	A	+	14	14
		–	6	6
	B	+	13	13
		–	5	5
Reference mark	Z	+	12	12
		–	4	4
Limits	P†		11	-
	Q✧		10	-
Set-up	X		1	1
Alarm‡	E	+	-	11
		–	3	3
Resolution switching✧	-		-	10
Shield	Inner		-	-
	Outer		Case	Case

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

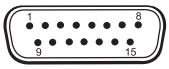
‡ The alarm signal can be output as a line driven signal or 3-state. Please select the preferred option at time of ordering.

✧ On TD interfaces pin 10 should be connected to 0 V to switch to lower resolution.

Analogue outputs

				Readhead T1xxx/2xxx	Interface Ti0000
Function		**Signal**		**Colour**	**Pin**
Power		5 V		Brown	4, 5
		0 V		White	12, 13
Incremental	**Cosine**	V_1	+	Red	9
			–	Blue	1
	Sine	V_2	+	Yellow	10
			–	Green	2
Reference mark		V_0	+	Violet	3
			–	Grey	11
Limits		V_p		Pink	7
		V_q		Black	8
Set-up		V_x		Clear	6
Remote CAL		CAL		Orange	14
Shield		Inner		Green/Yellow*	-
		Outer		Outer screen	Case

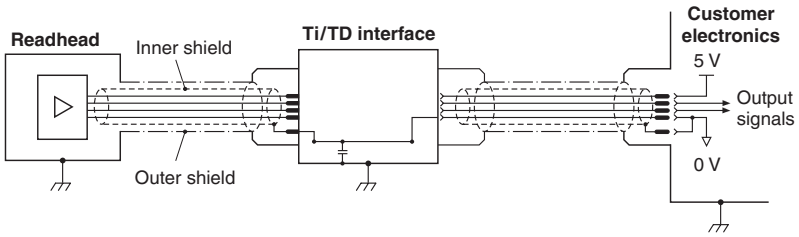
* Inner shield is connected to 0 V inside the Ti/TD interface.



15-pin D-type connector

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.

Maximum cable length

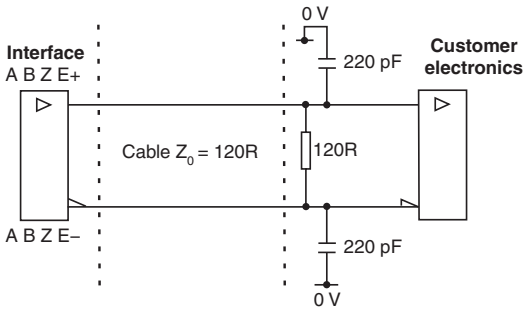
Readhead to interface: 10 m

Interface to controller: Dependent on clocked output option. See table below for details.

Receiver clock frequency (MHz)	Maximum cable length (m)
40 to 50	25
< 40	50
analogue	50

Recommended signal termination

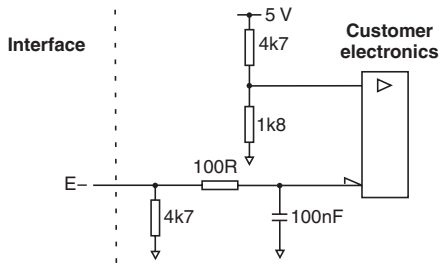
Digital outputs



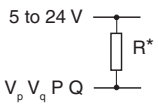
Standard RS422A line receiver circuitry.
Capacitors recommended for improved noise immunity.

Single ended alarm signal termination

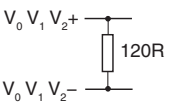
(Ti options A, B, C, D)



Limit outputs (Ti interface only)



Analogue outputs



* Select R so maximum current does not exceed 20 mA.
Alternatively, use a suitable relay or opto-isolator.

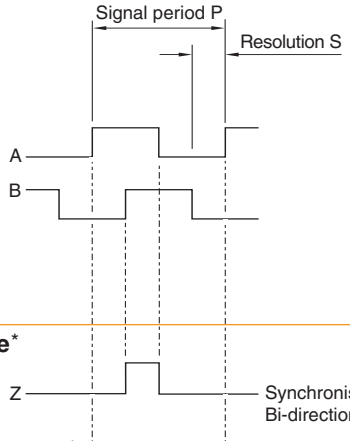
Output specifications

Digital output signals

Interface models Ti0004 - Ti20KD and TD4000 - TD0040

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)



Model	P (µm)	S (µm)
Ti0004	20	5
Ti0020	4	1
Ti0040	2	0.5
Ti0100	0.8	0.2
Ti0200	0.4	0.1
Ti0400	0.2	0.05
Ti1000	0.08	0.02
Ti2000	0.04	0.01
Ti4000	0.02	0.005
Ti10KD	0.008	0.002
Ti20KD	0.004	0.001

Reference*

Z — Synchronised pulse Z, duration as resolution. Bi-directionally repeatable.†

Wide reference*

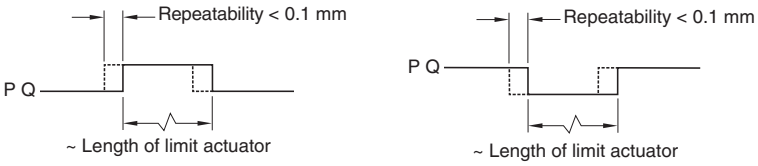
Z — Synchronised pulse Z, duration as signal period. Bi-directionally repeatable.†

NOTES:
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.

Limits Open collector output, asynchronous pulse

Digital Ti interfaces only

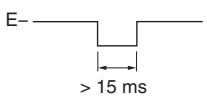
Active high or **Active low**



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

Alarm*

Line driven (Asynchronous pulse)

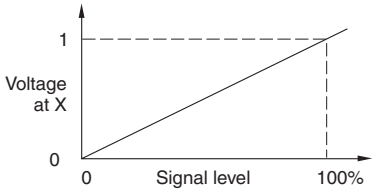


Alarm asserted when:
– Signal amplitude < 20% or > 135%
– Readhead speed too high for reliable operation

Inverse signal E+ only available for Ti options E, F, G and H.

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.

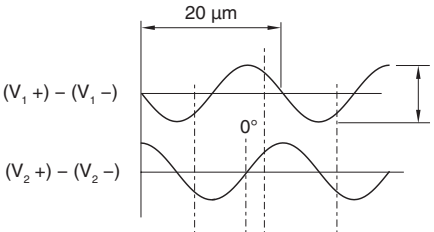
* Inverse signals not shown for clarity.
† Only calibrated reference mark is bi-directionally repeatable.
‡ Set-up signal as shown is not present during calibration routine.

Output specifications (continued)

Analogue output signals

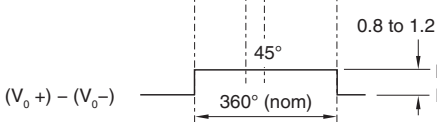
Interface model Ti0000 and direct output from all readheads

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



0.7 to 1.35 Vpp with green LED indication (readhead) and 120R termination.
NOTE: Ti0000A00V centred on 2.5 V.

Reference

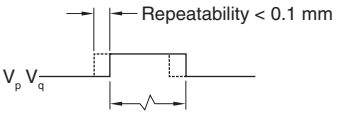


Bi-directionally repeatable.*
Differential pulse V_0 centred on 45°.

Limits Open collector output, asynchronous pulse

Ti0000 interface only

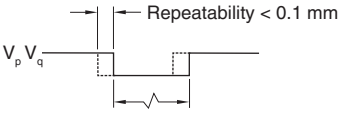
Active high



~ Length of limit actuator

Direct output from readhead

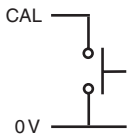
Active low



~ Length of limit actuator

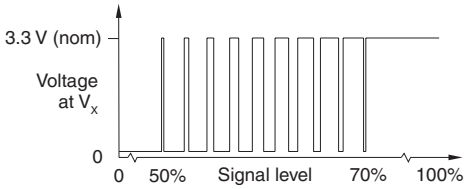
NOTE: Ti0000 interface contains a transistor to invert the readhead's 'active low' signal to give an 'active high' output.

Remote CAL operation (analogue versions only)



All Ti and TD interfaces include a push-button switch to enable CAL/AGC features.
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.

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.

* Only calibrated reference mark is bi-directionally repeatable.

† Set-up signal as shown is not present during calibration routine.

Linear readhead part numbers

Series
T - TONiC

Scale form
1 - Linear

Readhead type
0 - Standard

Scale type compatibility
1 - RSLM20 / RELM20
3 - RTLC20 / RTLC20-S / RKLC20-S

Reference mark
0 - Customer selectable reference mark
1 - All reference marks are output*

Cable length
02 - 0.2 m
05 - 0.5 m
10 - 1 m
15 - 1.5 m
20 - 2 m
30 - 3 m
50 - 5 m
60 - 6 m
99 - 10 m

Cable termination
A - Standard mini connector to mate with Ti/TD interface

* Only calibrated reference mark is bi-directionally repeatable.

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

Rotary readhead part numbers

Series
T - TONiC

Scale form
2 - Rotary

Readhead type
0 - Standard

Scale type compatibility
0 - RESM20 / REXM20 > Ø135 mm
1 - RESM20 / REXM20 Ø60 mm to Ø135 mm
2 - RESM20 / REXM20 < Ø60 mm

Reference mark
1 - All reference marks are output

Cable length
02 - 0.2 m
05 - 0.5 m
10 - 1 m
15 - 1.5 m
20 - 2 m
30 - 3 m
50 - 5 m
60 - 6 m
99 - 10 m

Cable termination
A - Standard mini connector to mate with Ti/TD interface

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

Partial arc readhead part numbers

T 2 0 6 1 - 15 A

Series
T - TONiC

Scale form
2 - Rotary

Readhead type
0 - Standard

Scale type compatibility
6 - RKLC20-S partial arc radius > 67.5 mm
7 - RKLC20-S partial arc radius 30 mm to 67.5 mm

Reference mark
1 - All reference marks are output*

Cable length
02 - 0.2 m
05 - 0.5 m
10 - 1 m
15 - 1.5 m
20 - 2 m
30 - 3 m
50 - 5 m
60 - 6 m
99 - 10 m

Cable termination
A - Standard mini connector to mate with Ti/TD interface

* Only calibrated reference mark is bi-directionally repeatable.

For more information refer to *RKL scale for partial arc applications* data sheet (Renishaw part no. L-9517-9897).

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

Ti interface part numbers

Compatible with all TONiC readheads

Analogue:

Ti 0000 A 00 A

Options

A - Dual active high limits
V - 2V5 Vmid dual active high limits

Digital:

Ti 0200 A 20 A

Series

Ti - TONiC interface

Interpolation factor/resolution*

0004 - 5 µm†	1000 - 20 nm
0020 - 1 µm	2000 - 10 nm
0040 - 0.5 µm	4000 - 5 nm
0100 - 0.2 µm	10KD - 2 nm
0200 - 0.1 µm	20KD - 1 nm
0400 - 50 nm	

Alarm format and conditions†

A - Line driven E output; All alarms
B - Line driven E output; Low signal and high signal alarms only
E - 3-state; All alarms
F - 3-state; Low signal and high signal alarms only

Clocked output option†

50 - 50 MHz	10 - 10 MHz
40 - 40 MHz	08 - 8 MHz
25 - 25 MHz	06 - 6 MHz
20 - 20 MHz	04 - 4 MHz
12 - 12 MHz	01 - 1 MHz

Options

A - P/Q limits – 'active high', standard reference mark
B - P/Q limits – 'active low', standard reference mark
C - P/Q limits – 'active high', wide reference mark‡
D - P/Q limits – 'active low', wide reference mark‡
E - Q limit only – 'active high', differential alarm, standard reference mark
F - Q limit only – 'active low', differential alarm, standard reference mark
G - Q limit only – 'active high', differential alarm, wide reference mark‡
H - Q limit only – 'active low', differential alarm, wide reference mark‡

* Additional interpolation factors available. Contact your local Renishaw representative for further details.
† When using with a DSi, the interface should be configured with line driven alarm outputs and a clocked output option of 01, 04, 06, 08, 10, 12 or 20.
‡ Wide reference mark not available on Ti0004 (5 µm) interfaces.

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

TD interface part numbers

Compatible with all TONiC readheads

Dual resolution:

TD 4000 A 20 A

Series

TD - TONiC dual resolution

Interpolation factor/resolution*

Pin 10 open	Pin 10 = 0 V
4000 - 5 nm	10 nm
2000 - 10 nm	20 nm
1000 - 20 nm	40 nm
0400 - 50 nm	0.1 µm
0200 - 0.1 µm	0.2 µm
0040 - 0.5 µm	1 µm

Alarm format and conditions†

A - Line driven, differential output; All alarms
B - Line driven, differential output; Low signal and high signal alarms only
E - 3-state; All alarms
F - 3-state; Low signal and high signal alarms only

Clocked output option†

50 - 50 MHz	10 - 10 MHz
40 - 40 MHz	08 - 8 MHz
25 - 25 MHz	06 - 6 MHz
20 - 20 MHz	04 - 4 MHz
12 - 12 MHz	01 - 1 MHz

Options

A - Standard reference mark
B - Wide reference mark

* Additional interpolation factors available. Contact your local Renishaw representative for further details.

† When using with a DSi, the interface should be configured with line driven alarm outputs and a clocked output option of 01, 04, 06, 08, 10, 12 or 20.

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

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RENISHAW
apply innovation™

TONiC compatible products

TONiC series

TONiC DOP
Dual output interface

RTLC20-S self-adhesive tape scale

RTLC20 tape scale and *FASTRACK* carrier

RKLC20-S self-adhesive mastered tape scale

RELM20 self-adhesive or clip/clamp mounted ZeroMet spar scale

RSLM20 self-adhesive or clip/clamp mounted stainless steel spar scale

RKLC20-S self-adhesive tape scale (partial arc)

RESM20 stainless steel ring

REXM20 high-accuracy stainless steel ring

DSi for dual-readhead rotary systems

For worldwide contact details, visit www.renishaw.com/contact

Part no.: L-9517-9337-07-H
Issued: 12.2022

Data sheet
L-9517-9878-02-A

RENISHAW
apply innovation™

TONiC™ Functional Safety incremental encoder system

Renishaw's TONiC Functional Safety (FS) is an open optical encoder system certified to the following international safety standards:

- **ISO 13849 Category 3 PLd**
- **IEC 61508 SIL2**
- **IEC 61800-5-2 SIL2**

TONiC FS offers all the benefits of the established TONiC linear and angle encoder systems giving exceptional metrology performance and ultimate reliability.

TONiC readheads incorporate Renishaw's market-proven third-generation filtering optics; this is further enhanced by dynamic signal processing including Auto Gain Control (AGC) and Auto Offset Control (AOC). The result is low sub-divisional error (SDE) and even lower noise (jitter) giving smoother velocity control for improved scanning performance and increased positional stability.

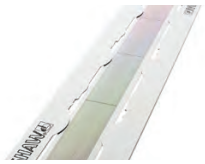
TONiC FS is also available for use in UHV environments. It has a clean residual gas analysis (RGA), low out-gassing and a bake-out temperature of 120 °C.

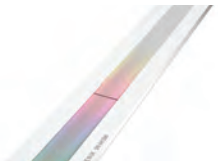
- **Functional Safety certified**
- **Ultra-high vacuum compatible variant**
- **Detachable analogue (Ti) or dual output (DOP) interface**
- **Compatible with a wide range of linear and rotary scales with customer-selectable *IN-TRAC* ™ auto-phase optical reference mark (datum)**
- **Optimised filtering optics for even lower noise**
- **Dynamic signal processing provides ultra-low SDE of typically ±30 nm**
- **Auto Gain Control ensures consistent signal strength for long-term reliability**
- **Integral set-up LED for ease of installation**
- **Maximum speed to 10 m/s (3.24 m/s at 0.1 µm resolution)**

www.renishaw.com/tonicdownloads

#renishaw

Compatible linear scales

	RTLC20-S	RTLC20 (with *FASTRACK*™ carrier)
	Self-adhesive mounted stainless steel tape scale	**Stainless steel tape scale and self-adhesive mounted carrier**
		
Form (height × width)	0.4 mm × 8 mm including adhesive	RTLC20 scale: 0.2 mm × 8 mm *FASTRACK* carrier: 0.4 mm × 18 mm including adhesive
Accuracy (includes slope and linearity)	±5 µm/m	±5 µm/m
Linearity (Figures achievable with two-point error correction)	±2.5 µm/m	±2.5 µm/m
Maximum length	10 m [1] (> 10 m available on request)	RTLC20 lengths up to 10 m (> 10 m available on request) *FASTRACK* carrier lengths up to 25 m
Coefficient of thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C	10.1 ±0.2 µm/m/°C

	RELx20	RSLx20
	Self-adhesive mounted low-expansion ZeroMet™ spar scale [2]	**Self-adhesive mounted stainless steel spar scale [2]**
		
Form (height × width)	1.5 mm × 14.9 mm	1.6 mm × 14.9 mm
Accuracy (at 20 °C)	Up to 1 m : ±1 µm 1 m to 1.5 m : ±1 µm/m	Up to 1 m : ±1.5 µm 1 m to 2 m : ±2.25 µm 2 m to 3 m: ±3 µm 3 m to 5 m : ±4 µm
Maximum length [2]	1.5 m	5 m
Coefficient of thermal expansion (at 20 °C)	0.75 ±0.35 µm/m/°C	10.1 ±0.2 µm/m/°C

1 For RTLC20-S axis lengths > 2 m, the *FASTRACK* carrier with RTLC20 is recommended.

2 Clip and clamp mounting is not Functional Safety approved. RELx20 and RSLx20 spar scales **must** be mounted with the supplied self-adhesive backing tape to be Functional Safety approved.

For more information about the linear scales refer to the relevant absolute scale data sheet which can be downloaded from **www.renishaw.com/tonicdownloads**.

Compatible rotary scale

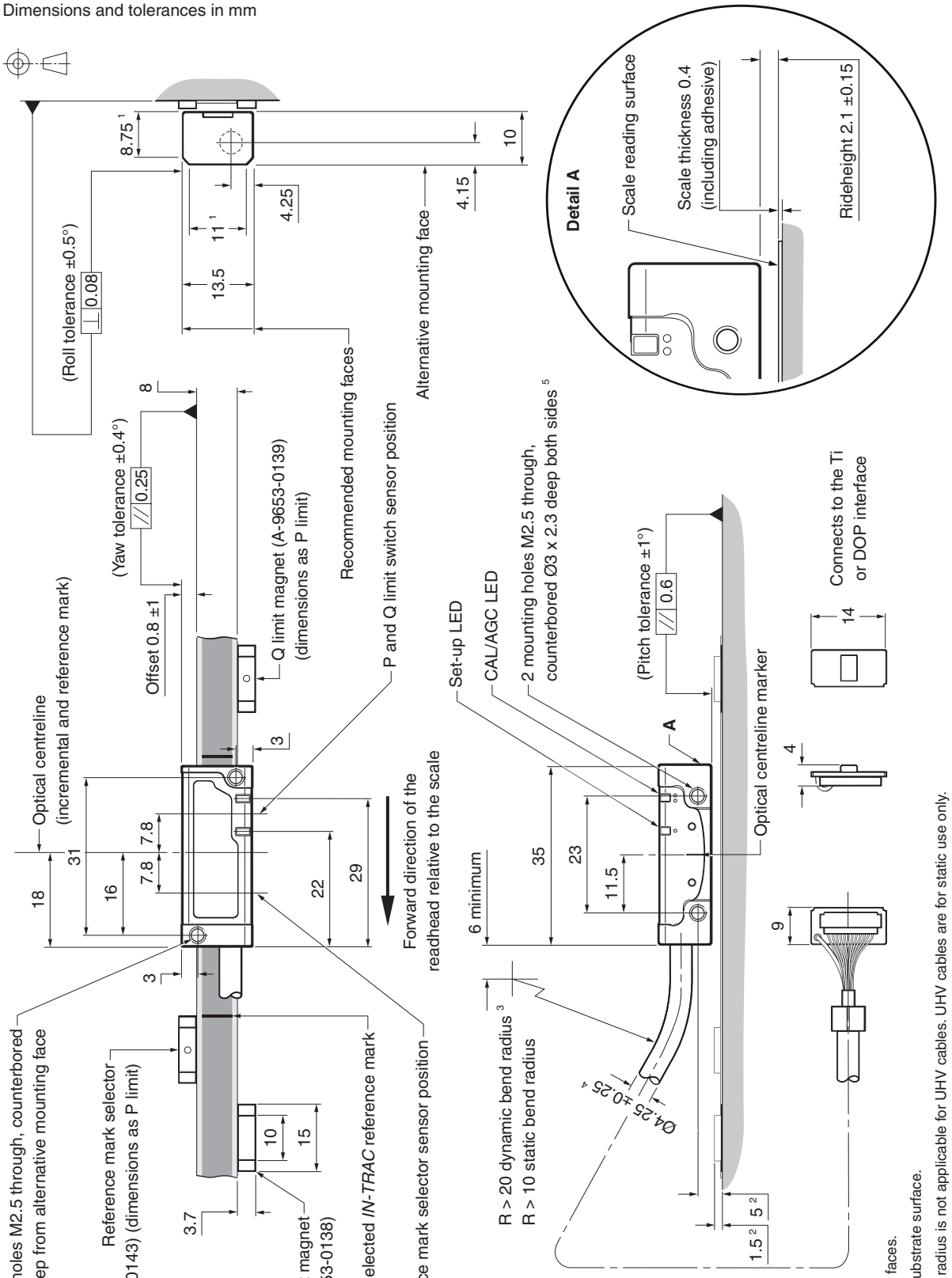
	RESM20 303/304 stainless steel ring
	
Accuracy (at 20 °C)	±1.9 arc second (Typical installed accuracy for a 550 mm diameter ring) [1]
Ring diameters	52 mm to 550 mm
Coefficient of thermal expansion (at 20 °C)	15.5 ±0.5 µm/m/°C

[1] 'Typical' installations are a result of graduation and installation errors combining and, to some magnitude, cancelling.

For more information about the RESM20 ring, refer to *RESM rotary scale* data sheet (Renishaw part no. L-9517-9154) which can be downloaded from www.renishaw.com/tonicdownloads.

TONiC FS T3xxx readhead installation drawing (RTLC20-S scale shown)

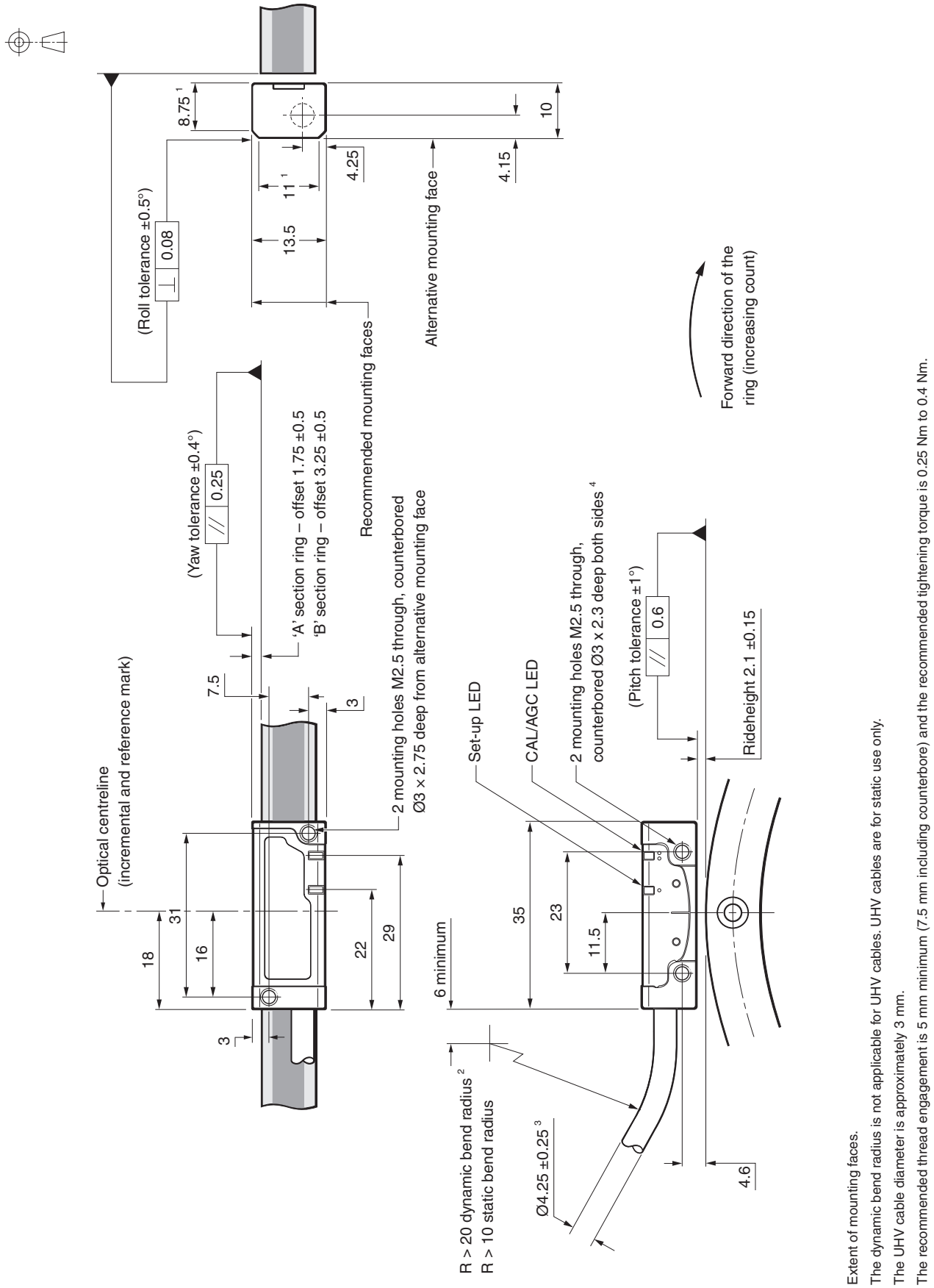
Dimensions and tolerances in mm



1 Extent of mounting faces.
2 Dimensions from substrate surface.
3 The dynamic bend radius is not applicable for UHV cables. UHV cables are for static use only.
4 The UHV cable diameter is approximately 3 mm.
5 The recommended thread engagement is 5 mm minimum (7.5 mm including counterbore) and the recommended tightening torque is 0.25 Nm to 0.4 Nm.

TONiC FS T4xxx readhead installation drawing (RESM20 ring shown)

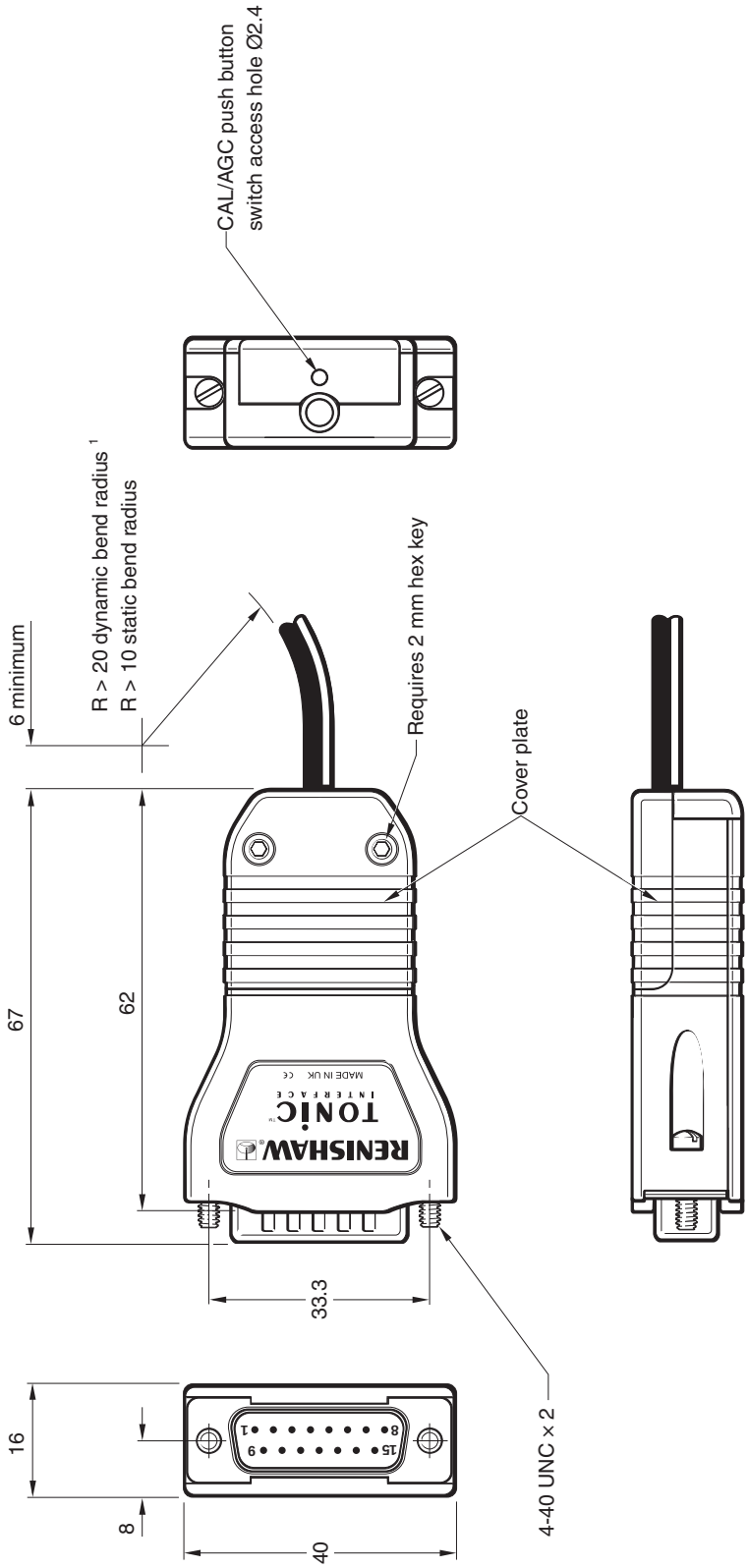
Dimensions and tolerances in mm



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

Ti interface installation drawing

Dimensions and tolerances in mm

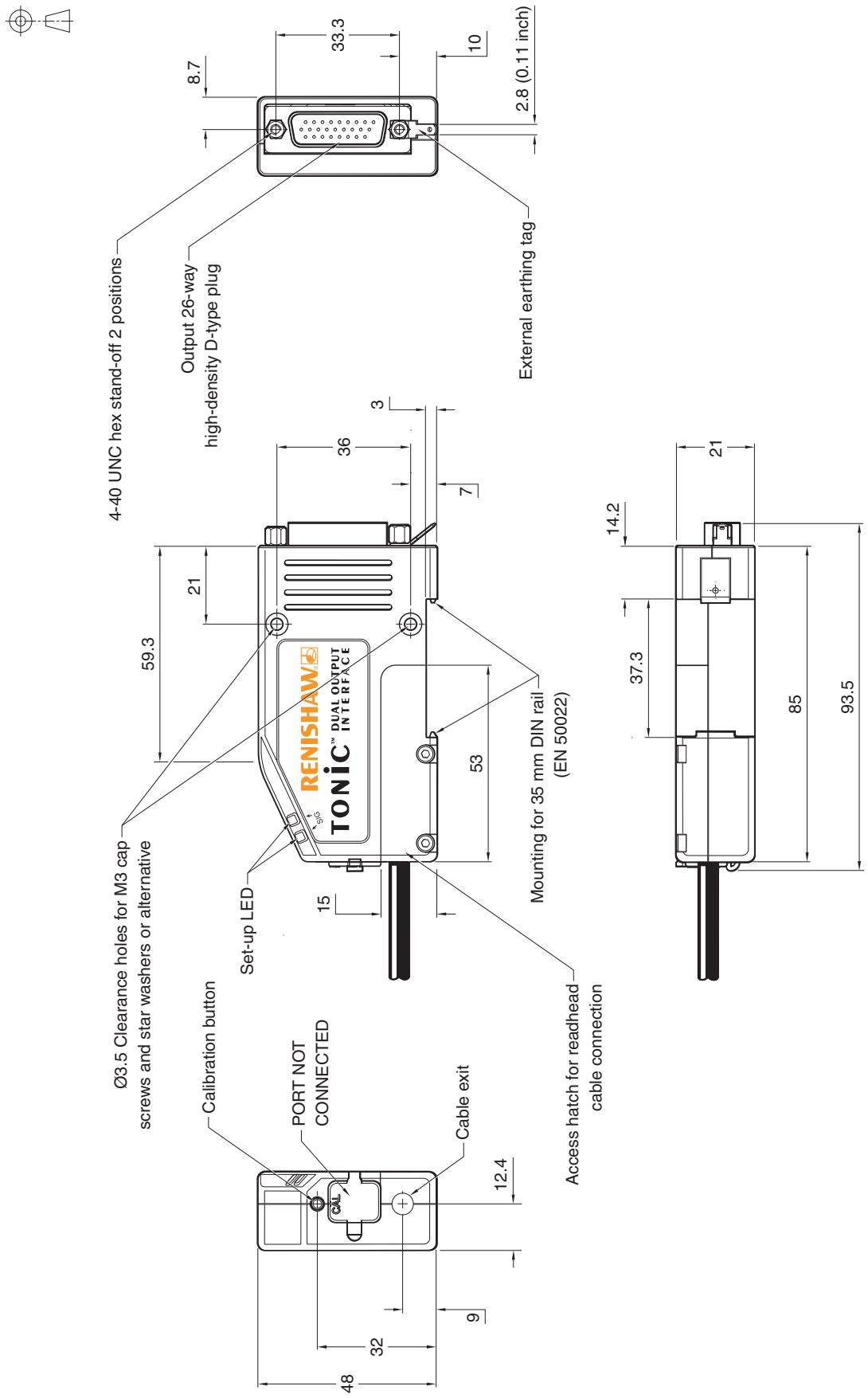


NOTE: The Ti interface is not suitable for mounting in a UHV environment.

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

DOP interface installation drawing

Dimensions and tolerances in mm



NOTE: The DOP interface is not suitable for mounting in a UHV environment.

General specifications

Power supply	5 V ±10%	Readhead only: < 100 mA T3xxx/T4xxx with Ti0000 < 100 mA T3xxx/T4xxx with DOP < 275 mA 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 120 R. For analogue outputs, a further 20 mA in total will be drawn when terminated with 120 R. Power from a 5 Vdc supply complying with the requirements for PELV of standard IEC 60950.
	Ripple	200 mVpp maximum @ frequency up to 500 kHz maximum
Temperature	Storage	–20 °C to 70 °C
	Operating	0 °C to +70 °C
	Bakeout (UHV readhead)	+120 °C
Humidity	System	95% relative humidity (non-condensing) to IEC 60068-2-78
Sealing	Standard readhead	IP40
	UHV readhead	IP20
	Ti interface	IP20
	DOP interface	IP30
Acceleration	Operating (readhead)	500 m/s^2, 3 axes
Shock	Operating (system)	500 m/s^2, 11 ms, ½ sine, 3 axes
Vibration	Operating (system)	100 m/s^2, 55 Hz to 2000 Hz, 3 axes
Shock	Non-operating	1000 m/s^2, 6 ms, ½ sine, 3 axes
Mass	Readhead	10 g
	Ti interface	100 g
	DOP interface	205 g
	Standard cable	26 g/m
	UHV cable	14 g/m
EMC compliance		IEC 61800-5-2 Annex E
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	25 m (with 40 MHz to 50 MHz clocked output interface) 50 m (with < 40 MHz clocked output interface) 50 m (with analogue interface)
Typical sub-divisional error (SDE)		±30 nm
Functional Safety certification [1]		ISO 13849 Category 3 PLd IEC 61508 SIL2 IEC 61800-5-2 SIL2

[1] The system must be installed and operated in accordance with the instructions defined in the relevant TONiC FS installation guide. Failure to follow the correct use instructions and failure to heed the limitations may result in SIL2 and/or PLd not being achieved and will invalidate the Functional Safety certification.

The TONiC FS installation guides can be downloaded from our website at **www.renishaw.com/fsencoders**.

Safety sub-functions

The TONiC Functional Safety (FS) encoder system provides safe position data that supports the following safety sub-functions defined by IEC 61800-5-2:2016:

- Safe stop 1 (SS1) and Safe stop 2 (SS2)
- Safe operating stop (SOS)
- Safe limited acceleration (SLA) ≤ 500 m/s^2
- Safe acceleration range (SAR) ≤ 500 m/s^2
- Safe limited speed (SLS) ≤ 10 m/s
- Safe speed range (SSR) ≤ 10 m/s
- Safely limited position (SLP)
- Safely limited increment (SLI)
- Safe direction (SDI)
- Safe speed monitor (SSM) ≤ 10 m/s

The system must be installed and operated in accordance with the instructions defined by the installation guide. Failure to follow the correct use instructions and failure to heed the limitations may result in PLd and / or SIL2 not being achieved and will invalidate the functional safety certification.

Functional Safety data declaration

Product identification	TONiC™ Functional Safety (FS) encoder system

IEC 61508 safety data

	TONiC FS readhead	TONiC FS readhead and Ti interface	TONiC FS readhead and DOP interface
Safety Integrity Level	2		
Random Hardware Failures (per hour)	$\lambda_S = 1.77 \times 10^{-7}$ $\lambda_D = 8.41 \times 10^{-8}$ $\lambda_{DD} = 7.57 \times 10^{-8}$ $\lambda_{DU} = 8.41 \times 10^{-9}$	$\lambda_S = 1.77 \times 10^{-7}$ $\lambda_D = 1.38 \times 10^{-7}$ $\lambda_{DD} = 1.25 \times 10^{-7}$ $\lambda_{DU} = 1.38 \times 10^{-8}$	$\lambda_S = 1.77 \times 10^{-7}$ $\lambda_D = 4.14 \times 10^{-7}$ $\lambda_{DD} = 3.73 \times 10^{-7}$ $\lambda_{DU} = 4.14 \times 10^{-7}$
PFD_{avg}	Not available as this system does not support low demand mode		
PFH (per hour)	$\lambda_{DU} = 8.41 \times 10^{-9}$	$\lambda_{DU} = 1.38 \times 10^{-8}$	$\lambda_{DU} = 4.14 \times 10^{-7}$
Architectural Constraints	Type B HFT = 0 SFF = 96%		
Hardware safety integrity compliance	Route 1H		
Systematic safety integrity compliance	Route 1S		
Systematic capability	SC2		
Demand mode	Continuous		

ISO 13849 safety data

	TONiC FS readhead	TONiC FS readhead and Ti interface	TONiC FS readhead and DOP interface
$MTTF_D$ (years)	1300	800	270
Diagnostic coverage	Medium (90%)		
Category	3		
Performance level	d		
Lifetime/Replacement limits	20 years		

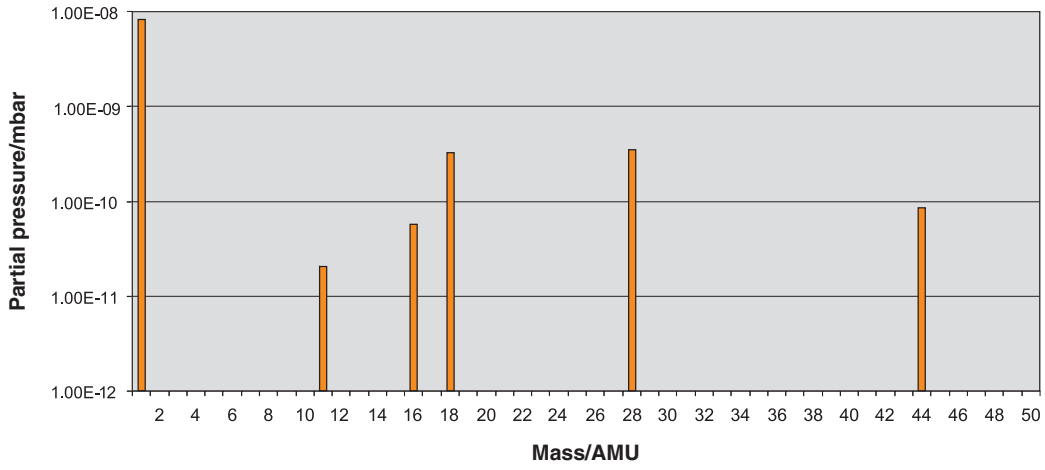
RGA results

Test schedule

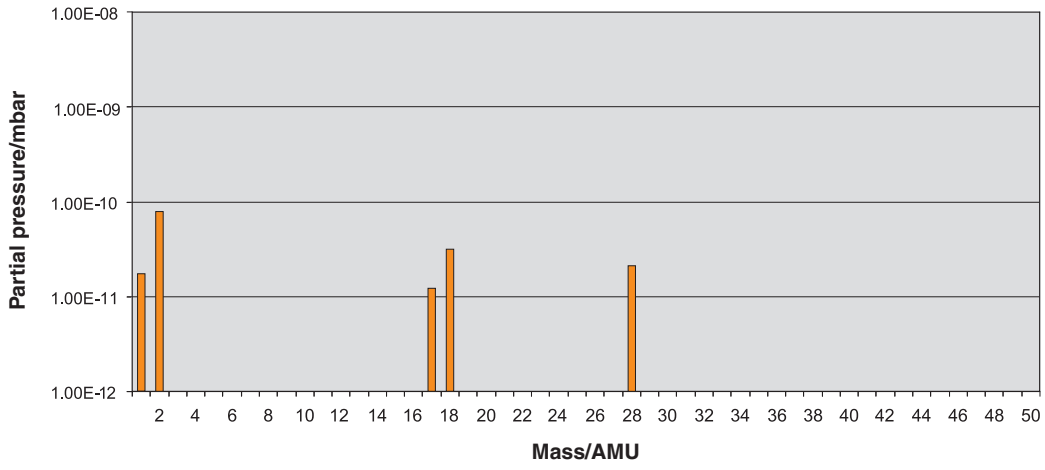
A quadrupole mass spectrometer (AccuQuad 200 RGA), set to 200AMU scan range, was used to collect RGA (residual gas analysis) data and to measure total chamber pressure. After initial conditioning of the system, a background spectrum was recorded together with the total pressure in the test chamber.

The component was placed in the vacuum chamber (0.015 m^3) and the system was then pumped using an KJL Lion 802 (800/s) diode ion pump and a Divac diaphragm pump at ambient temperature for 24 hours, after which a background scan and the total pressure in the test chamber were recorded again. If the system pressure was better than 5×10^{-9} mbar, the test specimen was baked at 120 °C for 48 hours. The system was then allowed to cool to ambient temperature before a final mass spectrum and the total pressure in the test chamber were recorded. These final RGA scans are shown below.

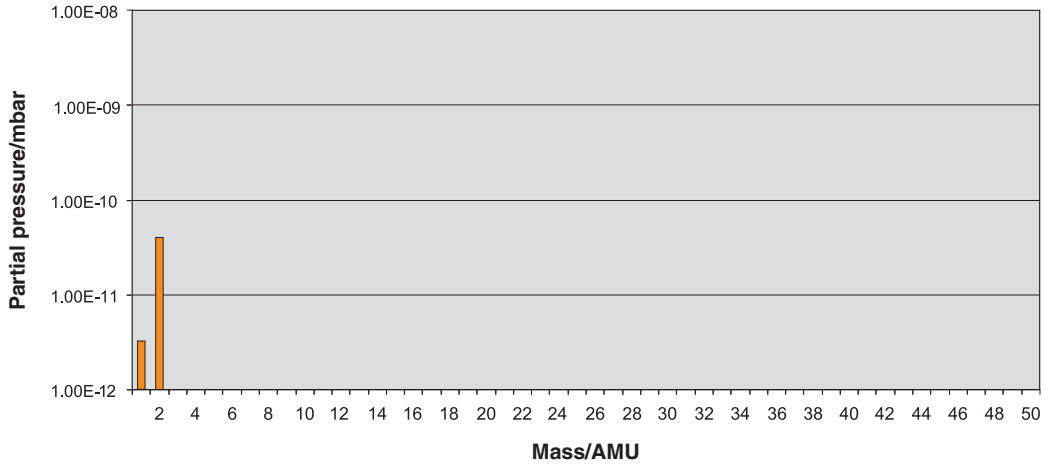
TONiC readhead with 1.0 m cable after bake-out (total pressure = 9.0×10^{-10} mbar)



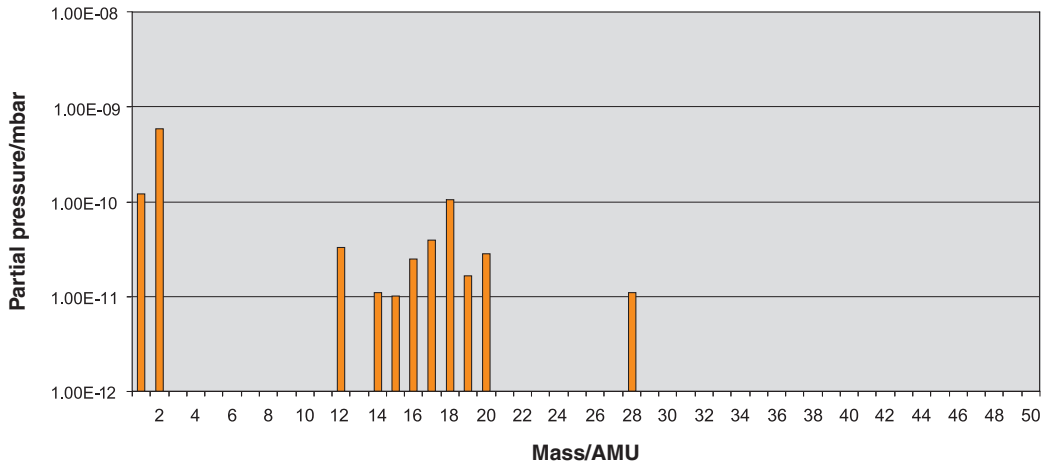
RTLC20-S self-adhesive stainless steel linear tape scale after bake-out (total pressure = 2.8×10^{-10} mbar)



RELx self-adhesive mounted linear spar scale after bake-out
(total pressure = 3.0 × 10^{-10} mbar)



RESM20 ring (Ø115 mm) after bake-out
(total pressure = 7.76 × 10^{-10} mbar)



Speed

Digital speeds

Clocked output option (MHz)	Maximum speed (m/s)					
	DOP0004 5 µm	DOP0020 1 µm	DOP0040 0.5 µm	DOP0100 0.2 µm	DOP0200 0.1 µm	DOP0400 50 nm
50	10	10	10	6.48	3.24	1.62
40	10	10	10	5.40	2.70	1.35
25	10	10	8.10	3.24	1.62	0.810
20	10	10	6.75	2.70	1.35	0.675
12	10	9	4.50	1.80	0.900	0.450
10	10	8.10	4.05	1.62	0.810	0.405
08	10	6.48	3.24	1.29	0.648	0.324
06	10	4.50	2.25	0.90	0.450	0.225
04	10	3.37	1.68	0.67	0.338	0.169
01	4.2	0.84	0.42	0.16	0.084	0.042

Clocked output option (MHz)	Maximum speed (m/s)				
	DOP1000 20 nm	DOP2000 10 nm	DOP4000 5 nm	DOP10KD 2 nm	DOP20KD 1 nm
50	0.648	0.324	0.162	0.0654	0.032
40	0.540	0.270	0.135	0.054	0.027
25	0.324	0.162	0.081	0.032	0.016
20	0.270	0.135	0.068	0.027	0.013
12	0.180	0.090	0.045	0.018	0.009
10	0.162	0.081	0.041	0.016	0.0081
08	0.130	0.065	0.032	0.013	0.0065
06	0.090	0.045	0.023	0.009	0.0045
04	0.068	0.034	0.017	0.0068	0.0034
01	0.017	0.008	0.004	0.0017	0.0008

Analogue speeds

Analogue output (Ti0000 and DOP interfaces)

10 m/s (–3dB)

Angular speed

Linear to angular speed conversion.

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 RESM20 ring (mm).

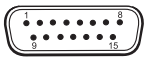
Output signals

NOTE: Only analogue sine and cosine outputs are functionally safe.

TONIC FS readhead output

Function	Output type		Signal		Colour
Power	-		5 V Power		Brown
			0 V Power		White
Incremental signals	Analogue	Cosine	V_1	+	Red
				–	Blue
		Sine	V_2	+	Yellow
				–	Green
Reference mark	Analogue		V_0	+	Violet
				–	Grey
Limits	Open collector		V_p		Pink
			V_q		Black
Set-up	-		V_X		Clear
Calibrate	-		CAL		Orange
Shield	-		Inner shield [1]		Green/Yellow
	-		Outer shield		Outer screen

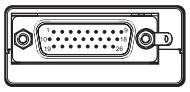
Ti0000 interface output

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
				–	1
		Sine	V_2	+	10
				–	2
Reference mark	Analogue		V_0	+	3
				–	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
					 15-way D-type plug

[1] Standard cable: The inner shield is connected to 0 V inside the Ti interface.
UHV cable: There is no inner shield on UHV cables.

DOP interface output

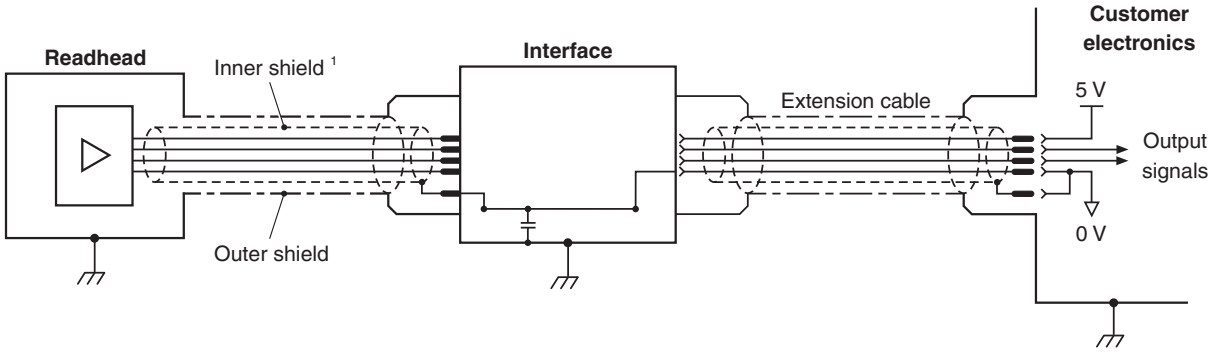
Function	Output type		Signal		Pin
Power	-		5 V Power		26
			5 V Sense		18
			0 V Power		9
			0 V Sense		8
Incremental signals	RS422A digital		A	+	24
				–	6
			B	+	7
				–	16
	Analogue	Cosine	V_1	+	1
				–	19
		Sine	V_2	+	2
				–	11
Reference mark	RS422A digital		Z	+	15
				–	23
	Analogue		V_0	+	12
				–	20
Alarm	RS422A digital		E	+	25
				–	17
Limits	Open collector		P		4
			Q		13
Readhead set-up	-		X		10
Shield	-		Inner shield		Not connected
	-		Outer shield		Case



26-way high-density D-type plug

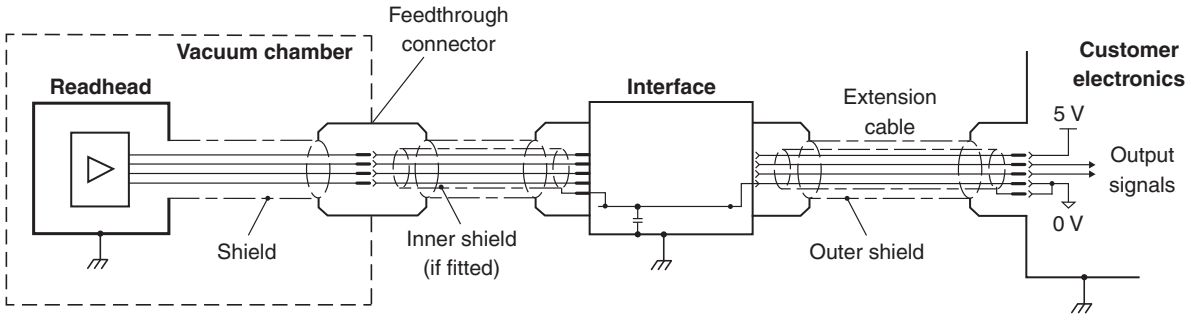
Electrical connections

Grounding and shielding - standard TONiC FS system



IMPORTANT: The outer shield must be connected to the machine earth (Field Ground). The inner shield must 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.

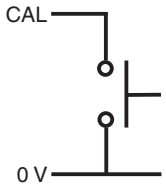
Grounding and shielding - Ultra-high vacuum (UHV) TONiC FS system



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: For DOP interfaces the external earthing tag on the interface must be used when mounting the interface on a DIN rail.

Remote CAL operation



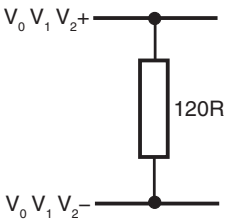
The Ti and DOP interfaces include a push-button switch to enable CAL/AGC features.

Remote operation of the CAL/AGC is possible via pin 14 of Ti0000 interfaces.

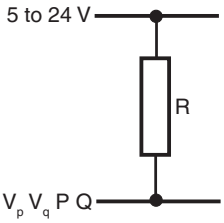
For applications where no interface is used, remote operation of CAL/AGC is essential.

Recommended signal terminations [1]

Analogue outputs

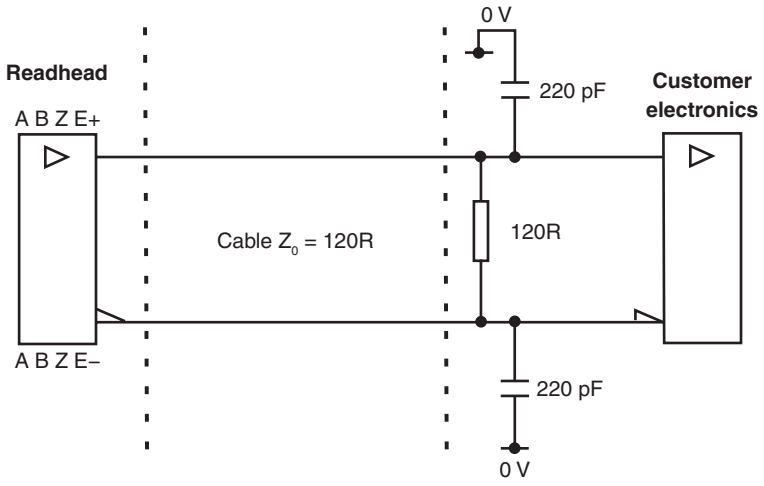


Limit outputs



NOTE: Select the resistor R so that the maximum current does not exceed 20 mA. Alternatively use a suitable relay or opto-isolator.

Digital outputs



Standard RS422A line receiver circuitry.

The capacitors are recommended for improved noise immunity.

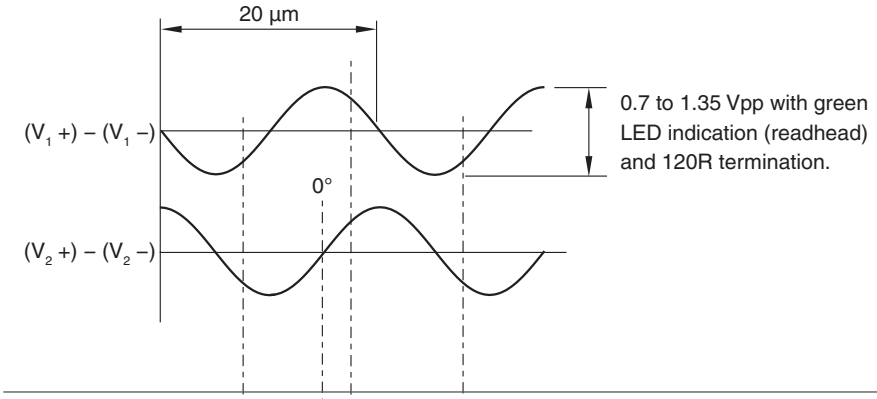
[1] Only the analogue sine and cosine outputs are functionally safe.

Output specifications

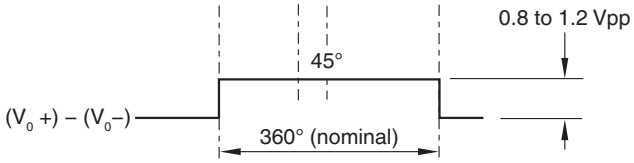
Analogue output signals [1]

Incremental

2 channels V_1 and V_2 differential sinusoids in quadrature (90° phase shifted)



Reference



The reference output is bi-directionally repeatable. [2]

The differential pulse V_0 is centred on 45°.

NOTE: The Ti0000 differential signals are centred on on ~1.65 V. and the DOP interface differential signals are centred on 2.5V.

[1] Only the analogue sine and cosine outputs are functionally safe.

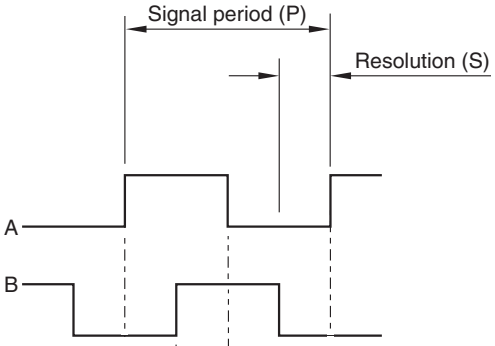
[2] Only the calibrated reference mark is bi-directionally repeatable.

Digital output signals (DOP interface only) [1]

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

Incremental [2]

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



Model	P (µm)	S (µm)
DOP0004	20	5
DOP0020	4	1
DOP0040	2	0.5
DOP0100	0.8	0.2
DOP0200	0.4	0.1
DOP0400	0.2	0.05
DOP1000	0.08	0.02
DOP2000	0.04	0.01
DOP4000	0.02	0.005
DOP10KD	0.008	0.002
DOP20KD	0.004	0.001

Reference [2]

Bi-directionally repeatable pulse Z, duration equal to the resolution

Wide reference [2]

Bi-directionally repeatable pulse Z, duration equal to the signal period

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 DOP0004

[1] Only the analogue sine and cosine outputs are functionally safe.

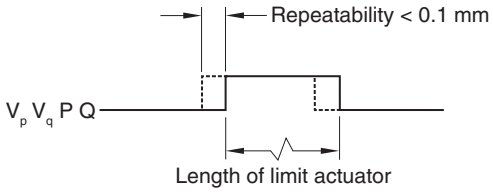
[2] For clarity, the inverse signals are not shown.

Limits

Open collector output, asynchronous pulse

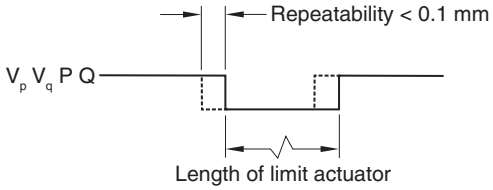
Active high

- Ti0000 interface
- DOP interface (dependent on reference mark option selected; see page 24)



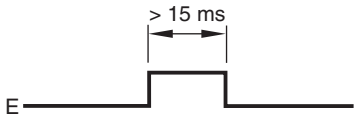
or active low

- TONiC FS readhead
- DOP interface (dependent on reference mark option selected; see page 24)



Alarm (DOP interface only)

Line driven [1] (asynchronous pulse)



The line driven alarm is asserted when:

- The signal amplitude is < 20% or > 135%
- The readhead speed is too high for reliable operation

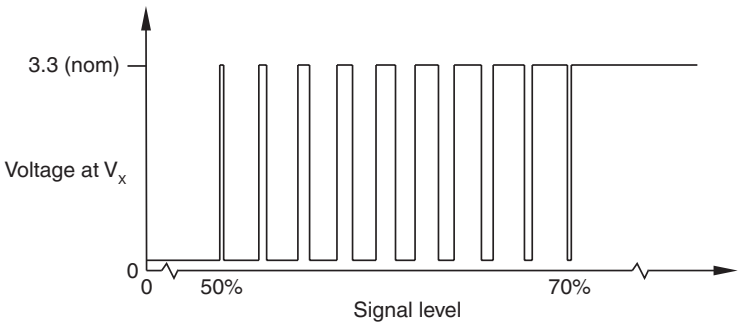
or 3-state alarm

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

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

Set-up signal [1]

Ti0000 interface

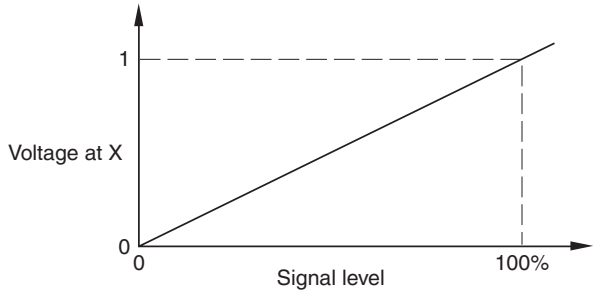


Between 50% and 70% the signal level V_X is a duty cycle.

Time spent at 3.3 V increases with incremental signal level.

At > 70% the signal level V_X is nominal 3.3 V.

DOP interface



The set-up signal voltage is proportional to the incremental signal amplitude.

[1] The set-up signals as shown are not present during the calibration routine.

T3xxx linear readhead part numbers

Compatible with RTLC20-S, RTLC20/*FASTRACK*, RSLx20, or RELx20 scale

T3 0 3 0 - 15 A

Series

T3 = TONiC FS linear readhead

Readhead type

0 = Standard (select 'cable termination' A)

6 = Ultra-high vacuum (select 'cable termination' M)

Scale type compatibility

1 = RSLx20 / RELx20

3 = RTLC20-S / RTLC20

Reference mark

0 = Customer selectable reference mark

1 = All reference marks are output [1]

Cable length

02 = 0.2 metres (standard 'readhead type' only)

05 = 0.5 metres (standard 'readhead type' only)

10 = 1.0 metres

15 = 1.5 metres

20 = 2.0 metres (standard 'readhead type' only)

30 = 3.0 metres

50 = 5.0 metres

60 = 6.0 metres

99 = 10.0 metres

Cable termination

A = Standard mini connector to mate with Ti or DOP interfaces

M = Vacuum cable with mini connector to mate with Ti or DOP interfaces

Valid system configurations can be checked at **www.renishaw.com/epc**.

[1] Only the calibrated reference mark is bi-directionally repeatable.

T4xxx rotary readhead part numbers

Compatible with RESM20 rings

T4 0 0 1 - 15 A

Series

T4 = TONiC FS rotary readhead

Readhead type

0 = Standard (select 'cable termination' A)

6 = Ultra-high vacuum (select 'cable termination' M)

Ring diameter

0 = RESM20 > Ø135 mm

1 = RESM20 Ø60 mm to Ø135 mm

2 = RESM20 < Ø60 mm

Reference mark

1 = All reference marks are output

Cable length

02 = 0.2 metres (standard 'readhead type' only)

05 = 0.5 metres (standard 'readhead type' only)

10 = 1.0 metres

15 = 1.5 metres

20 = 2.0 metres (standard 'readhead type' only)

30 = 3.0 metres

50 = 5.0 metres

60 = 6.0 metres

99 = 10.0 metres

Cable termination

A = Standard mini connector to mate with Ti or DOP interfaces

M = Vacuum cable with mini connector to mate with Ti or DOP interfaces

Valid system configurations can be checked at www.renishaw.com/epc.

Ti interface part number

Compatible with all TONiC FS readheads

Ti0000A00A

DOP interface part numbers

Compatible with all TONiC FS readheads

DOP 0200 A 20 A

Series

DOP = TONiC dual output interface

Interpolation factor / resolution [1]

0004 = 5 µm	0200 = 0.1 µm	4000 = 5 nm
0020 = 1 µm	0400 = 50 nm	10KD = 2 nm
0040 = 0.5 µm	1000 = 20 nm	20KD = 1 nm
0100 = 0.2 µm	2000 = 10 nm	

Alarm format and conditions

A = Line driven E output; all alarms

B = Line driven E output; low signal and high signal alarms only

E = 3 state; all alarms

F = 3 state; low signal and high signal alarms only

Clock frequency

50 = 50 MHz	12 = 12 MHz	04 = 4 MHz
40 = 40 MHz	10 = 10 MHz	01 = 1 MHz
25 = 25 MHz	08 = 8 MHz	
20 = 20 MHz	06 = 6 MHz	

Reference mark

A = P / Q limits - ‘Active high’, standard reference mark

B = P / Q limits - ‘Active low’, standard reference mark

C = P / Q limits - ‘Active high’, wide reference mark [2]

D = P / Q limits - ‘Active low’, wide reference mark [2]

NOTE: For TONiC FS UHV systems, only the readhead is UHV compatible. The Ti and DOP interfaces must be kept outside of the vacuum chamber.

Valid system configurations can be checked at www.renishaw.com/epc.

1 Contact Renishaw for other interpolation factors.

2 A wide reference mark is not available with DOP0004 (5 µm) interfaces.

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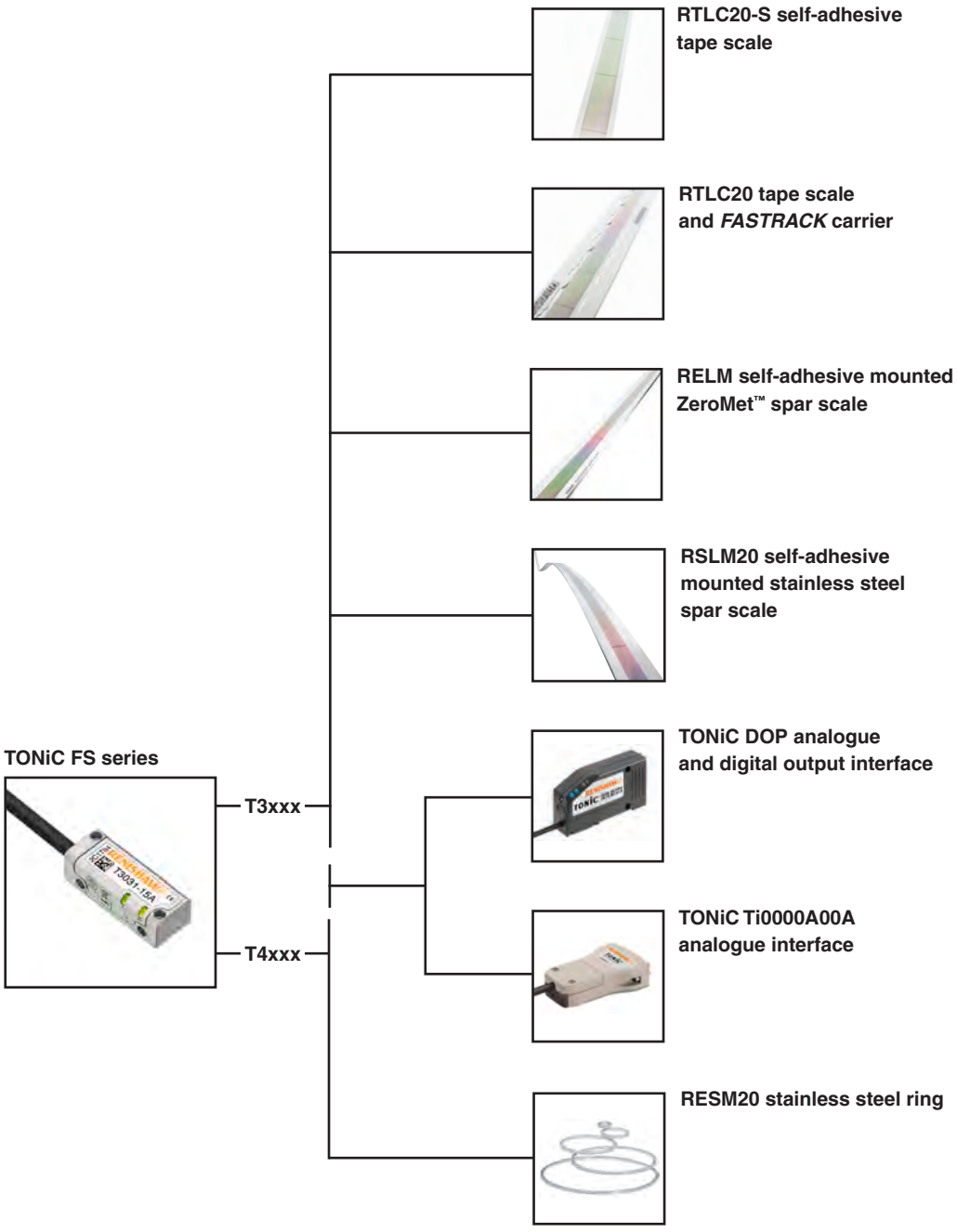
TONiC FS compatible products



www.renishaw.com/contact

#renishaw

+44 (0) 1453 524524 **uk@renishaw.com**

Part no.: L-9517-9878-02-A
Issued: 06.2023

Data sheet
L-9517-9426-03-E

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TONiC™ UHV encoder system

TONiC UHV encoder offers all the benefits of the established TONiC linear and rotary encoder systems, in a readhead that has been designed and constructed using ultra-high vacuum compatible materials and processes.

The TONiC UHV readhead is compatible with a wide range of linear and rotary scales with bi-directional optical *IN-TRAC*™ reference marks.

For ultimate reliability and high immunity to optical degradation,TONiC UHV readheads incorporate Renishaw's market proven filtering optics, tuned for even lower noise (jitter), further enhanced by dynamic signal processing including Auto Gain Control (AGC) and Auto Offset Control (AOC). The result is ultra-low sub-divisional error (SDE) giving smoother velocity control for improved scanning performance and increased positional stability.

TONiC UHV readheads also feature a detachable analogue or digital interface in the form of a robust, convenient connector that can be located up to 10 m from the readhead. The interface offers digital interpolation to 1 nm resolution, with clocked outputs for optimised speed performance at all resolutions for industry-standard controllers.

The readhead carries an integral set-up LED that enables quick and easy installation. All of these readheads are supplied with an RFI screened UHV compatible cable as standard.

- Clean RGA
- Low outgassing rates
- High bake-out temperature of 120 °C
- Low power consumption readheads
- Non-contact open optical system
- Detachable analogue or digital connector with integral interpolation to 1 nm resolution (0.00075 arc seconds)
- Resolution to 1 nm
- Dynamic signal processing provides ultra-low SDE of typically ±30 nm
- Auto Gain Control (AGC) ensures constant signal strength for long-term reliability
- Compatible with a wide range of linear and rotary scales with customer selectable *IN-TRAC* auto-phase optical reference mark (datum)

Compatible scales

Linear scales	RTLC20-S	RTLC20/*FASTRACK*™	RKLC20-S
	Self-adhesive mounted stainless steel tape scale	Stainless steel tape scale and self-adhesive mounted carrier	Self-adhesive mounted stainless steel tape scale
			
Form (H × W)	0.4 mm × 8 mm including adhesive	RTLC20 scale: 0.2 mm × 8 mm *FASTRACK* carrier: 0.4 mm × 18 mm including adhesive	0.15 mm × 6 mm including adhesive
Accuracy (Includes slope and linearity)	±5 µm/m	±5 µm/m	±5 µm/m
Linearity (Figures achievable with two-point error correction)	±2.5 µm/m	±2.5 µm/m	±2.5 µm/m
Maximum length	10 m* (> 10 m available on request)	10 m (> 10 m available on request)	20 m (> 20 m available on request)
Coefficient of thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C	10.1 ±0.2 µm/m/°C	Matches that of substrate material when scale ends rigidly fixed†

	RSLM20	RELM20
	Self-adhesive or clip/clamp mounted stainless steel spar scale	Self-adhesive or clip/clamp mounted low-expansion ZeroMet™ spar scale
		
Form (H × W)	1.5 mm × 14.9 mm	1.6 mm × 14.9 mm
Accuracy (includes slope and linearity)	±4 µm (Total accuracy over a complete 5 m length)	±1 (Total accuracy up to 1 m)
Linearity (Figures achievable with two-point error correction)	N/A	N/A
Maximum length	5 m	1.5 m
Coefficient of thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C	0.75 ±0.35 µm/m/°C

* For RTLC20-S axis lengths > 2 m, *FASTRACK* with RTLC20 is recommended.

† Scale mastering is not guaranteed after system bakeout.

For more information about the scales refer to the relevant scale data sheet which can be downloaded from www.renishaw.com/tonicdownloads.

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Rotary scales	RESM20	REXM20
	Stainless steel ring	Ultra-high accuracy stainless steel ring
		
Accuracy	±1.9 arc second (Typical installed accuracy for 550 mm diameter RESM20 ring)*	±1 arc second† (Total installed accuracy for 417 mm diameter REXM20 ring)
Ring diameters	52 mm to 550 mm	52 mm to 417 mm
Coefficient of thermal expansion (at 20 °C)	15.5 ±0.5 µm/m/°C	15.5 ±0.5 µm/m/°C

* Typical' installations are a result of graduation and installation errors combining and, to some magnitude, cancelling.

† When using two readheads and an additional DSi interface.

For more information about the scales refer to the relevant scale data sheet which can be downloaded from www.renishaw.com/tonicdownloads.

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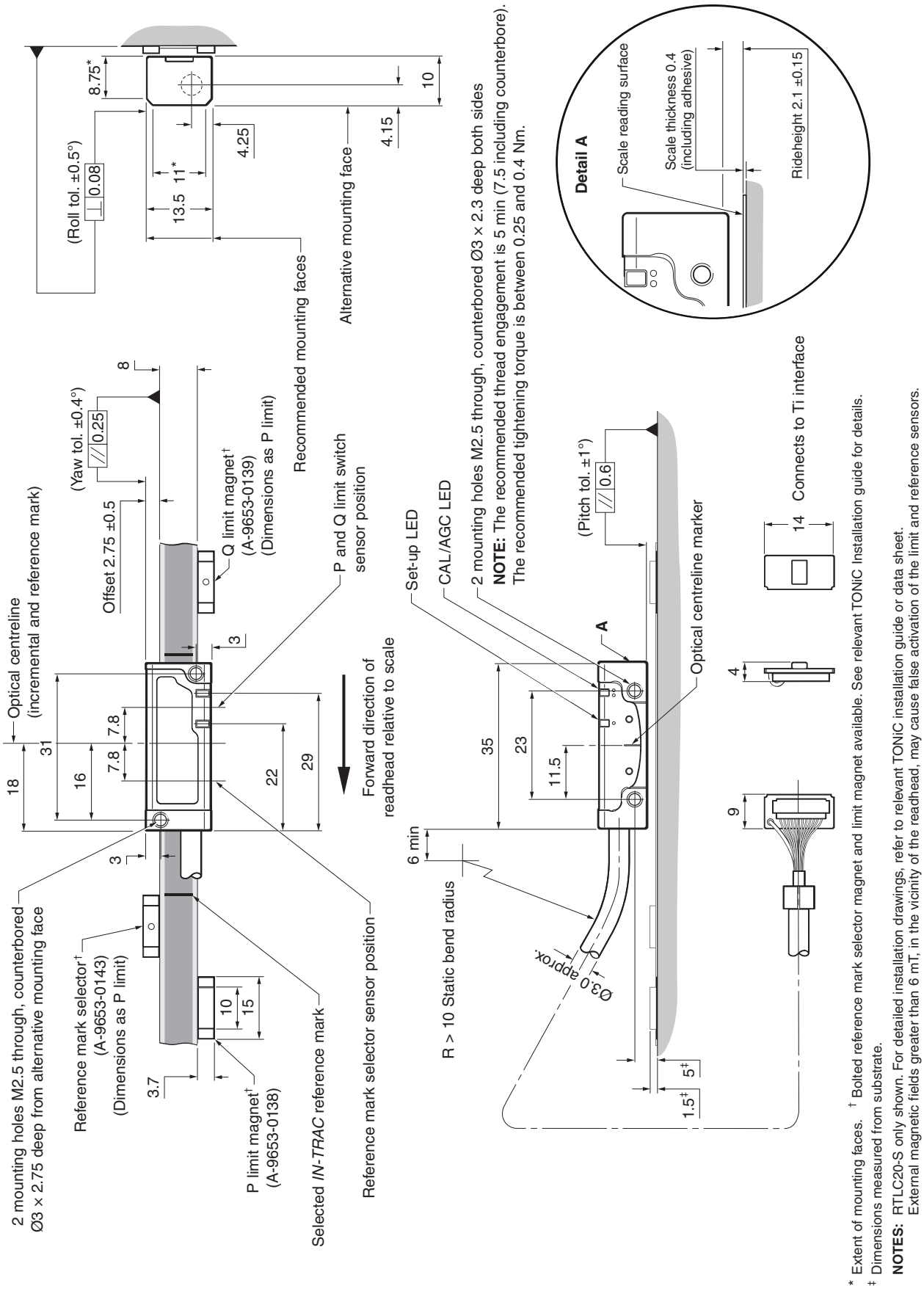
TONiC readhead installation drawing (on RTLC20-S scale)

Dimensions and tolerances in mm



* Extent of mounting faces. † Bolted reference mark selector magnet and limit magnet available. See relevant TONiC Installation guide for details.
‡ Dimensions measured from substrate.

NOTES: RTLC20-S only shown. For detailed installation drawings, refer to relevant TONiC installation guide or data sheet.
External magnetic fields greater than 6 mT, in the vicinity of the readhead, may cause false activation of the limit and reference sensors.

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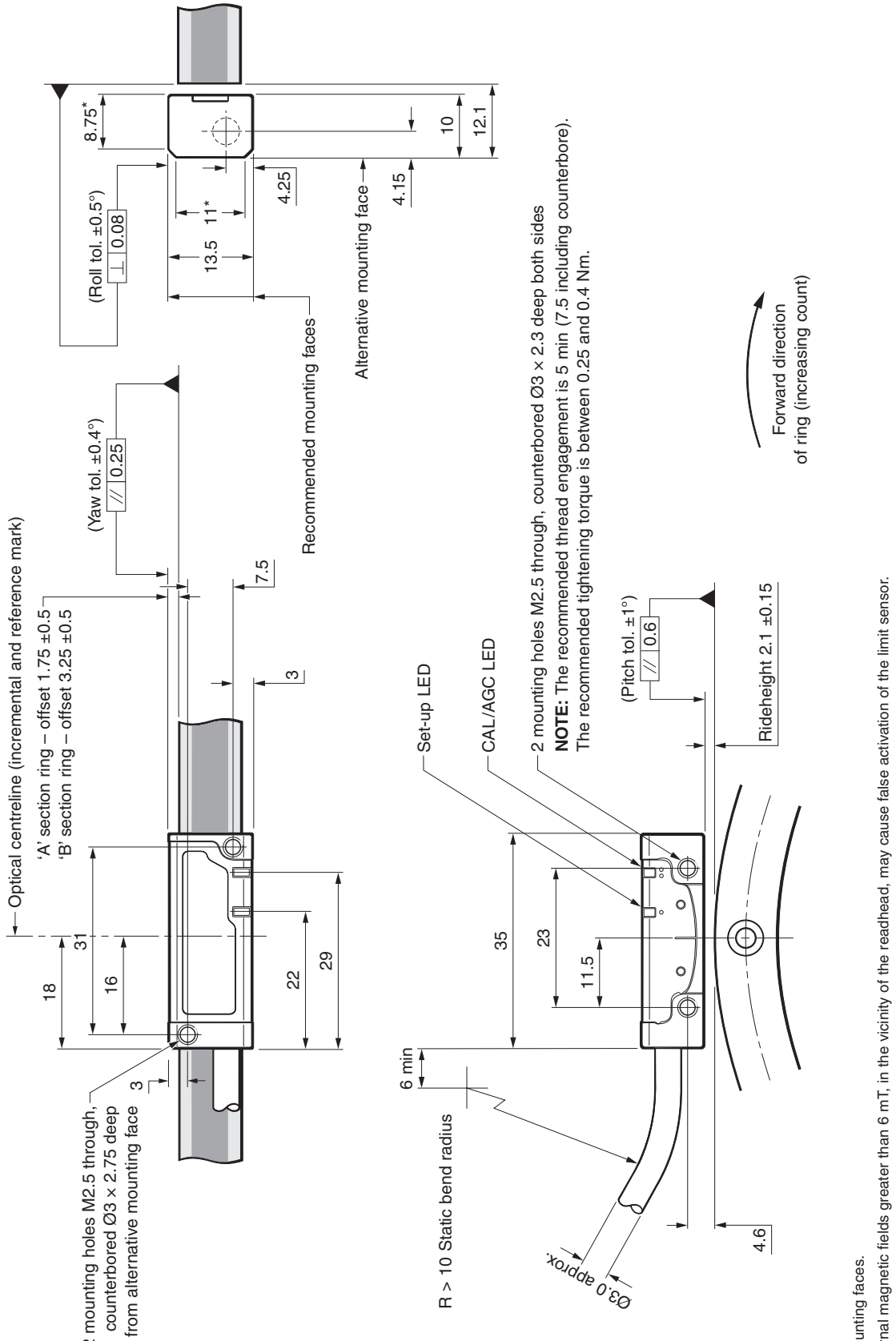
TONiC readhead installation drawing (on RESM20 ring)

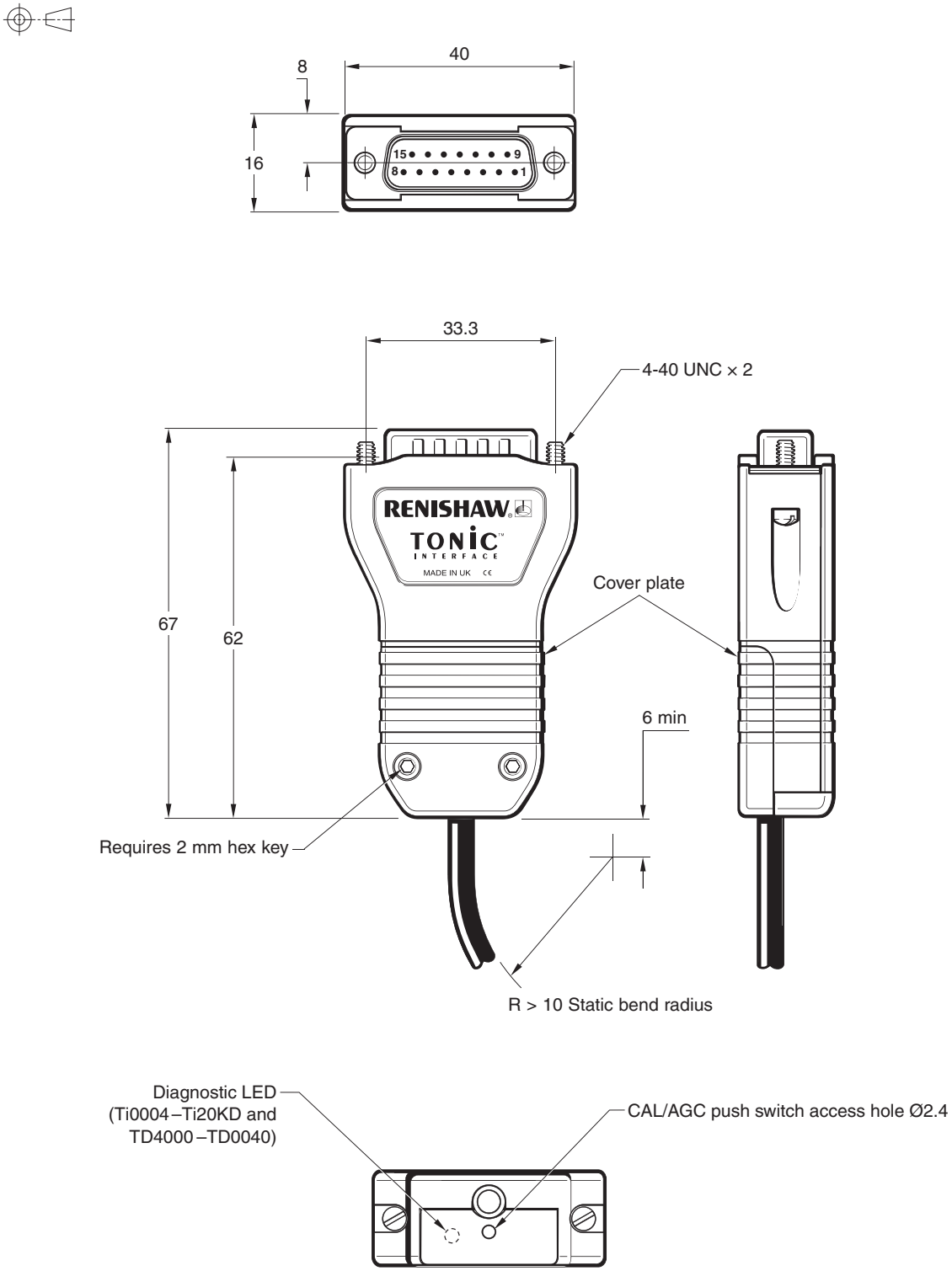
Dimensions and tolerances in mm



* Extent of mounting faces.
NOTE: External magnetic fields greater than 6 mT, in the vicinity of the readhead, may cause false activation of the limit sensor.

Ti/TD interface dimension drawing

Dimensions and tolerances in mm



TD dual resolution interface

Allows output to be switched between two resolutions. See TD interface part number section for details of available resolutions.

NOTES:

- It is recommended that movement should be halted before switching resolutions.
- No limit outputs.

General specifications

Power supply	5V ±10%	Readhead only < 100 mA T16xx/T26xx with Ti0000 < 100 mA T16xx/T26xx 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
(readhead)	Bakeout	120 °C
Humidity (system)		95% relative humidity (non-condensing) to IEC 60068-2-78
Sealing (readhead)		IP20
(interface)		IP20
Acceleration (readhead)	Operating	500 m/s², 3 axes
Shock (system)	Operating	500 m/s², 11 ms, ½ sine, 3 axes
Vibration (system)	Operating	100 m/s² max @ 55 Hz to 2000 Hz, 3 axes
Mass	Readhead	10 g
	Interface	100 g
	Cable	14 g/m
EMC compliance (system)		IEC 61326-1
Readhead cable		Tinned copper braided single screen. FEP core insulation
Typical sub-divisional errror (SDE)		±30 nm

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	3.240	1.625	0.648	0.324	0.162	0.065	0.032
40	10	10	10	5.40	2.700	1.350	0.540	0.270	0.135	0.054	0.027
25	10	10	8.10	3.24	1.620	0.810	0.324	0.162	0.081	0.032	0.016
20	10	10	6.75	2.70	1.350	0.670	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	4.00	1.62	0.810	0.400	0.162	0.081	0.041	0.016	0.0081
8	10	6.48	3.24	1.29	0.648	0.324	0.130	0.065	0.032	0.013	0.0065
6	10	4.50	2.25	0.90	0.450	0.225	0.090	0.045	0.023	0.009	0.0045
4	10	3.37	1.68	0.67	0.338	0.169	0.068	0.034	0.017	0.0068	0.0034
1	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 interface maximum speeds are resolution dependent as defined above.

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

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

Where V = maximum linear speed (m/s) and
D = external diameter of RESM20 or REXM20 ring (mm)

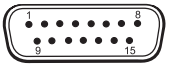
Output signals

Digital outputs

			Interface	
			Ti0004 – Ti20KD	TD4000 – TD0040
Function	**Signal**		**Pin**	**Pin**
Power	5 V		7, 8	7, 8
	0 V		2, 9	2, 9
Incremental	A	+	14	14
		–	6	6
	B	+	13	13
		–	5	5
Reference mark	Z	+	12	12
		–	4	4
Limits	P*		11	-
	Q		10	-
Set-up	X		1	1
Alarm†	E	+	-	11
		–	3	3
Resolution switching‡	-		-	10
Shield	Inner		-	-
	Outer		Case	Case

Analogue outputs

				Readhead T16xx/26xx	Interface Ti0000
Function		**Signal**		**Colour**	**Pin**
Power		5 V		Brown	4, 5
		0 V		White	12, 13
Incremental	**Cosine**	V_1	+	Red	9
			–	Blue	1
	Sine	V_2	+	Yellow	10
			–	Green	2
Reference mark		V_0	+	Violet	3
			–	Grey	11
Limits		V_p		Pink	7
		V_q		Black	8
Set-up		V_x		Clear	6
Remote CAL		CAL		Orange	14
Shield		-		Screen	Case



15-pin D-type connector

* Becomes alarm (E+) for Ti options E, F, G, H.

† The alarm signal can be output as a line driven 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.

RGA results

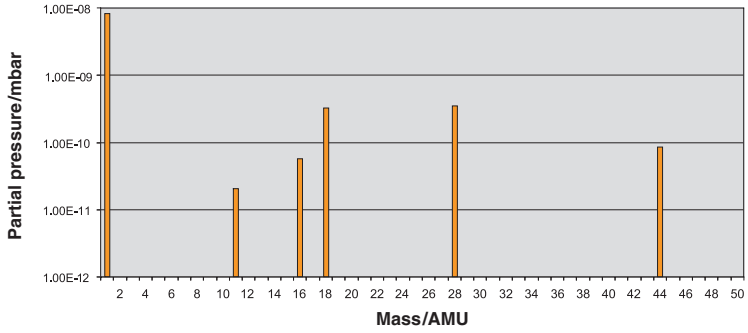
Test schedule

A quadrupole mass spectrometer (AccuQuad 200 RGA), set to 200AMU scan range, was used to collect RGA (residual gas analysis) data and to measure total chamber pressure. After initial conditioning of the system, a background spectrum was recorded together with the total pressure in the test chamber.

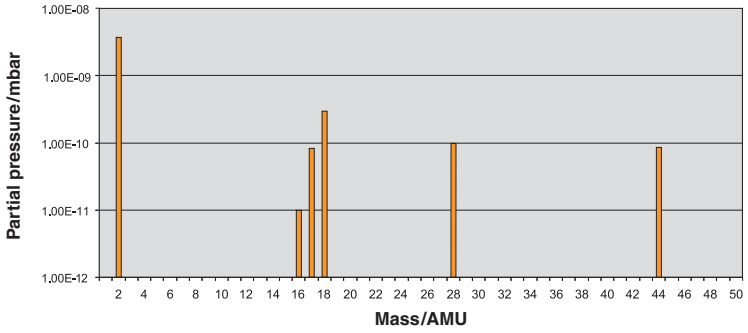
The component was placed in the vacuum chamber (0.015 m^3) and the system was then pumped using an KJL Lion 802 (800/s) diode ion pump and a Divac diaphragm pump at ambient temperature for 24 hours, after which a background scan and the total pressure in the test chamber were recorded again. If the system pressure was better than 5×10^{-9} mbar, the test specimen was baked at 120 °C for 48 hours. The system was then allowed to cool to ambient temperature before a final mass spectrum and the total pressure in the test chamber were recorded. These final RGA scans are shown below.

NOTE: Exact reproduction of these results should not be expected, as RGA data depends on many factors including environmental factors and initial chamber conditions. However, the data is fully representative of vacuum performance.

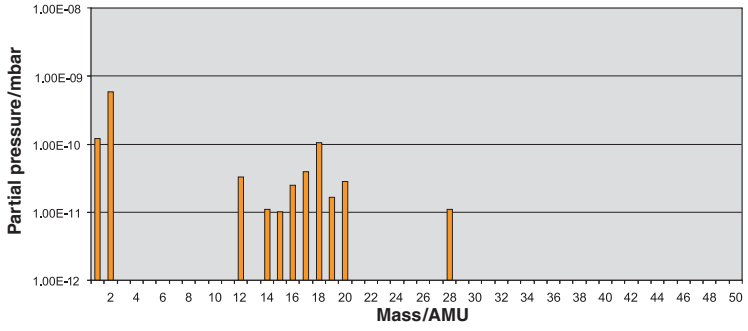
TONiC readhead with 1.0 m cable after bake-out (total pressure = 9.0×10^{-10} mbar)



RSLM20 linear scale (180 mm length) with 2 clips and 1 clamp after bake-out (total pressure = 3.0×10^{-10} mbar)

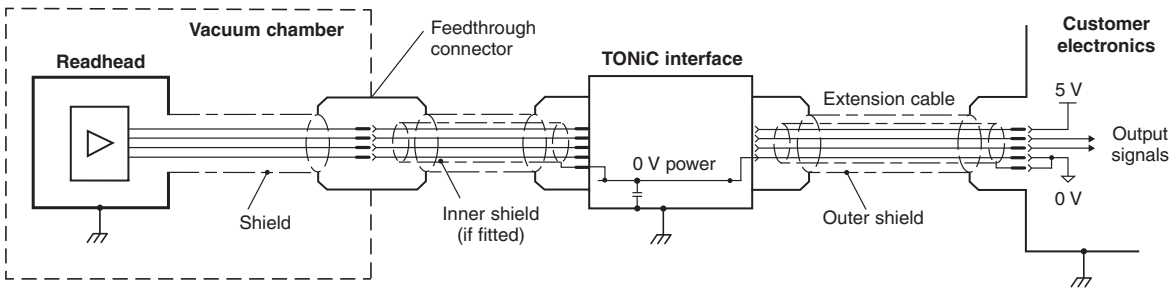


RESM20 (Ø115 mm) after bake-out (total pressure = 7.76×10^{-10} mbar)



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.

Maximum cable length

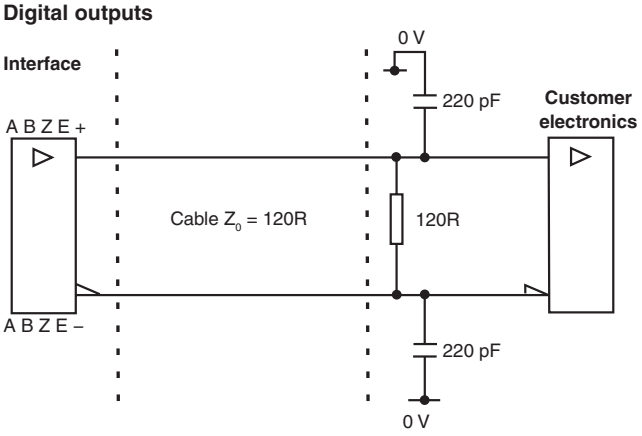
Readhead to interface: 10 m

Interface to controller: Dependent on clocked output option. See table below for details.

Receiver clock frequency (MHz)	Maximum cable length (m)
40 to 50	25
< 40	50
analogue	50

Recommended signal termination

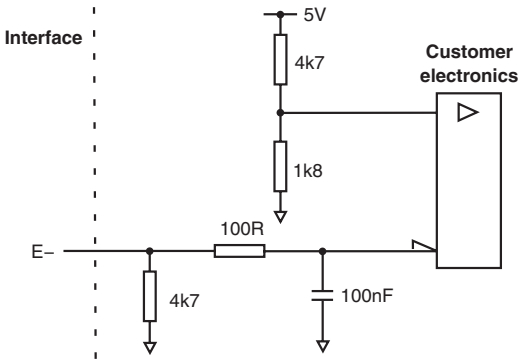
Digital outputs



Standard RS422A line receiver circuitry.
Capacitors recommended for improved noise immunity.

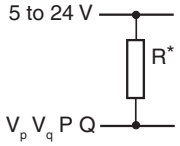
Single ended alarm signal termination

(Ti options A, B, C, D)



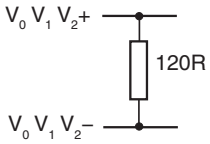
Limit outputs

(Ti interface only)



*Select R so maximum current does not exceed 20 mA. Alternatively, use a suitable relay or opto-isolator.

Analogue outputs



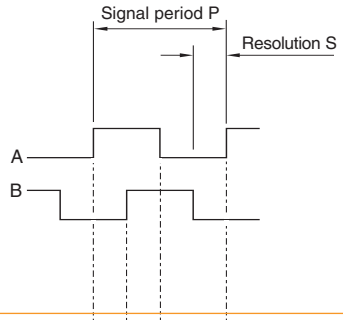
Output specifications

Digital output signals

Interface models Ti0004 - Ti20KD and TD4000 - TD0040

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

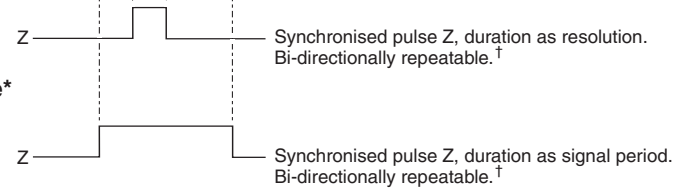
Incremental* 2 channels A and B in quadrature (90° phase shifted)



Model	P (µm)	S (µm)
Ti0004	20	5
Ti0020	4	1
Ti0040	2	0.5
Ti0100	0.8	0.2
Ti0200	0.4	0.1
Ti0400	0.2	0.05
Ti1000	0.08	0.02
Ti2000	0.04	0.01
Ti4000	0.02	0.005
Ti10KD	0.008	0.002
Ti20KD	0.004	0.001

Reference*

Wide reference*

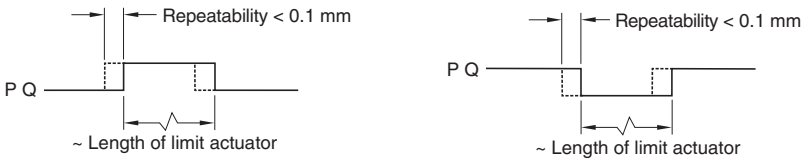


NOTES:
Select 'standard' or 'wide' reference at time of ordering, to match the requirements of the controller being used.
Wide reference mark not available on Ti0004.

Limits Open collector output, asynchronous pulse

Digital Ti interfaces only

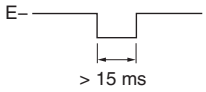
Active high **or** **Active low**



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

Alarm*

Line driven (Asynchronous pulse)



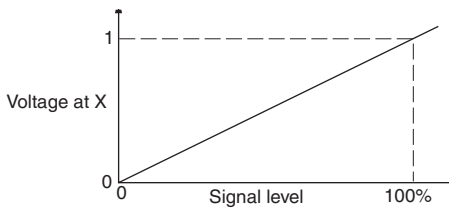
Alarm asserted when:
– Signal amplitude < 20% or > 135%
– Readhead speed too high for reliable operation

Inverse signal E+ only available for Ti options E, F, G and H.

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.

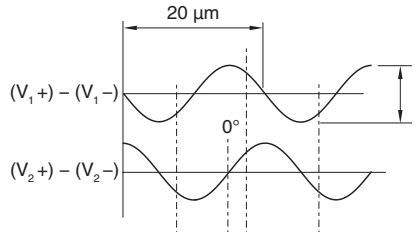
* Inverse signals not shown for clarity.
† Only calibrated reference mark is bi-directionally repeatable.
‡ Set-up signal as shown is not present during calibration routine.

Output specifications (continued)

Analogue output signals

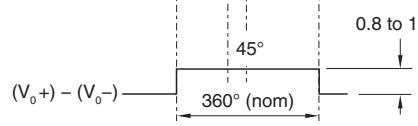
Interface model Ti0000 and direct output from all readheads

Incremental 2 channels V1 and V2 differential sinusoids in quadrature, centred on ~1.65 V (90° phase shifted)



0.7 to 1.35 Vpp with green LED indication (readhead) and 120R termination.
NOTE: Ti0000A00V centred on 2.5 V.

Reference

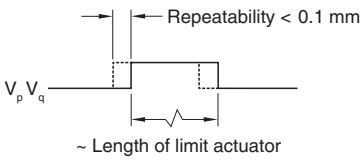


Bi-directionally repeatable.†
Differential pulse V_0 centred on 45°.

Limits Open collector output, asynchronous pulse

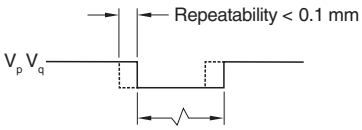
Ti0000 interface only

Active high



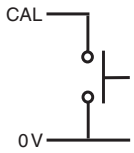
Direct output from readhead

Active low



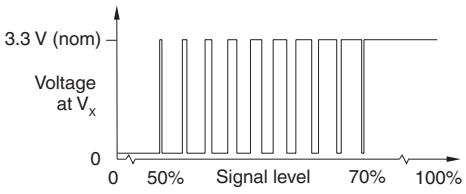
NOTE: Ti0000 interface contains a transistor to invert the readhead's 'active low' signal to give an 'active high' output.

Remote CAL operation (analogue versions only)



All Ti and TD interfaces include a push-button switch to enable CAL/AGC features.
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.

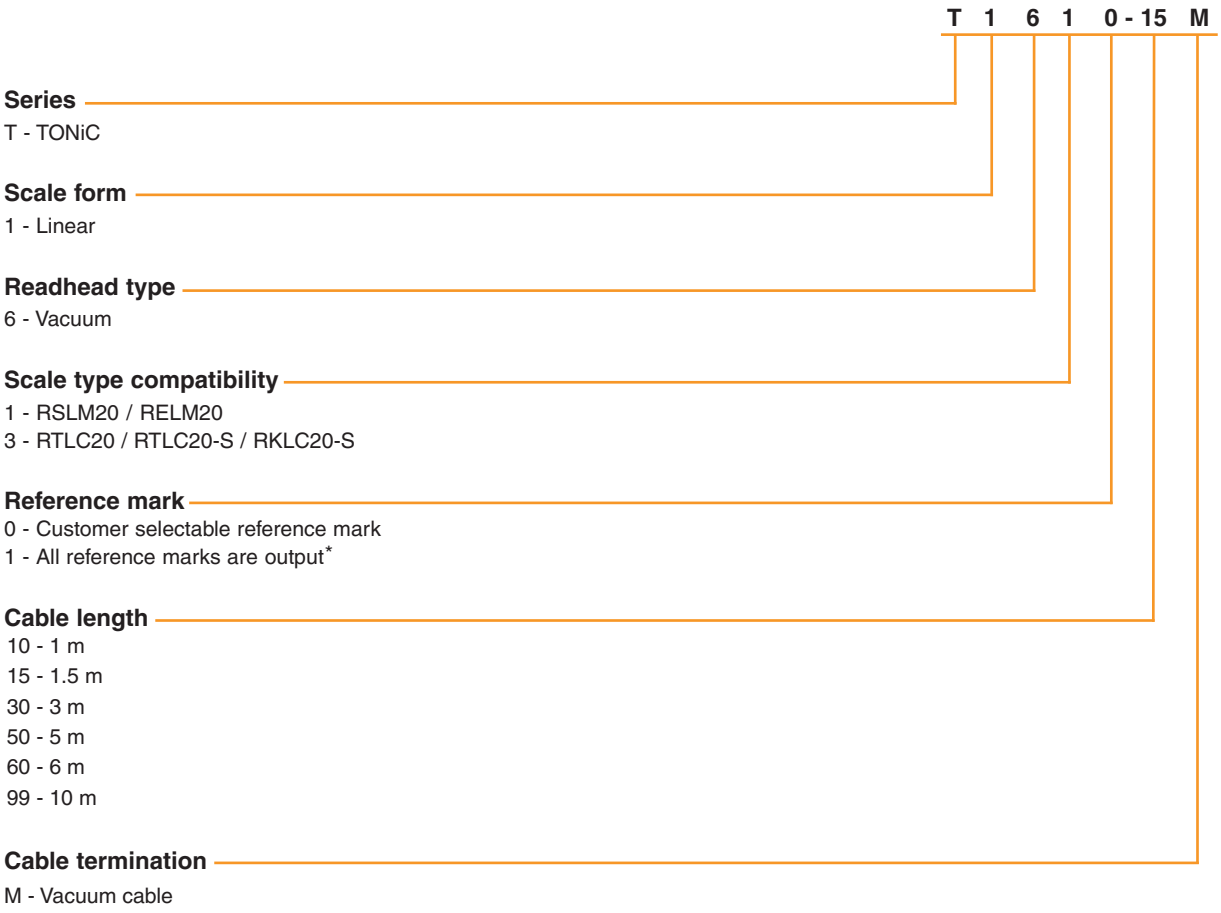
Set-up*



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 signal as shown is not present during calibration routine.
† Only calibrated reference mark is bi-directionally repeatable.

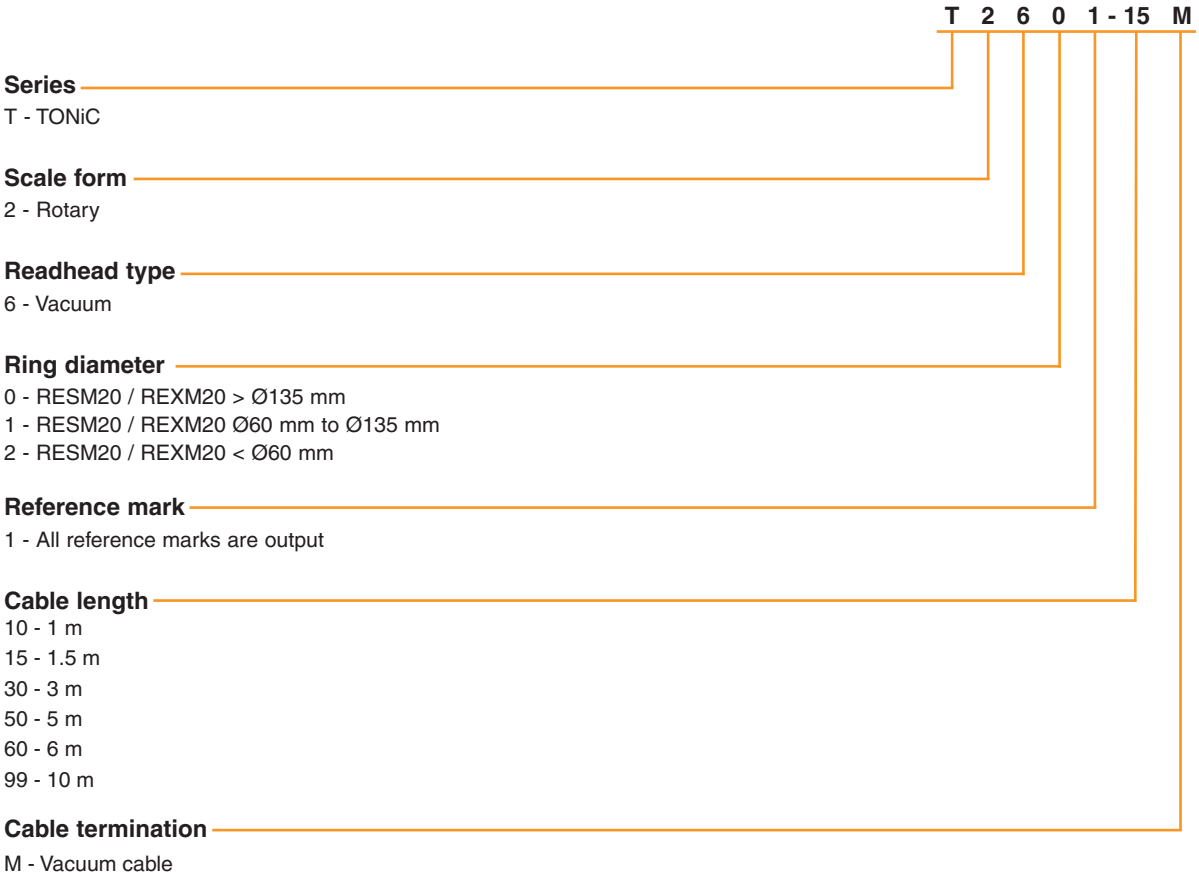
Linear readhead part numbers



* Only calibrated reference mark is bi-directionally repeatable.

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

Rotary readhead part numbers



Please contact your local Renishaw representative if you require a partial arc application.

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

Ti interface part numbers

Compatible with all TONiC readheads

Analogue:

Ti 0000 A 00 A

Options
A - Dual active high limits
V - 2V5 Vmid dual active high limits

Digital:

Ti 0200 A 20 A

Series
Ti - TONiC interface

Interpolation factor/resolution*

0004 - 5 µm	1000 - 20 nm
0020 - 1 µm	2000 - 10 nm
0040 - 0.5 µm	4000 - 5 nm
0100 - 0.2 µm	10KD - 2 nm
0200 - 0.1 µm	20KD - 1 nm
0400 - 50 nm	

Alarm format and conditions†
A - Line driven E output; All alarms
B - Line driven E output; Low signal and high signal alarms only
E - 3 state; All alarms
F - 3 state; Low signal and high signal alarms only

Clocked output option†

50 - 50 MHz	10 - 10 MHz
40 - 40 MHz	08 - 8 MHz
25 - 25 MHz	06 - 6 MHz
20 - 20 MHz	04 - 4 MHz
12 - 12 MHz	01 - 1 MHz

Options
A - P/Q limits – 'active high', standard reference mark
B - P/Q limits – 'active low', standard reference mark
C - P/Q limits – 'active high', wide reference mark‡
D - P/Q limits – 'active low', wide reference mark‡
E - Q limit only – 'active high', differential alarm, standard reference mark
F - Q limit only – 'active low', differential alarm, standard reference mark
G - Q limit only – 'active high', differential alarm, wide reference mark‡
H - Q limit only – 'active low', differential alarm, wide reference mark‡

* Additional interpolation factors available. Contact your local Renishaw representative for further details.
† When using with a DSi, the interface should be configured with line driven alarm outputs and a clocked output option of 01, 04, 06, 08, 10, 12 or 20.
‡ Wide reference mark not available on Ti0004 (5 µm) interfaces.

NOTE: Only the readhead is UHV compatible, the Ti interface must be kept outside of the vacuum chamber.

NOTE: Not all combinations are valid. Check valid options online at **www.renishaw.com/epc**

TD interface part numbers

Compatible with all TONiC readheads

Dual resolution:

TD 4000 A 20 A

Series

TD - TONiC dual resolution

Interpolation factor/resolution*

Pin 10 open	Pin 10 - 0 V
4000 - 5 nm	10 nm
2000 - 10 nm	20 nm
1000 - 20 nm	40 nm
0400 - 50 nm	0.1 µm
0200 - 0.1 µm	0.2 µm
0040 - 0.5 µm	1 µm

Alarm format and conditions†

A - Line driven, differential output; All alarms
B - Line driven, differential output; Low signal and high signal alarms only
E - 3 state; All alarms
F - 3 state; Low signal and high signal alarms only

Clocked output option†

50 - 50 MHz	10 - 10 MHz
40 - 40 MHz	08 - 8 MHz
25 - 25 MHz	06 - 6 MHz
20 - 20 MHz	04 - 4 MHz
12 - 12 MHz	01 - 1 MHz

Options

A - Standard reference mark
B - Wide reference mark

* Contact Renishaw for other interpolation factors.
† When using with a DSi, the interface should be configured with line driven alarm outputs and a clocked output option of 01, 04, 06, 08, 10, 12 or 20.

NOTE: Only the readhead is UHV compatible, the TD interface must be kept outside of the vacuum chamber.

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

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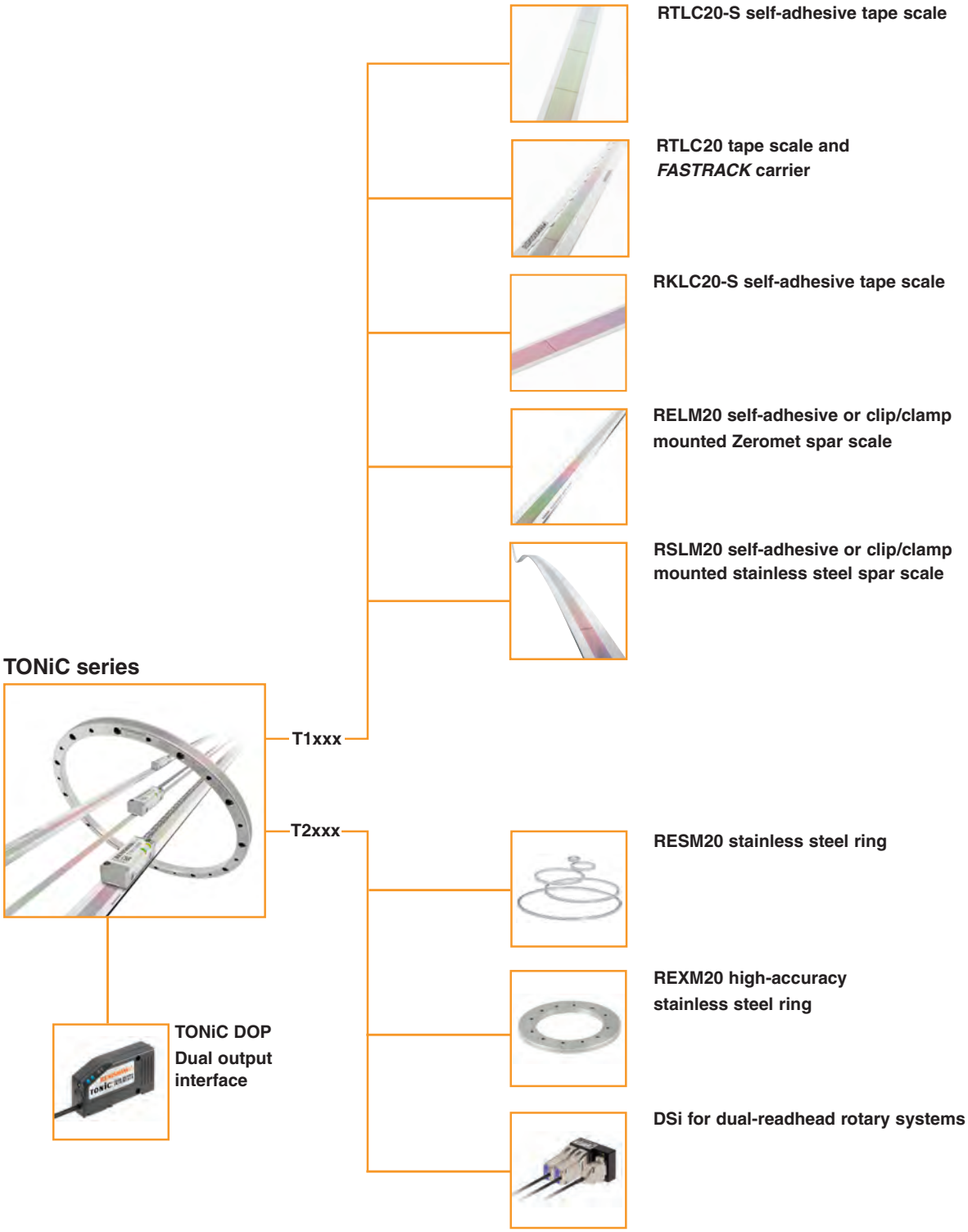
TONiC UHV compatible products:



For worldwide contact details, visit www.renishaw.com/contact

Part no.: L-9517-9426-03-E
Issued: 12.2022

Data sheet
L-9517-9466-01-E

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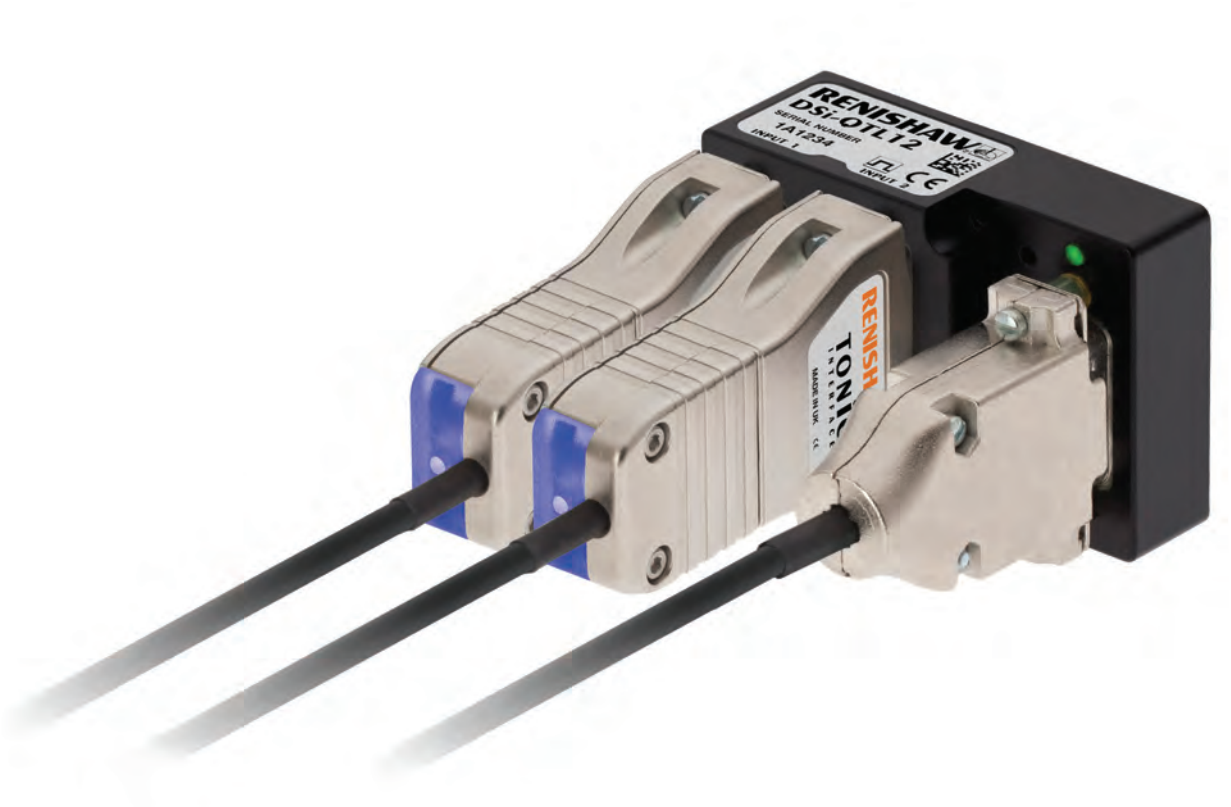
TONiC™ DSi dual readhead rotary encoder system



DSi brings higher accuracy to rotary axes whilst *propoZ*™ technology offers a selectable reference mark position.

Using two readheads on an angle encoder improves the accuracy of the system by eliminating eccentricity, bearing wander and all odd error harmonics. DSi makes adding that second readhead easy by taking care of the combination of incremental channels and reference mark processing.

DSi features patented *propoZ* technology that allows the customer to select reference output position with the press of a button.

The *propoZ* output position is angularly repeatable, regardless of bearing wander or power cycling.

DSi is available in two versions, known as 'local' and 'remote'. The local version is mounted directly onto the readhead interfaces, while the remote version can be mounted up to 30 metres away.

Each version is available with either line-driven or 3-state alarms.

Resolution is determined by the encoder interfaces that are connected to the DSi.

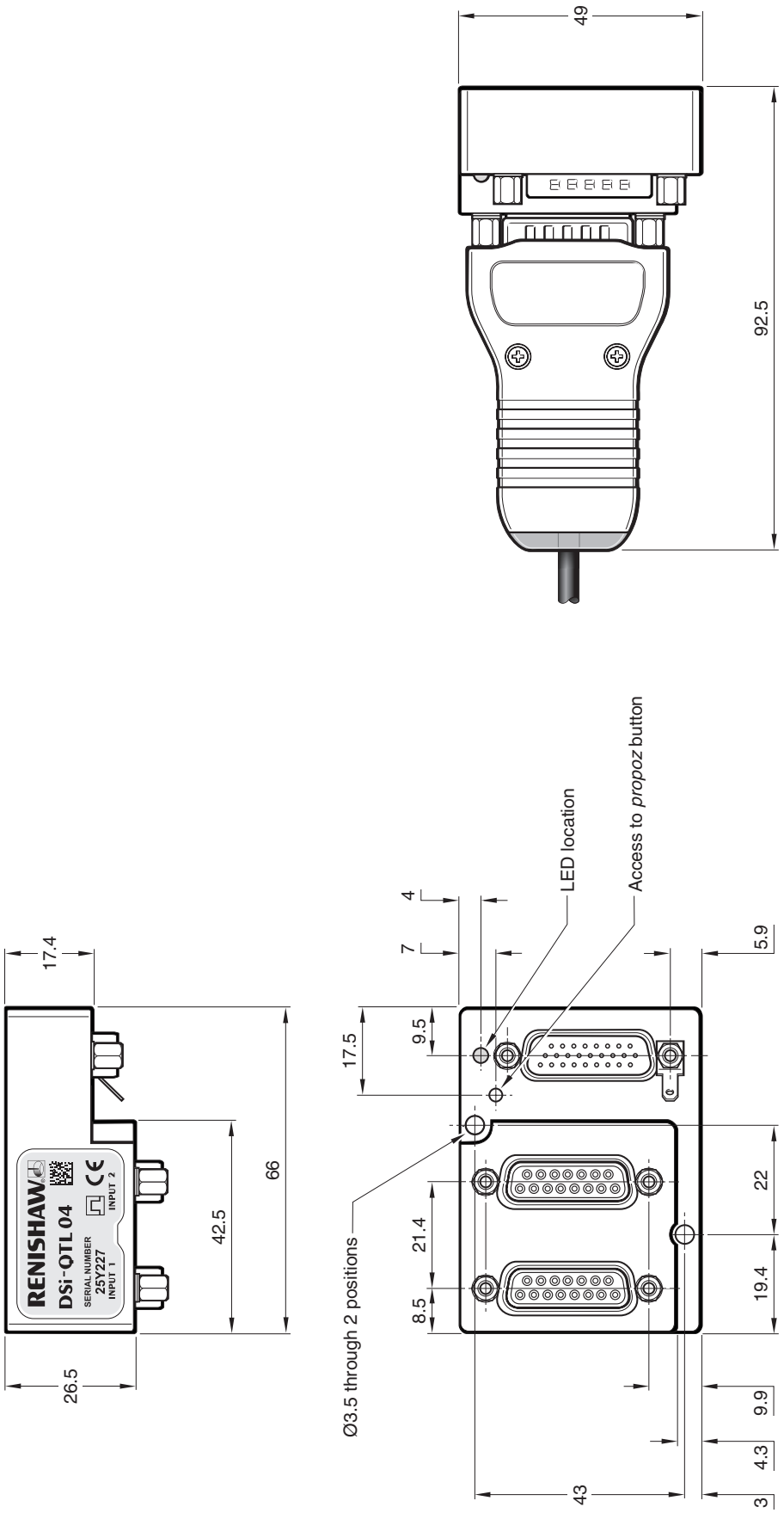
DSi is available with several retiming frequencies to suit industry-standard controllers.

Version now available for partial arc applications.

- **Works with TONiC™ system angle encoders to give very high accuracy**
- **Compensates encoder measurement errors caused by:**
  - **bearing wander**
  - **eccentricity**
  - **all odd error harmonics**
- ***propoZ* customer-selected reference output position**
- ***propoZ* is angularly repeatable and unaffected by bearing wander or power cycling**
- **'Local' version mounts directly onto the rear of the TONiC system interfaces**
- **'Remote' version can be located up to 30 metres from the TONiC system interfaces**
- **RS422 digital quadrature signals**

DSi installation drawing

Dimensions and tolerances in mm



General specifications

Power supply		5V +10%	1 amp maximum when terminated with 120 ohms. Renishaw encoder systems must be powered 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
	(readhead)	Operating	0 °C to +70 °C
	(interface + DSi)	Operating	0 °C to +70 °C
Humidity			95% relative humidity (non-condensing) to IEC 60068-2-78
Sealing		Readhead	IP40
		Ti interface	IP20
		DSi	IP20
Acceleration (readhead)		Operating	500 m/s², 3 axes
DSi unit only			
Shock		Non-operating	1000 m/s², 6 ms, ½ sine, 3 axes
Vibration		Operating	50 m/s², 55 Hz to 2000 Hz, 3 axes
Mass		Readhead	10 g
		Interface	100 g
		DSi	85 g
		Cable	26 g/m
EMC compliance (system)			IEC 61326-1
Environmental			Compliant with EU Directive 2002/95/EC (RoHS)
Readhead cable			Double-shielded, outside diameter 4.25 ±0.25 mm Flex life > 20 × 10^6 cycles at 20 mm bend radius UL recognised component
Maximum cable length		Readhead to interface	10 m
		Interface to DSi (remote version) and DSi to controller	

Output frequency (MHz)	Maximum cable length (m)
15 to 20	25
≤ 14	30

NOTE: When using extension cables customers should ensure correct voltage at DSi unit and also correct voltage at TONiC system interface for remote versions.

The TONiC and DSi encoder system conforms to the relevant harmonised European standards for electromagnetic compatibility, but must be correctly integrated to achieve EMC compliance. In particular, attention to shielding arrangements is essential.

The *propoZ* reference output

Reference mark position

On a single readhead system the TONiC encoder outputs a reference signal when the *IN-TRAC*™ reference mark passes the readhead. However, because the DSi system uses two encoders it can apply further processing to the reference signal to increase the angular repeatability of the zero position, thus improving the metrology of the complete system. Instead of outputting a reference signal when the *IN-TRAC* reference mark passes a readhead, the DSi outputs a reference signal at the position selected by the customer. This new standard in metrology is called *propoZ*.

Reference mark repeatability

The *propoZ* position is angularly repeatable, regardless of bearing wander or power cycling. Furthermore, the position is even repeatable if the centre of rotation changes while the axis is switched off. This is achieved because the DSi determines the centre of rotation by using the physical *IN-TRAC* reference mark. The DSi performs this calculation every time it is switched on.

DSi initialisation

To determine the *propoZ* position the *IN-TRAC* reference mark must pass both readheads, so the axis may need to be rotated up to one full revolution. This occurs each time the DSi is switched on, or after an alarm condition has occurred. After initialisation the DSi will then give the *propoZ* reference output each time it arrives at the customer-determined *propoZ* position.

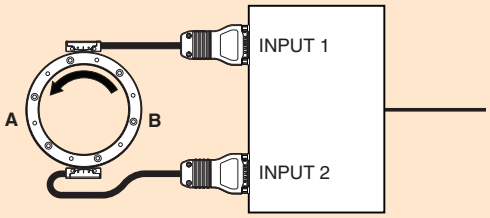
DSI-QT will not work in partial rotary applications unless during the first initialisation (calibration) a full 360° rotation can be achieved so that it can 'learn' the pulse count.

For partial arc applications a REST or REXT ring with two reference marks is required with a DSi-QU (see part number section for more details).

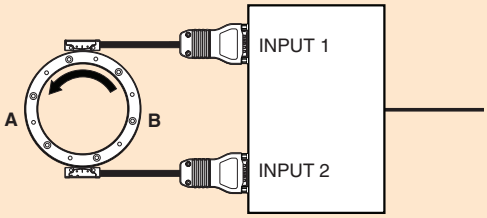
Readhead orientation

The DSi enables any readhead orientation to be selected with a switch. The configuration shown below in 'Option 1' should be used where possible, to achieve the highest accuracy. 'Option 2' can be used where space is limited, but the accuracy will be degraded. Please contact your local Renishaw representative for further details.

Option 1: recommended for highest accuracy

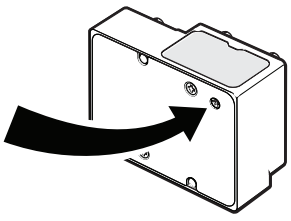


Option 2: alternative configuration, only for applications where space is limited. Accuracy will be degraded



For more information refer to the TONiC DSi installation guide.

Ensure that the orientation switch is set correctly for your application. Refer to the DSi installation guide.



Resolution

The output resolution of DSi is determined by the resolution of the TONiC encoders connected to the DSi. TONiC interfaces are available in the following resolutions: 5 µm, 1 µm, 0.5 µm, 0.2 µm, 0.1 µm, 50 nm, 20 nm, 10 nm, 5 nm, 2 nm and 1 nm.

NOTE: DSi does not work with analogue versions of TONiC.

Retiming

DSi is available with the following retiming frequencies: 20 MHz, 12 MHz, 10 MHz, 8 MHz, 6 MHz, 4 MHz and 1 MHz. These figures refer to the minimum counter clock frequency required of the host controller. There is no 40 MHz or 50 MHz version.

As with a single readhead system, the retiming frequency should be selected so that it is the same or slower than the counter clock frequency of the receiving electronics. The retiming frequency of the Ti interfaces should match that of the DSi, although it is OK to use Ti interfaces with slower retiming frequencies. Do not use Ti interfaces that have a faster retiming frequency than the selected DSi.

Example: If the counter clock frequency of the receiving electronics is 14 MHz, the 12 MHz DSi and 12 MHz, Ti interfaces should be used.

Refer to the *TONiC encoder system* data sheet (Renishaw part number L-9517-9337) for further details.

Accuracy

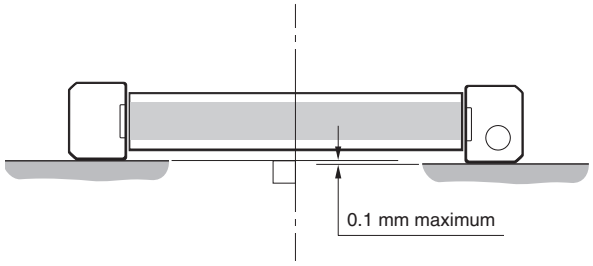
DSi compensates the effects of bearing wander and eliminates all odd error harmonics including eccentricity. However, 'even' error harmonics such as ovality remain. The total installed error is affected by the spread of error harmonics, but in most RESM/REST installations with two readheads, the total installed error generally increases if the supporting shaft is eccentric because the ring is swashed to correct the eccentricity. For the highest accuracy the roundness (including eccentricity) of the supporting shaft should be controlled to the values shown in the table here:

Recommended taper roundness when using two heads and DSi

Diameter (mm)	Roundness value (mm TIR)
≤ 115	0.0125
150 to 255	0.025
≥ 300	0.0375

Swash of the ring can also induce a once-per-revolution component that is not compensated by the DSi box. To minimise this, the following conditions must be met:

- The readheads should be mounted on the same mounting face, i.e. the cables should be pointing in opposite directions. This ensures that the optical centrelines are coincident upon the ring.
- The axial misalignment of the readhead mounting faces should be within 0.1 mm, as shown in the diagram. Again, this ensures that the optical centrelines are coincident upon the ring.



For optimum accuracy performance, the readheads should be mounted diametrically opposite each other so that the optical centrelines are 180 ±1° apart.

NOTE: For ring alignment in partial arc applications refer to the RESM/REST or REXM/REXT installation guides.

The total installed accuracy of an A-section ring RESM/REST installed so that the radial deflection measured at the screw locations agrees to within ±3 µm and using two TONiC encoders and DSi will be as described in the following table.

Ring diameter (mm)	Typical installed accuracy (arc seconds)	Worst case accuracy (arc seconds)
52	±3.4	±9.3
57	±3.2	±8.6
75	±2.6	±7.0
100	±2.2	±5.5
103	±2.1	±5.4
104	±2.1	±5.4
115	±2.0	±5.0
150	±1.6	±4.0
200	±1.3	±3.2
206	±1.3	±3.1

Ring diameter (mm)	Typical installed accuracy (arc seconds)	Worst case accuracy (arc seconds)
209	±1.3	±3.1
229	±1.2	±2.9
255	±1.1	±2.7
300	±1.0	±2.3
350	±0.9	±2.1
413	±0.8	±1.8
417	±0.8	±1.8
489	±0.7	±1.6
550	±0.6	±1.5

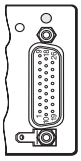
It should be noted that although the use of two readheads compensates the effects of bearing wander upon the encoder reading, in most applications there are metrology effects that are associated with the workpiece moving as the bearing wanders.

REXM/REXT accuracy

Total installed accuracy of REXM/REXT with two TONiC encoders and DSi will be better than ±1 arc second.

Connections

DSi output



26-way 'D' type plug

Function	Output type	Signal	Output
Power	-	5 V power	26
		5 V sense	18
		0 V power	9
		0 V sense	8
Incremental signals	RS422A	A+	24
		A–	6
		B+	7
		B–	16
Reference mark	RS422A	Z+	15
		Z–	23
Alarm†	RS422A	E+	25
		E–	17
Limits*	Open collector	P	4
		Q	13
Initialization 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

† Alarm format can be 3-state or line driven. Please specify at time of ordering (refer to part numbers on back page of this data sheet).
NOTE: Although the DSi can be supplied to output alarms in either line-driven or 3-state alarm formats, the input to the DSi must be a Ti interface configured with line-driven alarm format only.

* Limit switch outputs are taken directly from the readhead connected to input 1.

Electrical connections

Connecting a separate power supply

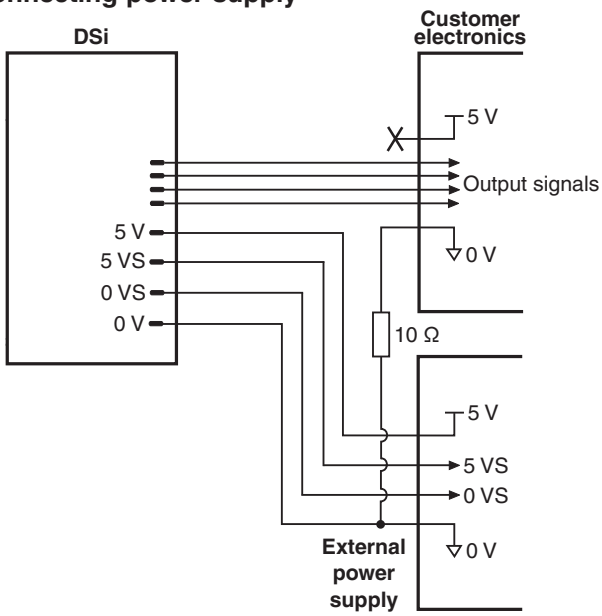
Many controllers cannot supply 1 amp at 5 volts, so it may be necessary to connect a separate power supply.

To ensure correct operation, the separate power supply should be connected as per the diagram opposite.

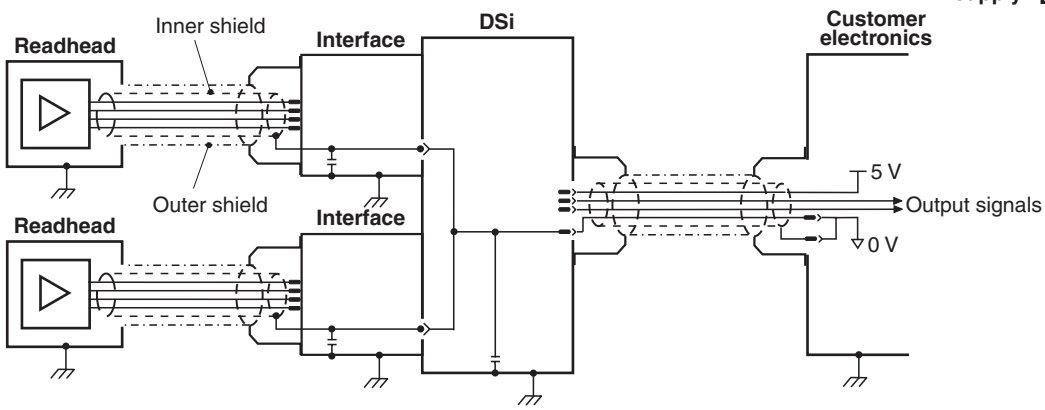
The 0 V of the separate power supply should be connected to the 0 V of the controller to ensure that the line driver in the DSi and line receiver in the controller are using the same reference voltage.

The 10 ohm resistor minimises current flow due to different 0 V potentials.

Connecting power supply

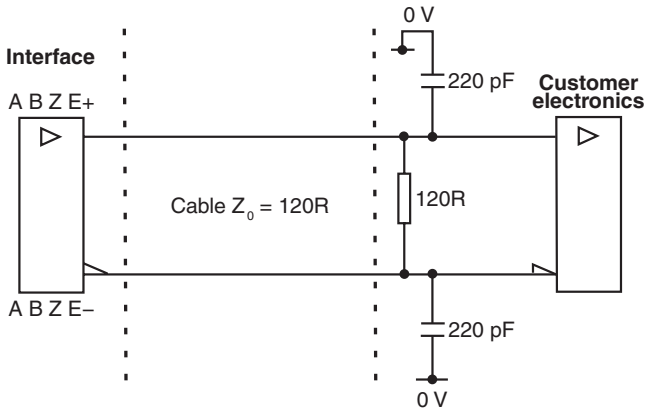


System grounding and shielding



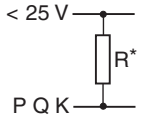
Recommended signal termination

Digital outputs



Standard RS422A line receiver circuitry.
Capacitors recommended for improved noise immunity.

Limits and initialisation monitor outputs

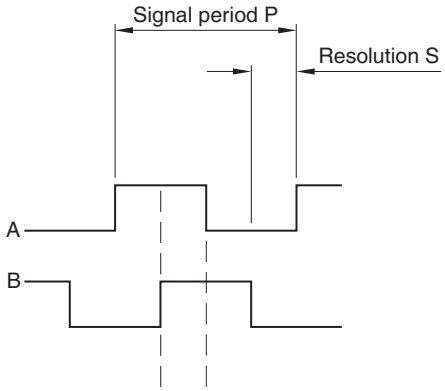


* Select R so max. current does not exceed 20 mA. Alternatively, use a suitable relay or opto-isolator.

DSi output specifications

Form – Square wave differential line driver to EIA RS422A
(except limit switch and initialisation monitor)

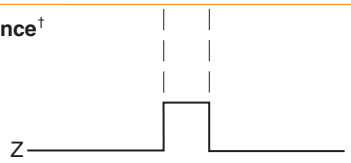
Incremental† 2 channels A and B in quadrature (90° phase shifted)



Resolution and retiming frequency are determined by the TONiC Ti interfaces connected to the DSi.

Always ensure that the two Ti interfaces have the same part numbers.

***propoZ* reference**†



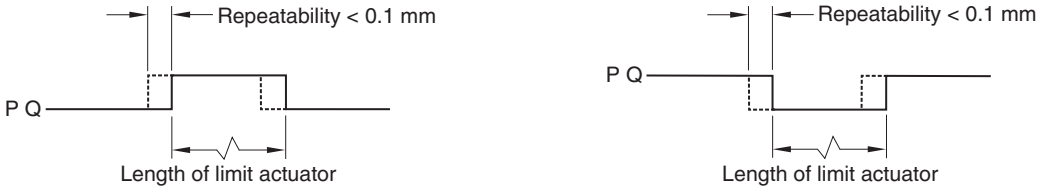
Synchronised pulse Z, duration as resolution S.

Customer-positionable.

To maintain angular repeatability regardless of bearing wander, the *propoZ* reference output will be re-synchronised at power-up with any one of the quadrature states (00, 01, 11, 10).

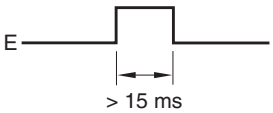
Limits
Open collector output, asynchronous pulse

Active high **or** **Active low**



DSi outputs the limit switch from the encoder connected to input 1.

Alarm†

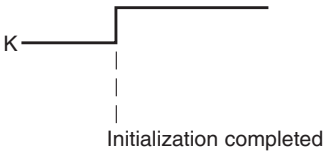


3-state or line-driven alarm format should be chosen at time of order.*

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

Miscount alarm will be cleared when DSi detects correct count.

Initialisation monitor
Open collector output



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

† Inverse signals not shown for clarity.

* Ensure only Ti interfaces with line-driven alarm are connected to the DSi.

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Part numbers

The partial arc DSi (DSi-QU) system should only be considered when:

- The customer has an axis which is limited to < 360° rotation.
- The readheads can be diametrically opposed as per full axis DSi.

The partial arc DSi should always be used with an encoder ring which has two reference marks. These being either rings with a prefix of REST or REXT (the T denoting 'two').

The current structure for DSi is as follows:

Interface part number **DSi-Q T L 12**

Series

Input state
Q = Quadrature

Interface and ring types:
T = TONiC Ti with RESM/REXM (one reference mark)
U = TONiC Ti with REST/REXT (two reference marks) for partial arc applications

Output options
L = Local, line-driven alarm signal, standard reference mark
M = Local, 3-state alarm signal, standard reference mark
R = Remote, line-driven alarm signal, standard reference mark
S = Remote, 3-state alarm signal, standard reference mark

Receiver clock frequency (MHz)
1, 4, 6, 8, 10, 12, 20

NOTE: If a variant of the DSi is not currently available please speak to Renishaw UK so that this part can be added to the sales system.

For worldwide contact details, visit www.renishaw.com/contact

Part no.: L-9517-9466-01-E
Issued: 12.2022

Data sheet
L-9517-9411-03-E

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TONiC™ DOP (dual output) encoder system

Renishaw's TONiC series encoders are now available with simultaneous dual output interfacing.

The robust DOP interface can be situated up to 10 m from the TONiC readhead and offers simultaneous analogue and digital outputs with interpolation to 1 nm resolution. Digital outputs are clocked for optimised speed performance at all resolutions for industry-standard controllers.

The readhead is compatible with a wide range of linear, partial arc and rotary scales with bi-directional optical *IN-TRAC*™ reference marks.

For ultimate reliability and high dirt immunity, TONiC readheads incorporate Renishaw's market proven filtering optics, tuned for even lower noise (jitter), further enhanced by dynamic signal processing including Auto Gain Control (AGC) and Auto Offset Control (AOC). The result is ultra-low sub-divisional error (SDE) giving smoother velocity control for improved scanning performance and increased positional stability.

- **Compact readhead (35 mm × 13.5 mm × 10 mm)**
- **Detachable DOP interface with integral interpolation to 1 nm resolution (0.00075 arc seconds) and simultaneous digital and analogue outputs**
- **Compatible with a wide range of linear, partial arc and rotary scales with customer-selectable *IN-TRAC* auto-phase optical reference mark (datum)**
- **Optimised filtering optics for even lower noise (jitter)**
- **Dynamic signal processing inside the readhead, provides ultra-low SDE of typically ±30 nm**
- **Auto Gain Control ensures consistent signal strength for long-term reliability**
- **Increased ride height tolerance and integral set-up LED for ease of installation**
- **Maximum speed to 10 m/s (3.24 m/s at 0.1 µm resolution)**
- **Integral dual limits (linear only)**
- **Operating temperature to 70 °C**

Compatible scales

Linear scales

	RTLC20-S	RTLC20/*FASTRACK*™	RKLC20-S†
	Self-adhesive mounted stainless steel tape scale	Stainless steel tape scale and self-adhesive mounted carrier	Self-adhesive mounted stainless steel tape scale
			
Form (H × W)	0.4 mm × 8 mm including adhesive	RTLC20 scale: 0.2 mm × 8 mm *FASTRACK* carrier: 0.4 mm × 18 mm including adhesive	0.15 mm × 6 mm including adhesive
Accuracy (includes slope and linearity)	±5 µm/m	±5 µm/m	±5 µm/m
Linearity (Figures achievable with two-point error correction)	±2.5 µm/m	±2.5 µm/m	±2.5 µm/m
Maximum length	10 m* (> 10 m available on request)	10 m (> 10 m on available request)	20 m (> 20 m available on request)
Coefficient of thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C	10.1 ±0.2 µm/m/°C	Matches that of substrate material when scale ends fixed by epoxy mounted end clamps

* For RTLC20-S axis lengths > 2 m, *FASTRACK* with RTLC20 is recommended.

† Suitable for partial arc applications. For more information refer to *RKL scale for partial arc applications* data sheet (Renishaw part no. L-9517-9897).

	RSLM20	RELM20
	Self-adhesive or clip/clamp mounted stainless steel spar scale	Self-adhesive or clip/clamp mounted low-expansion ZeroMet™ spar scale
		
Form (H × W)	1.5 mm × 14.9 mm	1.6 mm × 14.9 mm
Accuracy (includes slope and linearity)	±4 µm (Total accuracy over a complete 5 m length)	±1 (Total accuracy up to 1 m)
Linearity (Figures achievable with two-point error correction)	N/A	N/A
Maximum length	5 m	1.5 m
Coefficient of thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C	0.75 ±0.35 µm/m/°C

For more information about the scales refer to the relevant scale data sheet which can be downloaded from www.renishaw.com/tonicdownloads.

Rotary scales

	RESM20	REXM20
	Stainless steel ring	Ultra-high accuracy stainless steel ring
		
Accuracy	±1.9 arc second (Typical installed accuracy for 550 mm diameter RESM20 ring) *	±1 arc second † (Total installed accuracy for 417 mm diameter REXM20 ring)
Ring diameters	52 mm to 550 mm	52 mm to 417 mm
Coefficient of thermal expansion (at 20 °C)	15.5 ±0.5 µm/m/°C	15.5 ±0.5 µm/m/°C

* Typical' installations are a result of graduation and installation errors combining and, to some magnitude, cancelling.

† When using two readheads and an additional DSi interface.

For more information about the scales refer to the relevant scale data sheet which can be downloaded from www.renishaw.com/tonicdownloads.

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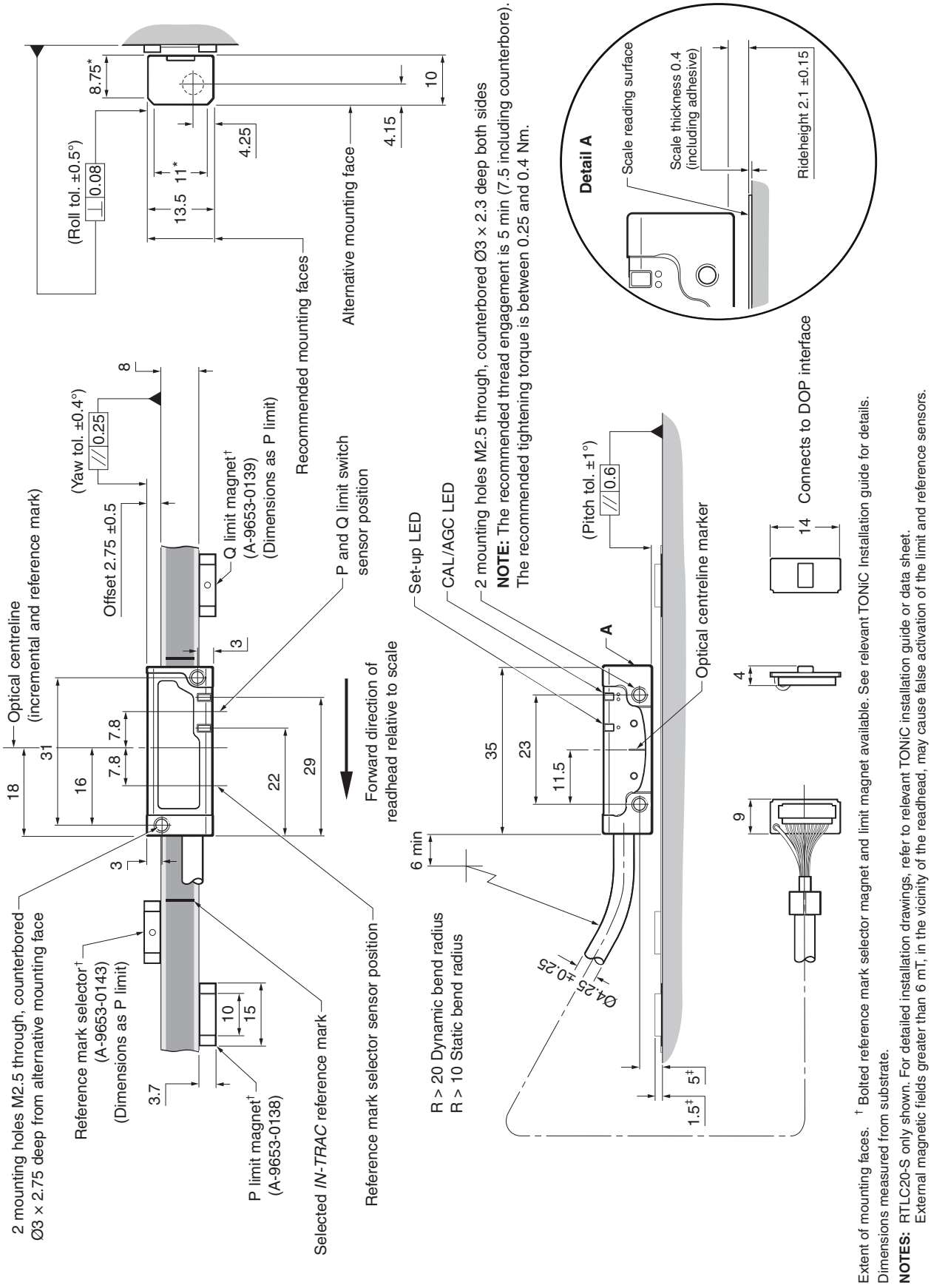
TONiC readhead installation drawing (on RTLC20-S scale)

Dimensions and tolerances in mm



* Extent of mounting faces. † Bolted reference mark selector magnet and limit magnet available. See relevant TONiC Installation guide for details.
‡ Dimensions measured from substrate.

NOTES: RTLC20-S only shown. For detailed installation drawings, refer to relevant TONiC installation guide or data sheet.
External magnetic fields greater than 6 mT, in the vicinity of the readhead, may cause false activation of the limit and reference sensors.

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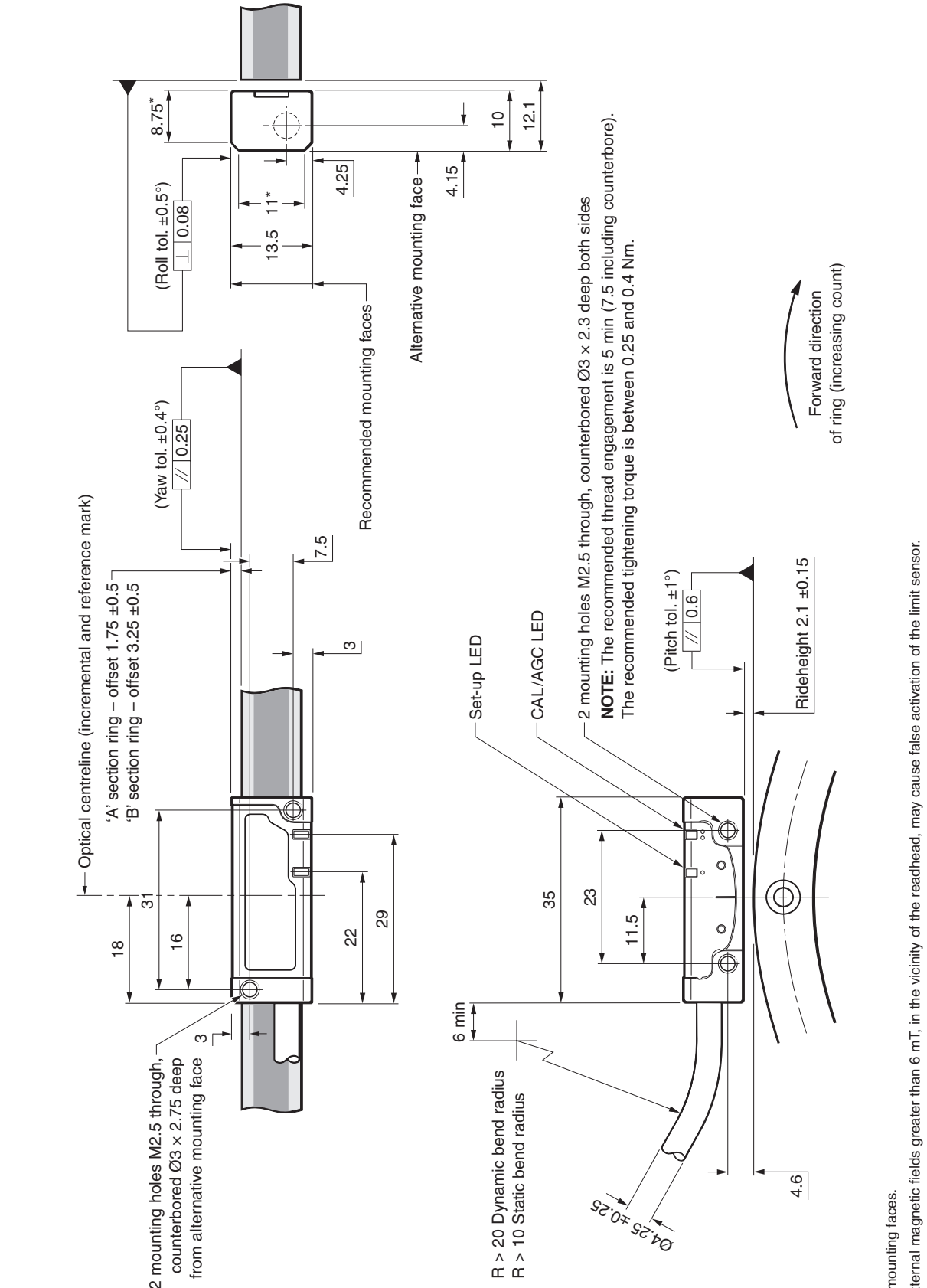
TONiC readhead installation drawing (on RESM20 ring)

Dimensions and tolerances in mm



* Extent of mounting faces.
NOTE: External magnetic fields greater than 6 mT, in the vicinity of the readhead, may cause false activation of the limit sensor.

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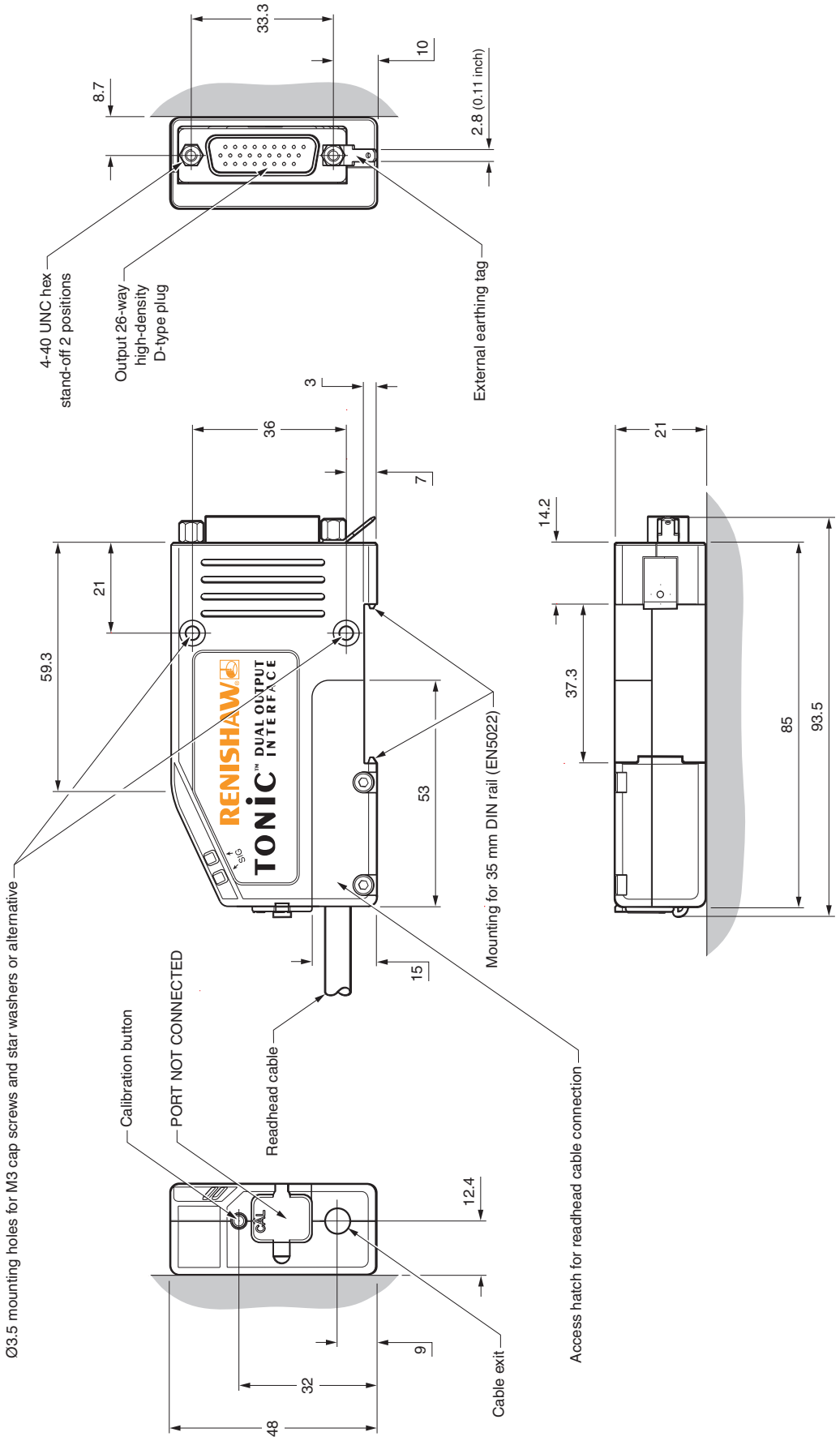
DOP interface dimension drawing

Dimensions and tolerances in mm



General specifications

Power supply	5V ±10%	Readhead only < 100 mA
		System < 275 mA (typical)
		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 120 R.
		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
Humidity (system)		95% relative humidity (non-condensing) to IEC 60068-2-78
Sealing (readhead)		IP40
(interface)		IP30
Acceleration (readhead)	Operating	500 m/s², 3 axes
Shock (system)	Non-operating	1000 m/s², 6 ms, ½ sine, 3 axes
Vibration (system)	Operating	100 m/s² max @ 55 Hz to 2000 Hz, 3 axes
Mass	Readhead	10 g
	Interface	205 g
	Cable	26 g/m
EMC compliance (system)		IEC 61326-1
Readhead cable		Double-shielded, outside diameter 4.25 ±0.25 mm
		Flex life > 20 × 10^6 cycles at 20 mm bend radius
		UL recognised component
Typical sub-divisional error (SDE)		±30 nm

Speed

Clocked output option (MHz)	Maximum speed (m/s)										
	DOP0004 5 µm	DOP0020 1 µm	DOP0040 0.5 µm	DOP0100 0.2 µm	DOP0200 0.1 µm	DOP0400 50 nm	DOP1000 20 nm	DOP2000 10 nm	DOP4000 5 nm	DOP10KD 2 nm	DOP20KD 1 nm
50	10	10	10	6.48	3.24	1.625	0.648	0.324	0.162	0.065	0.032
40	10	10	10	5.4	2.7	1.35	0.54	0.27	0.135	0.054	0.027
25	10	10	8.1	3.24	1.62	0.81	0.324	0.162	0.081	0.032	0.016
20	10	10	6.75	2.7	1.35	0.67	0.27	0.135	0.068	0.027	0.013
12	10	9	4.5	1.8	0.9	0.45	0.18	0.09	0.045	0.018	0.009
10	10	8	4.05	1.62	0.81	0.4	0.162	0.081	0.041	0.016	0.0081
08	10	6.48	3.24	1.29	0.648	0.324	0.13	0.065	0.032	0.013	0.0065
06	10	4.5	2.25	0.9	0.45	0.225	0.09	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)										

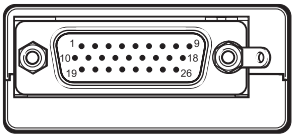
Angular speed depends on ring diameter – use the following equation to convert to rev/min:

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

Where V = maximum linear speed (m/s) and
D = external diameter of RESM20 or REXM20 ring (mm).

DOP output signals

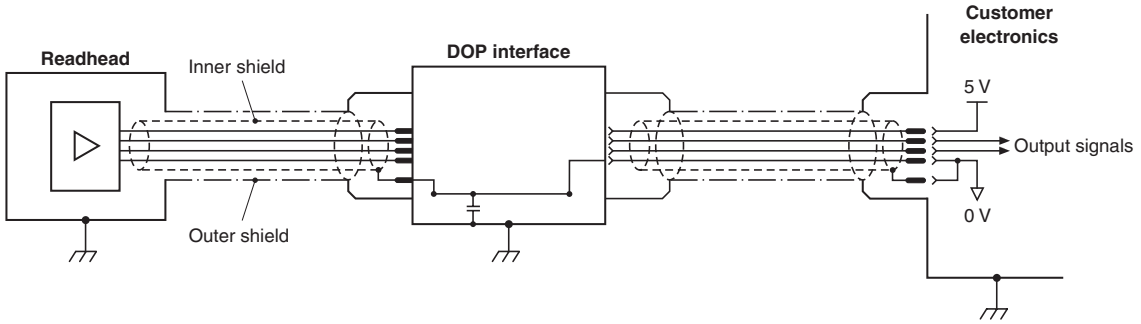
Function	Output signals		Signal	Pin
Power	-		5 V Power	26
			5 V Sense	18
			0 V Power	9
			0 V Sense	8
Incremental signals	RS422A digital		A+	24
			A–	6
			B+	7
			B–	16
	Analogue	Cosine	V_1+	1
			V_1–	19
		Sine	V_2+	2
			V_2–	11
Reference mark	RS422A digital		Z+	15
			Z–	23
	Analogue		V_0+	12
			V_0–	20
Alarm	RS422A digital		E+	25
			E–	17
Limits	Open collector		P	4
			Q	13
Readhead set-up	-		X	10
Shield	-		Inner shield	Not connected
	-		Outer shield	Case



26-pin high-density D-type plug

Electrical connections

System 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: The external earthing tag on the interface should be used when mounting the interface on a DIN rail.

Maximum cable length

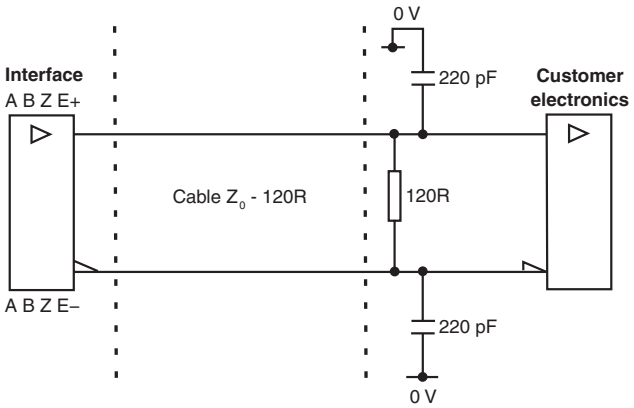
Readhead to interface: 10 m

Interface to controller: Dependent on clocked output option. See table below for details.

Receiver clock frequency (MHz)	Maximum cable length (m)
40 to 50	25
< 40	50
analogue	50

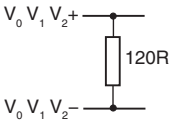
Recommended signal termination

Digital outputs

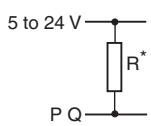


Standard RS422A line receiver circuitry.
Capacitors recommended for improved noise immunity.

Analogue outputs



Limit outputs



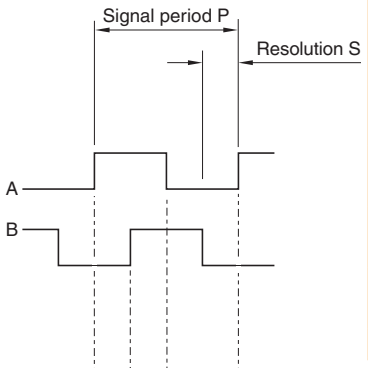
* Select R so maximum current does not exceed 20 mA.
Alternatively, use a suitable relay or opto-isolator.

Output specifications

Digital output signals

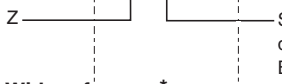
Form – Square wave differential line driver to EIA RS422A (except limits P and Q)

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



Model	P (µm)	S (µm)
DOP0004	20	5
DOP0020	4	1
DOP0040	2	0.5
DOP0100	0.8	0.2
DOP0200	0.4	0.1
DOP0400	0.2	0.05
DOP1000	0.08	0.02
DOP2000	0.04	0.01
DOP4000	0.02	0.005
DOP10KD	0.008	0.002
DOP20KD	0.004	0.001

Reference*



Synchronised pulse Z, duration as resolution. Bi-directionally repeatable.†

Wide reference*

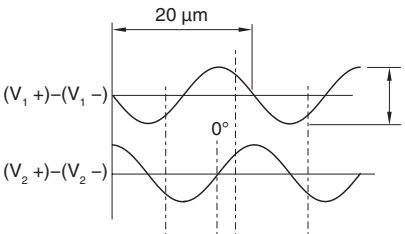
Synchronised pulse Z, duration as signal period. Bi-directionally repeatable.†

NOTE: Select 'standard' or 'wide' reference at time of ordering, to match the requirements of the controller being used. Wide reference mark not available with DOP0004 (5 µm resolution).

Analogue output signals

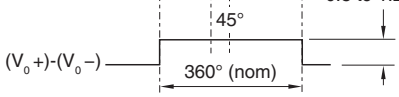
NOTE: Analogue signals are also available direct from all TONiC readheads

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



0.7 to 1.35 Vpp with green LED indication (readhead) and 120R termination. Centred on 2.5 V.

Reference



0.8 to 1.2 Vpp

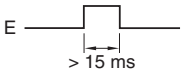
Bi-directionally repeatable. Differential pulse V_0 centred on 45°.

Limits Open collector output, asynchronous pulse

Active high or **Active low**

Alarm* Asynchronous pulse

Line driven

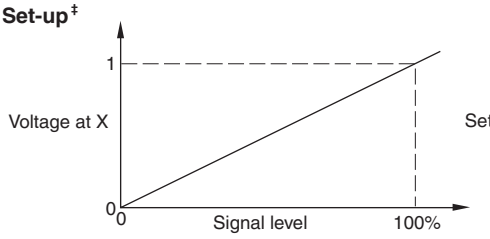


Alarm asserted when:
– Signal amplitude < 20% or > 135%
– Readhead speed too high for reliable operation

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.

* Inverse signals not shown for clarity.
† Only calibrated reference mark is bi-directionally repeatable.
‡ Set-up signal as shown is not present during calibration routine.

Linear readhead part numbers

Series

T - TONiC

Scale form

1 - Linear

Readhead type

0 - Standard

Scale type compatibility

1 - RSLM20 / RELM20

3 - RTLC20 / RTLC20-S / RKLC20-S

Reference mark

0 - Customer selectable reference mark

1 - All reference marks are output*

Cable length

02 - 0.2 m

05 - 0.5 m

10 - 1 m

15 - 1.5 m

20 - 2 m

30 - 3 m

50 - 5 m

60 - 6 m

99 - 10 m

Cable termination

A - Standard mini connector to mate with DOP interface

* Only calibrated reference mark is bi-directionally repeatable.

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

Rotary readhead part numbers

Series
T - TONiC

Scale form
2 - Rotary

Readhead type
0 - Standard

Ring diameter
0 - RESM20 / REXM20 > ∅135 mm
1 - RESM20 / REXM20 ∅60 mm to ∅135 mm
2 - RESM20 / REXM20 < ∅60 mm

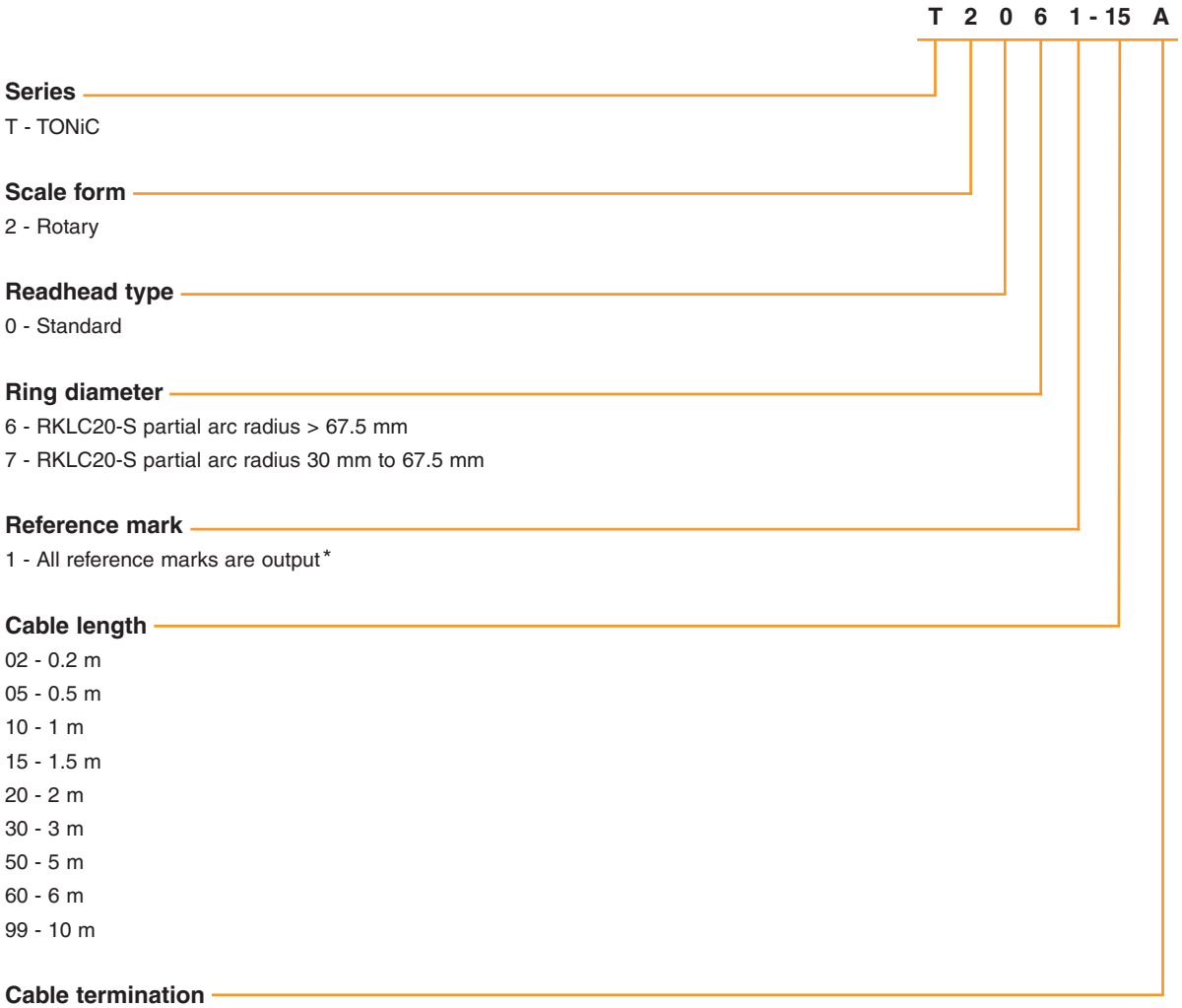
Reference mark
1 - All reference marks are output

Cable length
02 - 0.2 m
05 - 0.5 m
10 - 1 m
15 - 1.5 m
20 - 2 m
30 - 3 m
50 - 5 m
60 - 6 m
99 - 10 m

Cable termination
A - Standard mini connector to mate with DOP interface

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

Partial arc readhead part numbers



* Only calibrated reference mark is bi-directionally repeatable.

For more information on partial arcs refer to *RKL scale for partial arc applications* data sheet (Renishaw part no. L-9517-9897).

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

DOP interface part numbers

Compatible with all TONiC readheads

DOP 0200 A 20 A

Series

DOP - TONiC dual output interface

Interpolation factor / resolution*

0004 - 5 µm†
0020 - 1 µm
0040 - 0.5 µm
0100 - 0.2 µm
0200 - 0.1 µm
0400 - 50 nm
1000 - 20 nm
2000 - 10 nm
4000 - 5 nm
10KD - 2 nm
20KD - 1 nm

Alarm format and conditions

A - Line driven E output; All alarms
B - Line driven E output; Low signal and high signal alarms only
E - 3 state; All alarms
F - 3 state; Low signal and high signal alarms only

Clocked output option

50 - 50 MHz	10 - 10 MHz
40 - 40 MHz	08 - 8 MHz
25 - 25 MHz	06 - 6 MHz
20 - 20 MHz	04 - 4 MHz
12 - 12 MHz	01 - 1 MHz

Reference mark

A - P/Q limits - 'Active high', standard reference mark
B - P/Q limits - 'Active low', standard reference mark
C - P/Q limits - 'Active high', wide reference mark†
D - P/Q limits - 'Active low', wide reference mark†

* Additional interpolation factors available. Contact your local Renishaw representative for further details.

† Wide reference mark not available with DOP0004 (5 µm) interfaces.

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc

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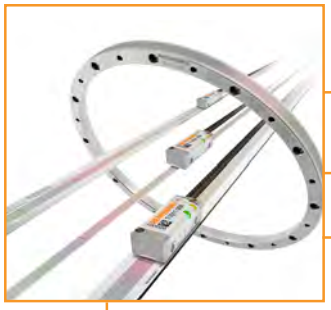
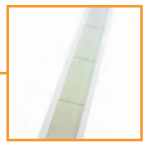
TONiC series compatible products

TONiC series



TONiC DOP
Dual output interface



RTLC20-S self-adhesive tape scale

RTLC20 tape scale and *FASTRACK* carrier

RKLC20-S self-adhesive mastered tape scale

RELM20 self-adhesive or clip/clamp mounted ZeroMet spar scale

RSLM20 self-adhesive or clip/clamp mounted stainless steel spar scale

RKLC20-S self-adhesive tape scale (partial arc)

RESM20 stainless steel ring

REXM20 high-accuracy stainless steel ring

For worldwide contact details, visit www.renishaw.com/contact

Part no.: L-9517-9411-03-E
Issued: 12.2022

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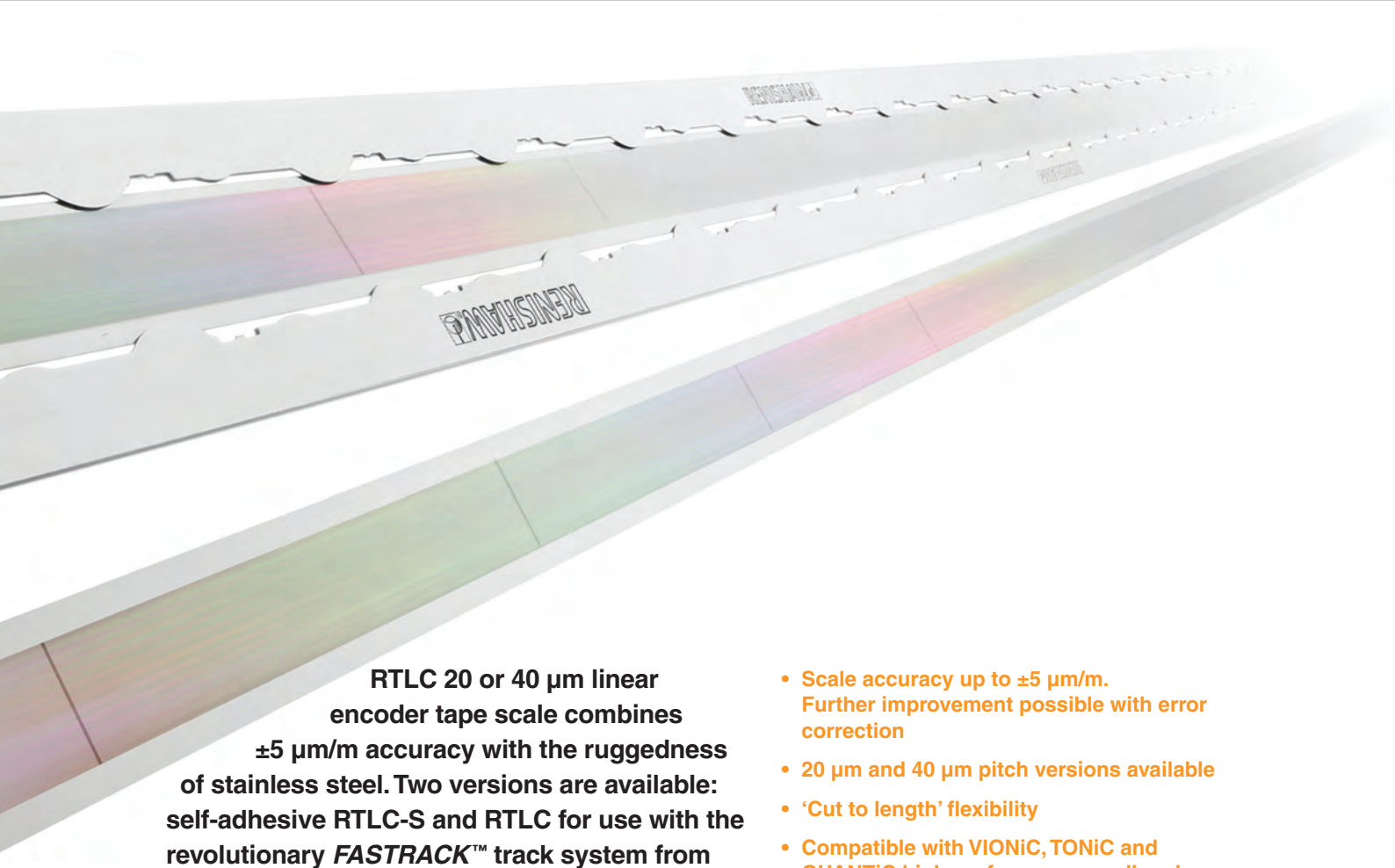
RTLC incremental linear scale



RTLC 20 or 40 µm linear encoder tape scale combines ±5 µm/m accuracy with the ruggedness of stainless steel. Two versions are available: self-adhesive RTLC-S and RTLC for use with the revolutionary *FASTRACK*™ track system from Renishaw.

Designed for applications that demand high accuracy and an independent expansion coefficient with tape scale convenience, RTLC is read by Renishaw's compact and reliable VIONiC™, TONiC™ and QUANTiC™ readheads.

RTLC-S is laid onto the substrate using its self-adhesive backing tape. An application tool makes this a quick, simple and inexpensive process. A datum clamp is fitted at a single point to lock the scale to the substrate.

RTLC (without self-adhesive) is used with *FASTRACK*. In this case, the scale is held securely in place by two miniature, yet rugged, guide rails. Again, the scale is clamped in a single point to allow independent expansion with extremely low hysteresis, even over wide temperature ranges. If damaged, the scale can be pulled out of the guide rails and quickly replaced, even where access is limited, thus reducing machine downtime. This feature also makes the new linear encoder system ideal for large machines that need to be sectioned for transportation.

- **Scale accuracy up to ±5 µm/m. Further improvement possible with error correction**
- **20 µm and 40 µm pitch versions available**
- **'Cut to length' flexibility**
- **Compatible with VIONiC, TONiC and QUANTiC high-performance readheads**
- **RTLC scale expands at its own low thermal coefficient (10.1 ±0.2 µm/m/°C @ 20 °C)**
- **Use with *FASTRACK* for very low hysteresis**
- ***FASTRACK* guide rails are pre-aligned in reels for cut-to-suit flexibility**
- **Quick installation. *FASTRACK* adds fast scale replacement capability**
- **Scale can be locked to the substrate at a single datum point anywhere along the axis**
- **RTLC scale can bridge gaps in the *FASTRACK* up to 25 mm**
- **High solvent immunity**

General specifications

Coefficient of thermal expansion (at 20 °C)		10.1 ±0.2 µm/m/°C
Temperature (system)	Storage	–20 °C to +70 °C
	Operating	0 °C to +70 °C
Humidity (system)		95% relative humidity (non-condensing) to IEC 60068-2-78
Shock (system)	Operating	500 m/s², 11 ms, ½ sine, 3 axe
Vibration (system)	Operating	100 m/s² max @ 55 to 2000 Hz, 3 axes

RTLC-S scale specifications

Self-adhesive incremental scale

Form (H × W)		0.4 mm × 8 mm including adhesive
Pitch	RTLC20-S	20 µm
	RTLC40-S / RTLC40H-S	40 µm
Accuracy (at 20 °C)	RTLC20-S / RTLC40H-S	±5 µm/m
	RTLC40-S	±15 µm/m
Linearity	RTLC20-S / RTLC40H-S	±2.5 µm/m achievable with two point error correction
	RTLC40-S	±5 µm/m achievable with two point error correction
Maximum supplied length		10 m†
Material		Hardened and tempered stainless steel
Mass		12.9 g/m

RTLC scale and *FASTRACK* carrier specifications

Incremental scale for use with *FASTRACK* carrier self-adhesive mounting system

Form (H × W)		0.4 mm × 18 mm including adhesive
Pitch	RTLC20	20 µm
	RTLC40 / RTLC40H	40 µm
Accuracy (at 20 °C)	RTLC20 / RTLC40H	±5 µm/m
	RTLC40	±15 µm/m
Linearity	RTLC20 / RTLC40H	±2.5 µm/m achievable with two point error correction
	RTLC40	±5 µm/m achievable with two point error correction
Maximum supplied length	RTLC	10 m
	FASTRACK	25 m
Minimum recommended length of *FASTRACK*		100 mm
Material	RTLC	Hardened and tempered stainless steel
	FASTRACK	Hardened stainless steel
Mass	RTLC	12.2 g/m
	FASTRACK	24 g/m

† For lengths >2 m *FASTRACK* with RTLC is recommended.

Reference mark

Type	*IN-TRAC*™ reference mark, directly embedded into incremental track 50 mm (nominal) spacing. Bi-directional position repeatability
Selection	Single reference mark selection by magnetic actuator (A-9653-0143) customer positioned
Repeatability	Unit of resolution repeatability (bi-directional) across full system rated speed and temperature ranges

Limit switches

Type	Magnetic actuators; with dimple triggers Q limit, without dimple triggers P limit (see RTLC scale installation drawing)
Trigger point	The limit output is nominally asserted when the readhead limit switch sensor passes the limit magnet leading edge, but can trigger up to 3 mm before that edge
Mounting	Customer placed at desired locations
Repeatability	< 0.1 mm

Compatible readheads

	VIONiC	TONiC	QUANTiC
			
Scale type	RTLC20	RTLC20	RTLC40
Pitch	20 µm	20 µm	40 µm
Outputs	Digital resolutions from 5 µm to 2.5 nm direct from the readhead	Analogue 1 Vpp. Digital resolutions from 5 µm to 1 nm from an interface.	Analogue 1 Vpp. Digital resolutions from 10 µm to 50 nm direct from the readhead.
SDE (typical)	< ±15 nm	±30 nm	< ±80 nm*
Jitter (RMS)	down to 1.6 nm	down to 0.5 nm	down to 2.73
Maximum speed	12 m/s	10 m/s	24 m/s*

*Digital variants.

Readhead features

- Filtering optics and Auto Gain Control for high reliability and solid Lissajous signals.
- Dynamic signal processing ensures ultra-low sub-divisional error (SDE).
  Result: smoother scanning performance.
- High signal-to-noise ratio provides ultra-low jitter for optimum positional stability.
- Auto-phasing of *IN-TRAC* reference mark.
- Clocked outputs ensure optimised speed performance for all resolutions, for a wide variety of industry-standard controllers.
- DOP Dual output interfaces available to provide simultaneous analogue and digital outputs (TONiC systems only).

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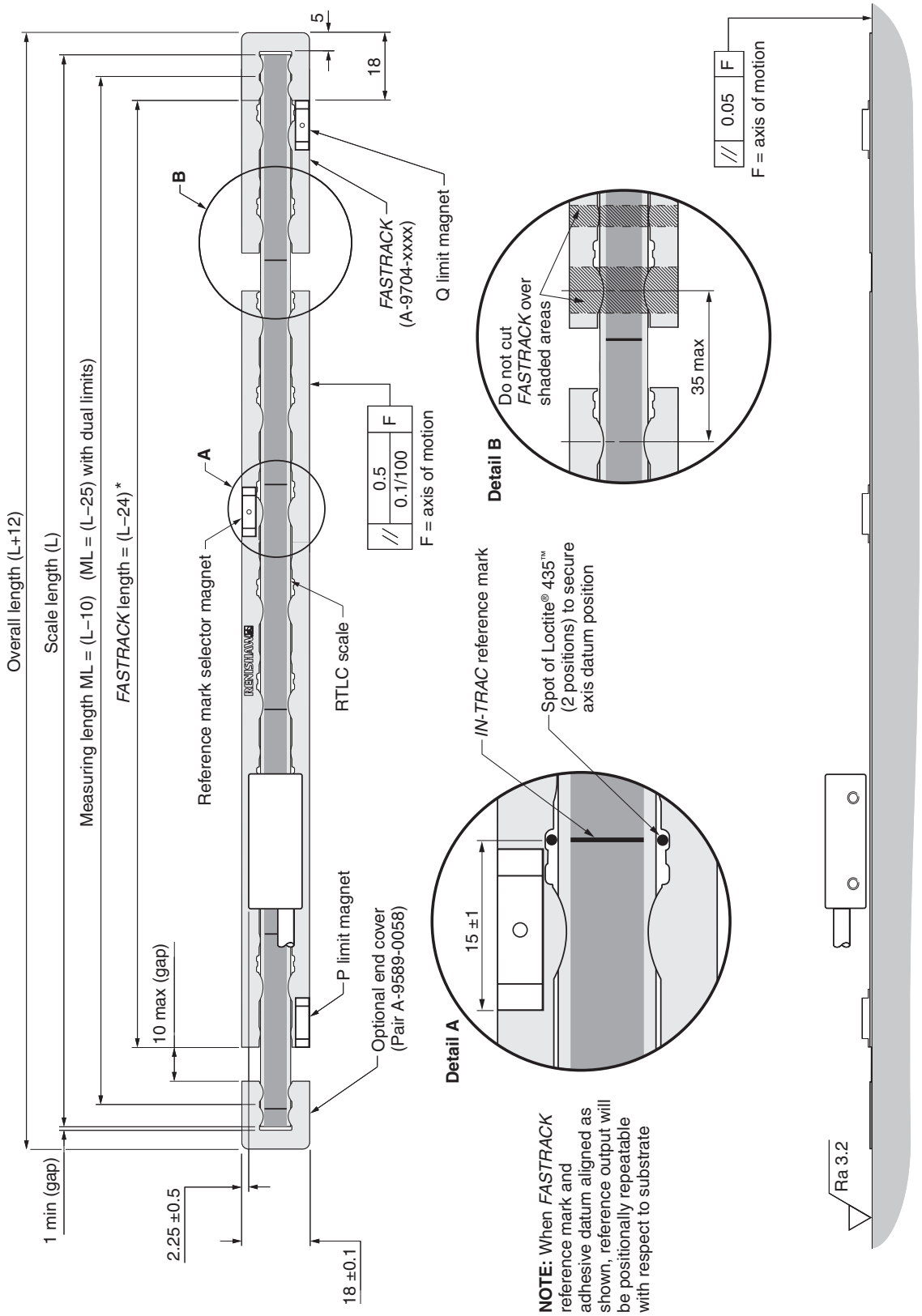
RTLC and *FASTRACK* carrier installation drawing

(adhesive datum clamp method†)

For further details, please refer to the relevant system installation guides.

Dimensions and tolerances in mm



*Assumes 1 mm gap between scale and end covers and zero gap between *FASTRACK* and end covers. †For alternative mechanical datum clamp method refer to the relevant system Installation guide.
NOTES: Minimum recommended *FASTRACK* length = 100 mm. The reference mark selector and limit actuator locations are correct for the readhead orientation shown.

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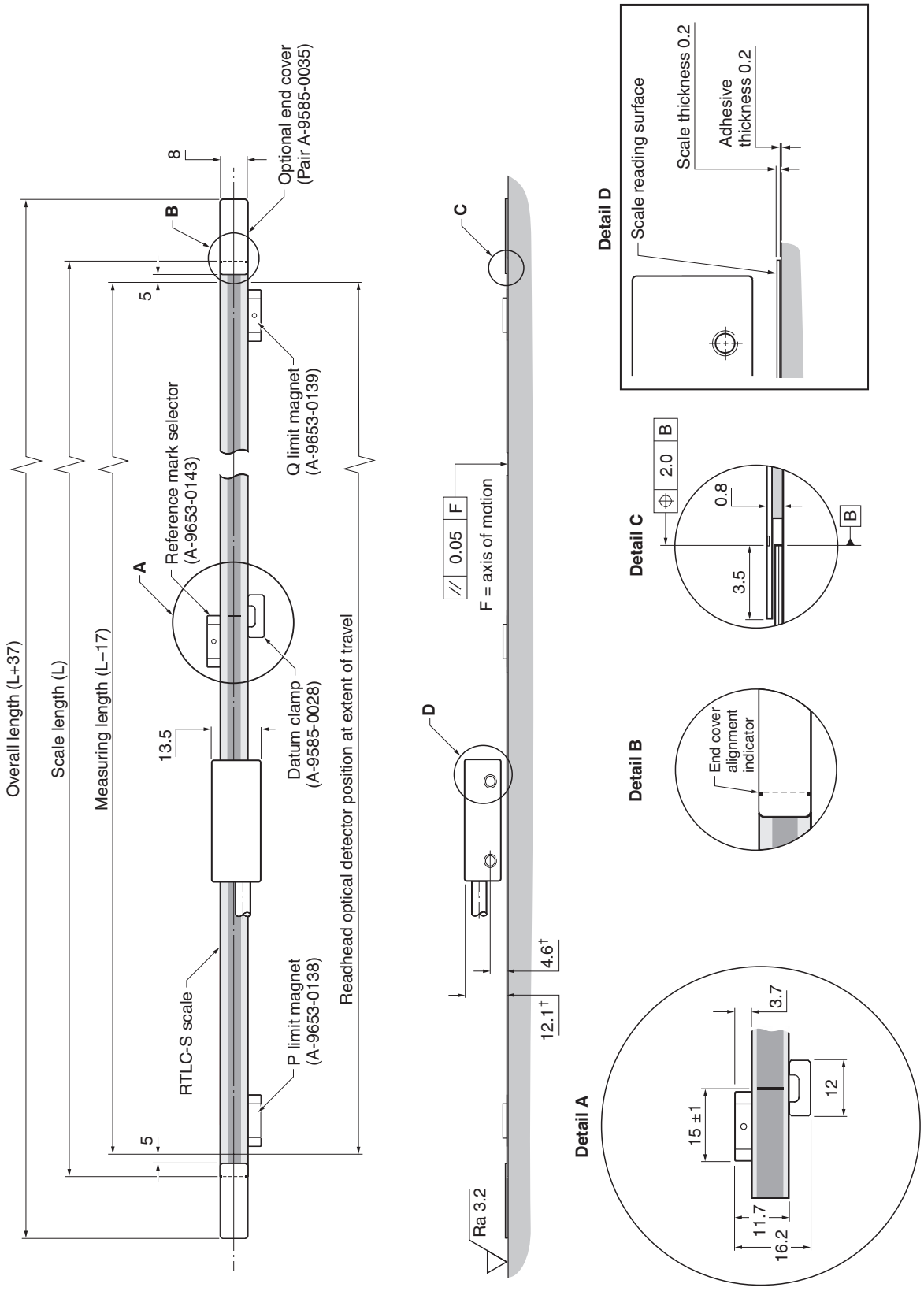
RTLC-S installation drawing

(Adhesive datum clamp method)

For further details, please refer to the relevant system installation guides.

Dimensions and tolerances in mm



†Dimensions from scale surface. **NOTE:** Bolted reference mark selector and limits also available. See the relevant system installation guide for details.

Scale part numbers

RTLC

Stainless steel tape scale for use with the *FASTRACK* carrier.

Available lengths	Available in increments of	Reference mark spacing	Distance from scale end to first reference mark	Part number (where xxxx is the length in cm)*		
				RTLC20 (Compatible with VIONiC and TONiC)	RTLC40 (Compatible with QUANTiC)	RTLC40H (Compatible with QUANTiC)
20 mm to 100 mm	10 mm	Middle of scale length	Middle of scale length	A-9705-xxxx	A-6566-xxxx	A-6668-xxxx
> 100 mm to 10 m	10 mm	50 mm	50 mm			

FASTRACK carrier

Stainless steel carrier for use with RTLC tape scale.

Available lengths	Available in increments of	Part number (where xxxx is the length in cm)*
100 mm to 25 m	25 mm†	A-9704-xxxx

† Part numbers for *FASTRACK* lengths ending in 25 mm are: A-9704-xxx3
Part numbers for *FASTRACK* lengths ending in 75 mm are: A-9704-xxx8

RTLC-S

Stainless steel tape scale with self-adhesive backing tape.

Available lengths	Available in increments of	Reference mark spacing	Distance from scale end to first reference mark	Part number (where xxxx is the length in cm)*		
				RTLC20-S (Compatible with VIONiC and TONiC)	RTLC40-S (Compatible with QUANTiC)	RTLC40H-S (Compatible with QUANTiC)
20 mm to 100 mm	10 mm	Middle of scale length	Middle of scale length	A-9715-xxxx	A-6567-xxxx	A-6670-xxxx
> 100 mm to 10 m	10 mm	50 mm	50 mm			

*Ordering A-9705-0070, for example, will result in a length of 70 cm of RTLC20.

Accessory part numbers

Reference mark and limit magnets†

Part description	Part number	Product image
Reference mark selector magnet – Adhesive mounted	A-9653-0143	
Bolted reference mark selector magnet (For use with RTLC-S only)	A-9653-0290	
Q limit switch actuator magnet – Adhesive mounted	A-9653-0139	
Bolted Q limit switch actuator magnet (For use with RTLC-S only)	A-9653-0291	
P limit switch actuator magnet – Adhesive mounted	A-9653-0138	
Bolted P limit switch actuator magnet (For use with RTLC-S only)	A-9653-0292	
Magnet applicator device (Aids positioning)	A-9653-0201	

†Longer limit magnets are available. Contact your local Renishaw representative for more information.

Datum clamps

Part description	Part number	Product image
Self-adhesive datum clamp (For use with RTLC-S only)	A-9585-0028	
Loctite 435 adhesive – 20 g bottle (For securing axis datum position of RTLC in *FASTRACK* carrier or RTLC-S)	P-AD03-0012	
Dispensing tip for Loctite 435 adhesive	P-TL50-0209	
Bolted datum clamp (For use with RTLC and *FASTRACK* only)	A-9589-0077	

Accessory part numbers (continued)

RTLC/RTLC-S scale and *FASTRACK* accessories

Part description	Part number	Product image
Guillotine (For cutting RTLC/RTLC-S scale and *FASTRACK* carrier)	A-9589-0071	
Shears (For cutting RTLC/RTLC-S scale and *FASTRACK* carrier)	A-9589-0133	
RTLC-S scale applicator	A-9589-0115	
FASTRACK centre section removal tool (Removes centre section of *FASTRACK* when carrier has been mounted)	A-9589-0066	
FASTRACK separator assembly (Removes centre section of *FASTRACK* when carrier has been mounted – includes removable side panels for use when *FASTRACK* is mounted against a ledge or dowels)	A-9589-0122	
RTLC scale pulling tool (Aids installation of RTLC scale through the *FASTRACK* carrier)	A-9589-0420	
End cover kit (RTLC-S only)	A-9585-0035	
End cover kit (*FASTRACK* only)	A-9589-0058	

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Compatible products

RTLC20
RTLC20-S

VIONiC

TONiC

RTLC40
RTLC40-S
RTLC40H
RTLC40H-S

QUANTiC

For worldwide contact details, visit www.renishaw.com/contact

L-9517-9417-06

Part no.: L-9517-9417-06-B
Issued: 12.2020

Data sheet
L-9517-9862-01-D

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RKLC incremental linear scale

RKLC is a robust, 6 mm wide stainless steel encoder tape scale with a thickness of 0.15 mm. This allows the scale, when rigidly fixed to a machine axis, to become 'mastered' to the machine substrate, matching its thermal expansion coefficient and behaviour. Differential movement between the scale and the machine is thus minimised, improving the metrological performance that can be achieved with simple thermal system compensation.

Index positions are provided by *IN-TRAC*™ optical reference marks which are directly embedded into the incremental scale markings to enable auto-phasing. The combination of these compact reference marks with the narrow 6 mm wide scale facilitates encoder installation in space-constrained applications.

RKLC tape scale also combines ±5 µm/m accuracy with the mechanical and chemical ruggedness of stainless steel, easy coiling and cut-to-length convenience.

RKLC is installed onto the axis substrate by a self-adhesive backing tape and a simple application tool makes this a quick, straightforward and inexpensive process. The scale ends are rigidly fixed to the axis substrate by means of epoxy fastened end clamps, eliminating the need to drill holes.

- **Mastered scale matches the coefficient of thermal expansion of the substrate**
- **Narrow 6 mm wide scale suitable for confined spaces**
- **Suitable for partial arc applications**
- ***IN-TRAC* optical reference marks**
- **20 µm and 40 µm pitch versions available**
- **'Cut-to-length' convenience**
- **Up to 20 m lengths (> 20 m available on request)**
- **Compatible with VIONiC™, TONiC™ and QUANTiC™ high-performance readheads**
- **High solvent immunity**
- **Scale accuracy up to ±5 µm/m. Further improvement possible with error correction**

Compatible readheads

	VIONiC	TONiC	QUANTiC
			
Scale type	RKLC20-S	RKLC20-S	RKLC40-S / RKLC40H-S
Pitch	20 µm	20 µm	40 µm
Outputs	Digital resolutions from 5 µm to 2.5 nm direct from the readhead.	Analogue 1 Vpp. Digital resolutions from 5 µm to 1 nm from an interface.	Analogue 1 Vpp. Digital resolutions from 10 µm to 50 nm direct from the readhead.
SDE (typical)	< ±15 nm	±30 nm	< ±80 nm†
Jitter (RMS)	down to 1.6 nm	down to 0.5 nm	down to 2.73 nm
Maximum speed	12 m/s	10 m/s	24 m/s†
UHV variant	No	Yes*	No

* Scale mastering is not guaranteed after system bakeout.
† Digital variants.

Readhead features

- Filtering optics and Auto Gain Control for high reliability and solid Lissajous signals.
- Dynamic signal processing ensures ultra-low sub-divisional error (SDE).
  Result: smoother scanning performance.
- High signal-to-noise ratio provides ultra-low jitter for optimum positional stability.
- Auto-phasing of *IN-TRAC* reference mark.
- Clocked outputs ensure optimised speed performance for all resolutions, for a wide variety of industry-standard controllers.
- Diagnostic tool compatibility for detailed information on encoder performance.
- DOP Dual output interfaces available to provide simultaneous analogue and digital outputs (TONiC systems only).

RKLC scale specifications*

Form (H × W)		0.15 mm × 6 mm including adhesive
Pitch	RKLC20-S	20 µm
	RKLC40-S / RKLC40H-S	40 µm
Accuracy (at 20 °C)	RKLC20-S / RKLC40H-S	±5 µm/m
	RKLC40-S	±15 µm/m
Linearity (at 20 °C)	RKLC20-S / RKLC40H-S	±2.5 µm/m achievable with two point error correction
	RKLC40-S	±3 µm/m achievable with two point error correction
Supplied length		20 mm to 20 m (> 20 m available on request)
Material		Hardened and tempered stainless steel
Mass		4.6 g/m
Coefficient of thermal expansion (at 20 °C)		Matches that of substrate material when scale ends fixed by epoxy mounted end clamps
Temperature	Storage	–20 °C to +80 °C
	Operating†	0 °C to +70 °C
	Installation	+10 °C to +35 °C
Humidity		95% relative humidity (non-condensing) to IEC 60068-2-78
Shock	Operating	500 m/s², 11 ms, ½ sine, 3 axes
Vibration	Operating	300 m/s² max @ 55 to 2000 Hz, 3 axes
End fixing		Epoxy mounted end clamps (A-9523-4015) Approved epoxy adhesive (A-9531-0342) Scale end movement typically < 1 µm‡

Reference mark

Type	*IN-TRAC* reference mark✧, directly embedded into incremental track, 50 mm (nominal) spacing
Selection	Single reference mark selection by magnetic actuator (A-9653-0143) customer positioned
Repeatability	Unit of resolution repeatability (bi-directional) across full system rated speed and temperature ranges

Limit switches

Type	Magnetic actuators; with dimple triggers Q limit, without dimple triggers P limit (see RKLC scale installation drawings)
Trigger point	The limit output is nominally asserted when the readhead limit switch sensor passes the limit magnet leading edge, but can trigger up to 3 mm before that edge
Mounting	Customer placed at desired locations
Repeatability	< 0.1 mm

* For more information on partial arc applications refer to *RKL scale for partial arc applications* data sheet (Renishaw part no. L-9517-9897).
† To limit maximum tension in the scale ($CTE_{substrate} - CTE_{scale}$) × ($T_{use\ extreme} - T_{install}$) ≤ 550 µm/m where CTE_{scale} = ~ 10.1 µm/m/°C.
‡ Ensure that scale and end clamps have been installed following the installation process described in the relevant RKLC installation guide.
✧Scale available with no *IN-TRAC* reference mark; see scale part numbers for details.

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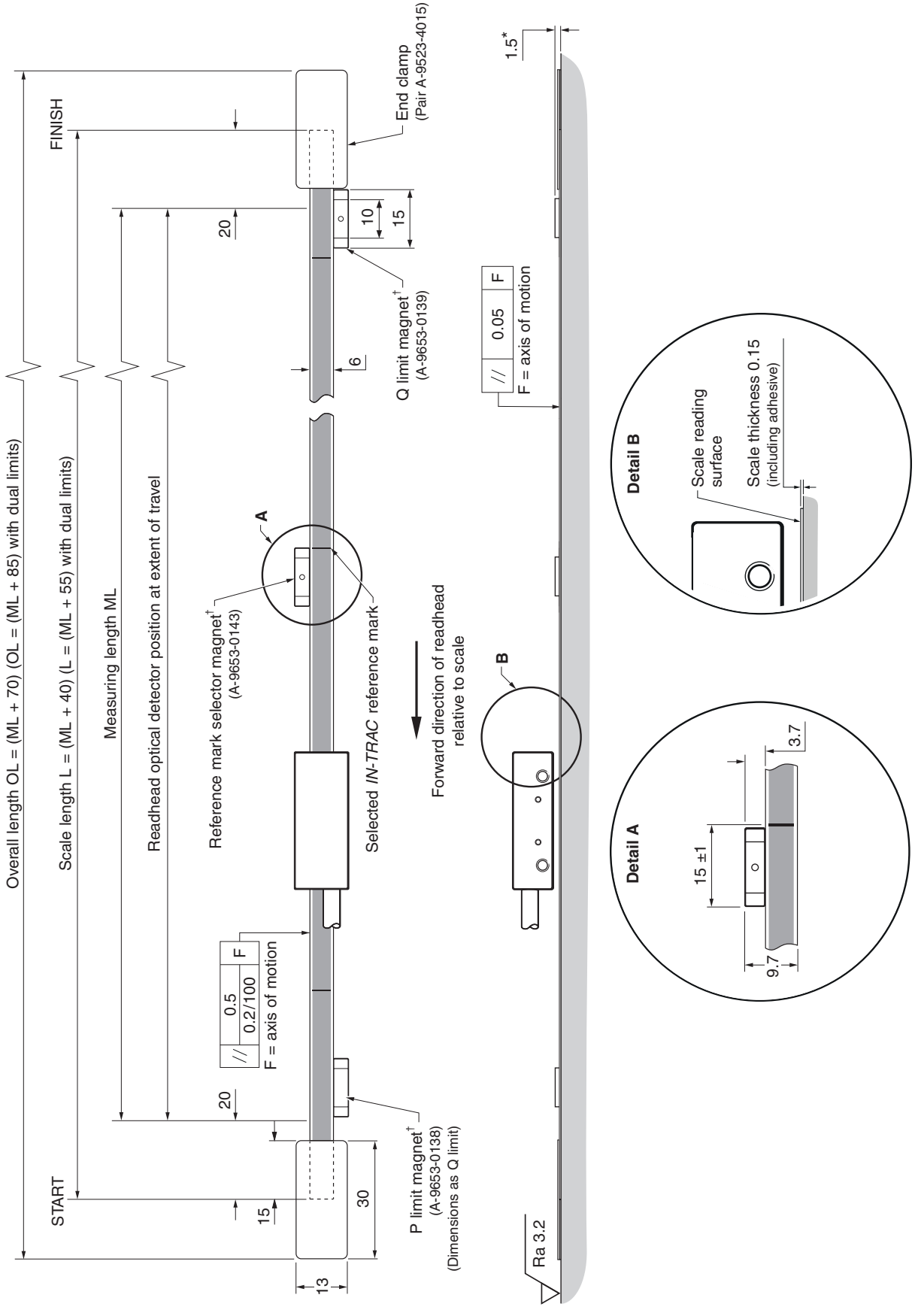
RKLC scale installation drawing

Dimensions and tolerances in mm



* Dimensions from substrate surface. † Bolted reference mark selector magnet and limit magnet available. See relevant system installation guide for further details.
NOTE: The reference mark selector and limit actuator locations are correct for the readhead orientation shown.

Scale part numbers

RKLC-S

Stainless steel tape scale with self-adhesive backing tape.

Available lengths	Available in increments of	Reference mark spacing*	Distance from scale end to first reference mark	Part number (where xxxx is the length in cm)†		
				RKLC20-S (Compatible with VIONiC and TONiC)	RKLC40-S (Compatible with QUANTiC)	RKLC40H-S (Compatible with QUANTiC)
20 mm to 100 mm	10 mm	Middle of scale length	Middle of scale length	A-6663-xxxx	A-6665-xxxx	A-6685-xxxx
> 100 mm to 20 m‡	10 mm	50 mm	50 mm			

RKLR-S (no reference mark)

Stainless steel tape scale with self-adhesive backing tape.

Available lengths	Available in increments of	Part number (where xxxx is the length in cm)†	
		RKLR20-S (Compatible with VIONiC and TONiC)	RKLR40-S (Compatible with QUANTiC)
20 mm to 20 m‡	10 mm	A-6753-xxxx	A-6744-xxxx

* Only calibrated reference mark is bi-directionally repeatable.
† Ordering A-6663-0070 for example, will result in a 70 cm length of RKLC20-S.
‡ Lengths greater than 20 m available on request.

Accessory part numbers

Reference mark and limit magnets*

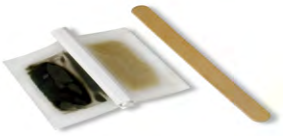
Part description	Part number	Product image
Reference mark selector magnet – Adhesive mounted	A-9653-0143	
Bolted reference mark selector magnet	A-9653-0290	
Q limit switch actuator magnet – Adhesive mounted	A-9653-0139	
Bolted Q limit switch actuator magnet	A-9653-0291	
P limit switch actuator magnet – Adhesive mounted	A-9653-0138	
Bolted P limit switch actuator magnet	A-9653-0292	
Magnet applicator device (Aids positioning)	A-9653-0201	

* Longer limit magnets are available. Contact your local Renishaw representative for more information.

RKLC scale accessories

Guillotine (For cutting RKLC scale)	A-9589-0071	
Shears (For cutting RKLC scale)	A-9589-0133	
RKLC-S side mount scale applicator (Compatible with all VIONiC, TONiC and QUANTiC side mount systems)	A-6547-1912	
RKLC-S top mount scale applicator (Required for TONiC top mounted systems only)	A-6547-1915	

End clamp accessories

Part description	Part number	Product image
RGC-F End clamp kit – epoxy mounted. The RGC-F end clamps master the RKLC scale to the substrate material to match its thermal expansion.	A-9523-4015	
End clamp kit, epoxy mounted, narrow The end clamps master the RKLC scale to the substrate material to match its thermal expansion.	A-9523-4027	
RGG-2 (2 part epoxy) The RGG-2 epoxy is recommended for the mounting of end clamps.	A-9531-0342	

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Compatible products

RKLC20-S

VIONiC

TONiC

RKLC40-S
RKLC40H-S

QUANTiC

For worldwide contact details, visit www.renishaw.com/contact

L-9517-9862-01

Part no.: L-9517-9862-01-D
Issued: 12.2020

Data sheet
L-9517-9897-02-A

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RKL scale for partial arc applications

Measuring a partial arc of rotation is made easy with Renishaw's flexible RKL encoder scales. The flexible nature of the small cross-sectional area of these scales allows them to be wrapped around a drum, shaft or arc with a minimum radius of 26 mm.

RKL scale is compatible with Renishaw's QUANTiC™, VIONiC™, TONiC™, ATOM DX™, ATOM™ and RESOLUTE™ readheads providing a partial arc solution for a wide range of applications.

RKL scale is installed onto the axis substrate by a self-adhesive backing tape making this a quick, straightforward and inexpensive process. The scale ends are rigidly fixed to the axis substrate by means of epoxy or epoxy fastened end clamps, eliminating the need to drill holes.

- **Small cross-sectional area making it ideal for partial arc rotation applications**
- **Suitable for external radii down to 26 mm**
- **Compatible with a wide range of Renishaw's incremental and absolute readheads**
- **20 µm, 30 µm and 40 µm pitch versions available**
- **'Cut-to-length' convenience**
- ***IN-TRAC*™ optical reference marks**
- **High solvent immunity**

RKL partial arc scale specifications

		Incremental			Absolute
		RKLC20-S	**RKLC40-S**	**RKLF40-S**	**RKLA30-S**
Compatible readheads		VIONiC and TONiC	QUANTiC	ATOM and ATOM DX [1]	RESOLUTE
Form (height × width)		0.15 mm × 6 mm (including adhesive)			
Pitch		20 µm	40 µm	40 µm	30 µm
Accuracy (at 20 °C) (based on neutral axis)		±5 µm/m	±15 µm/m	±15 µm/m	±5 µm/m (including slope and linearity)
Linearity (at 20 °C) (based on neutral axis)		±2.5 µm/m	±3 µm/m	±3 µm/m	-
Supplied length		20 mm to 20 m (> 20 m available on request)		20 mm to 10 m (> 10 m available on request)	20 mm to 21 m
Material		Hardened and tempered stainless steel			
Mass		4.6 g/m			
Coefficient of thermal expansion (at 20 °C)		10.1 ±0.2 µm/m/°C			
Temperature	Storage	–20 °C to +80 °C			
	Operating [2]	0 °C to +70 °C			
	Installation	+10 °C to +35 °C			
Humidity		95% relative humidity (non-condensing) to IEC 60068-2-78			
Shock	Operating	500 m/s², 11 ms, ½ sine, 3 axes			
Vibration	Operating	300 m/s² maximum @ 55 to 2000 Hz, 3 axes			
Recommended end fixing	R≥ 75 mm	Epoxy mounted end clamps (A-9523-4015)			
	R≥ 26 mm	Approved epoxy adhesive (A-9531-0342)			
Minimum arc radius [3]		30 mm	26 mm	26 mm	50 mm

Reference mark [4]

RKLC20-S and RKLC40-S [5]	*IN-TRAC* reference mark, directly embedded into incremental track. Bi-directional position repeatable to unit of resolution throughout specified speed. 50 mm spacing, first reference mark 50 mm from scale end. Reference mark at mid-point of scale length for lengths < 100 mm.
RKLF40-S	Customer de-selectable auto-phase optical reference mark. Bi-directional position repeatable to unit of resolution throughout specified speed. 50 mm spacing, first reference mark 50 mm from scale end. Reference mark at mid-point of scale length for lengths < 100 mm.
RKLA30-S	No reference mark

1 40 µm ATOM and ATOM DX readhead variants only.

2 To limit the maximum tension in the scale $(CTE_{substrate} - CTE_{scale}) \times (T_{use\ extreme} - T_{install}) \leq 550$ µm/m where CTE_{scale} = ~ 10.1 µm/m/°C.

3 For smaller radii contact your local Renishaw representative.

4 Only the calibrated reference mark is phased.

5 Where a specific reference mark location is required, contact your local Renishaw representative for advice on the best method to achieve this.

Compatible readheads

	Incremental		
	VIONiC	**TONiC**	**QUANTiC**
			
Readhead size (length × width × height in mm)	35 × 13.5 × 10	35 × 13.5 × 10	35 × 13.5 × 10
Interface	-	Ti, TD or DOP	-
Scale type	RKLC20-S	RKLC20-S	RKLC40-S
Output	Digital resolutions from 5 µm to 2.5 nm direct from the readhead	Analogue 1 Vpp. Digital resolutions from 5 µm to 1 nm from an interface.	Analogue 1 Vpp. Digital resolutions from 10 µm to 50 nm direct from the readhead.
Sub-divisional error (typical)	< ±15 nm	< ±30 nm	< ±150 nm (partial arc radius > 67.5 mm) < ±80 nm [1] (partial arc radius ≤ 67.5 mm)
Maximum speed	12 m/s	10 m/s	24 m/s [1]
Diagnostic tool	ADTi-100 and ADT View	TONiC diagnostic tool	ADTi-100 and ADT View

	Incremental		
	ATOM [2]	**ATOM DX [2]**	**RESOLUTE**
			
Readhead size (length × width × height in mm)	20.5 × 12.7 × 7.85 (FPC variant: 20.5 × 12.7 × 6.8)	20.5 × 12.7 × 10.85 (Top exit variant: 20.5 × 12.7 × 7.85)	36 × 16.5 × 17.2
Interface	Ri, Ti, ACi	-	DRIVE-CLiQ only
Scale type	RKLF40-S	RKLF40-S	RKLA30-S
Output	Analogue 1 Vpp. Digital resolutions from 10 µm to 2 nm from an interface.	Digital resolutions from 10 µm to 5 nm direct from the readhead.	BiSS, Siemens DRIVECLiQ, FANUC, Mitsubishi, Panasonic, Yaskawa
Sub-divisional error (typical)	< ±120 nm	< ±120 nm	±40 nm
Maximum speed	20 m/s	20 m/s	100 m/s
Diagnostic tool	ATOM diagnostic tool	ADTi-100 and ADT View	ADTa-100 and ADT View

NOTE: If installing RKL scale on a partial arc for a UHV or ETR application, contact your local Renishaw representative for more information.

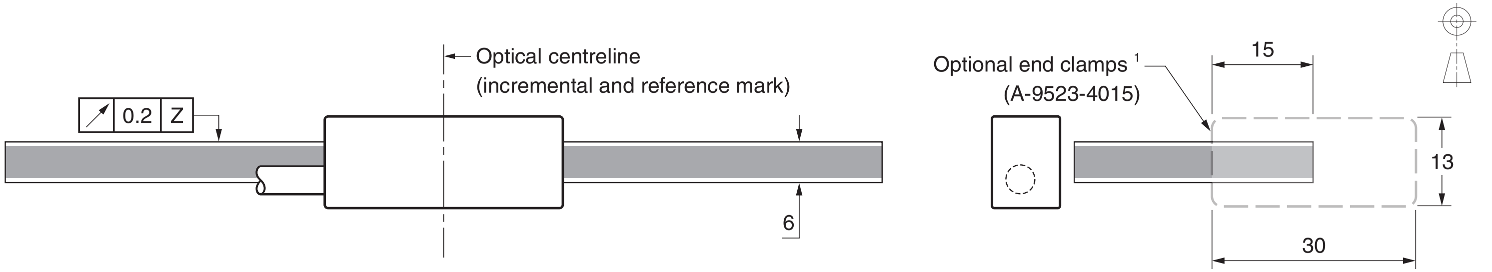
1 Digital variants only.

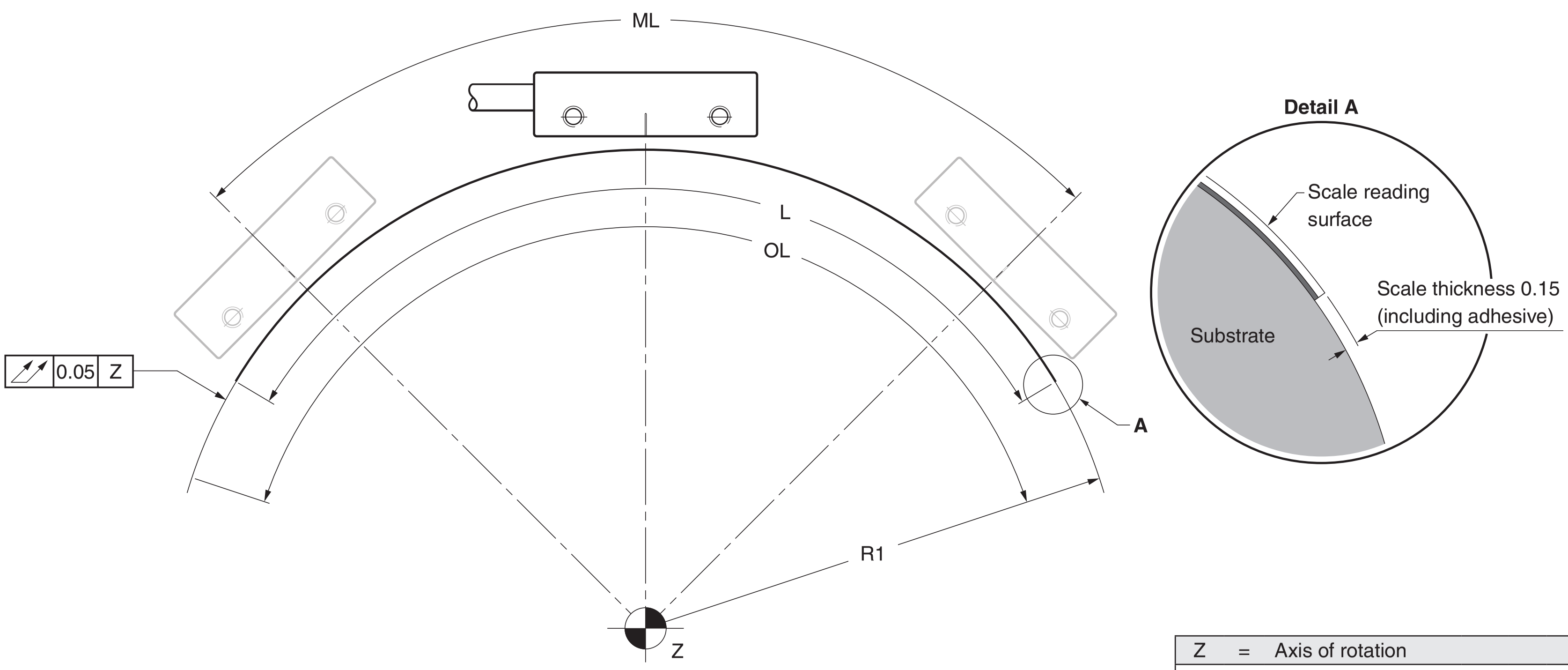
2 40 µm ATOM and ATOM DX readhead variants only.

RKLC partial arc installation drawing

Dimensions and tolerances in mm

NOTE: The drawing is applicable for all compatible readheads.





Z	=	Axis of rotation			
R1	=	Substrate radius			
R^N	=	Neutral axis radius (R1 + 100 µm)			
ML	=	Measuring length			
L	=	Scale length [2]			
		with end clamps	L	=	ML + 40 [3]
		without end clamps	L	=	ML + 20
OL	=	Overall length			
		with end clamps	OL	=	ML + 70 [3]

NOTE: The surface roughness of the substrate must be better than 3.2 µm. The parallelism of the scale surface to the axis guideway (readhead ride height variation) must be within 0.05 mm.

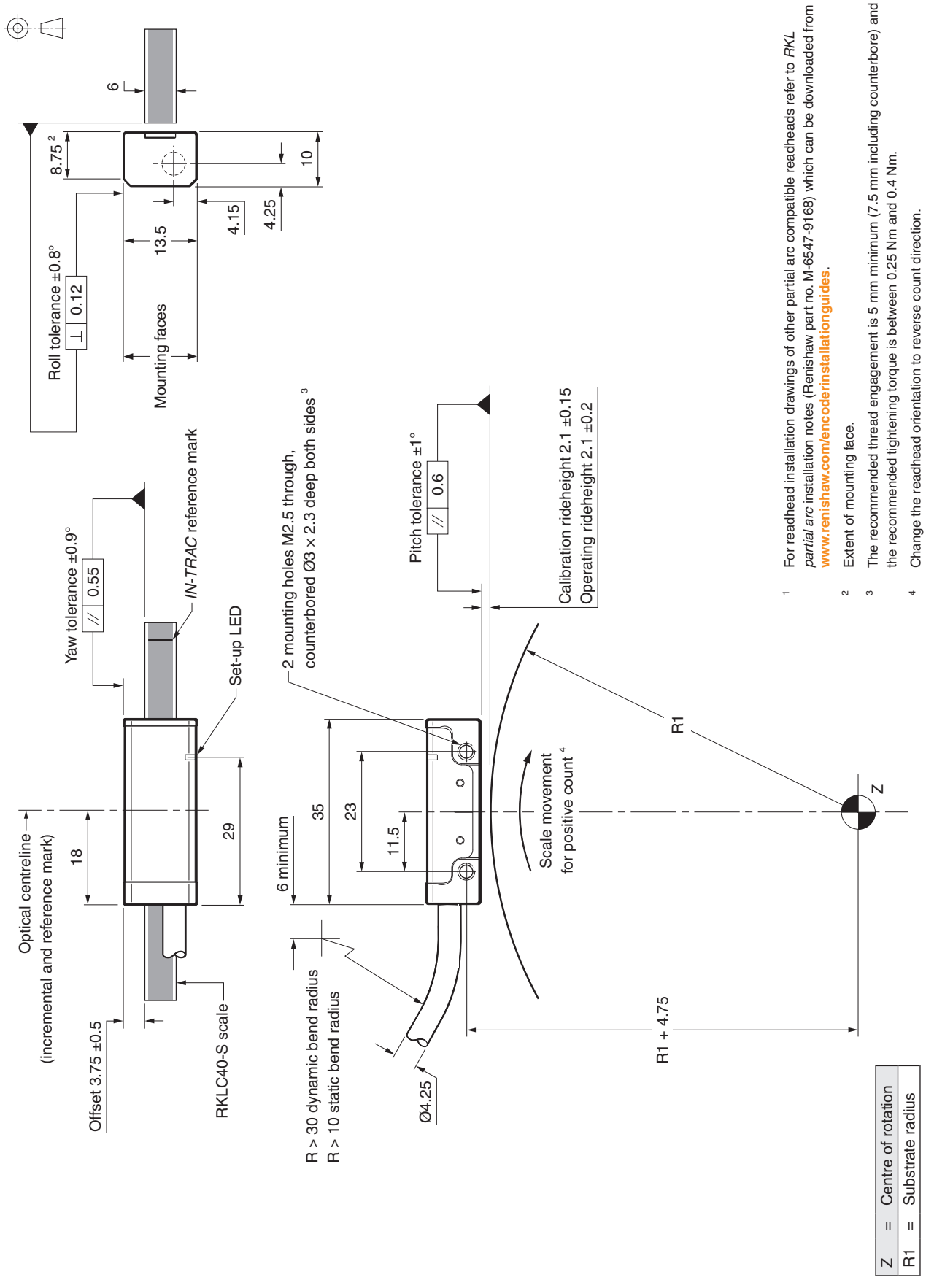
1 When not using end clamps, the scale ends must be secured using an alternative method. For further information refer to *RKL partial arc installation notes* (Renishaw part no. M-6547-9168) which can be downloaded from **www.renishaw.com/encoderinstallationguides**.

2 When calculating scale length, the first reference mark is 50 mm from scale end.

3 For RESOLUTE systems: To ensure readhead does not clash with the end clamps, L = ML + 66 and OL = ML + 96.

QUANTiC readhead installation drawing [1]

Dimensions and tolerances in mm



1 For readhead installation drawings of other partial arc compatible readheads refer to *RKL partial arc* installation notes (Renishaw part no. M-6547-9168) which can be downloaded from www.renishaw.com/encoderinstallationguides.

2 Extent of mounting face.

3 The recommended thread engagement is 5 mm minimum (7.5 mm including counterbore) and the recommended tightening torque is between 0.25 Nm and 0.4 Nm.

4 Change the readhead orientation to reverse count direction.

Scale part numbers

Scale type	Part number (where xxxx is the scale length in cm) [1]	Available lengths	Compatible readheads
RKLC40-S	A-6665-xxxx	20 mm to 20 m (> 20 m available on request)	QUANTiC
RKLC20-S	A-6663-xxxx	20 mm to 20 m (> 20 m available on request)	VIONiC and TONiC
RKLF40-S	A-6769-xxxx	20 mm to 20 m (> 20 m available on request)	ATOM and ATOM DX [2]
RKLA30-S	A-6667-xxxx	20 mm to 21 m	RESOLUTE

[1] For example, ordering A-6663-0110 will result in a 110 cm length of RKLC20-S.

[2] 40 µm ATOM and ATOM DX readhead variants only.

Accesssory part numbers

RKL scale accessories

Part description	Part number	Product image
Guillotine (for cutting RKL scale)	A-9589-0071	
Shears (for cutting RKL scale)	A-9589-0133	
RKLC-S side mount scale applicator (compatible with VIONiC, TONiC and QUANTiC side mount systems)	A-6547-1912	
RKLC-S top mount scale applicator (required for TONiC top mounted systems only)	A-6547-1915	
RKLF-S side mount applicator (compatible with ATOM and ATOM DX)	A-6547-1943	
RKLF-S top mount applicator (compatible with ATOM and ATOM DX)	A-6547-1939	
RKLF-S slim side mount applicator (compatible with ATOM and ATOM DX)	A-6547-1947	
RKLA-S scale applicator (compatible with RESOLUTE)	A-6547-1918	

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End clamp accessories

Part description	Part number	Product image
RGC-F end clamp kit - epoxy mounted (the RGC-F end clamps fix the ends of the partial arc scale to the substrate material)	A-9523-4015	
RGG-2 two part epoxy (the RGG-2 epoxy is recommended for the mounting of end clamps and scale ends)	A-9531-0342	

Reference mark accessories

Part description	Part number	Product image
Reference mark de-selector stickers (pack of 20 de-selector stickers - RKLF ATOM /ATOM DX systems only)	A-9402-0049	

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Part no.: L-9517-9897-02-A
Issued: 08.2023

Data sheet
L-9517-9219-07-B

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RELM20 high accuracy incremental linear scale

RELM20 ZeroMet™ scale is manufactured from near zero thermal expansion material, ensuring the high level of accuracy is maintained across the full temperature range.

It can be mounted direct to your machine, either mechanically or by the use of a self-adhesive backing tape. RELM20 scale also features the *IN-TRAC*™ optical reference mark allowing fast auto-phasing.

RELM20 is a 20 µm pitch scale and is compatible with Renishaw's VIONiC™ and TONiC™ range of encoders, offering levels of performance previously only available from delicate fine pitch systems.

- **High accuracy, certified to ±1 µm up to 1 m, calibrated against International Standards**
- **Robust ZeroMet offers 0.75 ±0.35 µm/m/°C@20 °C thermal expansion plus ease of handling and installation**
- **Scale mounting with self-adhesive or clips and clamps**
- ***IN-TRAC* bi-directional auto-phase optical reference mark**
- **Dual limits provide on-scale end of travel indication**

RELM20 scale specifications

Form (H × W)	1.6 mm × 14.9 mm
Scale lengths (L)	20 mm to 1.5 m (available in increments of 10 mm)
Pitch	20 µm
Accuracy	Certified to ±1 µm for lengths up to 1 m, ±1 µm/m for lengths >1 m to 1.5 m Calibrated traceable to International Standards
Material	ZeroMet. High stability, low-expansion nickel-iron alloy
Coefficient of thermal expansion (at 20 °C)	0.75 ±0.35 µm/m/°C
Mounting	Epoxy datum point and adhesive tape or datum clamp and mounting clips Adhesive backing tape is included with all scale (nominal thickness 0.2 mm)
Mass	184 g/m

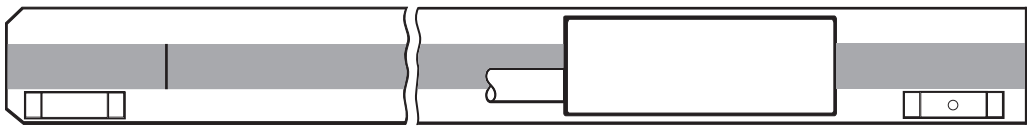
Reference mark

Type	*IN-TRAC* optical reference mark
Position	RELM20 – midpoint of scale length RELE20 – 20 mm from end of scale
Phasing	Auto-phased by readhead calibration routines
Repeatability	Repeatable to unit of resolution throughout specified temperature and speed range

NOTE: When using a VIONiC or TONiC system the readhead should be ordered so all reference marks are output; no actuator magnet is required.

Limit switches

Type	Magnetic actuators; with dimple triggers Q limit, without dimple triggers P limit (see image below)
Trigger point	The limit output is nominally asserted when the readhead limit switch sensor passes the limit magnet leading edge, but can trigger up to 3 mm before that edge
Mounting	Customer placed at desired locations
Repeatability	<0.1 mm



P limit (10 mm, A-9653-0138)

Q limit (10 mm, A-9653-0139)

Limit magnets are available in 10 mm, 20 mm and 50 mm lengths and supplied on a back plate with self-adhesive tape.

NOTE: Use of limits will affect the available measuring length (see page 6).

Compatible readheads

	VIONiC	TONiC
		
Outputs	Digital resolutions from 5 µm to 2.5 nm direct from the readhead	Analogue 1 Vpp only. RS422 digital resolutions from 5 µm to 1 nm available when connected to a Ti, TD or DOP interface
SDE (typical)	<±15 nm	±30 nm
Jitter (RMS)	down to 1.6 nm	down to 0.5 nm
Maximum speed	12 m/s	10 m/s

Readhead features

- Filtering optics and Auto Gain Control for high reliability and solid Lissajous signals.
- Dynamic signal processing ensures ultra-low Sub-Divisional Error (SDE).
  Result: smoother scanning performance.
- High signal-to-noise ratio provides ultra-low jitter for optimum positional stability.
- Auto-phasing of *IN-TRAC* reference mark.
- Clocked outputs ensure optimised speed performance for all resolutions, for a wide variety of industry-standard controllers.
- DOP Dual output interfaces available to provide simultaneous analogue and digital outputs (TONiC systems only).

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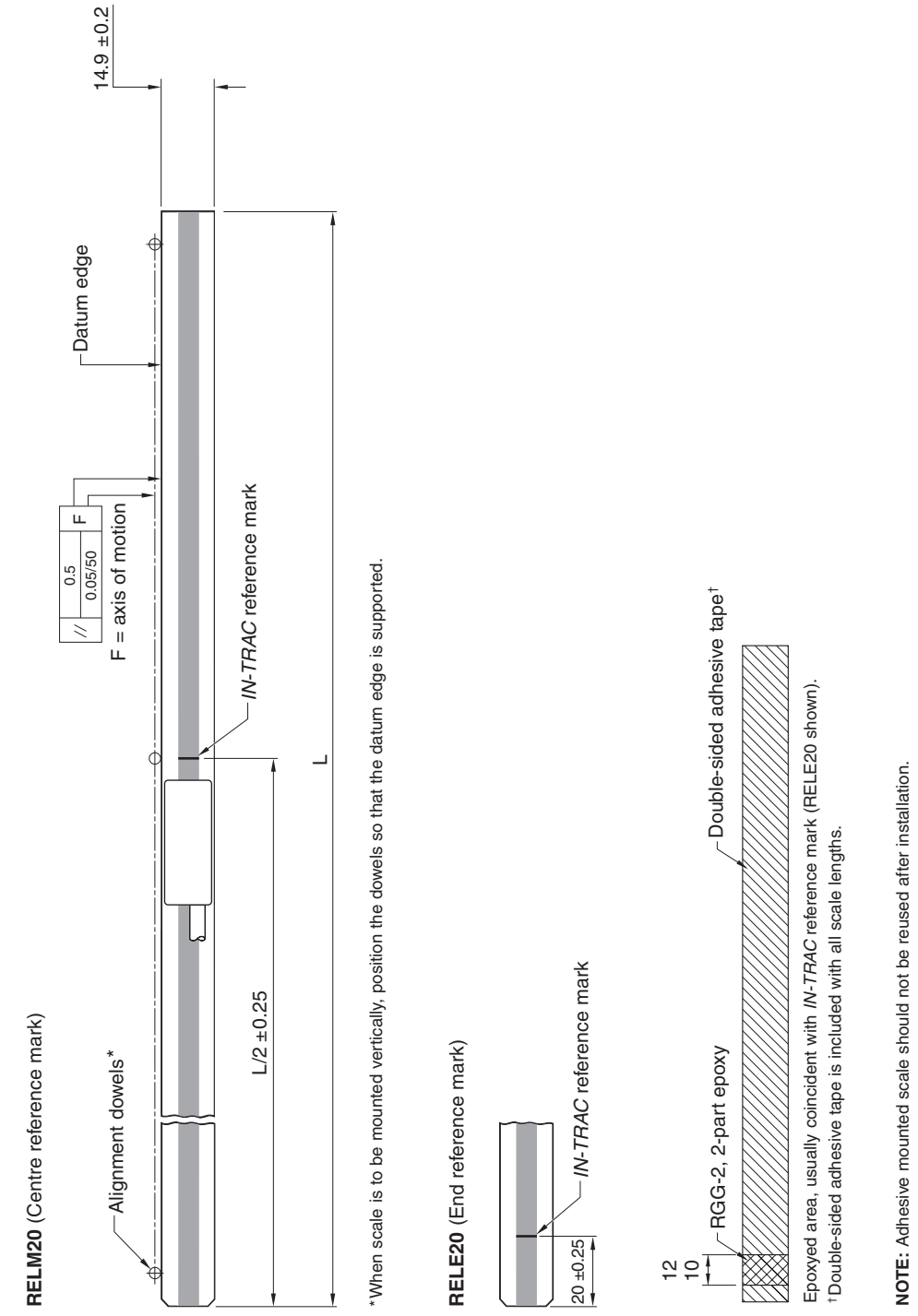
RELM20 scale installation drawing (adhesive mounting method shown)

For further details please refer to relevant system installation guides

Dimensions and tolerances in mm



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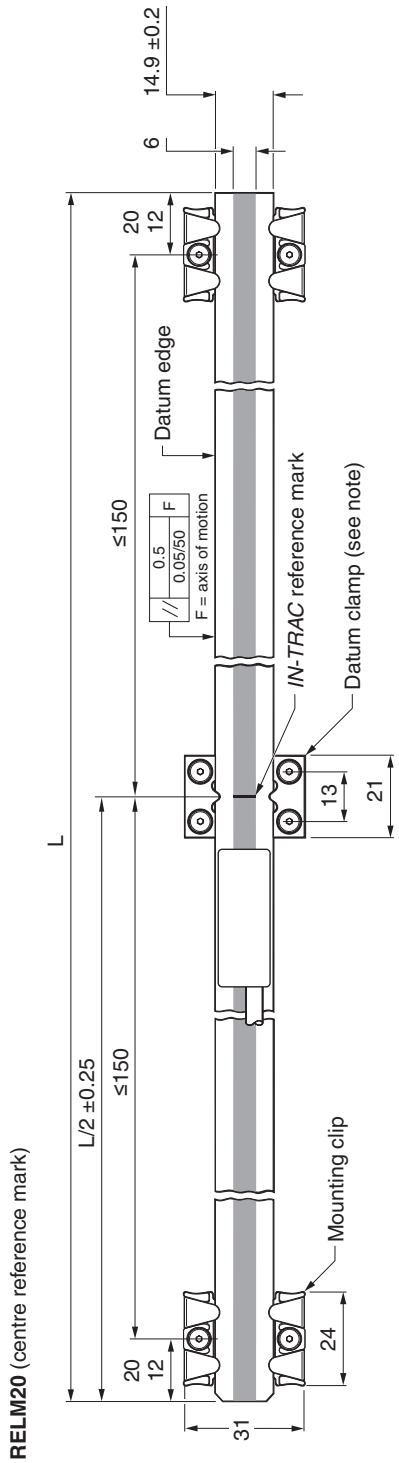
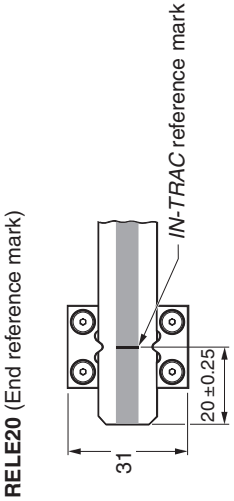
RELM20 scale installation drawing (clip/clamp mounting method shown)

For further details please refer to relevant system installation guides

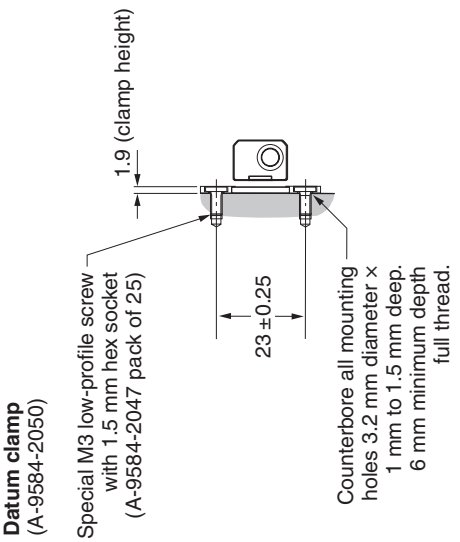
Dimensions and tolerances in mm

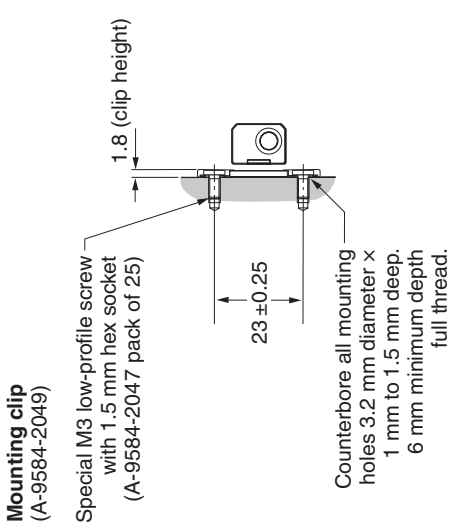




NOTES:

- Datum clamp usually coincident with selected *IN-TRAC* reference mark. However, the position is user selectable depending upon application.
- For lengths 80 ≤ L ≤ 190 ensure scale is clamped or clipped in the middle as well as at both ends.
- For optimum performance the readhead should be installed close to nominal geometry.
- Care should be taken to ensure sufficient clearance between the readhead/mounting bracket and clips/datum clamp.
- Only special low-profile screws should be used. Screws are provided with all clips/datum clamps and spares can be supplied if required.

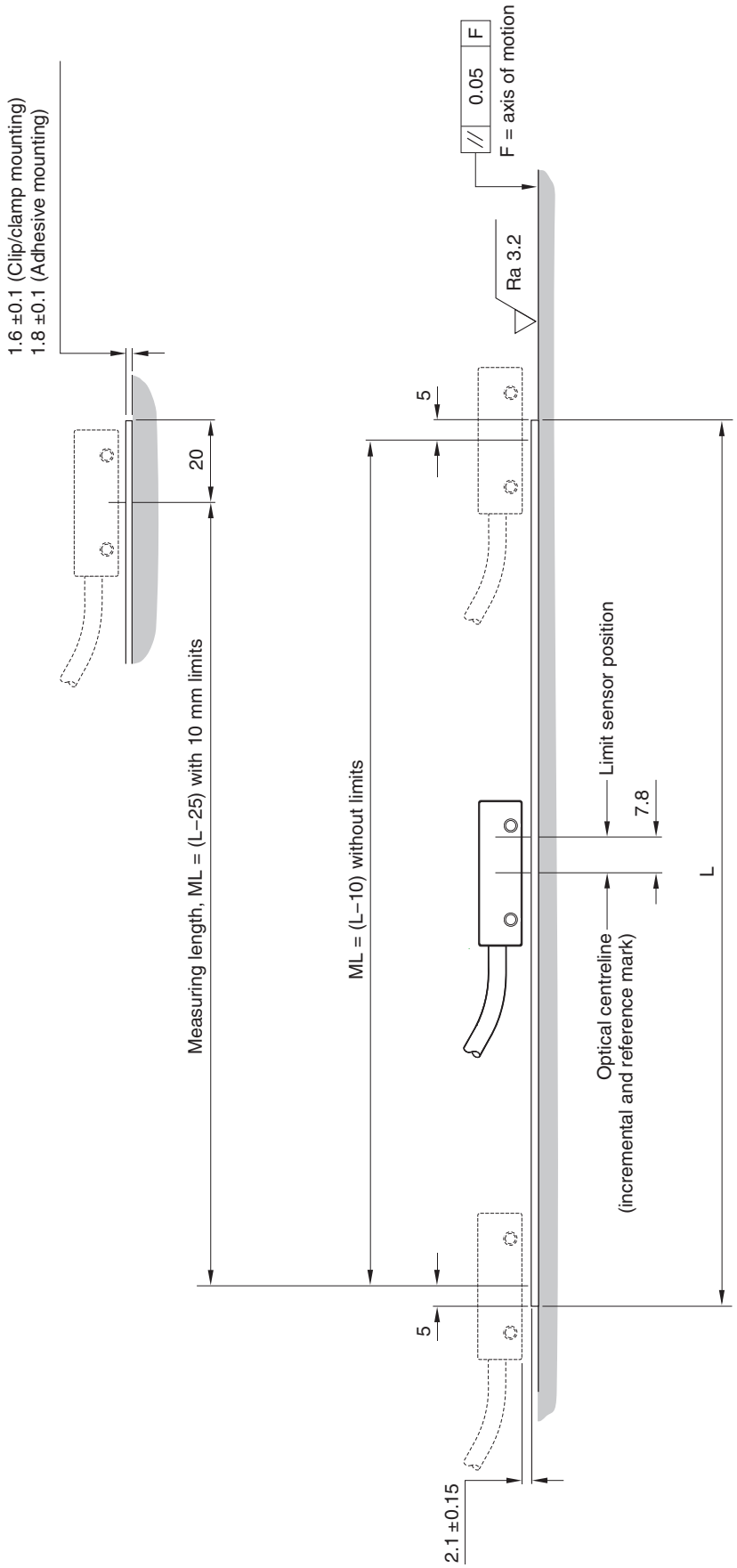




RELM20 scale measuring lengths

For further details please refer to relevant system installation guides

Dimensions and tolerances in mm



Scale part numbers

RELM20

20 µm pitch ZeroMet spar scale with single *IN-TRAC* reference mark at mid-point of scale length.

Part number	Available lengths	Available in increments of	Ordering instructions
A-9660-xxxx	20 mm to 1500 mm	10 mm	xxxx is the length in mm. Ordering A-9660-0450 for example will result in a length of 450 mm.

RELE20

20 µm pitch ZeroMet spar scale with single *IN-TRAC* reference mark 20 mm from scale end.

Part number	Available lengths	Available in increments of	Ordering instructions
A-9661-xxxx	30 mm to 1500 mm	10 mm	xxxx is the length in mm. Ordering A-9661-0450 for example will result in a length of 450 mm.

Accessory part numbers

Limit switch magnets*

Part description	Part number	Product image
10 mm Q limit switch actuator magnet Adhesive mounted	A-9653-0139	
10 mm P limit switch actuator magnet Adhesive mounted	A-9653-0138	
Magnet applicator device (Aids positioning)	A-9653-0201	

*Longer limit magnets are available. Contact your local subsidiary for more information.

Clip/clamp mounting accessories†

Part description	Part number	Product image
Mounting clips	A-9584-2049	
Datum clamp kit	A-9584-2050	
Replacement M3 screws (pack of 25)	A-9584-2047	
Spare clip setting shim	M-9584-0928	

† UHV and extra wide clip/clamp accessories are available. Contact your local subsidiary for more information.

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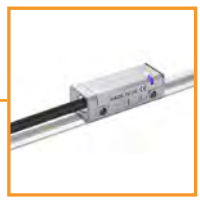
Compatible products

RELM20
RELE20

TONiC



VIONiC

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L-9517-9219-07

Part no.: L-9517-9219-07-B
Issued: 10.2019

Data sheet
L-9517-9305-08-B

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RSLM20 high accuracy incremental linear stainless steel scale

- Total accuracy of ±4 µm over 5 m
- Available in defined lengths up to 5 m
- Coilable for simple storage and handling
- *IN-TRAC* auto-phase optical reference mark
- Robust special composition stainless steel with defined coefficient of thermal expansion 10.1 ±0.2 µm/m/°C @ 20 °C
- Dual limits provide on-scale end-of-travel indication

RSLM20 high accuracy stainless steel scale is compatible with Renishaw's VIONiC™ and TONiC™ range of high performance encoders, offering advanced features including dynamic signal processing and the *IN-TRAC*™ optical reference mark.

RSLM20 scale is available in lengths up to 5 m with an overall accuracy better than ±4 µm on 5 m lengths – an industry first! Combined with readheads featuring ultra-low Sub-Divisional Error (SDE), unique filtering optics, resolutions down to 1 nm and simple installation and setup, RSLM20 provides all the performance of a fine pitch system with the benefits of a 20 µm encoder.

RSLM20 offers the ease of use of a tape scale yet the performance of a glass spar; the scale can be coiled for simple storage and handling yet behaves as a spar once uncoiled. Available with a number of *IN-TRAC* reference mark options and a choice of mechanical or adhesive mounting, RSLM20 is perfect for long-travel applications where metrology cannot be compromised.

RSLM20 scale specifications

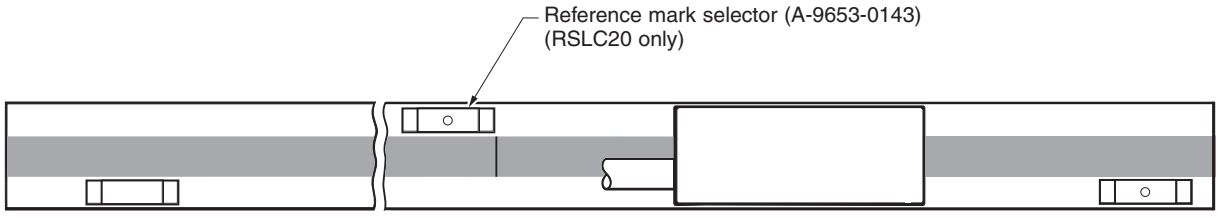
Form (H × W)	1.5 mm × 14.9 mm
Scale lengths	20 mm to 5 m (available in increments of 10 mm)
Pitch	20 µm
Accuracy (at 20 °C)	±1.5 µm up to 1 m ±2.25 µm from 1 m to 2 m ±3 µm from 2 m to 3 m ±4 µm from 3 m to 5 m (includes slope and linearity). Calibration traceable to International Standards.
Material	Hardened martensitic stainless steel
Coefficient thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C
Mounting	Epoxy datum point and adhesive tape (nominal thickness 0.2 mm) or datum clamp and mounting clips
Mass	172 g/m
Storage	Lengths over 1.13 m are coiled (> 600 mm diameter)

Reference mark

Type	*IN-TRAC* auto-phase optical reference mark, no physical adjustments required	
Position	**RSLM20**	Midpoint of scale length
	RSLE20	(Option A) – 20 mm from end of scale (for use with 10 mm limits)
	RSLE20	(Option B) – 70 mm from end of scale (for use with 20 mm and 50 mm limits)
	RSLC20	Selectable reference marks every 200 mm
	RSLR20	No *IN-TRAC* reference mark, suitable for use with RGH20; external magnetic reference mark required. Please refer to the RGH20 Data sheet (L-9517-9125) for more information.
Phasing	Auto-phased by readhead calibration routine	
Repeatability	Repeatable to unit of resolution throughout specified temperature and speed range	

Limit switches

Type	Magnetic actuators; with dimple triggers Q limit, without dimple triggers P limit (see image below)
Trigger point	The limit output is nominally asserted when the readhead limit switch sensor passes the limit magnet leading edge, but can trigger up to 3 mm before that edge
Mounting	Customer placed at desired locations
Repeatability	< 0.1 mm



P limit (10 mm, A-9653-0138)

Q limit (10 mm, A-9653-0139)

- Limit and reference mark selector magnets are available in 10 mm, 20 mm and 50 mm lengths and provided on a back plate with self-adhesive tape.
- For RSLM20 and RSLE20 scales VIONiC and TONiC readheads should be ordered with all reference marks output. (No reference mark selector required.)
- For RSLC20 scales VIONiC and TONiC readheads should be ordered with selected reference marks output. (Reference mark selector required at chosen reference mark location.)

Compatible readheads

	VIONiC	TONiC
		
Outputs	Digital resolutions from 5 µm to 2.5 nm direct from the readhead	Analogue 1 Vpp only. RS422 digital resolutions from 5 µm to 1 nm available when connected to a Ti, TD or DOP interface
SDE (typical)	< ±15 nm	±30 nm
Jitter (RMS)	down to 1.6 nm	down to 0.5 nm
Maximum speed	12 m/s	10 m/s

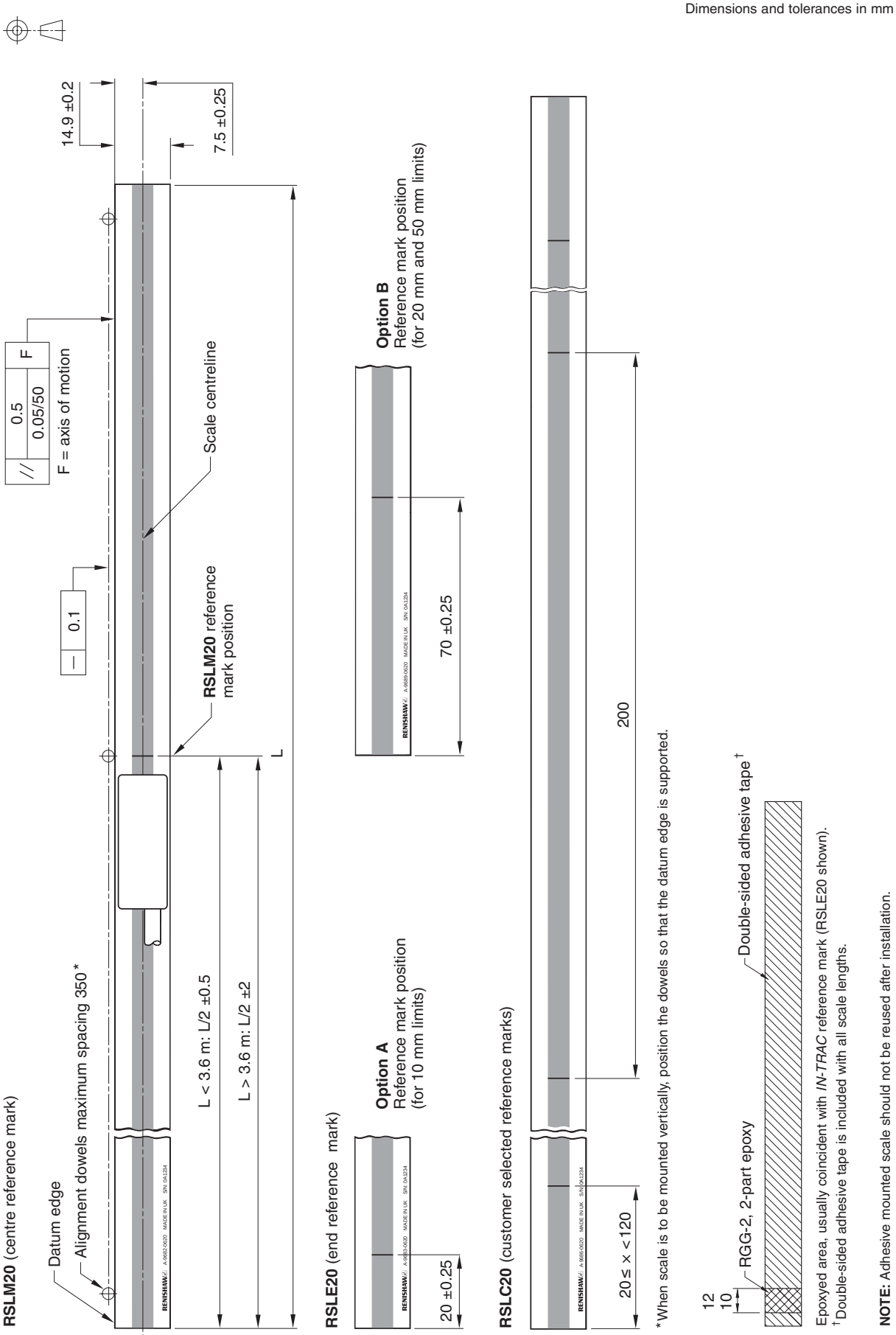
Readhead features

- Filtering optics and Auto Gain Control for high reliability and solid Lissajous signals.
- Dynamic signal processing ensures ultra-low Sub-Divisional Error (SDE).
  Result: smoother scanning performance.
- High signal-to-noise ratio provides ultra-low jitter for optimum positional stability.
- Auto-phasing of *IN-TRAC* reference mark.
- Clocked outputs ensure optimised speed performance for all resolutions, for a wide variety of industry-standard controllers.
- DOP Dual output interfaces available to provide simultaneous analogue and digital outputs (TONiC systems only).

RSLM20 scale installation drawing (adhesive mounting method shown)

For further details please refer to relevant system installation guides

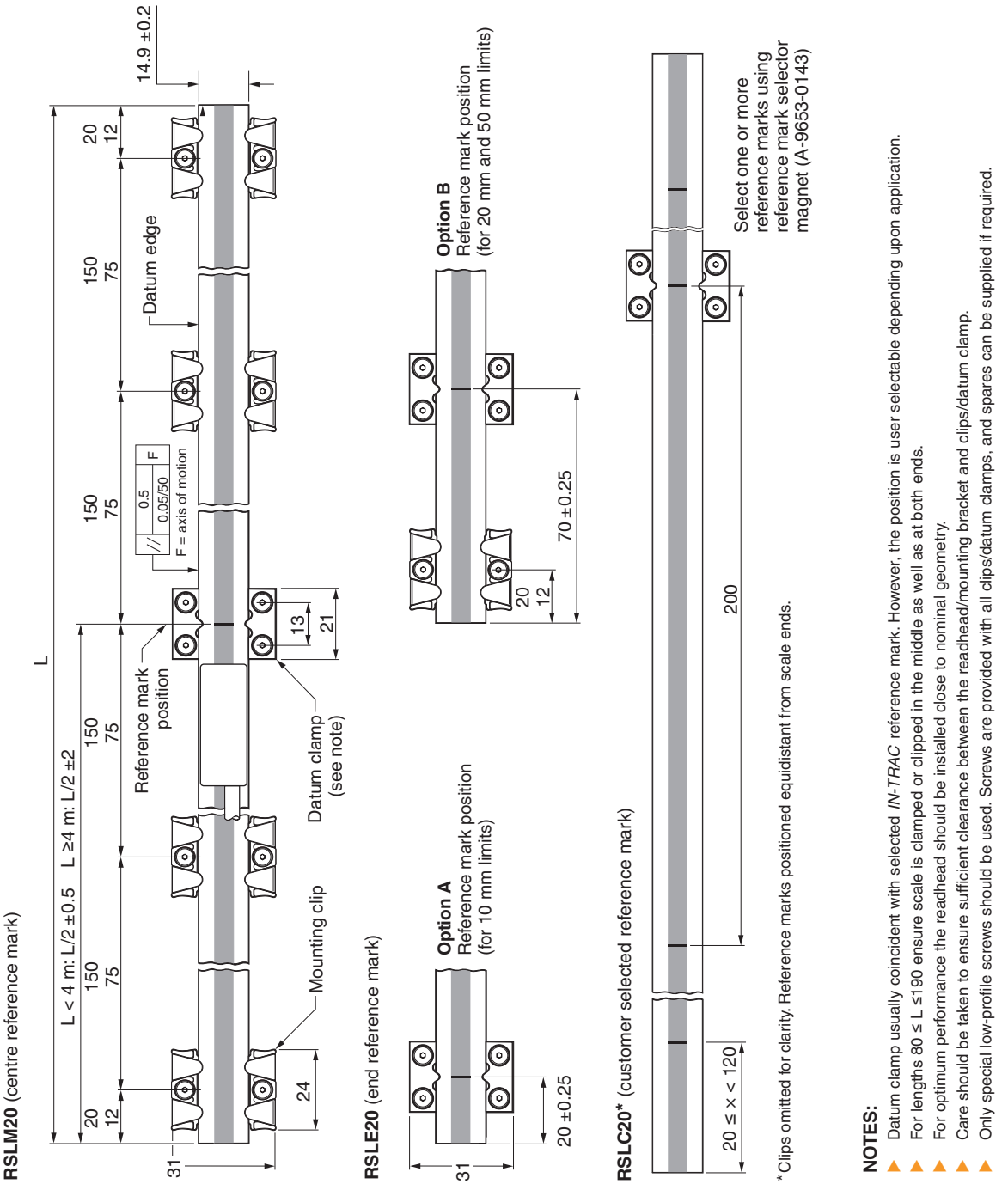
Dimensions and tolerances in mm



RSLM20 scale installation drawing (clip/clamp mounting method shown)

For further details please refer to relevant system installation guides

Dimensions and tolerances in mm



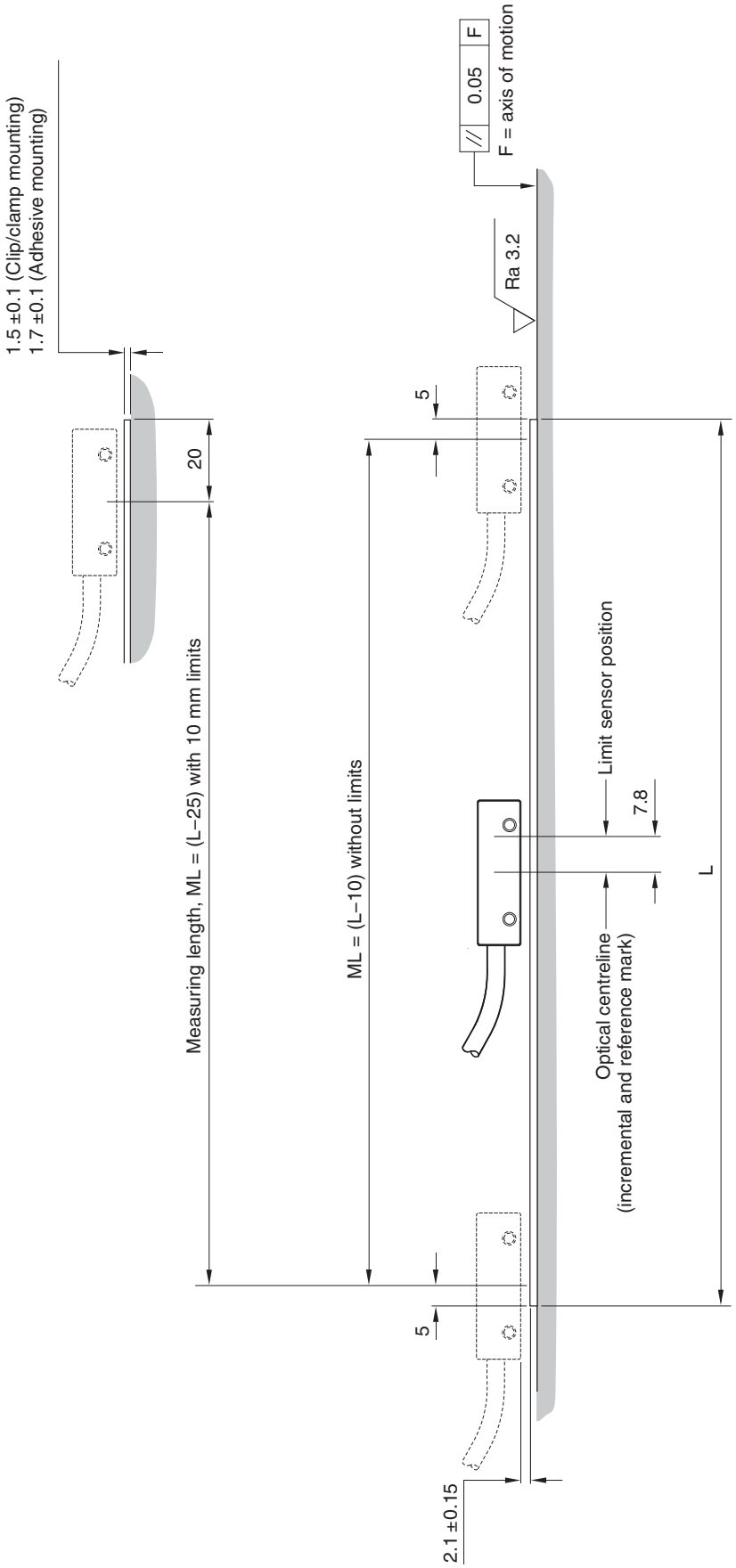
NOTES:

- Datum clamp usually coincident with selected *IN-TRAC* reference mark. However, the position is user selectable depending upon application.
- For lengths 80 ≤ L ≤190 ensure scale is clamped or clipped in the middle as well as at both ends.
- For optimum performance the readhead should be installed close to nominal geometry.
- Care should be taken to ensure sufficient clearance between the readhead/mounting bracket and clips/datum clamp.
- Only special low-profile screws should be used. Screws are provided with all clips/datum clamps, and spares can be supplied if required.

RSLM20 scale measuring length

For further details please refer to relevant system installation guides

Dimensions and tolerances in mm



Scale part numbers

20 µm pitch stainless steel spar scale

Series	Reference mark	Part number	Minimum length	Maximum length	Available in increments of	Ordering instructions
RSLM20	Single *IN-TRAC* reference mark at mid-point of scale length	A-9682-xxxx	20 mm	5 m	10 mm	Replace xxxx with one of the available standard lengths For example, 0480 will result in a length of 480 mm
RSLE20 (option A)	Single *IN-TRAC* reference mark 20 mm from scale end	A-9683-xxxx	50 mm	5 m		
RSLE20 (option B)	Single *IN-TRAC* reference mark 70 mm from scale end	A-9689-xxxx	130 mm	5 m		
RSLC20	Multiple *IN-TRAC* reference marks spaced every 200 mm Reference mark is customer selectable with selector magnet	A-9686-xxxx	280 mm	5 m		
RSLR20	No *IN-TRAC* reference mark	A-9684-xxxx	20 mm	5 m		

Accessory part numbers

Reference mark and limit magnets*

Part description	Part number	Product image
Reference mark selector magnet – Adhesive mounted **NOTE:** Only required for selecting *IN-TRAC* reference mark on RSLC20 scale	A-9653-0143	
Q limit switch actuator magnet Adhesive mounted	A-9653-0139	
P limit switch actuator magnet Adhesive mounted	A-9653-0138	
Magnet applicator device (Aids positioning)	A-9653-0201	

*Longer limit magnets are available. Contact your local subsidiary for more information.

Clip/clamp mounting accessories†

Part description	Part number	Product image
Mounting clips	A-9584-2049	
Datum clamp kit	A-9584-2050	
Replacement M3 screws (pack of 25)	A-9584-2047	
Spare clip setting shim	M-9584-0928	

† UHV and extra wide clip/clamp accessories are available. Contact your local subsidiary for more information.

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Compatible products

RSLM20
RSLE20
RSLC20

RSLR20

VIONiC

TONiC

RGH20

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RESM rotary scale

The RESM is a one-piece stainless steel ring with 20 µm or 40 µm scale marked directly onto the periphery, featuring the *IN-TRAC*™ auto-phase optical reference mark.

The RESM offers impressive accuracy with resolution to 0.00075 arc second, suiting the most demanding precision applications.

Read by Renishaw's VIONiC™, TONiC™ and QUANTiC™ encoder systems, it has high tolerance to dirt, scratches and greasy fingerprints that can cause other encoder systems to miscount.

The low profile RESM, with large internal diameter, is easy to design into most installations. Equally important, its low mass, low inertia design does not compromise system performance. Available in a wide range of sizes and line counts, providing compatibility with industry standard controllers.

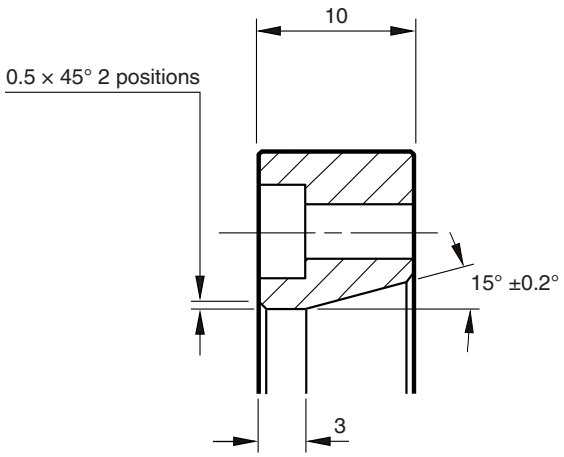
System features

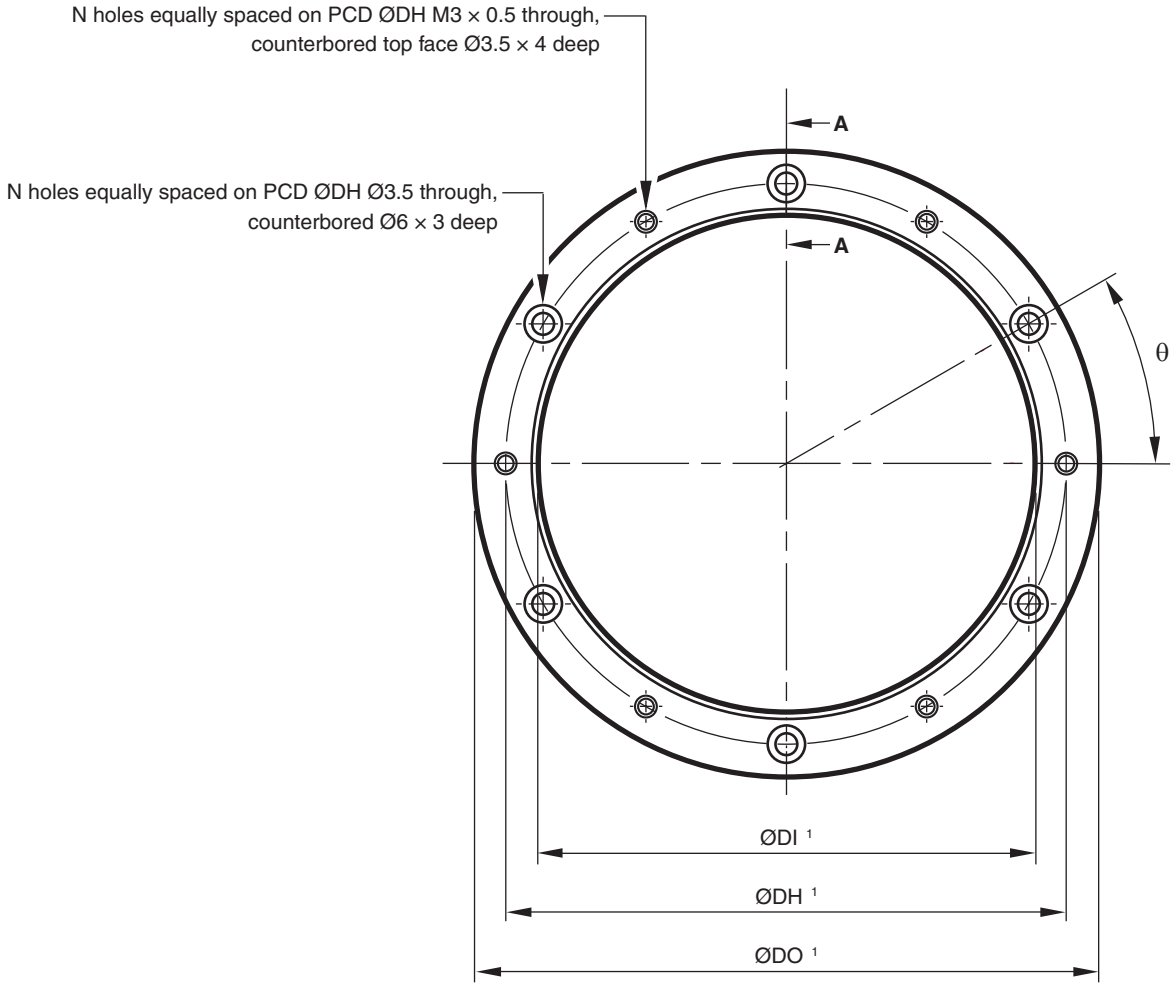
- **Compatible with the VIONiC, TONiC and QUANTiC encoder systems offering industry standard analogue or digital incremental outputs**
- ***IN-TRAC* bi-directional optical reference mark**
- **Typical installed accuracy to ±1.9 arc second (550 mm ring)**
- **Patented taper mount simplifies integration and minimises installation errors**
- **Large internal diameter for ease of integration**
- **Available in sizes from Ø52 mm to Ø550 mm with line counts from 4 096 to 86 400**
- **Custom sizes also available**
- **Low mass and low inertia**
- **Ultra-low inertia versions also available**
- **REST20 is a RESM20 with two reference marks, for use on dual readhead systems in partial arc applications**

RESM installation drawing (‘A’ section)

Dimensions and tolerances in mm

Section A-A





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

1 The dimensions DO, DI and DH for the RESM 'A' section rings are listed on the following page.

RESM specifications (‘A’ section)

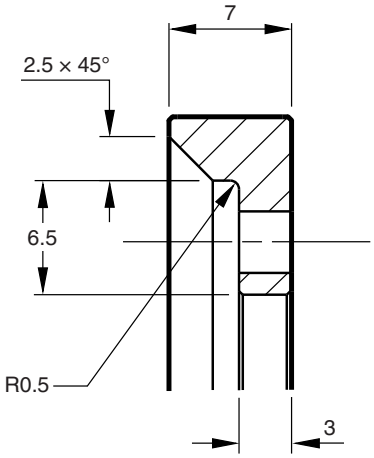
Nominal external diameter (mm)	Line count		DO (mm)	DI (mm)	Mounting holes		
	RESM20	RESM40			DH (mm)	N	θ
52	8 192	4 096	52.20 52.10	30.04 30.00	40	6	30°
57	9 000	4 500	57.35 57.25	37.04 37.00	47	6	30°
75	11 840	5 920	75.40 75.30	55.04 55.00	65	6	30°
94	14 800	7 400	94.30 94.26	74.59 74.55	84.5	6	30°
100	15 744	7 872	100.30 100.20	80.04 80.00	90	6	30°
103	16 200	8 100	103.20 103.00	80.04 80.00	90	6	30°
104	16 384	8 192	104.40 104.20	80.04 80.00	90	6	30°
115	18 000	9 000	114.70 114.50	95.04 95.00	105	6	30°
124	19 478	9 740	124.10 123.90	104.04 104.00	114	6	30°
150	23 600	11 800	150.40 150.20	130.04 130.00	140	9	20°
172	27 000	13 500	172.04 171.84	152.04 152.00	162	9	20°
183	28 800	14 400	183.45 183.25	163.04 163.00	173	9	20°
200	31 488	15 744	200.40 200.20	180.04 180.00	190	12	15°
206	32 400	16 200	206.50 206.10	186.05 186.00	196	12	15°
209	32 768	16 384	208.80 208.40	186.05 186.00	196	12	15°
229	36 000	18 000	229.40 229.00	209.05 209.00	219	12	15°
255	40 000	20 000	254.80 254.40	235.06 235.00	245	12	15°
300	47 200	23 600	300.40 300.20	280.06 280.00	290	16	11.25°
350	55 040	27 520	350.40 350.20	330.06 330.00	340	16	11.25°
413	64 800	32 400	412.70 412.30	392.08 392.00	402	18	10°
417	65 536	32 768	417.40 417.00	380.10 380.00	390	18	10°
489 [1]	76 800	38 400	489.12 488.72	451.10 450.90	462	20	18°
550	86 400	43 200	550.20 549.80	510.10 510.00	520	20	9°

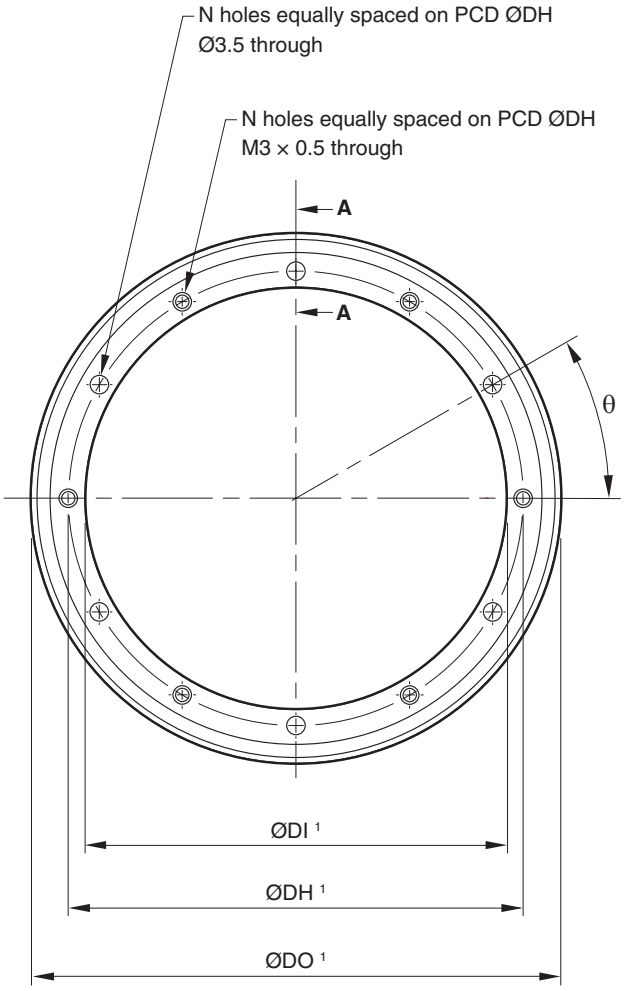
[1] There are no tapped holes on the 489 mm ring.

RESM installation drawing (‘B’ section)

Dimensions and tolerances in mm

Section A-A





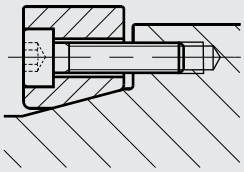
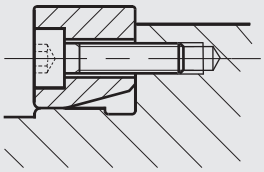
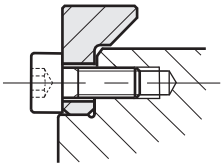
NOTE: θ is the angle between one tapped hole and the adjacent clearance hole. For example, the angle between two clearance holes is 2θ.

1 The dimensions DO, DI and DH for the RESM 'B' section rings are listed on the following page.

RESM specifications ('B' section)

Nominal external diameter (mm)	Line count		DO (mm)	DI (mm)	Mounting holes		
	RESM20	RESM40			DH (mm)	N	θ
52	8 192	4 096	52.20 52.10	32.04 32.00	38	6	30°
57	9 000	4 500	57.35 57.25	37.04 37.00	43	6	30°
75	11 840	5 920	75.40 75.30	55.04 55.00	61	6	30°
100	15 744	7 872	100.30 100.20	80.04 80.00	86	6	30°
115	18 000	9 000	114.70 114.50	95.04 95.00	101	6	30°
150	23 600	11 800	150.40 150.20	130.04 130.00	136	9	20°
165	25 920	12 960	165.10 164.90	145.04 145.00	151	9	20°
200	31 488	15 744	200.40 200.20	180.04 180.00	186	12	15°

RESM mounting methods

	Taper mount	Interference fit
'A' section		
'B' section	Not applicable	
Notes	**Recommended for all installations** • 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.	**Alternative installation** • Will not correct eccentricity of the supporting shaft.

For further information on installation and mounting options, refer to the relevant system installation guides, which are available from your local Renishaw representative, or can be downloaded from: **www.renishaw.com/encoderinstallationguides**.

Reference mark position

IN-TRAC reference mark is embedded 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.

NOTE: For REST20 rings the second reference mark is located 180° from the first reference mark.

Compatible readheads

	VIONiC	TONiC	QUANTiC
			
Scale type	RESM20/REST20	RESM20/REST20	RESM40
Pitch	20 µm	20 µm	40 µm
Outputs	Digital resolutions from 5 µm to 2.5 nm direct from the readhead	Analogue 1 Vpp. Digital resolutions from 5 µm to 1 nm from an interface	Analogue 1 Vpp. Digital resolutions from 10 µm to 50 nm direct from the readhead
SDE (typical)	∅ > 135 mm < ±15 nm ∅ ≤ 135 mm < ±20 nm	±30 nm	∅ > 135 mm < ±150 nm ∅ ≤ 135 mm < ±80 nm [1]
Jitter (RMS)	down to 1.6 nm	down to 0.5 nm	down to 2.73 nm
Maximum speed	12 m/s	10 m/s	24 m/s [1]

[1] Digital variants

Readhead features

- Filtering optics and Auto Gain Control for high reliability and solid Lissajous signals.
- Dynamic signal processing ensures ultra-low Sub-Divisional Error (SDE). Result: smoother scanning performance.
- High signal-to-noise ratio provides ultra-low jitter for optimum positional stability.
- Auto-phasing of *IN-TRAC* reference mark.
- Clocked outputs ensure optimised speed performance for all resolutions, for a wide variety of industry-standard controllers.
- DOP Dual output interfaces available to provide simultaneous analogue and digital outputs (TONiC systems only).

Operating specifications

Material		303/304 stainless steel
Coefficient of thermal expansion (at 20 °C)		15.5 ±0.5 µm/m/°C
Temperature	Storage	–20 °C to +70 °C
	Operating	0 °C to +70 °C

Nominal external diameter (mm)		**52**	**57**	**75**	**94**	**100**	**103**	**104**
Nominal internal diameter (mm)		30 [1]	37	55	75	80	80	80
Line count	RESM20 (20 µm)	8 192	9 000	11 840	14 800	15 744	16 200	16 384
	RESM40 (40 µm)	4 096	4 500	5 920	7 400	7 872	8 100	8 192
Mass (kg)	'A' section	0.098	0.1	0.15	0.18	0.2	0.24	0.26
	'B' section	0.043	0.049	0.068	-	0.094	-	-
Moment of inertia (kg mm²)	'A' section	46	61	161	338	425	519	561
	'B' section	22	31	79	-	202	-	-

Nominal external diameter (mm)		**115**	**124**	**150**	**165**	**172**	**183**	**200**
Nominal internal diameter (mm)		95	104	130	145	152	163	180
Line count	RESM20 (20 µm)	18 000	19 478	23 600	25 920	27 000	28 800	31 488
	RESM40 (40 µm)	9 000	9 740	11 800	12 960	13 500	14 400	15 744
Mass (kg)	'A' section	0.23	0.26	0.32	-	0.36	0.40	0.43
	'B' section	0.1	-	0.15	0.16	-	-	0.2
Moment of inertia (kg mm²)	'A' section	644	849	1 581	-	2 400	3 006	3 928
	'B' section	296	-	740	970	-	-	1 822

Nominal external diameter (mm)		**206**	**209**	**229**	**255**	**300**	**350**	**413**
Nominal internal diameter (mm)		186	186	209	235	280	330	392
Line count	RESM20 (20 µm)	32 400	32 768	36 000	40 000	47 200	55 040	64 800
	RESM40 (40 µm)	16 200	16 384	18 000	20 000	23 600	27 520	32 400
Mass (kg)	'A' section	0.44	0.5	0.5	0.54	0.66	0.78	0.93
	'B' section	-	-	-	-	-	-	-
Moment of inertia (kg mm²)	'A' section	4 315	4 960	6 000	8 112	13 962	22 606	37 945
	'B' section	-	-	-	-	-	-	-

Nominal external diameter (mm)		**417**	**489**	**550**
Nominal internal diameter (mm)		380	451	510
Line count	RESM20 (20 µm)	65 536	76 800	86 400
	RESM40 (40 µm)	32 768	38 400	43 200
Mass (kg)	'A' section	1.76	2.13	2.53
	'B' section	-	-	-
Moment of inertia (kg mm²)	'A' section	70 386	118 244	178 598
	'B' section	-	-	-

[1] 32 mm for 'B' section ring.

Accuracy

Nominal external diameter	Typical installed accuracy [2]					
	'A' section [1]		'B' section		'A' section - dual head	
mm	arc second	µm	arc second	µm	arc second	µm
52	±12.7	±1.6	±21.1	±2.7	±3.4	±0.4
57	±11.8	±1.6	±19.5	±2.7	±3.2	±0.4
75	±9.5	±1.7	±14.9	±2.7	±2.6	±0.5
94	±7.9	±1.8	-	-	±2.25	±0.5
100	±7.5	±1.8	±11.3	±2.7	±2.2	±0.5
103	±7.4	±1.8	-	-	±2.1	±0.5
104	±7.3	±1.8	-	-	±2.1	±0.5
115	±6.8	±1.9	±9.9	±2.8	±2	±0.5
124	±6.3	±1.9	-	-	±1.8	±0.5
150	±5.5	±2.0	±7.7	±2.8	±1.6	±0.6
165	-	-	±7.0	±2.8	-	-
172	±5.0	±2.1	-	-	±1.45	±0.6
183	±4.7	±2.1	-	-	±1.35	±0.6
200	±4.3	±2.1	±5.8	±2.8	±1.3	±0.6
206	±4.2	±2.1	-	-	±1.3	±0.6
209	±4.2	±2.1	-	-	±1.3	±0.6
229	±3.9	±2.2	-	-	±1.2	±0.7
255	±3.6	±2.2	-	-	±1.1	±0.7
300	±3.1	±2.3	-	-	±1	±0.7
350	±2.8	±2.4	-	-	±0.9	±0.8
413	±2.4	±2.4	-	-	±0.8	±0.8
417	±2.4	±2.4	-	-	±0.8	±0.8
489	±2.1	±2.5	-	-	±0.7	±0.8
550	±1.9	±2.6	-	-	±0.6	±0.9

[1] Taper mounted installations recommend an installation of ±3 µm at the bolt hole locations; adjustments are not possible for bore mounted systems.

[2] 'Typical' installations are a result of graduation and installation errors combining and, to some magnitude, cancelling.

All rings supplied are tested to ensure a minimum installed accuracy grade. The manufactured installed accuracy limit is dependent on the ring type:

- A section rings : ±5 µm (±7.5 µm for Ø413 mm ring)
- B section rings : ±8 µm

NOTE: Bore mounted A section rings, have an assumed ±8 µm installed accuracy. Refer to your local Renishaw representative for more information.

$$\text{Minimum installed accuracy in arc seconds} = \frac{\text{Minimum installed accuracy (µm)}}{\text{Ring diameter (mm)}} \times 412.5$$

Refer to Appendix for system accuracy figures.

Maximum speed (rev/min)

For details of maximum speeds for other clocked options, contact your local Renishaw representative.

VIONiC system: For 50 MHz clocked option

Nominal external diameter (mm)	Line count	Output resolution											
		5 µm	1 µm	0.5 µm	0.2 µm	0.1 µm	50 nm	40 nm	25 nm	20 nm	10 nm	5 nm	2.5 nm
52	**8 192**	4 407	4 407	4 407	2 663	1 332	666	533	333	266	133	66	33
57	**9 000**	4 021	4 021	4 021	2 429	1 215	607	486	304	243	122	61	30
75	**11 840**	3 056	3 056	3 056	1 846	923	462	369	231	185	92	46	23
94	**14 800**	2 438	2 438	2 438	1 473	738	368	295	184	147	74	37	18
100	**15 744**	2 292	2 292	2 292	1 385	693	346	277	173	138	69	35	17
103	**16 200**	2 225	2 225	2 225	1 344	672	336	269	168	134	67	34	17
104	**16 384**	2 204	2 204	2 204	1 331	666	333	266	166	133	67	33	17
115	**18 000**	1 993	1 993	1 993	1 204	602	301	241	150	120	60	30	15
124	**19 478**	1 848	1 848	1 848	1 117	559	279	223	140	112	56	28	14
150	**23 600**	1 528	1 528	1 528	923	462	231	185	115	92	46	23	12
165	**25 920**	1 389	1 389	1 389	839	420	210	168	105	84	42	21	11
172	**27 000**	1 332	1 332	1 332	805	403	201	161	101	81	40	20	10
183	**28 800**	1,252	1,252	1,252	757	379	189	151	95	76	38	19	9
200	**31 488**	1 146	1 146	1 146	692	346	173	138	87	69	35	17	8.7
206	**32 400**	1 113	1 113	1 113	672	336	168	134	84	67	34	17	8.4
209	**32 768**	1 097	1 097	1 097	663	331	166	133	83	66	33	17	8.3
229	**36 000**	1 001	1 001	1 001	605	302	151	121	76	60	30	15	7.6
255	**40 000**	899	899	899	543	272	136	109	68	54	27	14	6.8
300	**47 200**	764	764	764	462	231	115	92	58	46	23	12	5.8
350	**55 040**	655	655	655	396	198	99	79	49	40	20	10	5.0
413	**64 800**	555	555	555	335	168	84	67	42	34	17	8.4	4.2
417	**65 536**	550	550	550	332	166	83	66	41	33	17	8.3	4.2
489	**76 800**	469	469	469	283	142	71	57	35	28	14	7.1	3.6
550	**86 400**	417	417	417	252	126	63	50	31	25	13	6.3	3.2

Maximum speed (rev/min)

For details of maximum speeds for other clocked options, contact your local Renishaw representative.

TONiC system: For 50 MHz clocked option

Nominal external diameter (mm)	Line count	Digital output resolution											Analogue output
		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	Ti0000
52	**8 192**	3 673	3 673	3 673	2 380	1 190	597	238	119	59	24	12	3 673
57	**9 000**	3 351	3 351	3 351	2 171	1 086	544	217	109	54	22	11	3 351
75	**11 840**	2 546	2 546	2 546	1 650	825	414	165	83	41	17	8.1	2 546
94	**14 800**	2 032	2 032	2 032	1 317	658	330	132	66	33	13	7	2 032
100	**15 744**	1 910	1 910	1 910	1 238	619	310	124	62	31	12	6.1	1 910
103	**16 200**	1 854	1 854	1 854	1 202	601	301	120	60	30	12	5.9	1 854
104	**16 384**	1 836	1 836	1 836	1 190	595	298	119	59	30	12	5.9	1 836
115	**18 000**	1 661	1 661	1 661	1 076	538	270	108	54	27	11	5.3	1 661
124	**19 478**	1 540	1 540	1 540	998	499	250	100	50	25	10	5	1 540
150	**23 600**	1 273	1 273	1 273	825	413	207	83	41	21	8.3	4.1	1 273
165	**25 920**	1 157	1 157	1 157	750	375	188	75	38	19	8	4	1 157
172	**27 000**	1 110	1 110	1 110	720	360	180	72	36	18	7	4	1 110
183	**28 800**	1 044	1 044	1 044	676	338	170	68	34	17	7	3	1 044
200	**31 488**	955	955	955	619	309	155	62	31	15	6.2	3.1	955
206	**32 400**	927	927	927	601	300	151	60	30	15	6.0	3.0	927
209	**32 768**	914	914	914	592	296	148	59	30	15	5.9	2.9	914
229	**36 000**	834	834	834	540	270	136	54	27	14	5.4	2.7	834
255	**40 000**	749	749	749	485	243	122	49	24	12	4.9	2.4	749
300	**47 200**	637	637	637	413	206	103	41	21	10	4.1	2.0	637
350	**55 040**	546	546	546	354	177	89	35	18	8.8	3.5	1.7	546
413	**64 800**	462	462	462	300	150	75	30	15	7.5	3.0	1.5	462
417	**65 536**	458	458	458	297	148	74	30	15	7.4	3.0	1.5	458
489	**76 800**	391	391	391	253	127	63	25	13	6.3	2.5	1.2	391
550	**86 400**	347	347	347	225	113	56	23	11	5.6	2.3	1.1	347

Maximum speed (rev/min)

For details of maximum speeds for other clocked options, contact your local Renishaw representative.

QUANTiC system: For 50 MHz clocked option

Nominal external diameter (mm)	Line count	Digital output resolution							Analogue output
		10 µm	5 µm	1 µm	0.5 µm	0.2 µm	0.1 µm	50 nm	1 Vpp
52	**4 096**	8 815	8 815	8 815	6 659	2 663	1 332	666	7 346
57	**4 500**	8 042	8 042	8 042	6 075	2 429	1 215	607	6 701
75	**5 920**	6 112	6 112	6 112	4 617	1 846	923	462	5 093
94	**7 400**	4 876	4 876	4 876	3 684	1 473	737	368	4 064
100	**7 872**	4 584	4 584	4 584	3 463	1 385	693	346	3 820
103	**8 100**	4 450	4 450	4 450	3 362	1 344	672	336	3 708
104	**8 192**	4 407	4 407	4 407	3 329	1 331	666	333	3 673
115	**9 000**	3 986	3 986	3 986	3 011	1 204	602	301	3 321
124	**9 740**	3 697	3 697	3 697	2 792	1 117	558	279	3080
150	**11 800**	3 056	3 056	3 056	2 308	923	462	231	2 546
165	**12 960**	2 778	2 778	2 778	2 099	839	420	210	2 315
172	**13 500**	2 665	2 665	2 665	2 013	805	403	201	2 221
183	**14 400**	2 505	2 505	2 505	1 892	757	378	189	2 087
200	**15 744**	2 292	2 292	2 292	1 731	692	346	173	1 910
206	**16 200**	2 225	2 225	2 225	1 681	672	336	168	1 854
209	**16 384**	2 193	2 193	2 193	1 657	663	331	166	1 828
229	**18 000**	2 002	2 002	2 002	1 512	605	302	151	1 668
255	**20 000**	1 798	1 798	1 798	1 358	543	272	136	1 498
300	**23 600**	1 528	1 528	1 528	1 154	462	231	115	1 273
350	**27 520**	1 310	1 310	1 310	989	396	198	99	1 091
413	**32 400**	1 110	1 110	1 110	838	335	168	84	925
417	**32 768**	1 099	1 099	1 099	830	332	166	83	916
489	**38 400**	937	937	937	708	283	142	71	781
550	**43 200**	833	833	833	630	252	126	63	694

Resolution

VIONiC with RESM20

The RESM20 offers a range of standard ring diameters, as well as sizes that offer line counts that provide 2^n counts per revolution or resolutions that are precise sub-divisions of degrees or arc seconds.

NOTE: 1 arc second resolution = 1.296×10^6 counts per revolution ≈ 2.778×10^{-4} degree resolution.

	Nominal external diameter (line count)	VIONiC digital resolution (interpolation factor)										
		5 µm (×4)	1 µm (×20)	0.5 µm (×40)	0.2 µm (×100)	0.1 µm (×200)	50 nm (×400)	40 nm (×500)	25 nm (×800)	20 nm (×1 000)	10 nm (×2 000)	5 nm (×4 000)	2.5 nm (×8 000)
Standard outside diameters	75 mm (11 840)	≈ 27.4"	≈ 5.47"	≈ 2.74"	≈ 1.1"	≈ 0.55"	≈ 0.27"	≈ 0.22"	≈ 0.14"	≈ 0.11"	≈ 0.055"	≈ 0.028"	≈ 0.014"
	94 mm (14 800)	≈ 21.9"	≈ 4.4"	≈ 2.2"	≈ 0.9"	≈ 0.44"	≈ 0.22"	≈ 0.18"	≈ 0.11"	≈ 0.09"	≈ 0.044"	≈ 0.022"	≈ 0.011"
	100 mm (15 744)	≈ 20.6"	≈ 4.12"	≈ 2.06"	≈ 0.82"	≈ 0.41"	≈ 0.21"	≈ 0.16"	≈ 0.010"	≈ 0.082"	≈ 0.041"	≈ 0.021"	≈ 0.010"
	124 mm (19 478)	≈ 16.6"	≈ 3.3"	≈ 1.7"	≈ 0.7"	≈ 0.33"	≈ 0.17"	≈ 0.13"	≈ 0.08"	≈ 0.07"	≈ 0.033"	≈ 0.017"	≈ 0.008"
	150 mm (23 600)	≈ 13.7"	≈ 2.75"	≈ 1.37"	≈ 0.55"	≈ 0.27"	≈ 0.14"	≈ 0.11"	≈ 0.07"	≈ 0.055"	≈ 0.028"	≈ 0.014"	≈ 0.007"
	172 mm (27 000)	≈ 12.0"	≈ 2.4"	≈ 1.2"	≈ 0.5"	≈ 0.24"	≈ 0.12"	≈ 0.10"	≈ 0.06"	≈ 0.05"	≈ 0.024"	≈ 0.012"	≈ 0.006"
	200 mm (31 488)	≈ 10.3"	≈ 2.06"	≈ 1.03"	≈ 0.41"	≈ 0.21"	≈ 0.1"	≈ 0.08"	≈ 0.05"	≈ 0.041"	≈ 0.021"	≈ 0.010"	≈ 0.005"
	255 mm [1] (40 000)	≈ 8.1"	≈ 1.62"	≈ 0.81"	≈ 0.32"	≈ 0.16"	≈ 0.081"	≈ 0.06"	≈ 0.04"	≈ 0.032"	≈ 0.016"	≈ 0.0081"	≈ 0.004"
	300 mm (47 200)	≈ 6.9"	≈ 1.37"	≈ 0.69"	≈ 0.27"	≈ 0.14"	≈ 0.069"	≈ 0.05"	≈ 0.03"	≈ 0.027"	≈ 0.014"	≈ 0.0069"	≈ 0.003"
	350 mm (55 040)	≈ 5.9"	≈ 1.18"	≈ 0.59"	≈ 0.24"	≈ 0.12"	≈ 0.059"	≈ 0.05"	≈ 0.03"	≈ 0.024"	≈ 0.012"	≈ 0.0059"	≈ 0.003"
	489 mm (76 800)	≈ 4.22"	≈ 0.84"	≈ 0.42"	≈ 0.17"	≈ 0.084"	≈ 0.042"	≈ 0.03"	≈ 0.02"	≈ 0.017"	≈ 0.0084"	≈ 0.0042"	≈ 0.002"
	550 mm (86 400)	≈ 3.75"	≈ 0.75"	≈ 0.38"	≈ 0.15"	≈ 0.075"	≈ 0.38"	≈ 0.03"	≈ 0.02"	≈ 0.015"	≈ 0.075"	≈ 0.038"	≈ 0.002"
2^n line count	52 mm (8 192)	≈ 39.6"	≈ 7.9"	≈ 3.96"	≈ 1.58"	≈ 0.79"	≈ 0.4"	≈ 0.32"	≈ 0.20"	≈ 0.16"	≈ 0.079"	≈ 0.040"	≈ 0.020"
	104 mm (16 384)	≈ 19.8"	≈ 3.96"	≈ 1.98"	≈ 0.79"	≈ 0.4"	≈ 0.2"	≈ 0.16"	≈ 0.010"	≈ 0.08"	≈ 0.040"	≈ 0.020"	≈ 0.010"
	209 mm (32 768)	≈ 9.89"	≈ 1.98"	≈ 0.99"	≈ 0.4"	≈ 0.2"	≈ 0.1"	≈ 0.8"	≈ 0.05"	≈ 0.04"	≈ 0.02"	≈ 0.0099"	≈ 0.005"
	417 mm (65 536)	≈ 4.9"	≈ 0.99"	≈ 0.49"	≈ 0.2"	≈ 0.1"	≈ 0.05"	≈ 0.04"	≈ 0.02"	≈ 0.02"	≈ 0.0099"	≈ 0.0049"	≈ 0.002"
Subdivisions of degrees	57 mm (9 000)	0.01°	0.002°	0.001°	0.0004°	0.0002°	0.0001°	0.00008°	0.00005°	0.00004°	0.00002°	0.00001°	0.000005°
	115 mm (18 000)	0.005°	0.001°	0.0005°	0.0002°	0.0001°	0.00005°	0.00004°	0.00003°	0.00002°	0.00001°	0.000005°	0.000003°
	229 mm (36 000)	0.0025°	0.0005°	0.00025°	0.0001°	0.00005°	0.000025°	0.00002°	0.00001°	0.00001°	0.000005°	0.0000025°	0.000001°
Subdivisions of arc second	103 mm (16 200)	20"	4"	2"	0.8"	0.4"	0.2"	0.16"	0.10"	0.08"	0.040"	0.020"	0.010"
	165 mm (25 920)	12.50"	2.5"	1.25"	0.5"	0.25"	0.125"	0.1"	0.0625"	0.05"	0.025"	0.0125"	0.00625"
	183 mm (28 800)	11.25"	2.25"	1.125"	0.45"	0.225"	0.1125"	0.09"	0.05625"	0.045"	0.0225"	0.01125"	0.005625"
	206 mm (32 400)	10"	2"	1"	0.4"	0.2"	0.1"	0.08"	0.05"	0.04"	0.020"	0.010"	0.0050"
	413 mm (64 800)	5"	1"	0.5"	0.2"	0.1"	0.05"	0.04"	0.03"	0.02"	0.010"	0.0050"	0.003"

[1] Line count as a multiple of 1 000.

NOTES:

- The symbol " indicates units of arc seconds.
- Numbers preceded with a ≈ symbol show rounded resolution values. To calculate the exact resolution in arc seconds, use the following equation:

$$\theta \text{ (arc seconds)} = \frac{1.296 \times 10^6}{[\text{Line count}] \times [\text{Interpolation factor}]}$$

Resolution

TONiC with RESM20

The RESM20 offers a range of standard ring diameters, as well as sizes that offer line counts that provide 2^n counts per revolution or resolutions that are precise sub-divisions of degrees or arc seconds.

NOTE: 1 arc second resolution = 1.296×10^6 counts per revolution ≈ 2.778×10^{-4} degree resolution.

	Nominal external diameter (line count)	TONiC digital resolution (interpolation factor)										
		5 µm (×4)	1 µm (×20)	0.5 µm (×40)	0.2 µm (×100)	0.1 µm (×200)	50 nm (×400)	20 nm (×1 000)	10 nm (×2 000)	5 nm (×4 000)	2 nm (×10 000)	1 nm (×20 000)
Standard outside diameters	75 mm (11 840)	≈ 27.4"	≈ 5.47"	≈ 2.74"	≈ 1.1"	≈ 0.55"	≈ 0.27"	≈ 0.11"	≈ 0.055"	≈ 0.028"	≈ 0.011"	≈ 0.0055"
	94 mm (14 800)	≈ 21.9"	≈ 4.38"	≈ 2.19"	≈ 0.88"	≈ 0.44"	≈ 0.22"	≈ 0.09"	≈ 0.044"	≈ 0.022"	≈ 0.009"	≈ 0.0044"
	100 mm (15 744)	≈ 20.6"	≈ 4.12"	≈ 2.06"	≈ 0.82"	≈ 0.41"	≈ 0.21"	≈ 0.082"	≈ 0.041"	≈ 0.021"	≈ 0.0082"	≈ 0.0041"
	124 mm (19 478)	≈ 16.6"	≈ 3.33"	≈ 1.66"	≈ 0.67"	≈ 0.33"	≈ 0.17"	≈ 0.07"	≈ 0.033"	≈ 0.017"	≈ 0.007"	≈ 0.0033"
	150 mm (23 600)	≈ 13.7"	≈ 2.75"	≈ 1.37"	≈ 0.55"	≈ 0.27"	≈ 0.14"	≈ 0.055"	≈ 0.028"	≈ 0.014"	≈ 0.0055"	≈ 0.0027"
	172 mm (27 000)	≈ 12.0"	≈ 2.40"	≈ 1.2"	≈ 0.48"	≈ 0.24"	≈ 0.12"	≈ 0.05"	≈ 0.024"	≈ 0.012"	≈ 0.005"	≈ 0.0024"
	200 mm (31 488)	≈ 10.3"	≈ 2.06"	≈ 1.03"	≈ 0.41"	≈ 0.21"	≈ 0.1"	≈ 0.041"	≈ 0.021"	≈ 0.010"	≈ 0.0041"	≈ 0.0020"
	255 mm [1] (40 000)	≈ 8.1"	≈ 1.62"	≈ 0.81"	≈ 0.32"	≈ 0.16"	≈ 0.081"	≈ 0.032"	≈ 0.016"	≈ 0.0081"	≈ 0.0032"	≈ 0.0016"
	300 mm (47 200)	≈ 6.9"	≈ 1.37"	≈ 0.69"	≈ 0.27"	≈ 0.14"	≈ 0.069"	≈ 0.027"	≈ 0.014"	≈ 0.0069"	≈ 0.0027"	≈ 0.0014"
	350 mm (55 040)	≈ 5.9"	≈ 1.18"	≈ 0.59"	≈ 0.24"	≈ 0.12"	≈ 0.059"	≈ 0.024"	≈ 0.012"	≈ 0.0059"	≈ 0.0024"	≈ 0.0012"
	489 mm (76 800)	≈ 4.22"	≈ 0.84"	≈ 0.42"	≈ 0.17"	≈ 0.084"	≈ 0.042"	≈ 0.017"	≈ 0.0084"	≈ 0.0042"	≈ 0.0017"	≈ 0.00084"
	550 mm (86 400)	≈ 3.75"	≈ 0.75"	≈ 0.38"	≈ 0.15"	≈ 0.075"	≈ 0.38"	≈ 0.015"	≈ 0.075"	≈ 0.038"	≈ 0.0015"	≈ 0.00075"
2^n line count	52 mm (8 192)	≈ 39.6"	≈ 7.9"	≈ 3.96"	≈ 1.58"	≈ 0.79"	≈ 0.4"	≈ 0.16"	≈ 0.079"	≈ 0.040"	≈ 0.016"	≈ 0.0079"
	104 mm (16 384)	≈ 19.8"	≈ 3.96"	≈ 1.98"	≈ 0.79"	≈ 0.4"	≈ 0.2"	≈ 0.08"	≈ 0.040"	≈ 0.020"	≈ 0.0080"	≈ 0.0040"
	209 mm (32 768)	≈ 9.89"	≈ 1.98"	≈ 0.99"	≈ 0.4"	≈ 0.2"	≈ 0.1"	≈ 0.04"	≈ 0.02"	≈ 0.0099"	≈ 0.0040"	≈ 0.0020"
	417 mm (65 536)	≈ 4.9"	≈ 0.99"	≈ 0.49"	≈ 0.2"	≈ 0.1"	≈ 0.05"	≈ 0.02"	≈ 0.0099"	≈ 0.0049"	≈ 0.0020"	≈ 0.00099"
Subdivisions of degrees	57 mm (9 000)	0.01°	0.002°	0.001°	0.0004°	0.0002°	0.0001°	0.00004°	0.00002°	0.00001°	0.000004°	0.000002°
	115 mm (18 000)	0.005°	0.001°	0.0005°	0.0002°	0.0001°	0.00005°	0.00002°	0.00001°	0.000005°	0.000002°	0.000001°
	229 mm (36 000)	0.0025°	0.0005°	0.00025°	0.0001°	0.00005°	0.000025°	0.00001°	0.000005°	0.0000025°	0.000001°	0.0000005°
Subdivisions of arc second	103 mm (16 200)	20"	4"	2"	0.8"	0.4"	0.2"	0.08"	0.040"	0.020"	0.0080"	0.0040"
	165 mm (25 920)	12.5"	2.5"	1.25"	0.5"	0.25"	0.125"	0.05"	0.025"	0.0125"	0.005"	0.0025"
	183 mm (28 800)	11.25"	2.25"	1.125"	0.45"	0.225"	0.1125"	0.05"	0.0225"	0.01125"	0.005"	0.00225"
	206 mm (32 400)	10"	2"	1"	0.4"	0.2"	0.1"	0.04"	0.020"	0.010"	0.0040"	0.0020"
	413 mm (64 800)	5"	1"	0.5"	0.2"	0.1"	0.05"	0.02"	0.010"	0.0050"	0.0020"	0.0010"

[1] Line count as a multiple of 1 000.

NOTES:

- The symbol " indicates units of arc seconds.
- Numbers preceded with a ≈ symbol show rounded resolution values. To calculate the exact resolution in arc seconds, use the following equation:

$$\theta \text{ (arc seconds)} = \frac{1.296 \times 10^6}{[\text{Line count}] \times [\text{Interpolation factor}]}$$

Resolution

QUANTiC with RESM40

The RESM40 offers a range of standard ring diameters, as well as sizes that offer line counts that provide 2^n counts per revolution or resolutions that are precise sub-divisions of degrees or arc seconds.

NOTE: 1 arc second resolution = 1.296×10^6 counts per revolution ≈ 2.778×10^{-4} degree resolution.

	Nominal external diameter (line count)	QUANTiC digital resolution (interpolation factor)						
		10 µm (×4)	5 µm (×8)	1 µm (×40)	0.5 µm (×80)	0.2 µm (×200)	0.1 µm (×400)	50 nm (×800)
Standard outside diameters	75 mm (5 920)	≈ 54.73"	≈ 27.36"	≈ 5.47"	≈ 2.74"	≈ 1.09"	≈ 0.55"	≈ 0.27"
	94 mm (7 400)	≈ 43.8"	≈ 21.9"	≈ 4.4"	≈ 2.2"	≈ 0.876"	≈ 0.438"	≈ 0.219"
	100 mm (7 872)	≈ 41.16"	≈ 20.58"	≈ 4.12"	≈ 2.06"	≈ 0.82"	≈ 0.41"	≈ 0.21"
	124 mm (9 740)	≈ 33.3"	≈ 16.6"	≈ 3.3"	≈ 1.7"	≈ 0.665"	≈ 0.333"	≈ 0.166"
	150 mm (11 800)	≈ 27.46"	≈ 13.73"	≈ 2.75"	≈ 1.37"	≈ 0.55"	≈ 0.27"	≈ 0.14"
	172 mm (13 500)	≈ 24.0"	≈ 12.0"	≈ 2.4"	≈ 1.2"	≈ 0.48"	≈ 0.24"	≈ 0.12"
	200 mm (15 744)	≈ 20.58"	≈ 10.29"	≈ 2.06"	≈ 1.03"	≈ 0.41"	≈ 0.21"	≈ 0.10"
	255 mm* (20 000)	≈ 16.20"	≈ 8.10"	≈ 1.62"	≈ 0.81"	≈ 0.32"	≈ 0.16"	≈ 0.08"
	300 mm (23 600)	≈ 13.73"	≈ 6.86"	≈ 1.37"	≈ 0.69"	≈ 0.27"	≈ 0.14"	≈ 0.07"
	350 mm (27 520)	≈ 11.77"	≈ 5.89"	≈ 1.18"	≈ 0.59"	≈ 0.24"	≈ 0.12"	≈ 0.06"
	489 mm (38 400)	≈ 8.44"	≈ 4.22"	≈ 0.84"	≈ 0.42"	≈ 0.17"	≈ 0.08"	≈ 0.04"
	550 mm (43 200)	≈ 7.50"	≈ 3.75"	≈ 0.75"	≈ 0.38"	≈ 0.15"	≈ 0.08"	≈ 0.04"
2^n line count	52 mm (4 096)	≈ 79.10"	≈ 39.55"	≈ 7.91"	≈ 3.96"	≈ 1.58"	≈ 0.79"	≈ 0.40"
	104 mm (8 192)	≈ 39.55"	≈ 19.78"	≈ 3.96"	≈ 1.98"	≈ 0.79"	≈ 0.40"	≈ 0.20"
	209 mm (16 384)	≈ 19.78"	≈ 9.89"	≈ 1.98"	≈ 0.99"	≈ 0.40"	≈ 0.20"	≈ 0.10"
	417 mm (32 768)	≈ 9.89"	≈ 4.94"	≈ 0.99"	≈ 0.49"	≈ 0.20"	≈ 0.10"	≈ 0.05"
Subdivisions of degrees	57 mm (4 500)	0.02°	0.01°	0.002°	0.001°	0.0004°	0.0002°	0.0001°
	115 mm (9 000)	0.01°	0.005°	0.001°	0.0005°	0.0002°	0.0001°	0.00005°
	229 mm (18 000)	0.005°	0.0025°	0.0005°	0.00025°	0.0001°	0.00005°	0.000025°
Subdivisions of arc second	103 mm (8 100)	40"	20"	4"	2"	0.8"	0.4"	0.2"
	165 mm (12 960)	25"	12.5"	2.5"	1.25"	0.5"	0.25"	0.125"
	183 mm (14 400)	22.5"	11.25"	2.25"	1.125"	0.45"	0.225"	0.1125"
	206 mm (16 200)	20"	10"	2"	1"	0.4"	0.2"	0.1"
	413 mm (32 400)	10"	5"	1"	0.5"	0.2"	0.1"	0.05"

[1] Line count as a multiple of 1 000.

NOTES:

- The symbol " indicates units of arc seconds.
- Numbers preceded with a ≈ symbol show rounded resolution values. To calculate the exact resolution in arc seconds, use the following equation:

$$\theta \text{ (arc seconds)} = \frac{1.296 \times 10^6}{[\text{Line count}] \times [\text{Interpolation factor}]}$$

Rotary scale part numbers

RESM 20U S A 300

Ring diameter

052 = 52 mm	115 = 115 mm	206 = 206 mm	417 = 417 mm
057 = 57 mm	124 = 124 mm	209 = 209 mm	489 = 489 mm
075 = 75 mm	150 = 150 mm	229 = 229 mm	550 = 550 mm
094 = 94 mm	165 = 165 mm	255 = 255 mm	
100 = 100 mm	172 = 172 mm	300 = 300 mm	
103 = 103 mm	183 = 183 mm	350 = 350 mm	
104 = 104 mm	200 = 200 mm	413 = 413 mm	

Form

A = Tapered internal diameter

B = Low inertia (only available in 52, 57, 75, 100, 115, 150, 165 and 200 mm diameters)

Material

S = Stainless steel

Pitch

20U = 20 µm

40U = 40 µm (RESM rotary scale series only)

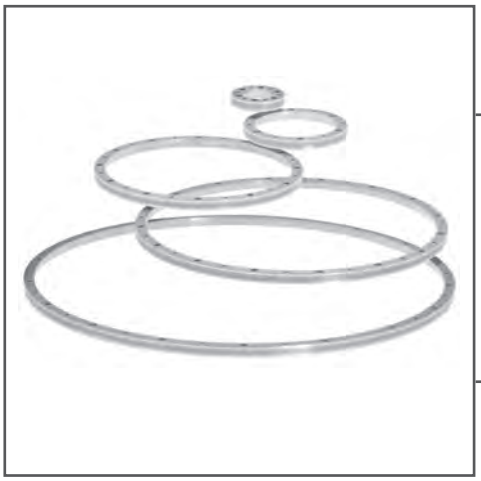
Rotary scale series

RESM = Single reference mark for axes capable of full rotation

REST = Two reference marks for partial-rotation axws (20 µm pitch only)

Compatible products

RESM



RESM20

VIONiC

TONiC

RESM40

QUANTiC

Appendix

Graduation and system accuracy

Nominal external diameter	Graduation accuracy		System accuracy		
			VIONiC	TONiC	QUANTiC
mm	arc second	µm	arc second	arc second	arc second
52	±2.3	±0.3	±2.4	±2.5	±2.9
57	±2.2	±0.3	±2.3	±2.4	±2.8
75	±1.9	±0.4	±2.0	±2.1	±2.4
94	±1.7	±0.4	±1.8	±1.9	±2.1
100	±1.7	±0.4	±1.7	±1.8	±2.0
103	±1.6	±0.4	±1.7	±1.8	±2.0
104	±1.6	±0.4	±1.7	±1.8	±1.9
115	±1.6	±0.4	±1.6	±1.7	±1.8
124	±1.6	±0.4	±1.7	±1.7	±1.9
150	±1.4	±0.5	±1.4	±1.4	±1.6
165	±1.3	±0.5	±1.4	±1.4	±1.5
172	±1.3	±0.5	±1.3	±1.4	±1.5
183	±1.3	±0.5	±1.3	±1.3	±1.4
200	±1.2	±0.6	±1.2	±1.2	±1.3
206	±1.2	±0.6	±1.2	±1.2	±1.3
209	±1.2	±0.6	±1.2	±1.2	±1.3
229	±1.1	±0.6	±1.1	±1.2	±1.2
255	±1.0	±0.7	±1.1	±1.1	±1.2
300	±1.0	±0.7	±1.0	±1.0	±1.1
350	±0.9	±0.8	±0.9	±0.9	±1.0
413	±0.8	±0.8	±0.8	±0.9	±0.9
417	±0.8	±0.8	±0.8	±0.8	±0.9
489	±0.8	±0.9	±0.8	±0.8	±0.8
550	±0.7	±1.0	±0.7	±0.7	±0.8

Graduation accuracy is the maximum difference between the angle measured by a single readhead and the true rotation of the encoder as graduated. Application disturbances such as eccentricity are not included.

System accuracy is graduation accuracy plus SDE. For application advice, contact your local Renishaw representative.

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www.renishaw.com/contact

#renishaw

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Part no.: L-9517-9154-09-A
Issued: 12.2022

Data sheet
L-9517-9318-07-A

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REXM20 ultra-high accuracy angle encoder

With zero coupling losses and exceptional repeatability, the REXM20 ultra-high accuracy angle encoder achieves better than ±1 arc second total installed accuracy.

Like the RESM20 encoder, the REXM20 is a stainless steel ring with the scale graduations marked axially onto the periphery, but with a number of differences to improve upon RESM20's already impressive accuracy.

REXM20 has a thicker cross-section, to ensure that the only significant installation error is eccentricity. Eccentricity is easily removed using two readheads, either with Renishaw's DSi (Dual Signal interface), or by combining the signals inside the host controller. The only errors remaining are graduation errors and readhead SDE, both of which are so small they are often negligible.

As a non-contact encoder, REXM20 offers dynamic performance advantages, eliminating coupling losses, oscillation, shaft torsion and other hysteresis errors that plague enclosed encoders.

Combining two readheads is easy with the DSi, which also offers an angularly repeatable reference position (*propoZ*™) which is unaffected by bearing wander or power cycling.

REXM20 total installed accuracy grades:

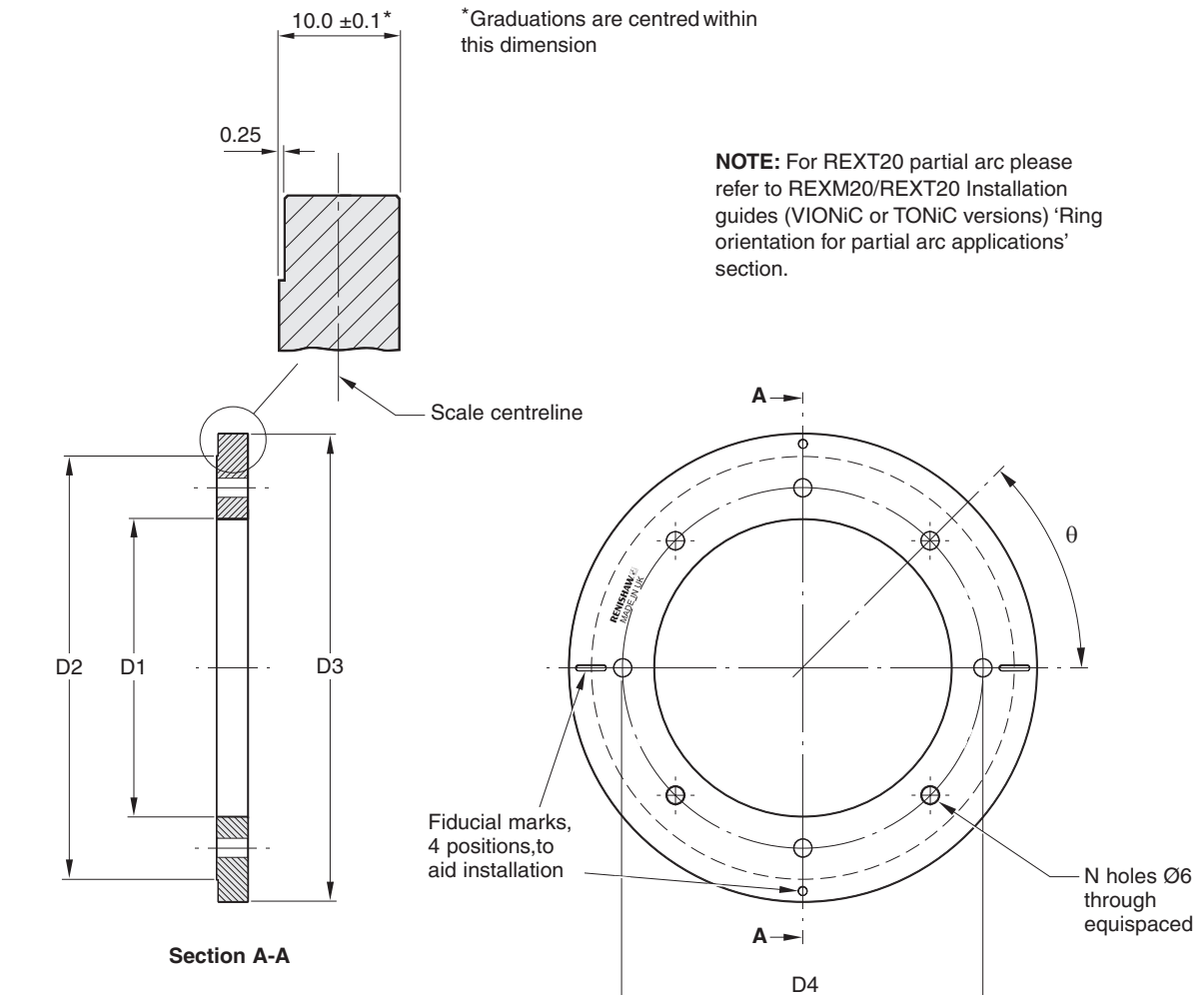
Ring diameter	Total installed accuracy
≥ 100 mm	±1 arc second
75 mm	±1.5 arc second
≤ 57 mm	±2 arc second

Designed for axes that are limited to partial rotation, REXT20 rings have two reference marks, oriented diametrically opposed, for use with partial arc versions of DSi. DSi processes these reference marks to give a single, angularly-repeatable *propoZ* reference output.

- **Use with two VIONiC™ or TONiC™ encoders, combined with DSi to give ultra-high accuracy**
- **Installed accuracy to ±1 arc second with dual readheads**
- **Wide range of standard sizes from 52 mm to 417 mm**
- **Large internal diameter for ease of integration**
- **Flange mounted with easy 4-point adjustment method**
- **Angularly repeatable *propoZ* reference position is unaffected by bearing wander or power cycling**

Installation drawing

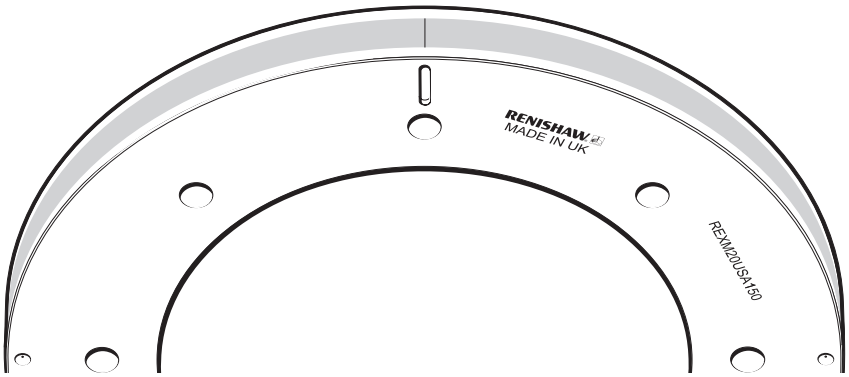
Dimensions and tolerances in mm



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

*52 mm and 57 mm rings have dimple fiducial features and no slots.

Reference mark position



REXM20

IN-TRAC™ reference mark is embedded in the scale, radially aligned to the line fiducial mark to the left of the 'Renishaw' logo. No external actuators or physical adjustment are required.

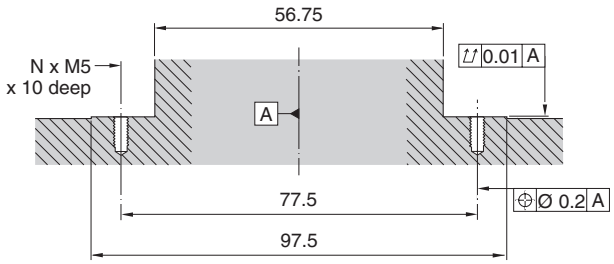
REXT20

The second reference mark is 180° from the first.

Mounting method (IMPORTANT: flange mount only. DO NOT interference fit)

Mounting surface preparation

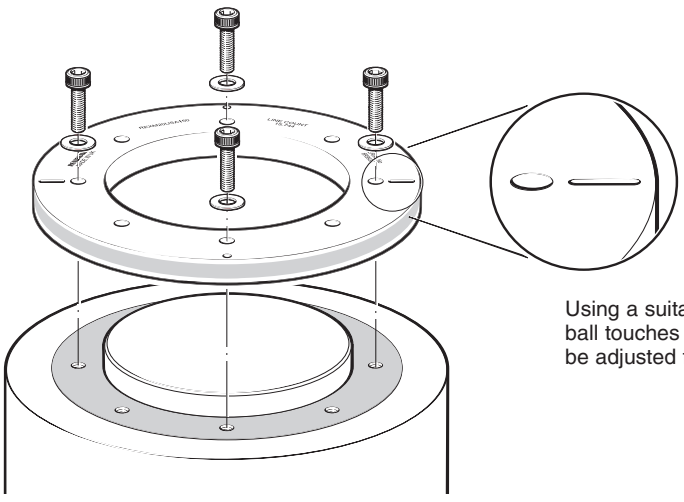
The mounting surface should have an axial run-out of 10 µm. This tolerance only needs to be held over the region where the flat surface of the ring mates to the mounting surface.



For other ring sizes refer to the VIONiC REXM20/REXT20 installation guide (M-6195-9239) or TONiC REXM20/REXT20 installation guide (M-9653-9248), which can be found on **www.renishaw.com/support**

Example of mounting surface for 100 mm REXM20

Installation technique (Please refer to the REXM20/REXT20 installation guide for full details)



REXM20 rings are made with 4 fiducial points engraved onto the top surface, which simplify alignment.

Using a suitable dial test indicator, positioned so that the stylus ball touches directly onto the scale surface, the ring only needs to be adjusted for run-out at the 4 fiducial points.

Operating specifications

Material	303/304 stainless steel		
Coefficient of thermal expansion (at 20 °C)	15.5 ±0.5 µm/m/°C		
Temperature	Storage	System	–20 °C to +70 °C
	Operating	VIONiC and TONiC	0 °C to + 70 °C

Ring mass and inertia

Ring diameter (mm)	52	57	75	100	103	104	115	150	183
Mass (kg)	0.13	0.17	0.26	0.43	0.47	0.48	0.54	0.85	1.18
Inertia (kg cm²)	0.55	0.82	2.3	7.2	8.1	8.5	12	34	71

Ring diameter (mm)	200	206	209	229	255	300	350	417
Mass (kg)	1.37	1.44	1.50	1.69	2.03	2.74	3.59	5.09
Inertia (kg cm²)	100	113	120	165	250	470	845	1700

Accuracy

The total installed accuracy of the REXM20 rings when used with two VIONiC or TONiC encoders, with the ring flange mounted onto a shaft surface prepared to the specifications detailed in the REXM20/REXT20 installation guide, centred so that the radial run-out at the fiducial points agrees to within 10 µm TIR, will be as follows:

Nominal external diameter (mm)	Total installed accuracy (arc second)
52	±2
57	±2
75	±1.5
100	±1
103	±1
104	±1
115	±1
150	±1
183	±1
200	±1
206	±1
209	±1
229	±1
255	±1
300	±1
350	±1
417	±1

NOTE: The figures in this table refer to 'total installed accuracy', not to be confused with 'system accuracy'. Total installed accuracy includes graduation errors, readhead sub-divisional errors, installation errors and errors caused by bearing wander.

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Maximum speed (rev/min)

For details of maximum speeds for other clocked options, please contact your local representative.

VIONiC system: For 20 MHz clocked option

Nominal external diameter (mm)	Line count	Output resolution											
		5 µm	1 µm	0.5 µm	0.2 µm	0.1 µm	50 nm	40 nm	25 nm	20 nm	10 nm	5 nm	2.5 nm
52	8 192	4 395	4 395	2 950	1 180	590	295	236	148	118	59	30	15
57	9 000	4 000	4 000	2 686	1 074	537	269	215	134	107	54	27	13
75	11 840	3 041	3 041	2 041	817	408	204	163	102	82	41	20	10
100	15 744	2 287	2 287	1 535	614	307	154	123	77	61	31	15	7.7
103	16 200	2 222	2 222	1 492	597	298	149	119	75	60	30	15	7.5
104	16 384	2 197	2 197	1 475	590	295	148	118	74	59	30	15	7.4
115	18 000	2 000	2 000	1 343	537	269	134	107	67	54	27	13	6.7
150	23 600	1 525	1 525	1 024	410	205	102	82	51	41	20	10	5.1
183	28 800	1 250	1 250	839	336	168	84	67	42	34	17	8.4	4.2
200	31 488	1 143	1 143	768	307	154	77	61	38	31	15	7.7	3.8
206	32 400	1 111	1 111	746	298	149	75	60	37	30	15	7.5	3.7
209	32 768	1 099	1 099	738	295	148	74	59	37	30	15	7.4	3.7
229	36 000	1 000	1 000	671	269	134	67	54	34	27	13	6.7	3.4
255	40 000	900	900	604	242	121	60	48	30	24	12	6.0	3.0
300	47 200	763	763	512	205	102	51	41	26	20	10	5.1	2.6
350	55 040	654	654	439	176	88	44	35	22	18	8.8	4.4	2.2
417	65 536	549	549	369	148	74	37	30	18	15	7.4	3.7	1.8

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Maximum speed (rev/min)

For details of maximum speeds for other clocked options, please contact your local representative.

TONiC system: For 20 MHz clocked option

Nominal external diameter (mm)	Line count	Output resolution											Analogue*
		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	Ti0000
52	8 192	3 673	3 673	2 479	992	496	246	99	50	25	10	4.8	3 673
57	9 000	3 350	3 350	2 261	904	452	224	90	45	23	9.0	4.4	3 350
75	11 840	2 546	2 546	1 719	688	344	171	69	34	17	6.9	3.3	2 546
100	15 744	1 910	1 910	1 289	516	258	128	52	26	13	5.2	2.5	1 910
103	16 200	1 854	1 854	1 251	501	250	124	50	25	12	5.0	2.4	1 854
104	16 384	1 836	1 836	1 239	496	248	123	50	25	12	5.0	2.4	1 836
115	18 000	1 661	1 661	1 121	448	224	111	45	22	11	4.5	2.2	1 661
150	23 600	1 273	1 273	859	344	172	85	34	17	8.6	3.4	1.7	1 273
183	28 800	1 044	1044	705	282	141	70	28	14	7.0	2.8	1.4	1 044
200	31 488	955	955	645	258	129	64	26	13	6.4	2.6	1.2	955
206	32 400	927	927	626	250	125	62	25	12	6.2	2.5	1.2	927
209	32 768	914	914	617	247	123	61	25	12	6.2	2.5	1.2	914
229	36 000	834	834	563	225	113	56	22	11	5.6	2.3	1.1	834
255	40 000	749	749	506	202	101	50	20	10	5.0	2.0	1.0	749
300	47 200	637	637	430	172	86	43	17	8.6	4.3	1.7	0.8	637
350	55 040	546	546	369	147	74	37	15	7.4	3.7	1.5	0.7	546
417	65 536	458	458	309	124	62	31	12	6.2	3.1	1.2	0.6	458

*Currently Renishaw do not offer an analogue Dual Head summing box: customer would have to do their own summing.

Resolution – VIONiC

The REXM20 offers a range of standard ring diameters, as well as sizes that offer line counts that provide 2^n counts per revolution or resolutions that are precise sub-divisions of degrees or arc seconds.

NOTE: 1 arc second resolution = 1.296×10^6 counts per revolution ≈ 2.778×10^{-4} degree resolution.

	Nominal external diameter (line count)	Digital resolution (interpolation factor)											
		5 µm (×4)	1 µm (×20)	0.5 µm (×40)	0.2 µm (×100)	0.1 µm (×200)	50 nm (×400)	40 nm (×500)	25 nm (×800)	20 nm (×1 000)	10 nm (×2 000)	5 nm (×4 000)	2.5 nm (×8 000)
Standard outside diameters	75 mm (11 840)	≈ 27.4"	≈ 5.47"	≈ 2.74"	≈ 1.1"	≈ 0.55"	≈ 0.27"	≈ 0.22"	≈ 0.14"	≈ 0.11"	≈ 0.055"	≈ 0.028"	≈ 0.014"
	100 mm (15 744)	≈ 20.6"	≈ 4.12"	≈ 2.06"	≈ 0.82"	≈ 0.41"	≈ 0.21"	≈ 0.16"	≈ 0.010"	≈ 0.082"	≈ 0.041"	≈ 0.021"	≈ 0.010"
	150 mm (23 600)	≈ 13.7"	≈ 2.75"	≈ 1.37"	≈ 0.55"	≈ 0.27"	≈ 0.14"	≈ 0.11"	≈ 0.07"	≈ 0.055"	≈ 0.028"	≈ 0.014"	≈ 0.007"
	183 mm (28 800)	≈ 11.3"	≈ 2.25"	≈ 1.13"	≈ 0.45"	≈ 0.23"	≈ 0.11"	≈ 0.090"	≈ 0.056"	≈ 0.045"	≈ 0.023"	≈ 0.011"	≈ 0.0056"
	200 mm (31 488)	≈ 10.3"	≈ 2.06"	≈ 1.03"	≈ 0.41"	≈ 0.21"	≈ 0.1"	≈ 0.08"	≈ 0.05"	≈ 0.041"	≈ 0.021"	≈ 0.010"	≈ 0.005"
	255 mm† (40 000)	≈ 8.1"	≈ 1.62"	≈ 0.81"	≈ 0.32"	≈ 0.16"	≈ 0.081"	≈ 0.06"	≈ 0.04"	≈ 0.032"	≈ 0.016"	≈ 0.0081"	≈ 0.004"
	300 mm (47 200)	≈ 6.9"	≈ 1.37"	≈ 0.69"	≈ 0.27"	≈ 0.14"	≈ 0.069"	≈ 0.05"	≈ 0.03"	≈ 0.027"	≈ 0.014"	≈ 0.0069"	≈ 0.003"
	350 mm (55 040)	≈ 5.9"	≈ 1.18"	≈ 0.59"	≈ 0.24"	≈ 0.12"	≈ 0.059"	≈ 0.05"	≈ 0.03"	≈ 0.024"	≈ 0.012"	≈ 0.0059"	≈ 0.003"
2^n line count	52 mm (8 192)	≈ 39.6"	≈ 7.9"	≈ 3.96"	≈ 1.58"	≈ 0.79"	≈ 0.4"	≈ 0.32"	≈ 0.20"	≈ 0.16"	≈ 0.079"	≈ 0.040"	≈ 0.020"
	104 mm (16 384)	≈ 19.8"	≈ 3.96"	≈ 1.98"	≈ 0.79"	≈ 0.4"	≈ 0.2"	≈ 0.16"	≈ 0.010"	≈ 0.08"	≈ 0.040"	≈ 0.020"	≈ 0.010"
	209 mm (32 768)	≈ 9.89"	≈ 1.98"	≈ 0.99"	≈ 0.4"	≈ 0.2"	≈ 0.1"	≈ 0.8"	≈ 0.05"	≈ 0.04"	≈ 0.02"	≈ 0.0099"	≈ 0.005"
	417 mm (65 536)	≈ 4.9"	≈ 0.99"	≈ 0.49"	≈ 0.2"	≈ 0.1"	≈ 0.05"	≈ 0.04"	≈ 0.02"	≈ 0.02"	≈ 0.0099"	≈ 0.0049"	≈ 0.002"
Subdivisions of degrees	57 mm (9 000)	0.01°	0.002°	0.001°	0.0004°	0.0002°	0.0001°	0.00008°	0.00005°	0.00004°	0.00002°	0.00001°	0.000005°
	115 mm (18 000)	0.005°	0.001°	0.0005°	0.0002°	0.0001°	0.00005°	0.00004°	0.00003°	0.00002°	0.00001°	0.000005°	0.000003°
	229 mm (36 000)	0.0025°	0.0005°	0.00025°	0.0001°	0.00005°	0.000025°	0.00002°	0.00001°	0.00001°	0.000005°	0.0000025°	0.000001°
Subdivisions of arc second	103 mm (16 200)	20"	4"	2"	0.8"	0.4"	0.2"	0.16"	0.10"	0.08"	0.040"	0.020"	0.010"
	206 mm (32 400)	10"	2"	1"	0.4"	0.2"	0.1"	0.08"	0.05"	0.04"	0.020"	0.010"	0.0050"

†Line count as a multiple of 1000.

NOTE: The symbol " indicates units of arc seconds.

NOTE: Numbers preceded with a ≈ symbol show rounded resolution values. To calculate the exact resolution in arc seconds, use the following equation:

$$\theta \text{ (arc seconds)} \quad \frac{1.296 \times 10^6}{[\text{Line count}] \times [\text{Interpolation factor}]}$$

Resolution – TONiC

The REXM20 offers a range of standard ring diameters, as well as sizes that offer line counts that provide 2^n counts per revolution or resolutions that are precise sub-divisions of degrees or arc seconds.

NOTE: 1 arc second resolution = 1.296×10^6 counts per revolution ≈ 2.778×10^{-4} degree resolution.

	Nominal external diameter (line count)	Digital resolution (interpolation factor)										
		5 µm (×4)	1 µm (×20)	0.5 µm (×40)	0.2 µm (×100)	0.1 µm (×200)	50 nm (×400)	20 nm (×1 000)	10 nm (×2 000)	5 nm (×4 000)	2 nm (×10 000)	1 nm (×20 000)
Standard outside diameters	75 mm (11 840)	≈ 27.4"	≈ 5.47"	≈ 2.74"	≈ 1.1"	≈ 0.55"	≈ 0.27"	≈ 0.11"	≈ 0.055"	≈ 0.028"	≈ 0.011"	≈ 0.0055"
	100 mm (15 744)	≈ 20.6"	≈ 4.12"	≈ 2.06"	≈ 0.82"	≈ 0.41"	≈ 0.21"	≈ 0.082"	≈ 0.041"	≈ 0.021"	≈ 0.0082"	≈ 0.0041"
	150 mm (23 600)	≈ 13.7"	≈ 2.75"	≈ 1.37"	≈ 0.55"	≈ 0.27"	≈ 0.14"	≈ 0.055"	≈ 0.028"	≈ 0.014"	≈ 0.0055"	≈ 0.0027"
	183 mm (28 800)	≈ 11.2"	≈ 2.25"	≈ 1.13"	≈ 0.45"	≈ 0.23"	≈ 0.11"	≈ 0.045"	≈ 0.023"	≈ 0.011"	≈ 0.045"	≈ 0.023"
	200 mm (31 488)	≈ 10.3"	≈ 2.06"	≈ 1.03"	≈ 0.41"	≈ 0.21"	≈ 0.1"	≈ 0.041"	≈ 0.021"	≈ 0.010"	≈ 0.0041"	≈ 0.0020"
	255 mm† (40 000)	≈ 8.1"	≈ 1.62"	≈ 0.81"	≈ 0.32"	≈ 0.16"	≈ 0.081"	≈ 0.032"	≈ 0.016"	≈ 0.0081"	≈ 0.0032"	≈ 0.0016"
	300 mm (47 200)	≈ 6.9"	≈ 1.37"	≈ 0.69"	≈ 0.27"	≈ 0.14"	≈ 0.069"	≈ 0.027"	≈ 0.014"	≈ 0.0069"	≈ 0.0027"	≈ 0.0014"
	350 mm (55 040)	≈ 5.9"	≈ 1.18"	≈ 0.59"	≈ 0.24"	≈ 0.12"	≈ 0.059"	≈ 0.024"	≈ 0.012"	≈ 0.0059"	≈ 0.0024"	≈ 0.0012"
2^n line count	52 mm (8 192)	≈ 39.6"	≈ 7.9"	≈ 3.96"	≈ 1.58"	≈ 0.79"	≈ 0.4"	≈ 0.16"	≈ 0.079"	≈ 0.040"	≈ 0.016"	≈ 0.0079"
	104 mm (16 384)	≈ 19.8"	≈ 3.96"	≈ 1.98"	≈ 0.79"	≈ 0.4"	≈ 0.2"	≈ 0.08"	≈ 0.040"	≈ 0.020"	≈ 0.0080"	≈ 0.0040"
	209 mm (32 768)	≈ 9.89"	≈ 1.98"	≈ 0.99"	≈ 0.4"	≈ 0.2"	≈ 0.1"	≈ 0.04"	≈ 0.02"	≈ 0.0099"	≈ 0.0040"	≈ 0.0020"
	417 mm (65 536)	≈ 4.9"	≈ 0.99"	≈ 0.49"	≈ 0.2"	≈ 0.1"	≈ 0.05"	≈ 0.02"	≈ 0.0099"	≈ 0.0049"	≈ 0.0020"	≈ 0.00099"
Subdivisions of degrees	57 mm (9 000)	0.01°	0.002°	0.001°	0.0004°	0.0002°	0.0001°	0.00004°	0.00002°	0.00001°	0.000004°	0.000002°
	115 mm (18 000)	0.005°	0.001°	0.0005°	0.0002°	0.0001°	0.00005°	0.00002°	0.00001°	0.000005°	0.000002°	0.000001°
	229 mm (36 000)	0.0025°	0.0005°	0.00025°	0.0001°	0.00005°	0.000025°	0.00001°	0.000005°	0.0000025°	0.000001°	0.0000005°
Subdivisions of arc second	103 mm (16 200)	20"	4"	2"	0.8"	0.4"	0.2"	0.08"	0.040"	0.020"	0.0080"	0.0040"
	206 mm (32 400)	10"	2"	1"	0.4"	0.2"	0.1"	0.04"	0.020"	0.010"	0.0040"	0.0020"

† Line count as a multiple of 1 000.

NOTE: The symbol " indicates units of arc seconds.

NOTE: Numbers preceded with a ≈ symbol show rounded resolution values. To calculate the exact resolution in arc seconds, use the following equation:

$$\theta \text{ (arc seconds)} \quad \frac{1.296 \times 10^6}{[\text{Line count}] \times [\text{Interpolation factor}]}$$

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REXM20 ultra high accuracy angle encoder part numbers

REXM 20U S A 183

High accuracy angle encoder series

REXM20 – Single reference mark for axes capable of full rotation
REXT20 – Two reference marks for partial-rotation axes

Pitch

20U – 20 µm

Material

S – Stainless steel

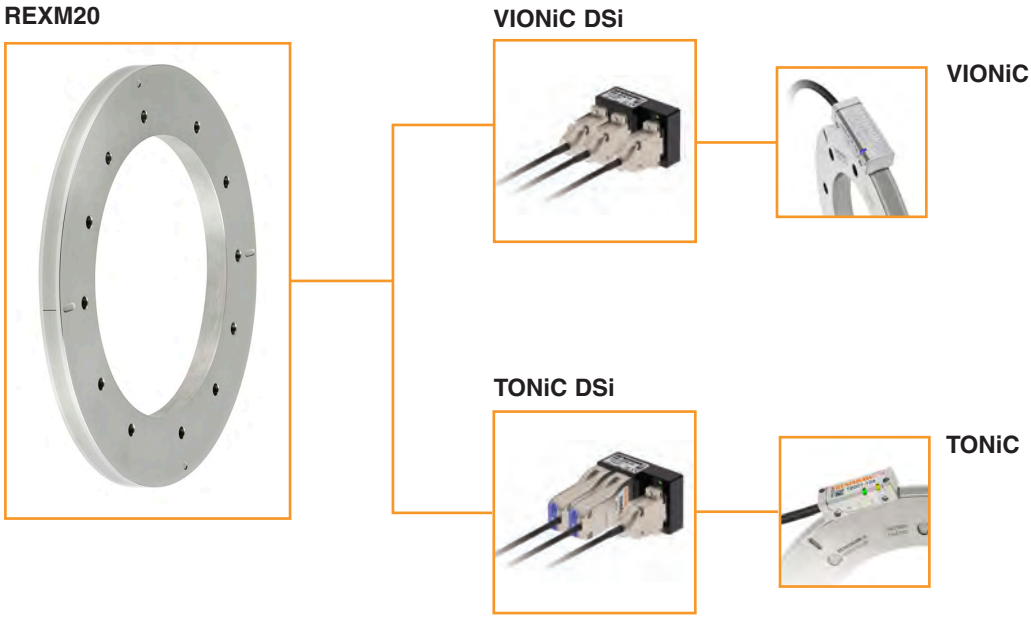
Form

A – Standard section

Diameter

052 – 52 mm
057 – 57 mm
075 – 75 mm
100 – 100 mm
103 – 103 mm
104 – 104 mm
115 – 115 mm
150 – 150 mm
183 – 183 mm
200 – 200 mm
209 – 209 mm
229 – 229 mm
255 – 255 mm
300 – 300 mm
350 – 350 mm
413 – 413 mm
417 – 417 mm

REXM20 compatible readheads



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