

# TONiC™ FS T3x1x RELM20/RSLM20 high-accuracy linear encoder system Functional Safety installation guide and safety manual



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## Legal notices

### Patents

Features of Renishaw's TONiC, RELM20, and RSLM20 encoder systems are the subjects of the following patents and patent applications:

|              |              |              |              |           |
|--------------|--------------|--------------|--------------|-----------|
| EP1173731    | US6775008B2  | JP4750998    | CN100543424C | US7659992 |
| EP1766334    | JP4932706    | CN100507454C | US7550710    | JP5386081 |
| EP1766335    | CN101300463B | EP1946048    | US7624513B2  | JP5017275 |
| CN101310165B | US7839296    | EP1957943    | CN1314511    | EP1469969 |
| JP5002559    | US8987633    | US8466943    |              |           |

### Terms and conditions and warranty

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

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

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

### Declaration of Conformity

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

- the applicable EU directives
- the relevant statutory instruments under UK law



The full text of the declaration of conformity is available at [www.renishaw.com/productcompliance](http://www.renishaw.com/productcompliance).

### Compliance

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

##### 47 CFR Section 15.19

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

##### 47 CFR Section 15.21

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

##### 47 CFR Section 15.105

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

## 47 CFR Section 15.27

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

## Supplier's Declaration of Conformity

### 47 CFR § 2.1077 Compliance Information

**Unique Identifier:** TONiC

#### Responsible Party - U.S. Contact Information

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

### ICES-001 — Industrial, Scientific and Medical (ISM) Equipment (Canada)

This ISM device complies with CAN ICES-001.

Cet appareil ISM est conforme à la norme ICES-001 du Canada.

## Intended use

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

## Product compliance

This document is an installation guide and safety manual, which details the actions required for the safe integration of the TONiC Functional Safety (FS) encoder system, as designated by the T3 prefix in the part number, into a functionally safe system; this will be referred to as TONiC FS system in the below document.

The TONiC FS system as defined in this document is suitable for use in a Category 3 performance level d (PLd) application in compliance with ISO 13849 and in a safety integrity level 2 (SIL2) application in compliance with IEC 61508 and IEC 61800-5-2 when installed and operated in accordance with the instructions defined.

Failure to follow the correct use instructions and heed the limitations may result in SIL2 and/or PLd not being achieved and will invalidate the Functional Safety certification.

A copy of the TONiC FS certificate is available from our website at [www.renishaw.com/productcompliance](http://www.renishaw.com/productcompliance).

## Further information

Further information relating to the TONiC FS encoder range can be found at [www.renishaw.com/safety-encoders](http://www.renishaw.com/safety-encoders) and is also available from your local Renishaw representative.

## Packaging

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

| Packaging Component | Material                      | ISO 11469      | Recycling Guidance |
|---------------------|-------------------------------|----------------|--------------------|
| Outer box           | Cardboard                     | Not applicable | Recyclable         |
|                     | Polypropylene                 | PP             | Recyclable         |
| Inserts             | Low density polyethylene foam | LDPE           | Recyclable         |
|                     | Cardboard                     | Not applicable | Recyclable         |
| Bags                | High density polyethylene bag | HDPE           | Recyclable         |
|                     | Metalised polyethylene        | PE             | Recyclable         |

## REACH regulation

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

## Disposal of waste electrical and electronic equipment



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

## TONiC software notices

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### US government notice

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[www.renishaw.com/legal/softwareterms](http://www.renishaw.com/legal/softwareterms).



## Definitions

**WARNING** A hazard with a medium risk of injury if not avoided

|   |  |
|---|--|
| <b>ESD handling</b>  | <p>The ESD Susceptibility Symbol consists of a triangle, a reaching hand, and a slash through the reaching hand. The triangle means 'Caution' and the slash through the reaching hand means 'Don't touch'.</p> |
| <b>Mechanical safe position</b>   | <p>The maximum distance the scale might move from its installed position, for example if the fixings work loose.</p>   |
| <b>Evaluation unit</b>  | <p>External item of equipment in which the output signal of the encoder is evaluated, e.g. machine controller or safety relay.</p>   |
| <b>System manufacturer</b>  | <p>Personnel with responsibility for selecting the encoder and verifying its capability is appropriate for the safety related application.</p>   |
| <b>System installer</b>   | <p>Personnel with responsibility for fitting the encoder in the specific application.</p>  |

## Information for use

**WARNING** Not to be used in environments where there is an explosive atmosphere

**WARNING** Not to be used by medical devices

The TONiC FS system is designed to be used as part of a safety-related control system as specified by the system manufacturer. It is the responsibility of the system manufacturer to set the evaluation unit to implement the appropriate actions when the TONiC FS system reports an error.

The decision to use this system for the intended purpose is the responsibility of the system manufacturer. The TONiC FS system is certified to the SIL and PL levels as shown in the 'Functional Safety data declaration' table, however the system manufacturer must conduct their own assessment of the full system to determine its safety capability.

### Correct use includes:

- Operating the TONiC FS system within the limits defined in this document.
- Installing the system as described in this document.
- Maintaining the system as described in this document.

## System components covered by this installation guide:

The TONiC FS system comprises of the following parts:

- TONiC FS readhead
- TONiC Ti0000A00A or DOP interface
- RELM20 and RSLM20 high-accuracy linear scales - adhesive mounted only
- Accessories

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### NOTES:

- Only adhesive mounted RELM20 or RSLM20 linear scales are functionally safe. Clip and clamp mounted RELM20 or RSLM20 linear scales are not approved for use with the TONiC FS encoder system.
- Only the analogue sine and cosine outputs are functionally safe.
- The UHV cable is for static use only.

**If the original termination is altered by the user, or an extension cable is used, then it is the responsibility of the system manufacturer to make sure the system is compliant with IEC 61800-5-2: Annex E second environment – Electromagnetic immunity requirement for safety related systems.**

---

## 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)    | $\lambda_s = 1.77 \times 10^{-7}$<br>$\lambda_D = 8.41 \times 10^{-8}$<br>$\lambda_{DD} = 7.57 \times 10^{-8}$<br>$\lambda_{DU} = 8.41 \times 10^{-9}$ | $\lambda_s = 1.77 \times 10^{-7}$<br>$\lambda_D = 1.38 \times 10^{-7}$<br>$\lambda_{DD} = 1.25 \times 10^{-7}$<br>$\lambda_{DU} = 1.38 \times 10^{-8}$ | $\lambda_s = 1.77 \times 10^{-7}$<br>$\lambda_D = 4.14 \times 10^{-7}$<br>$\lambda_{DD} = 3.73 \times 10^{-7}$<br>$\lambda_{DU} = 4.14 \times 10^{-7}$ |
| PFD <sub>avg</sub>                     | 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<br>HFT = 0<br>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 <sub>D</sub> (years)   | 1300              | 800                                | 270                                 |
| Diagnostic coverage         | Medium (90%)      |                                    |                                     |
| Category                    | 3                 |                                    |                                     |
| Performance level           | d                 |                                    |                                     |
| Lifetime/Replacement limits | 20 years          |                                    |                                     |

## 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:

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

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.

## Safety function

The TONiC FS encoder system provides 1 Vpp (nominal) sine and cosine outputs, where the sine and cosine outputs are 90° phase shifted, in order for the evaluation unit to perform incremental counting and thereby confirm machine position is within safe limits.

The following restrictions apply to this claim:

- The system installer must perform a verified commissioning test during installation.
- The system repairer must perform a verified commissioning test following replacement of a system part.
- When installed correctly, the TONiC FS system shall have mechanical safe position not exceeding  $\pm 1$  mm

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**NOTE:** Thermal expansion effects of the scale and readhead mounting tolerances are excluded from the mechanical safe position.

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- The TONiC FS system includes no self-diagnostic function.

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**NOTE:** Faults are detected only by the evaluation unit monitoring. When errors are detected it is the responsibility of the system manufacturer to place the system into a safe state.

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## Fault exclusions

The following actions will invalidate the Functional Safety certification of the TONiC FS system:

- Faults caused by cutting and reconnecting the readhead cable or extending the readhead cable.
- Incorrect installation of the readhead.
- Incorrect installation of the RELM20 or RSLM20 scale.
- Failure to follow the instructions contained within this installation manual.
- Dismantling of the TONiC readhead, Ti0000A00A interface or the DOP interface.
- Operating the system outside of the limits specified within this installation manual.

## Failure modes

Failure modes are detected by evaluation unit monitoring. See 'Functional Safety data declaration' on page 11 for a summary of the FMEDA.

**NOTE:** For the purposes of the FMEDA calculation the following conditions have been assumed:

|                    |                |
|--------------------|----------------|
| <b>Method</b>      | SN29500-2005-1 |
| <b>Environment</b> | Ground mobile  |
| <b>Temperature</b> | 85 °C          |

## Installation

For the safety function to be valid the instructions detailed in this installation guide must be followed. The information relating to all scale types and mounting options is listed. The builder/ installer/maintainer/repairer must apply the instructions for the product being installed as defined by this installation guide.

The following general conditions must be observed during installation:

- Observe ESD handling precautions when handling the cable connectors.
- Cleaning mating surfaces before mounting the scale.

## Commissioning test

The following checks **MUST** be performed following installation and commissioning of the TONiC FS encoder system for the first time, and also following repair of the system (replacement systems parts):

### Axis movement check

Move the axis over its full travel to verify the following:

- Position output is correct within a tolerance of  $\pm 10\%$ .
- Direction of movement is correct.
- The signal amplitude for both sine and cosine signals falls within the limits defined in 'Evaluation unit monitoring'.

---

**NOTE:** Should the working temperature of the readhead need to be measured attach a suitable sensor directly to the aluminium readhead housing. Do not attach to the label that shows the product details. Do not drill into the housing as this may compromise the sealing or technical function. Route the sensor cable away from moving parts and along the same path as the readhead cable.

---

## Evaluation unit monitoring

To achieve full system integrity the evaluation unit must continuously monitor the analogue outputs and, in the case of fault detection, place the system into a safe state within the process safety time.

|                                |  |
|--------------------------------|--|
| <b>Signal amplitude check</b>  | Nominal signal amplitude value is 1 V, indicating full signal strength where $\sqrt{(\text{sine}^2 + \text{cosine}^2)} = 1 \text{ V}$ .<br><br>A fault condition must be asserted if the analogue output is $\leq 0.7 \text{ V}$ and $\geq 1.35 \text{ V}$ .   |
| <b>Sine/cosine cross check</b> | Sine and cosine signals must be evaluated separately and the results compared. A fault condition must be asserted if the phase shift is incorrect with reference to the safe position limit for the system, see ' <a href="#">Ti interface output specifications</a> ' on page 49 or ' <a href="#">DOP interface output specifications</a> ' on page 51. |
| <b>Following error check</b>   | Following error is defined as the difference between the expected position and position feedback. A fault condition must be asserted if the following error exceeds the safe position limit for the system.  |

### NOTES:

- The evaluation unit must achieve medium diagnostic coverage ( $\geq 90\%$ ) according to ISO 13849.
  - Improper setting of the switching thresholds and hysteresis in signal evaluation can result in incorrect determination of direction of movement, position or speed.
  - A persistent fault condition may indicate a hardware failure of the TONiC FS system or an installation problem.
-

## Storage and handling

**DO** ensure that protection is provided for the scale, readhead and interfaces when transporting a machine with that equipment already installed.

**DO** store scale in a cool dry place out of direct sunlight and in its original packaging prior to installation.

**DO** allow scale to acclimatize to installation environment prior to installation.

**DO** store at < 95% RH

**DO** operate at < 80% RH

**DO** install between 15 °C and 25 °C

**DO** store between –20 °C and +70 °C

**DO** operate between 0 °C and +70 °C

## Maintenance and cleaning

In order to retain full Functional Safety compliance, this encoder system needs to be maintained appropriately. The maintenance check intervals will be defined by the machine builder/installer according to their risk assessment. There are no user serviceable parts within the readhead or interface. The lid of the readhead must not be removed.

The following checks should be carried out:

- Check the readhead to bracket screws are correctly tightened.
- Check for worn or damaged cable connecting the readhead to the interface.
- Check that the scale has not been damaged or contaminated. If required, clean the system using approved solvents (see 'Storage and handling' on page 20).

---

**NOTE:** Do not attempt to move the scale as this will damage the adhesive bond.

---

When cleaning the system:

**DO** use Renishaw (A-9523-4040) alcohol wetted scale wipes to clean the readhead optics and scale, available from your local Renishaw representative.

**Or** use a clean, dry, lint-free cloth.

**Or** use only the following solvents sparingly with a wetted lint-free cloth:

- Propan-2-ol (iso-propyl alcohol)  $\text{CH}_3\text{CHOHCH}_3$
- n-Heptane  $\text{CH}_3(\text{CH}_2)_5\text{CH}_3$

**DO NOT** use the following aggressive solvents to clean the TONiC FS readhead:

- Acetone  $\text{CH}_3\text{COCH}_3$
- Chlorinated solvents
- Methylated spirits

## Repair

Repair is by replacement of system parts only. The replacement parts must have the same part number as the parts being replaced. The new system must be installed and commissioned in accordance with the 'Commissioning test' on page 14. It is advisable that, in the event of failure, the affected parts should be returned to Renishaw for further analysis. Using damaged parts invalidates the Functional Safety certification.

## Proof testing

It is the responsibility of the system manufacturer to define any proof testing of the system. Due to the diagnostic coverage (DC) and safe failure fraction (SFF) required to achieve SIL2, the encoder can only support continuous demand use.



## Certification

**TONiC FS encoder system**  
**Functional Safety Certificate No. FSC001**



Under the terms of CSA SIRA Functional Safety Certificate SIRA CASS00023/02, for the management and self-certification of functional safety activities up to SIL3/PLd:

Renishaw plc declares that the products shown by this installation guide meet the requirements of:

IEC 61508-1:2010, IEC 61508-2:2010 and IEC 61508-3:2010

IEC 61800-5-2:2016

ISO 13849-1:2015 and ISO 13849-2:2012

when used as an element/subsystem in safety related systems performing safety functions requiring up to and including:

SIL2 with HFT = 0 (1oo1)

Category 3, PLd

# Declaration of conformity

## Summary of the EU declaration of conformity EUD2021-00817

This declaration of conformity is issued under the sole responsibility of the manufacturer, Renishaw plc.

The object of the declaration is identified below: -

|                      |  |
|----------------------|--|
| <b>Product name:</b> | TONiC Functional Safety (FS) encoder system                              |
| <b>Description:</b>  | Revision of TONiC, to comply with the requirements of Functional Safety. |

| <b>Part number:</b> | <b>Valid from:</b> | <b>Description:</b>      |
|---------------------|--------------------|--------------------------|
| T3xxx*              | 2AHF37             | TONiC FS linear readhead |

The object of the declaration described above is in conformity with all relevant EU harmonisation legislation and fulfils all the relevant provisions with EU directives: -

|                   |   |
|-------------------|---|
| <b>2006/42/EC</b> | Machinery Directive   |
| <b>2014/30/EU</b> | Electromagnetic Compatibility (EMC)   |
| <b>2011/65/EU</b> | On the restriction of the use of certain hazardous substances in electrical and electronic equipment - RoHS |

and complies with the following technical standards: -

|                            |  |
|----------------------------|--|
| <b>EN ISO 12100:2010</b>   | Safety of machinery - General principles for design - Risk assessment and risk reduction (ISO 12100:2010)                                |
| <b>EN ISO 13849-1:2015</b> | Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1:2015)                 |
| <b>EN ISO 13849-2:2012</b> | Safety of machinery - Safety-related parts of control systems - Part 2: Validation (ISO 13849-2:2012)                                    |
| <b>EN 61326-1:2013</b>     | Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements                       |
| <b>EN 62471:2008</b>       | Photobiological safety of lamps and lamp systems   |
| <b>EN IEC 63000:2018</b>   | Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances |

For the full declaration of conformity EUD2021-00817 see [www.renishaw.com/productcompliance](http://www.renishaw.com/productcompliance).

**EU based person authorised to compile the technical file:** - Renishaw (Ireland) DAC, Swords Business Park, Swords, Co. Dublin, K67 FX67, Ireland.

## Summary of the UK declaration of conformity UKD2021-00817

This declaration of conformity is issued under the sole responsibility of the manufacturer, Renishaw plc.

The object of the declaration is identified below: -

|                      |  |
|----------------------|--|
| <b>Product name:</b> | TONiC Functional Safety (FS) encoder system                              |
| <b>Description:</b>  | Revision of TONiC, to comply with the requirements of Functional Safety. |

| Part number: | Valid from: | Description:             |
|--------------|-------------|--------------------------|
| T3xxx*       | 2AHF37      | TONiC FS linear readhead |

The object of the declaration described above is in conformity with all relevant UK Statutory Instruments (and their amendments): -

|                           |   |
|---------------------------|---|
| <b>S.I. 2008 No. 1597</b> | Supply of Machinery (Safety) Regulations 2008   |
| <b>S.I. 2016 No. 1091</b> | Electromagnetic Compatibility Regulations 2016  |
| <b>S.I. 2012 No. 3032</b> | The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 - RoHS |

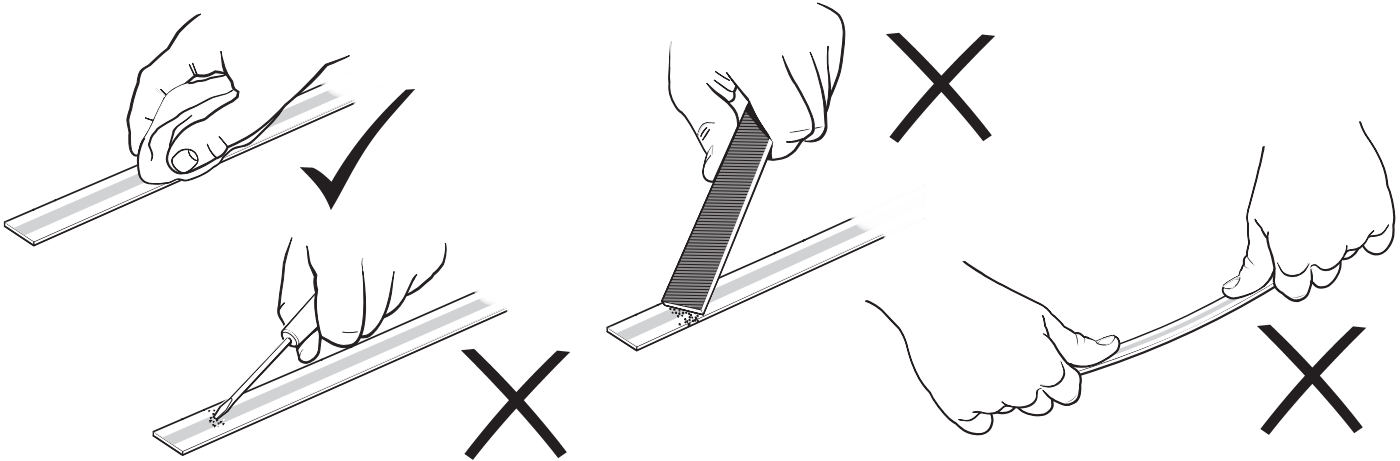
and complies with the following technical standards: -

|                            |  |
|----------------------------|--|
| <b>EN ISO 12100:2010</b>   | Safety of machinery - General principles for design - Risk assessment and risk reduction (ISO 12100:2010)                                |
| <b>EN ISO 13849-1:2015</b> | Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1:2015)                 |
| <b>EN ISO 13849-2:2012</b> | Safety of machinery - Safety-related parts of control systems - Part 2: Validation (ISO 13849-2:2012)                                    |
| <b>EN 61326-1:2013</b>     | Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements                       |
| <b>EN 62471:2008</b>       | Photobiological safety of lamps and lamp systems   |
| <b>EN IEC 63000:2018</b>   | Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances |

For the full declaration of conformity UKD2021-00817 see [www.renishaw.com/productcompliance](http://www.renishaw.com/productcompliance).

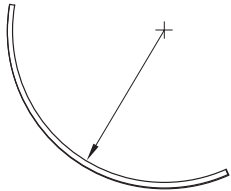
# Storage and handling

TONiC non-contact optical encoder systems provide good immunity against contaminants such as dust, fingerprints and light oils. However, in harsh environments such as machine tool applications, protection should be provided to prevent ingress of coolant or oil.



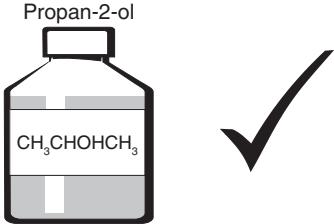
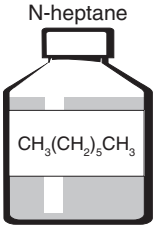
## Minimum bend radius

RELM20 - DO NOT BEND  
 RSLM20 - 250 mm

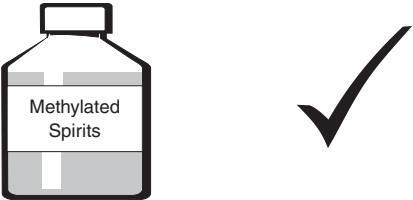
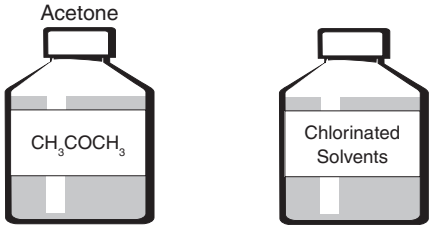


**NOTE:** Ensure self-adhesive tape is on the outside of bend.

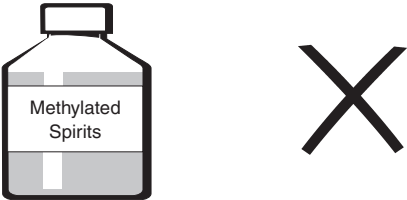
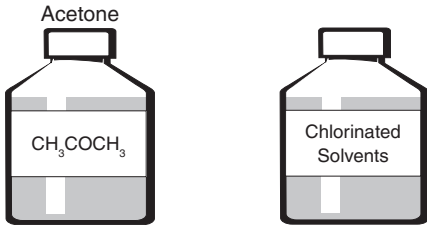
### System

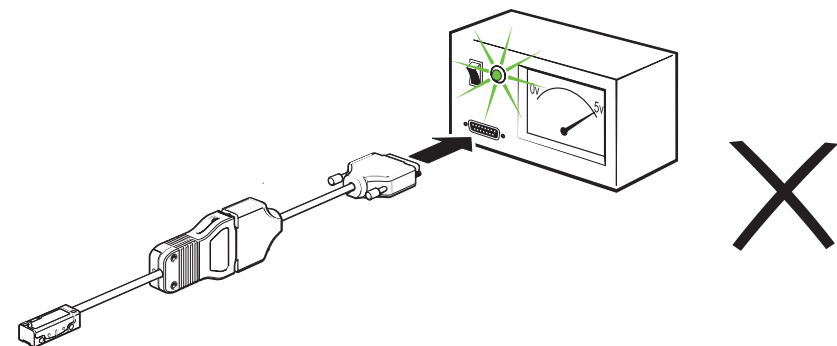
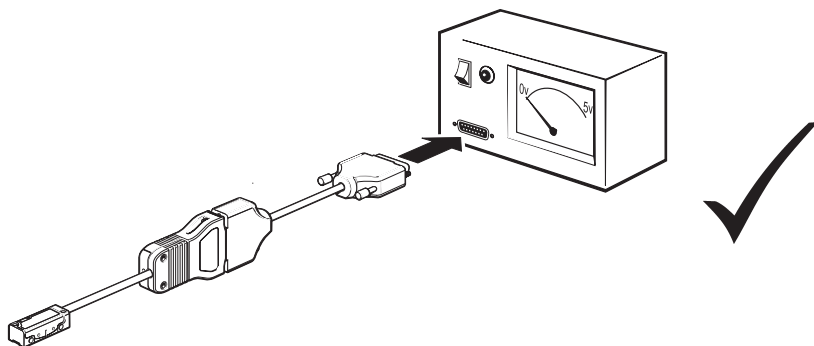
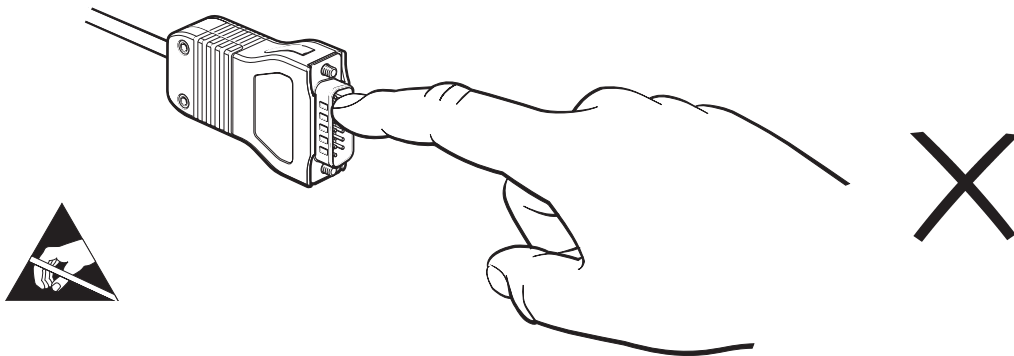
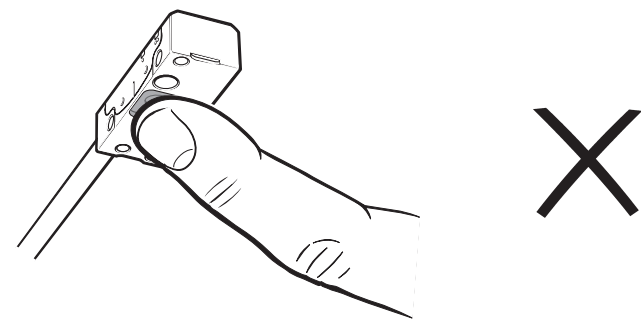
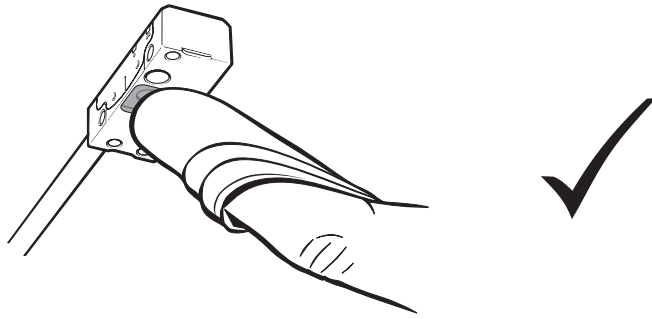


### Scale only



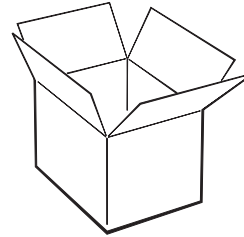
### Readhead only



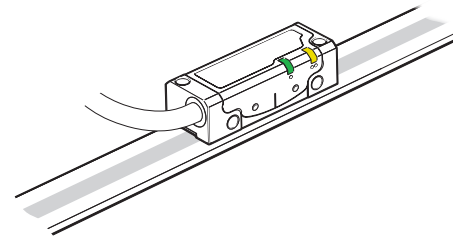


## Temperature

| Storage |                  |
|---------|------------------|
| System  | -20 °C to +70 °C |



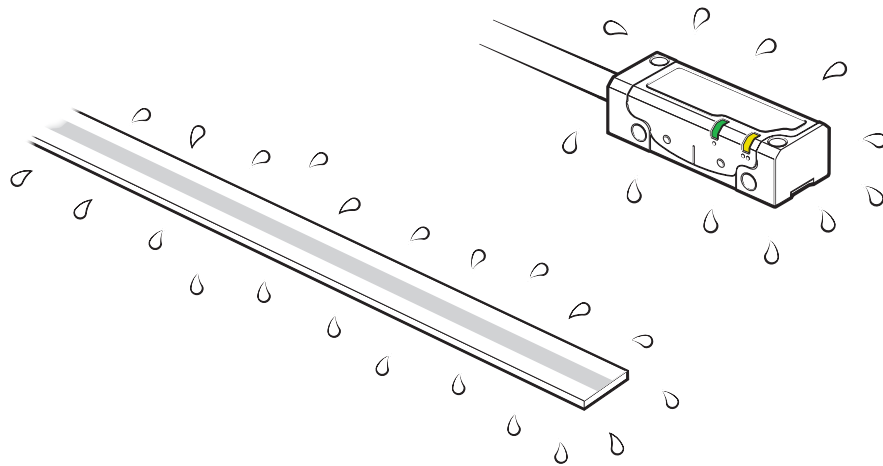
| Operating |                |
|-----------|----------------|
| System    | 0 °C to +70 °C |



---

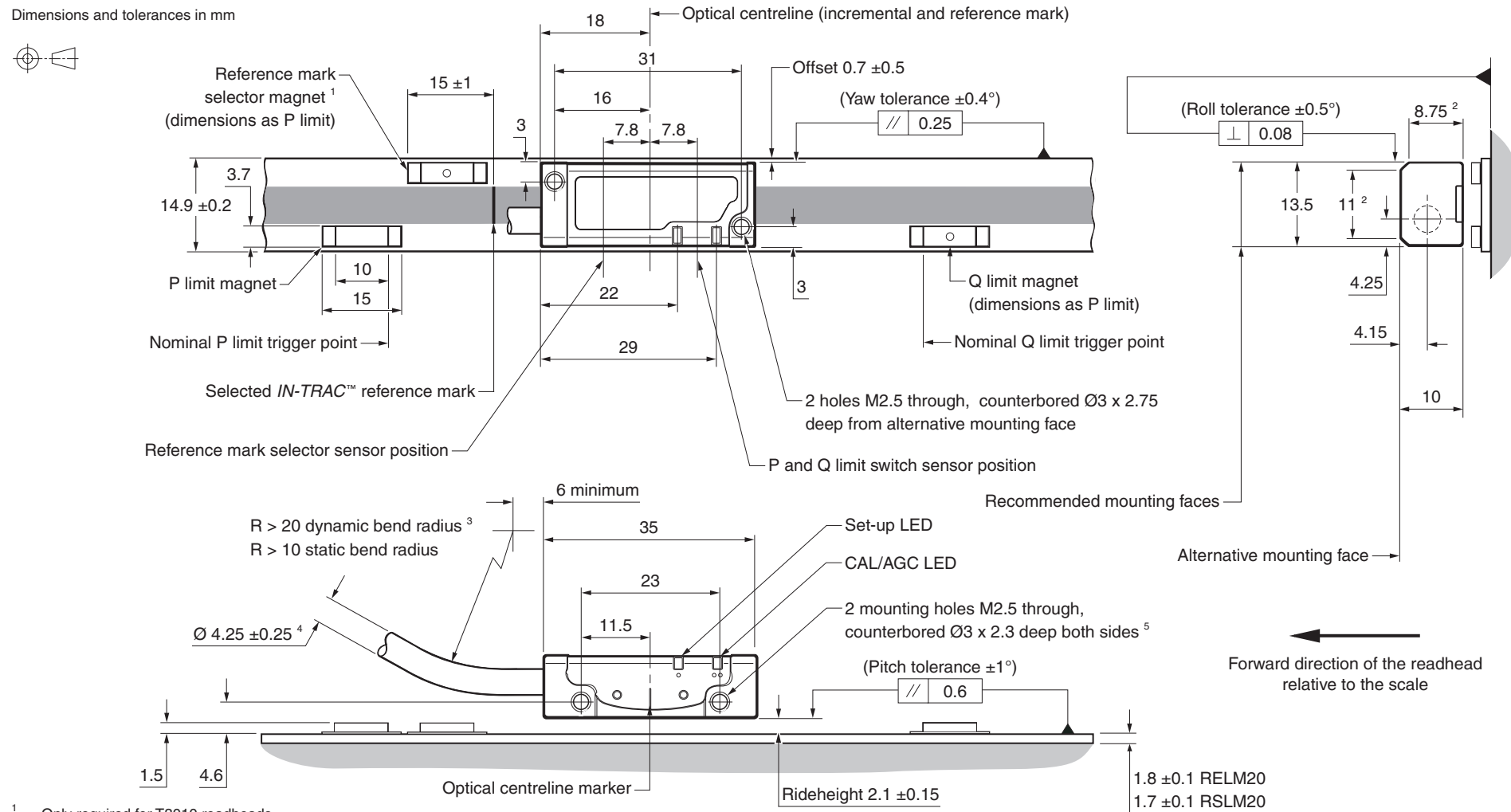
## Humidity

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



## TONiC T3x1x readhead installation drawing

Dimensions and tolerances in mm



<sup>1</sup> Only required for T3010 readheads.

<sup>2</sup> Extent of mounting faces.

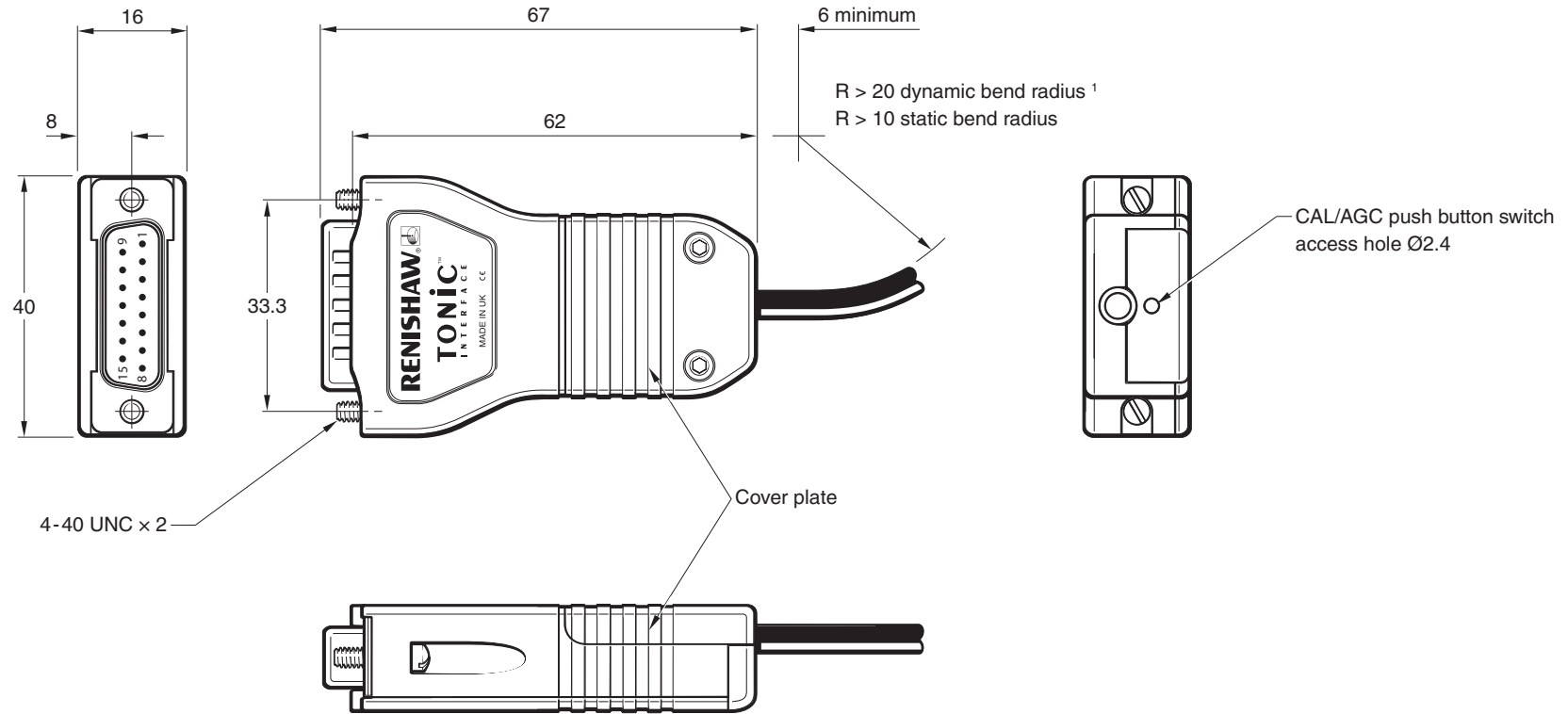
<sup>3</sup> The dynamic bend radius is not applicable for UHV cables. UHV cables are for static use only.

<sup>4</sup> The UHV cable diameter is approximately 3 mm.

<sup>5</sup> 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 drawing

Dimensions and tolerances in mm



## CAL button operation

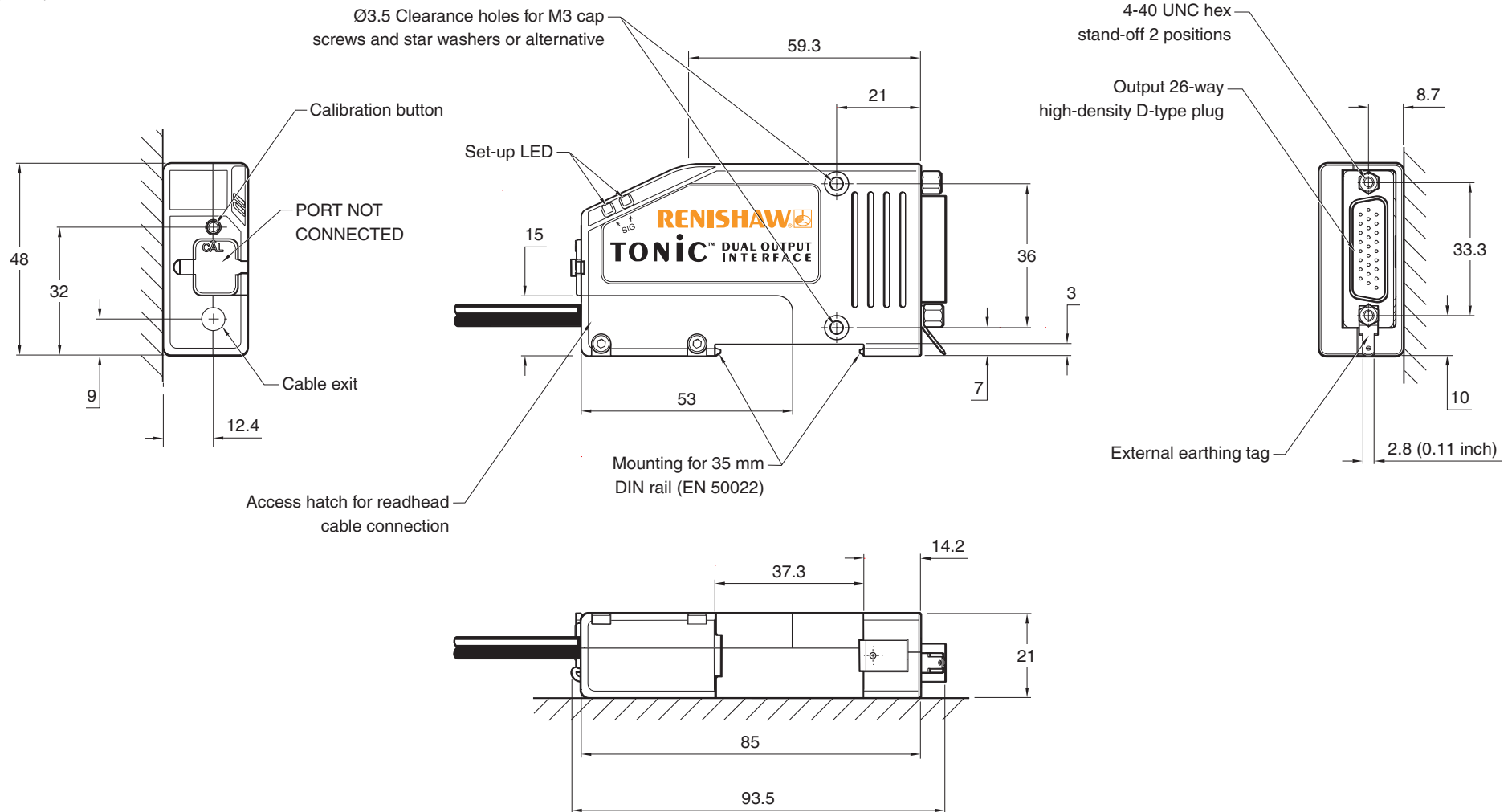
| Function                                    | Operation                                 |
|---|---|
| Calibration (CAL) routine enable/disable    | Push and release (< 3 seconds)            |
| Automatic Gain Control (AGC) enable/disable | Push and release (> 3 seconds)            |
| Restore factory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

<sup>1</sup> The dynamic bend radius is not applicable for UHV cables. UHV cables are for static use only.



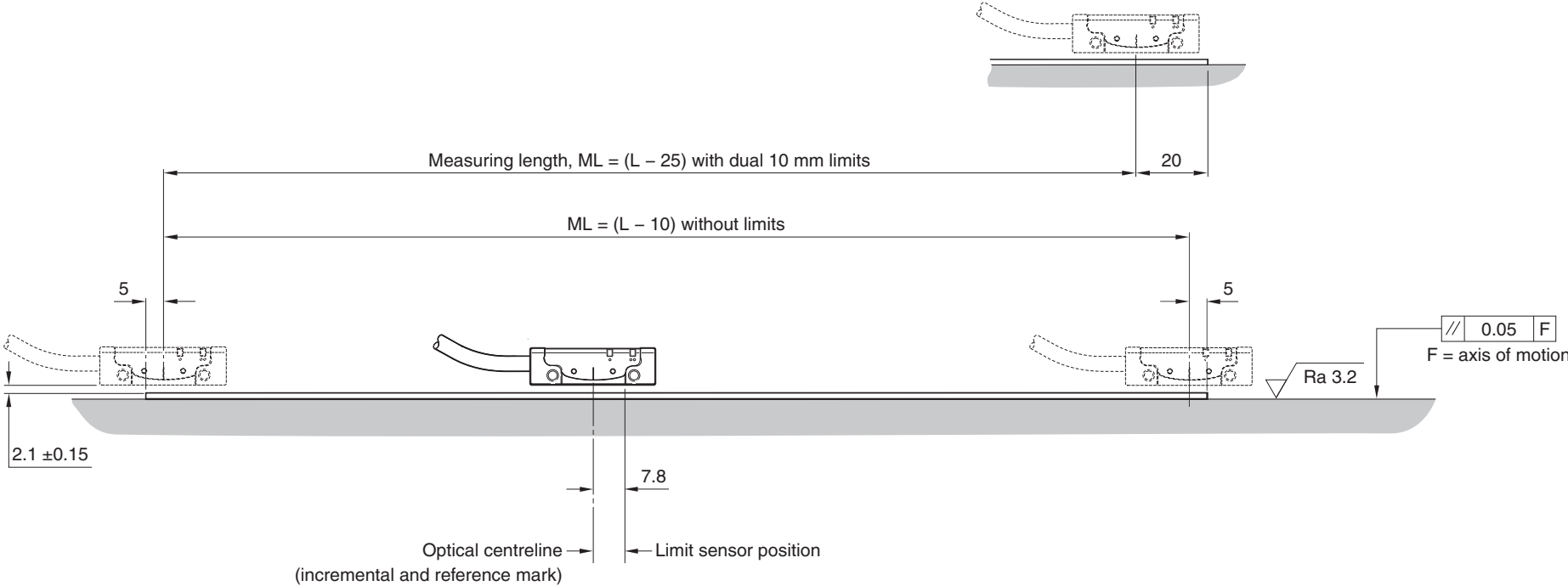
# DOP interface drawing

Dimensions and tolerances in mm



# RELx20/RSLx20 measuring lengths

Dimensions and tolerances in mm



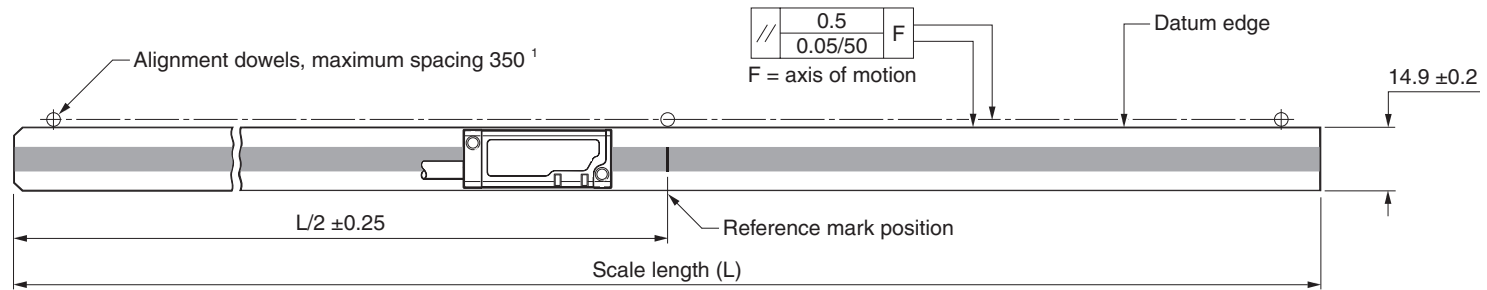
## RELx20 installation drawing

Dimensions and tolerances in mm

### RELM20

(Centre reference mark)

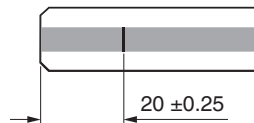
Use with T3011 readhead



### RELE20

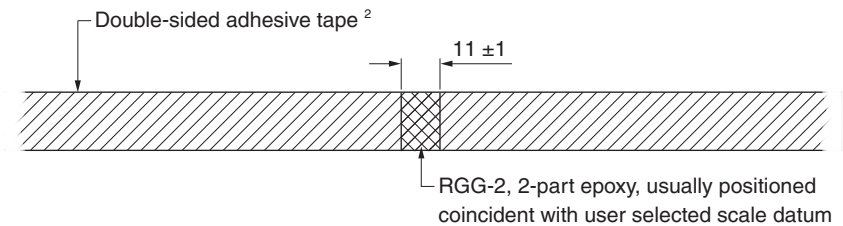
(End reference mark)

Use with T3011 readhead



### Adhesive datum clamp

Clamping in this way ensures scale positional stability relative to substrate.



### NOTES:

- Adhesive mounted scale must not be reused after installation.
- When installing the scale in a groove, allow a tolerance for scale width.
- See 'RELx20/RSLx20 measuring lengths' on page 26 for information on using limits.

<sup>1</sup> When scale is to be mounted horizontally on a vertical surface, position the dowels so that the datum edge is supported.

<sup>2</sup> Double-sided adhesive tape is included with all scale lengths.

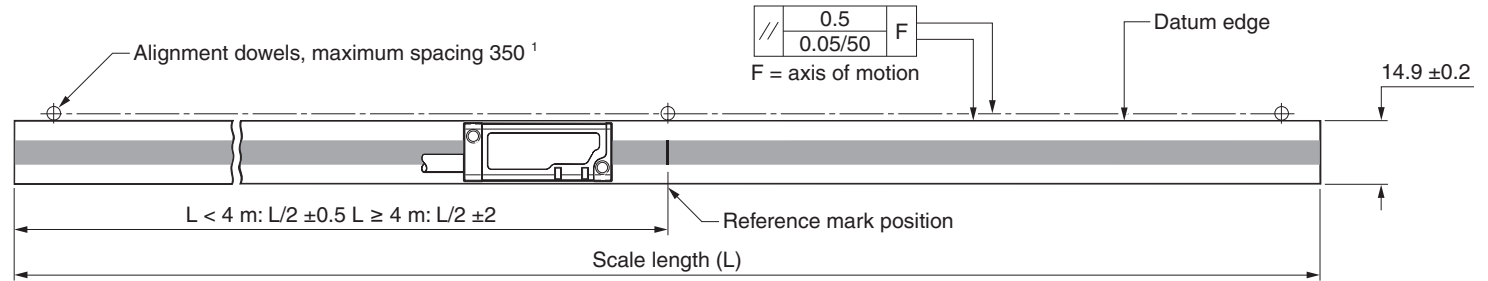
# RSLx20 installation drawings

Dimensions and tolerances in mm

## RSLM20

(Centre reference mark)

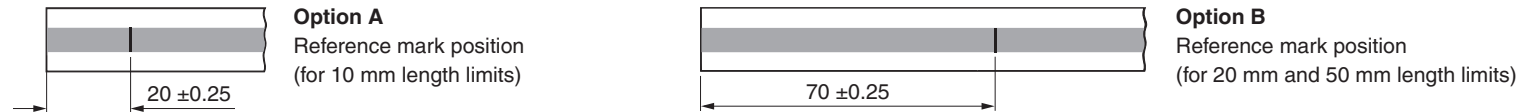
Use with T3011 readhead



## RSLE20

(End reference mark)

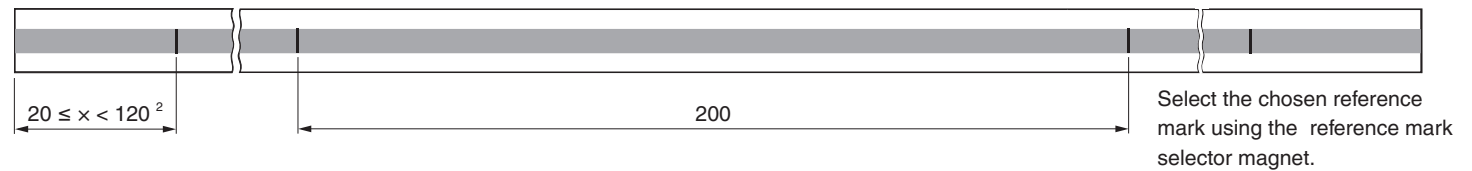
Use with T3011 readhead



## RSLC20

(Customer selected reference mark)

Use with T3010 readhead



### NOTES:

- Adhesive mounted scale must not be reused after installation.
- When installing the scale in a groove, allow a tolerance for scale width.
- See 'RELx20/RSLx20 measuring lengths' on page 26 for information on using limits.

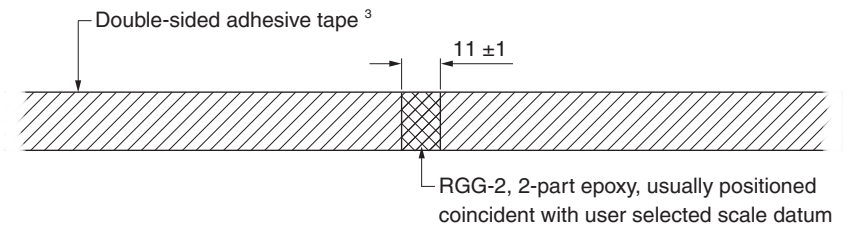
<sup>1</sup> When scale is to be mounted horizontally on a vertical surface, position the dowels so that the datum edge is supported.

<sup>2</sup> Reference marks positioned equidistant from scale ends.

<sup>3</sup> Double-sided adhesive tape is included with all scale lengths.

### Adhesive datum clamp

Clamping in this way ensures scale positional stability relative to substrate.



## Equipment required for adhesive mounting the RELx20/RSLx20 spar scale

### Required parts:

- RELM20 or RSLM20 spar scale
- RGG-2 two part epoxy adhesive (A-9531-0342)
- Appropriate cleaning solvents (see 'Storage and handling' on page 20)
- Pencil or other appropriate marker
- Scissors

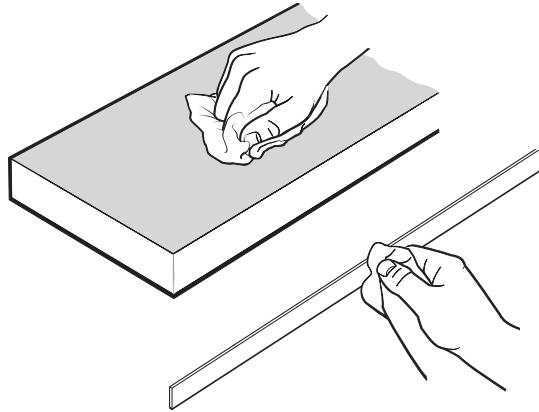
### Optional parts:

- Renishaw scale wipes (A-9523-4040)
- Lint-free cloth
- Reference mark selector magnet <sup>1</sup> (A-9653-0143)
- Q limit magnet (A-9653-0139)
- P limit magnet (A-9653-0138)
- Magnet applicator tool (A-9653-0201)

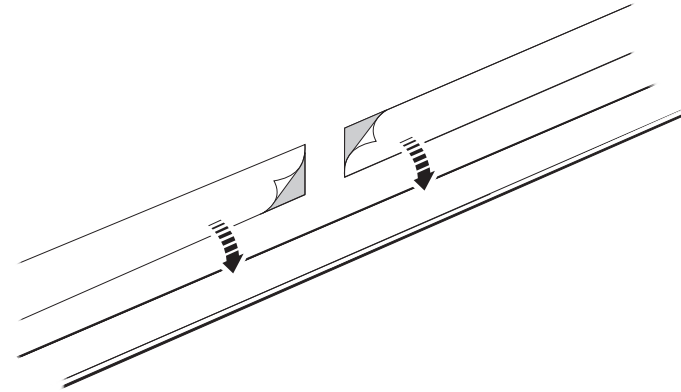
<sup>1</sup> The reference mark selector magnet is only required for 'Customer selectable reference mark' readheads.

## Installing the adhesive mounted RELx20/RSLx20 scale

1. Thoroughly clean and degrease the substrate with a lint-free cloth and clean the underside of the scale using approved solvents (see 'Storage and handling' on page 20)

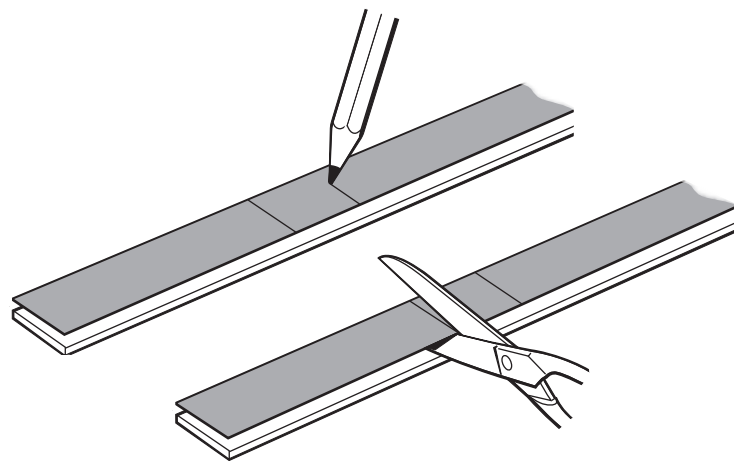


3. Remove the backing liner from one side of the adhesive tape and stick it to the underside of the scale.

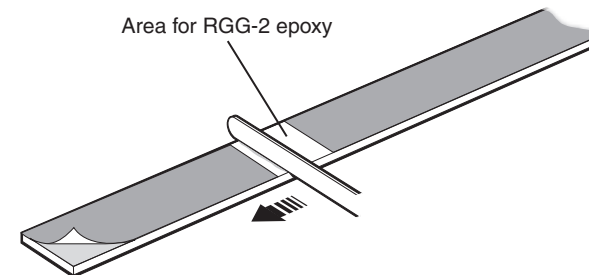


2. Mark the area for the epoxy datum clamp on the adhesive tape and cut the tape accordingly. The epoxy datum clamp fixes the scale rigidly to the substrate at the chosen location.

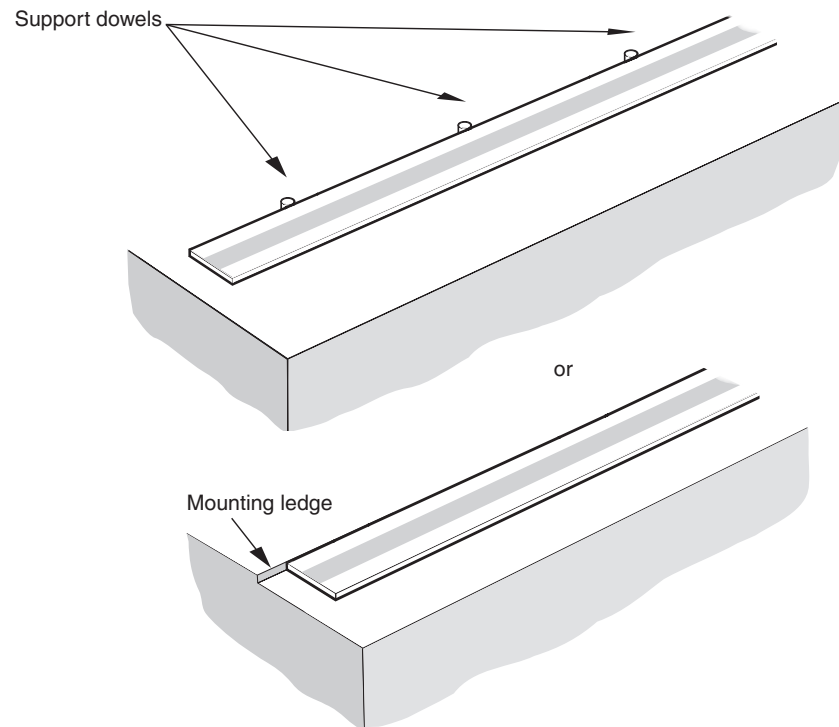
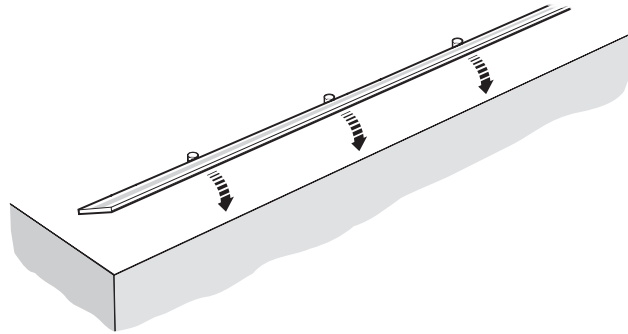
**CAUTION:** The metrology of the system may be compromised if the epoxy datum clamp is not used.



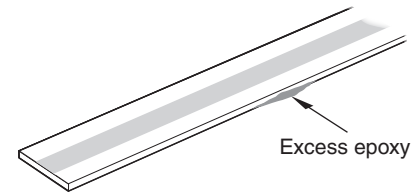
4. Thoroughly mix and apply the epoxy to the back of the scale and then remove the remaining backing liner.



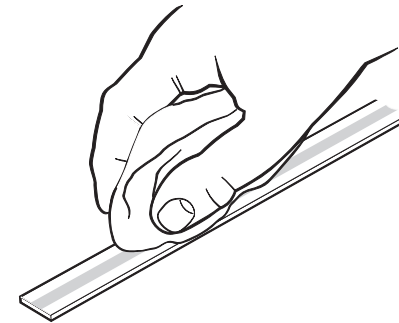
5. Locate the scale against dowels or a ledge and rotate it down onto the substrate. Press down with firm finger pressure.



6. Remove any excess epoxy



7. Allow 24 hours for the epoxy to cure fully and then clean the scale using Renishaw scale wipes or a clean, dry, lint-free cloth.



# Reference mark selector and limit magnet installation

**IMPORTANT:** Allow 24 hours after the scale application before fitting the magnets.

For accuracy and ease of positioning of the reference mark selector and limit magnets, the applicator tool should be used. The magnet should be attached to the applicator tool as shown. Limit magnets can be positioned at any user defined location along the scale, but the reference mark selector magnet (T3010 readheads only) should be positioned adjacent to the selected *IN-TRAC* reference mark as shown.

As the TONiC FS readhead passes the reference mark selector magnet or limit switch magnet, a force of up to 0.2 N is generated between the magnet and the concentrators on the readhead. The design of the bracket should be sufficiently stiff so that it is able to tolerate such force without distorting.

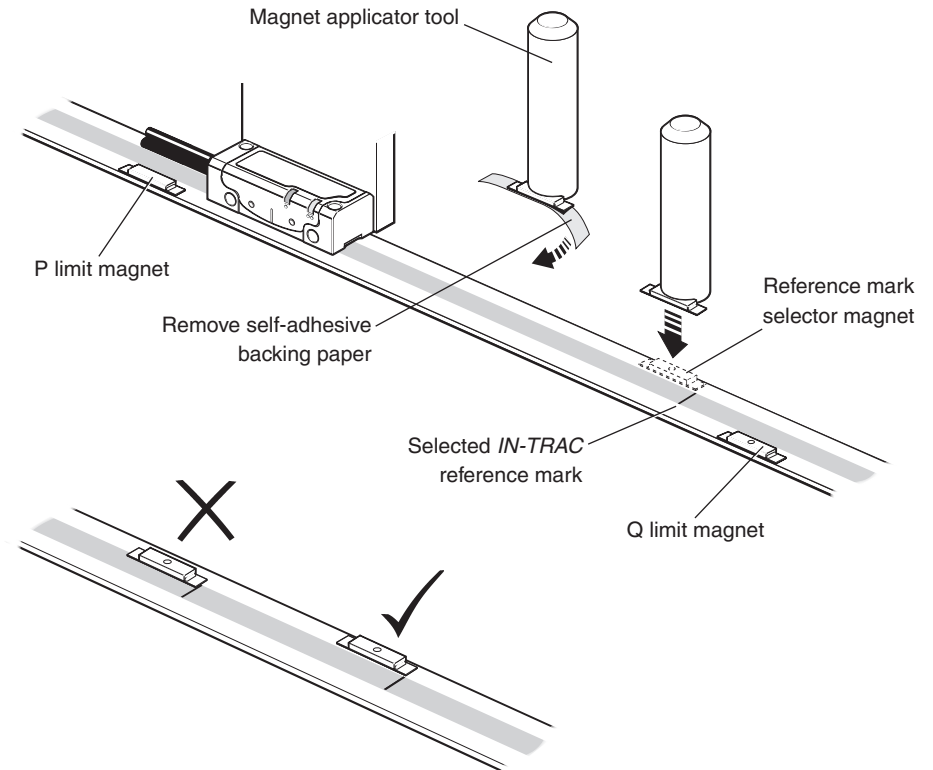
Following the scale installation instructions will prevent this magnetic force from disturbing the scale.

## Limit 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 (see '[TONiC T3x1x readhead installation drawing](#)' on page 23).

## NOTES:

- The reference and limit magnets may creep when influenced by magnetic materials in close proximity. In such cases, they should be held in place using an additional fillet of epoxy glue or similar along the outer edge of the magnet assembly.
- The reference mark selector and limit actuator locations are correct for the readhead orientation shown.
- The reference mark selector magnet is only required for RSLC20 scale with T3010 readheads.
- External magnetic fields greater than 6 mT, in the vicinity of the readhead, may cause false activation of the limit and reference sensors.





## TONiC quick-start guide

This section is a quick-start guide to installing a TONiC FS system. More detailed information on installing the system is contained on page 34 to page 42 of this installation guide.

### INSTALLATION

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



If required, ensure reference mark selector magnet is correctly positioned (see 'TONiC T3x1x readhead installation drawing' on page 23).



Plug the readhead cable into the Ti/DOP interface under the cover plate and reassemble the interface (see 'System connection - Ti interface' on page 35 or 'System connection - DOP interface' on page 37). Connect to the receiving electronics and power-up.



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



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

### CALIBRATION

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



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



#### No reference mark

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

#### Reference mark

Move the readhead back and forth over the reference mark until the CAL LED stops flashing and remains 'off'.



The system is now calibrated and ready for use.

**For the safety function to be valid, customer commissioning tests must be performed:**  
see 'Commissioning test' on page 14.

AGC can now be switched on if required by pressing and holding the CAL button until the CAL LED on the readhead switches on.

Calibration (CAL) values and AGC status are stored in readhead non-volatile memory at power down.

**NOTE:** If calibration fails, restore factory defaults (see 'Restoring factory defaults' on page 42). Then repeat the installation and calibration routine.

## Cable connection

- The cable must be secured to a part that does not move relative to the readhead using a suitable clip within 50 mm of exiting the readhead with a minimum bend radius > 10 mm.
- Cable rolling radius must be > 25 mm when the cable is routed through moving trunking/a cable chain.

---

**NOTE:** UHV cables are for static use only.

---

- The cable must be routed to avoid all moving parts of the machinery and the readhead itself.
- Route the cable away from operating environments that will exceed the EMC limits defined in IEC 61800-5-2: Annex E second environment.
- Use only Renishaw approved cables between the readhead and the interface.
- The customer is responsible for verifying the product function where the cable has been re-terminated, including the installation of extension cables. This includes EMC performance of the installed system defined in IEC 61800-5-2: Annex E second environment.
- The sine and cosine signals must be connected as described in '[Electrical connections](#)' on page 46.

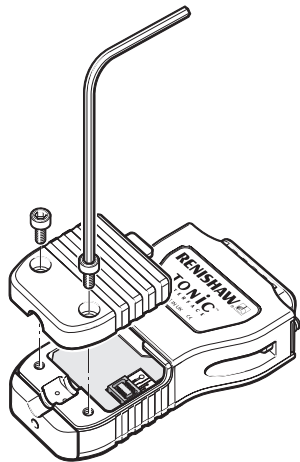
## System connection - Ti interface

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

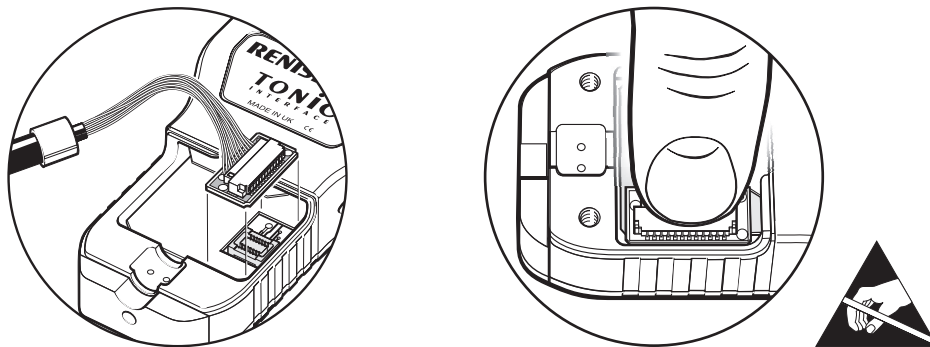
The readhead is connected to the Ti interface via a small, rugged connector to allow for easy feed-through during installation.

### Connecting the readhead

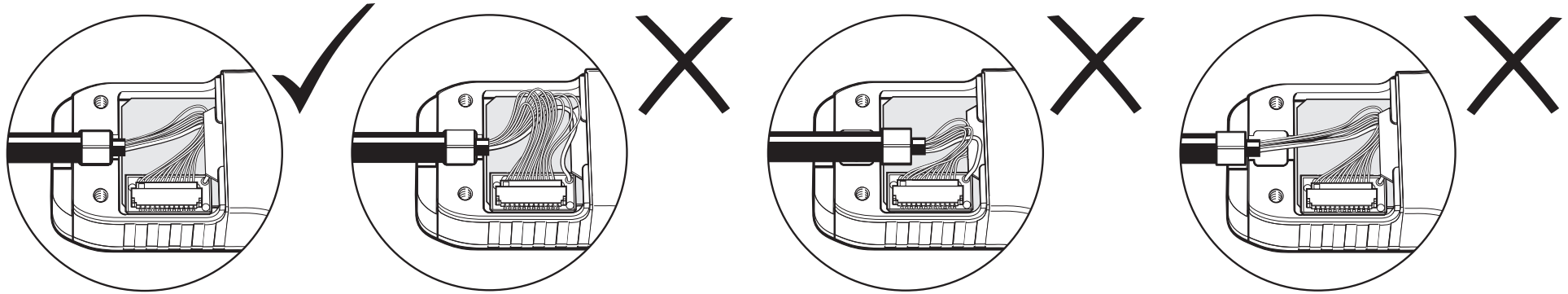
8. Remove the cover plate as shown (2 × M2.5 hex head screws).



9. Taking care not to touch the pins, plug the connector into the socket in the interface, ensuring correct orientation as shown.

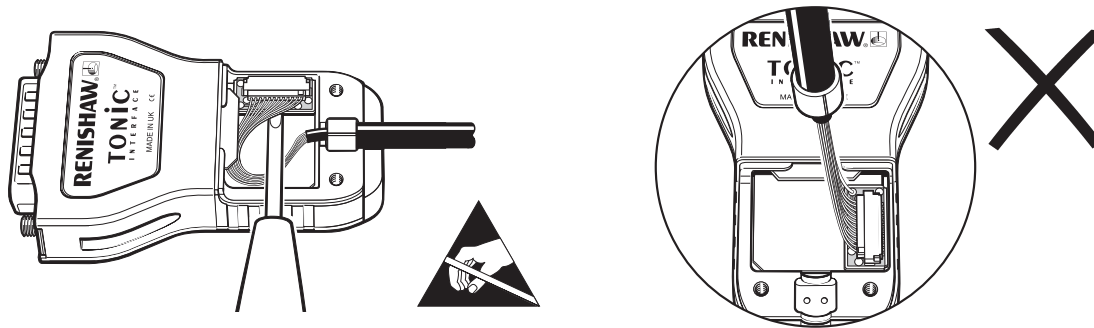


5. Refit the cover plate ensuring the cable ferrule is located in the recess on the inside and no wires are trapped under the cover plate.



## Disconnecting the readhead

1. Remove the cover plate on the interface (2 × M2.5 hex head screws).
2. Gently lever the connector PCB (on the end of the cable) out of the socket. Do not pull the cable to remove the connector.



3. Place the connector in an anti-static bag.
4. Refit the cover plate.

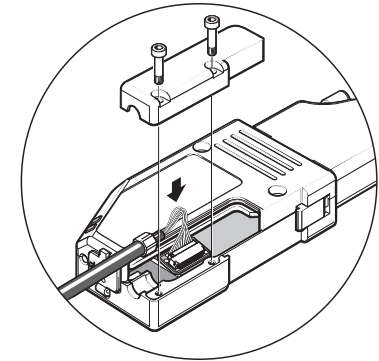
## System connection - DOP interface

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

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

### Connecting the readhead

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



### DOP interface mounting

The DOP interface can be DIN rail mounted or mounted to a suitable surface using customer-supplied screws.

#### NOTES:

- The recommended screw type M3 × 0.5 and must comply with: ISO 4762/DIN 912 grade 8.8 minimum/ANSI B18.3.1M.
- No washer is required under the screw head.
- The minimum thread engagement is 6 mm.
- The tightening torque should be between 0.9 Nm and 1.1 Nm.
- The DIN rail mounting, where used, must comply with EN 50022.

### Disconnecting the readhead

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

# Readhead mounting and alignment

## Mounting brackets

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

---

### NOTES:

- The recommended screw type M2.5 × 0.45 and must comply with: ISO 4762/DIN 912 grade 8.8 minimum/ANSI B18.3.1M.
  - The use of a thread locking compound is recommended.
  - No washer is required under the screw head.
  - The minimum thread engagement is 5 mm (7.5 mm including counterbore).
  - The tightening torque should be between 0.25 Nm and 0.4 Nm.
  - The mounting hole clearance will contribute to mechanical safe position.
-

## Readhead set-up

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

**NOTE:** When cleaning the readhead and the scale apply the cleaning fluid sparingly, do not soak.

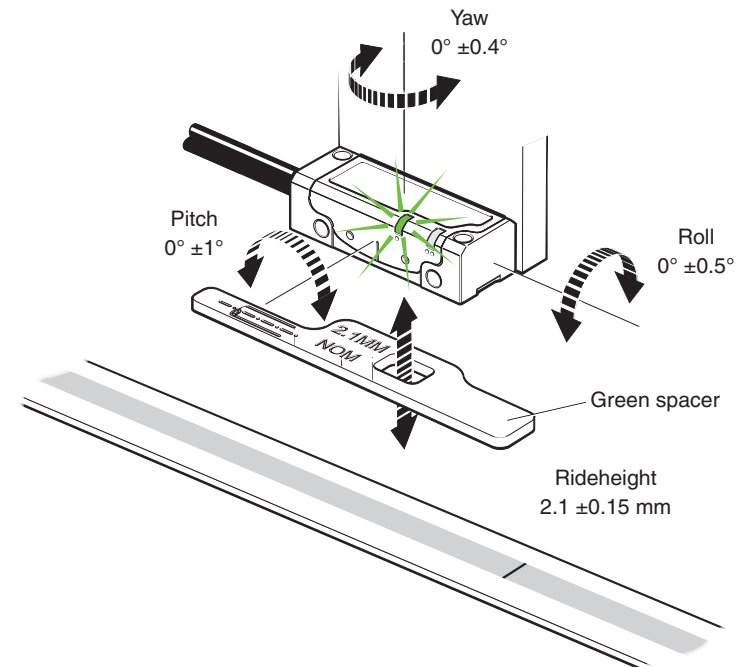
To set the nominal rideheight, place the green spacer with the aperture under the optical centre of the readhead to allow normal LED function during set-up procedure. Adjust the readhead to maximise the signal strength along the full axis of travel to achieve a green set-up LED on the readhead (> 70% signal). If a DOP interface is used, aim for a blue LED on the interface.

**NOTE:** The readhead should be installed and set-up with the Automatic Gain Control (AGC) switched off (CAL LED off). When reinstalling the readhead the factory defaults should be restored (see 'Restoring factory defaults' on page 42).

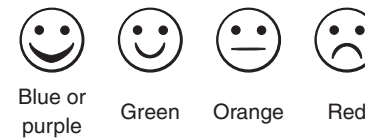
### Readhead set-up LED status



**NOTE:** For full readhead and interface LED diagnostics, see 'Diagnostic LEDs' on page 40.



### DOP interface set-up LED status



# Diagnostic LEDs

## T3x1x readhead LEDs

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

## DOP interface set-up LED

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

### NOTES:

- Alarm output will take the form of 3-state or line driven E signal depending on interface configuration. Also, some configurations do not output overspeed alarm. See *TONiC™ FS encoder system data sheet* (Renishaw part no. L-9517-9878) for details of interface configuration.
- Momentary alarm output status only, while fault condition remains.
- Alarm may result in axis position error, re-datum to continue.

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

<sup>2</sup> For Functional Safe applications the set-up LED must be green. See 'Evaluation unit monitoring' on page 14.

<sup>3</sup> For Functional Safe applications the LED must be purple, blue or green. See 'Evaluation unit monitoring' on page 14.



## System calibration

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

### Before system calibration:

1. Ensure the scale and readhead optical window are clean (contamination around the reference mark may result in reference mark dephasing).
2. If reinstalling, restore factory defaults (see 'Restoring factory defaults' on page 42).
3. Ensure Automatic Gain Control is switched off (CAL LED on readhead is not illuminated) before beginning calibration (see 'Switching Automatic Gain Control (AGC) on or off' on page 42).
4. Ensure signal strength has been optimised along the full axis of travel; the readhead LED will be green.

---

**NOTE:** CAL routine maximum speed: < 100 mm/s or less than the readhead maximum speed, whichever is slowest.

---

### Incremental signal calibration

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

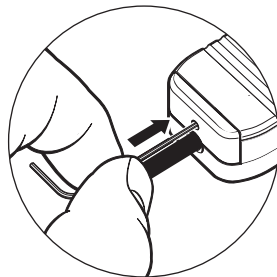
---

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

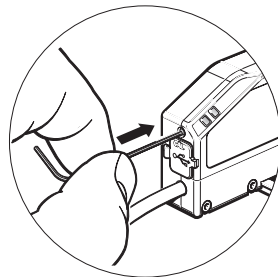
---

2. The CAL LED will now periodically single-flash to indicate that it is in incremental signal calibration mode.
3. Move the readhead along the axis, ensuring you do not pass the reference mark until the CAL LED starts double-flashing. This indicates the incremental signal is now calibrated and the new settings are stored in the readhead memory.
4. The system is now ready for reference mark phasing.
5. For systems without a reference mark, go to 'Calibration routine – manual exit' on page 42.
6. If the system does not automatically enter the reference mark phasing stage (no double-flashing of the CAL LED) the calibration of the incremental signals has failed. After ensuring failure is not due to overspeed, exit the calibration routine, restore factory defaults (see 'Restoring factory defaults' on page 42) and check the readhead installation and system cleanliness before repeating the calibration routine.

Ti interface



DOP interface



## Reference mark phasing

1. Move the readhead back and forth over the selected reference mark until the CAL LED stops flashing and remains off. The reference mark is now phased.
2. The system automatically exits the CAL routine and is ready for operation.
3. For the safety function to be valid, customer commissioning tests must be performed: see '[Commissioning test](#)' on page 14.
4. If the CAL LED continues double-flashing after passing the chosen reference mark many times, it is not detecting the reference mark. Ensure that the correct readhead configuration is being used. Readheads can either output all reference marks or only output a reference mark where a reference selector magnet is fitted depending on the options chosen when ordering.

---

**NOTE:** The LED on the interface will flash blank when the reference mark is detected (> 100 mm/s only). It indicates the presence of a reference mark, not the phasing status.

---

## Calibration routine – manual exit

1. To exit the calibration routine at any stage press the CAL button. The CAL LED will stop flashing.
2. For the safety function to be valid, customer commissioning tests must be performed: see '[Commissioning test](#)' on page 14.

## CAL LED status during system calibration

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

## Restoring factory defaults

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

### To restore factory defaults:

1. Switch system off.
2. Press and hold the CAL button whilst switching the system on. The CAL LED on the readhead will flash several times, indicating that the factory defaults have been restored.
3. Release the CAL button.
4. Check the '[Readhead mounting and alignment](#)' on page 38 and recalibrate the system (see '[System calibration](#)' on page 41).

---

**NOTE:** System must be recalibrated after restoring factory defaults.

---

## Switching Automatic Gain Control (AGC) on or off

The AGC can be switched on or off via the interface.

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

---

**NOTE:** The system must be calibrated before switching AGC on (see '[System calibration](#)' on page 41).

---

## Output signals

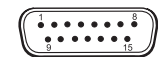
**NOTE:** Only analogue sine and cosine outputs are functionally safe.

### 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 <sup>1</sup> |   | 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          |

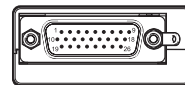


Ti0000 interface  
output connector:  
15-way D-type plug

<sup>1</sup> 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 <sub>1</sub> | +  | 1  |
|                     |                |                |                | -  | 19 |
| Sine                | V <sub>2</sub> | +              | 2              |    |    |
|                     |                | -              | 11             |    |    |
| Reference mark      | RS422A digital | Z              | +              | 15 |    |
|                     |                |                | -              | 23 |    |
|                     | Analogue       | V <sub>0</sub> | +              | 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           |    |    |



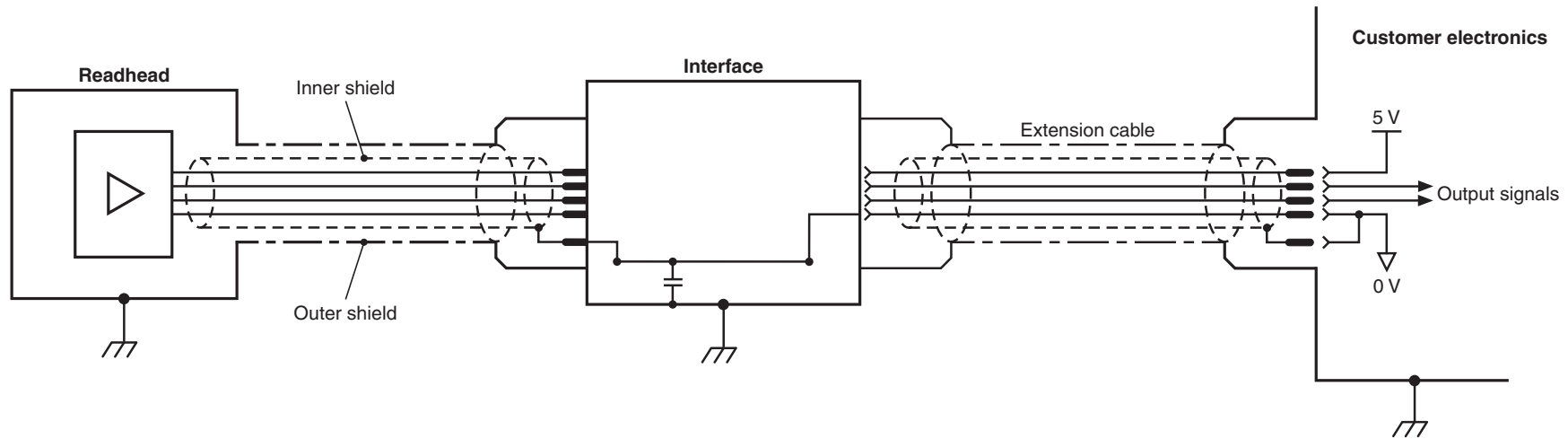
DOP interface output connector: 26-way high-density D-type plug

## Speed

| Clocked output option<br>(MHz)              | Maximum speed (m/s) |                 |                   |                   |                   |                  |                  |                  |                 |                 |                 |
|---|---------------------|-----------------|-------------------|-------------------|-------------------|------------------|------------------|------------------|-----------------|-----------------|-----------------|
|   | DOP0004<br>5 µm     | DOP0020<br>1 µm | DOP0040<br>0.5 µm | DOP0100<br>0.2 µm | DOP0200<br>0.1 µm | DOP0400<br>50 nm | DOP1000<br>20 nm | DOP2000<br>10 nm | DOP4000<br>5 nm | DOP10KD<br>2 nm | DOP20KD<br>1 nm |
| 50  | 10                  | 10              | 10                | 6.48              | 3.24              | 1.62             | 0.648            | 0.324            | 0.162           | 0.0654          | 0.032           |
| 40  | 10                  | 10              | 10                | 5.40              | 2.70              | 1.35             | 0.540            | 0.270            | 0.135           | 0.054           | 0.027           |
| 25  | 10                  | 10              | 8.10              | 3.24              | 1.62              | 0.810            | 0.324            | 0.162            | 0.081           | 0.032           | 0.016           |
| 20  | 10                  | 10              | 6.75              | 2.70              | 1.35              | 0.675            | 0.270            | 0.135            | 0.068           | 0.027           | 0.013           |
| 12  | 10                  | 9               | 4.50              | 1.80              | 0.900             | 0.450            | 0.180            | 0.090            | 0.045           | 0.018           | 0.009           |
| 10  | 10                  | 8.10            | 4.05              | 1.62              | 0.810             | 0.405            | 0.162            | 0.081            | 0.041           | 0.016           | 0.0081          |
| 08  | 10                  | 6.48            | 3.24              | 1.29              | 0.648             | 0.324            | 0.130            | 0.065            | 0.032           | 0.013           | 0.0065          |
| 06  | 10                  | 4.50            | 2.25              | 0.90              | 0.450             | 0.225            | 0.090            | 0.045            | 0.023           | 0.009           | 0.0045          |
| 04  | 10                  | 3.37            | 1.68              | 0.67              | 0.338             | 0.169            | 0.068            | 0.034            | 0.017           | 0.0068          | 0.0034          |
| 01  | 4.2                 | 0.84            | 0.42              | 0.16              | 0.084             | 0.042            | 0.017            | 0.008            | 0.004           | 0.0017          | 0.0008          |
| <b>Analogue output<br/>(Ti0000 and DOP)</b> | 10 (-3dB)           |                 |                   |                   |                   |                  |                  |                  |                 |                 |                 |

# Electrical connections

## Grounding and shielding - standard TONiC system

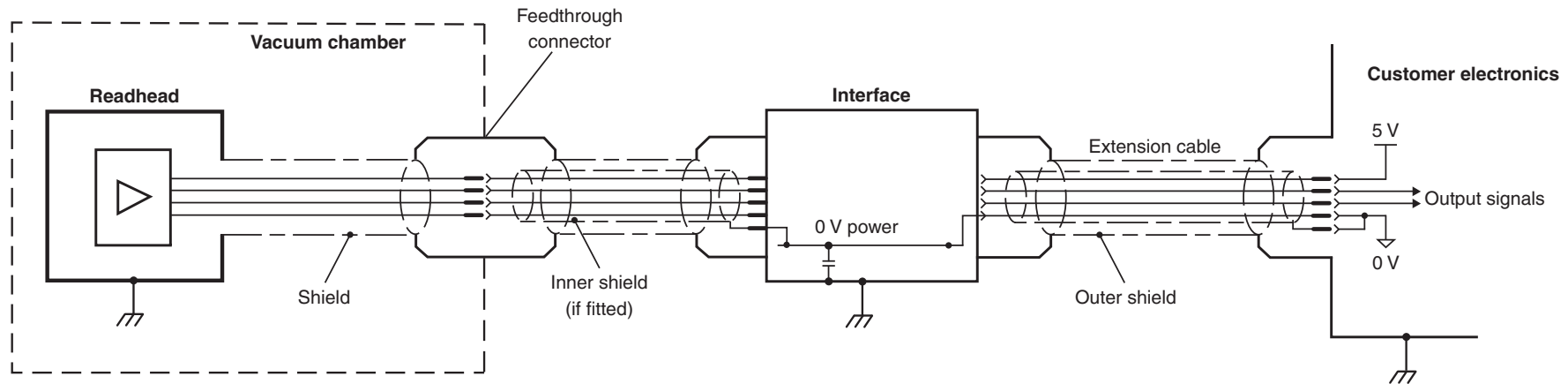


**IMPORTANT:** The outer shield should be connected to the machine earth (Field Ground). The inner shield should be connected to 0 V at the receiving electronics only. Care should be taken to ensure that the inner and outer shields are insulated from each other. If the inner and outer shields are connected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

### NOTES:

- The maximum cable length between the readhead and the interface is 10 m
- The maximum extension cable is dependent on the cable type, the readhead cable length and the clock speed. Contact your local Renishaw representative for more information.
- For DOP interfaces the external earthing tag on the interface must be used when mounting the interface on a DIN rail.

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



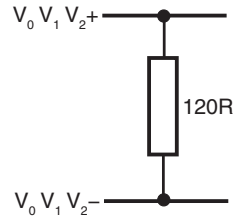
**IMPORTANT:** The outer shield should be connected to the machine earth (Field Ground). The inner shield should be connected to 0 V at receiving electronics only. Care should be taken to ensure that the inner and outer shields are insulated from each other. If the inner and outer shields are connected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

### NOTES:

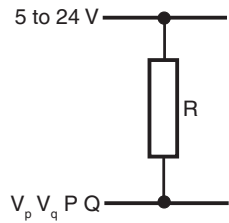
- The maximum cable length between the readhead and the interface is 10 m
- The maximum extension cable is dependent on the cable type, the readhead cable length and the clock speed. Contact your local Renishaw representative for more information.
- For DOP interfaces the external earthing tag on the interface must be used when mounting the interface on a DIN rail.

## Recommended signal termination <sup>1</sup>

### Analogue outputs

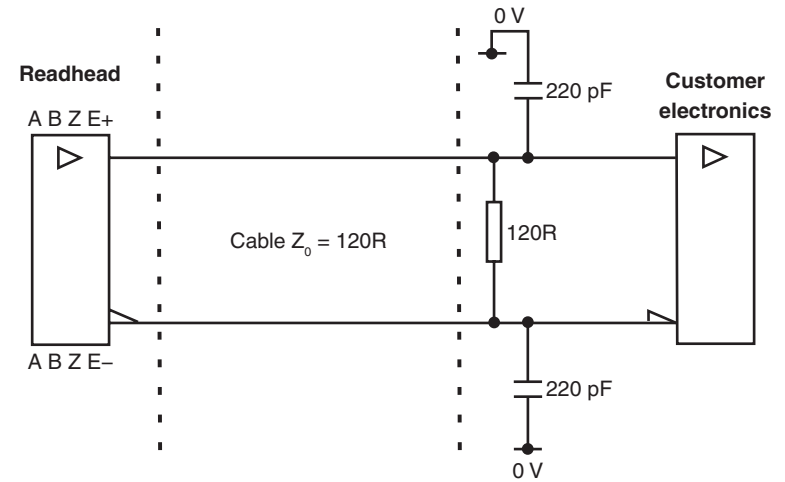


### Limit outputs



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

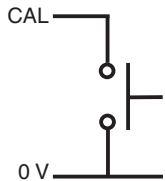
### Digital outputs (DOP only)



Standard RS422A line receiver circuitry.

The capacitors are recommended for improved noise immunity.

## Remote CAL operation



Ti and DOP interfaces include a push-button switch to enable CAL/AGC features. However, remote operation of the CAL/AGC is possible via pin 14 of analogue Ti0000 interfaces.

<sup>1</sup> Only the analogue sine and cosine outputs are functionally safe.

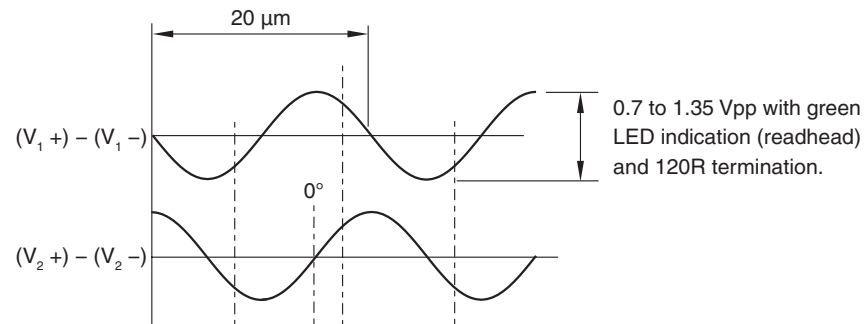


# Ti interface output specifications

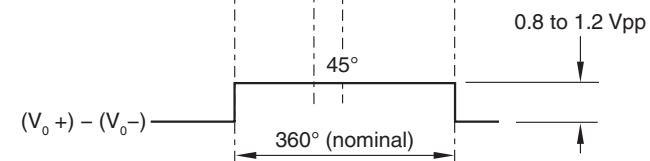
## Analogue signals <sup>1</sup>

### Incremental

2 channels  $V_1$  and  $V_2$  differential sinusoids in quadrature centred on  $\sim 1.65$  V ( $90^\circ$  phase shifted)



### Reference



The reference output is bi-directionally repeatable.

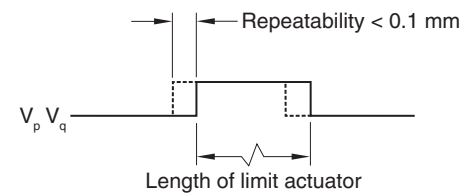
The differential pulse  $V_o$  is centred on  $45^\circ$ .

<sup>1</sup> Only the analogue sine and cosine outputs are functionally safe.

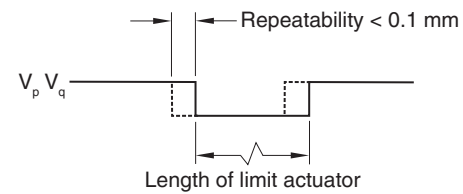
### Limits

Open collector output, asynchronous pulse

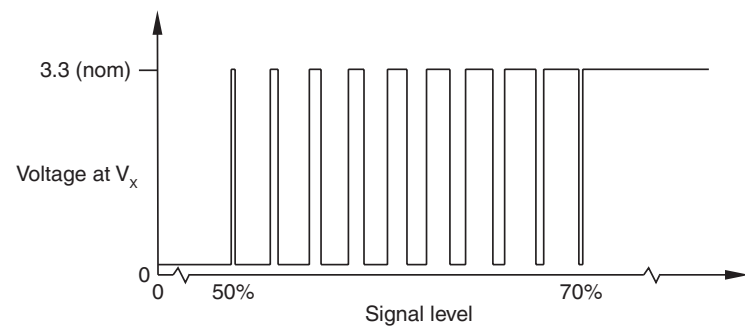
### Ti0000 interfaces (active high)



### T3x1x readheads (active low)



### Ti interface set-up <sup>1</sup>



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.

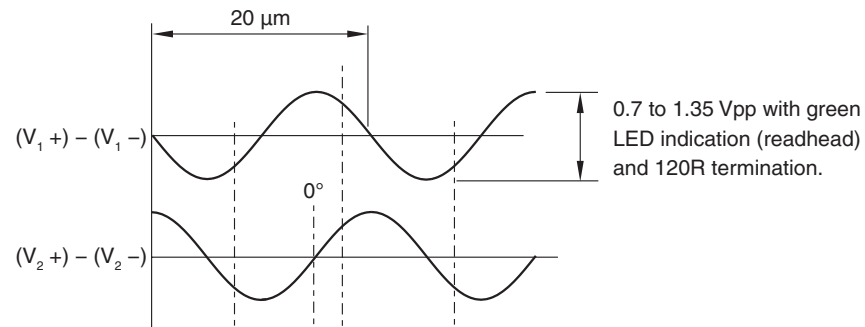
<sup>1</sup> The set-up signal as shown is not present during the calibration routine.

## DOP interface output specifications

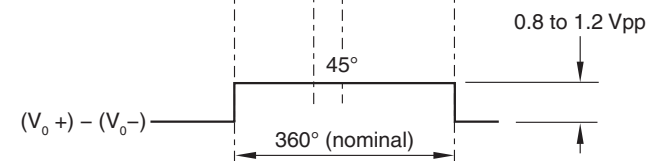
### Analogue signals <sup>1</sup>

#### Incremental

2 channels  $V_1$  and  $V_2$  differential sinusoids in quadrature centred on 2.5 V (90° phase shifted)



#### Reference



The reference output is bi-directionally repeatable.

The differential pulse  $V_0$  is centred on 45°.

<sup>1</sup> Only the analogue sine and cosine outputs are functionally safe.

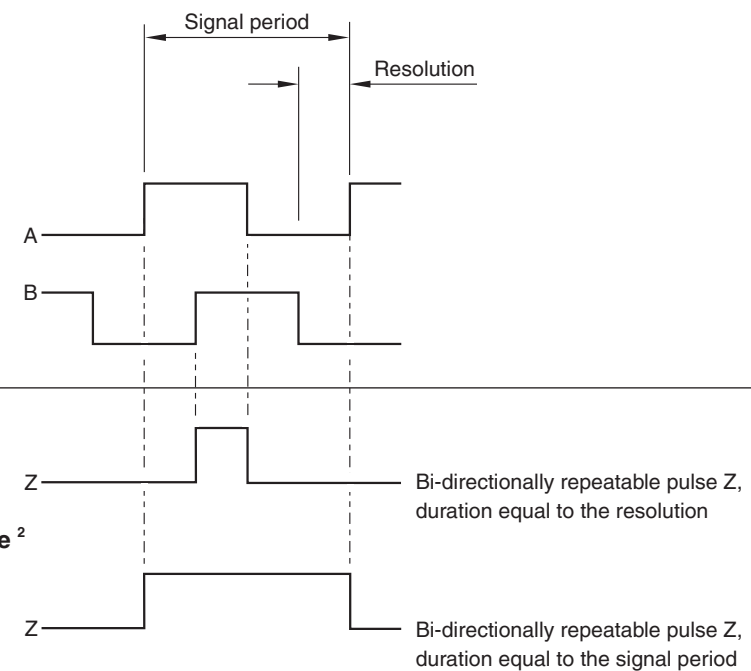
<sup>2</sup> For clarity, the inverse signals are not shown.

### Digital signals <sup>1</sup>

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

#### Incremental <sup>2</sup>

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

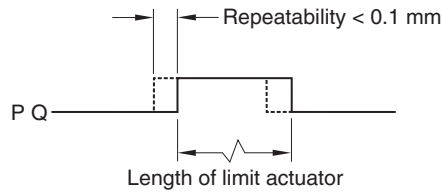


**NOTE:** Select 'standard' or 'wide' reference at time of ordering, to match the requirements of the controller being used.

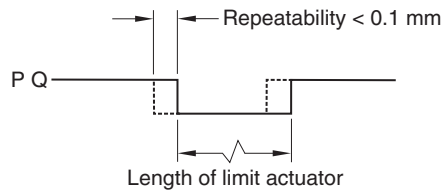
## Limits

Open collector output, asynchronous pulse

### Active high

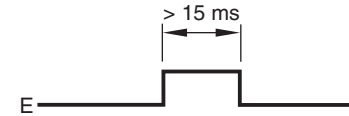


### or active low



## Alarm

### Line driven <sup>1</sup> (asynchronous pulse)



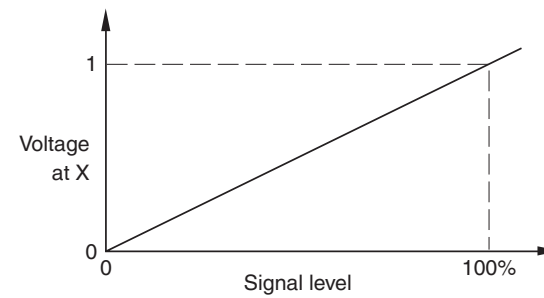
The line driven alarm is asserted when:

- 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.

## DOP set-up <sup>2</sup>




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

<sup>1</sup> For clarity, the inverse signals are not shown.

<sup>2</sup> The set-up signal as shown is not present during the calibration routine.

## General specifications

|                             |                         |  |
|-----------------------------|-------------------------|--|
| <b>Power supply</b>         | 5 V ±10%                | Readhead only < 100 mA<br>T3x1x with Ti0000 < 100 mA<br>T3x1x with DOP < 275 mA<br>Current consumption figures refer to unterminated systems.<br>For digital outputs a further 25 mA per channel pair (eg A+, A-) will be drawn when terminated with 120R.<br>For analogue outputs a further 20 mA in total will be drawn when terminated with 120R.<br>Power from a 5 V dc supply complying with the requirements for PELV of standard IEC 60950-1. |
|                             | Ripple                  | 200 mVpp maximum @ frequency up to 500 kHz   |
| <b>Temperature</b>          | Storage (system)        | -20 °C to +70 °C   |
|                             | Operating (system)      | 0 °C to +70 °C   |
|                             | Bakeout (UHV readhead)  | +120 °C  |
| <b>Humidity</b>             | System                  | 95% relative humidity (non-condensing) to IEC 60068-2-78   |
| <b>Sealing</b>              | Standard readhead       | IP40   |
|                             | UHV readhead            | IP20   |
|                             | Ti interface            | IP20   |
|                             | DOP interface           | IP30   |
| <b>Acceleration</b>         | Operating (readhead)    | 500 m/s <sup>2</sup> , 3 axes  |
| <b>Shock</b>                | Operating (system)      | 500 m/s <sup>2</sup> , 11 ms, ½ sine, 3 axes   |
| <b>Vibration</b>            | Operating (system)      | 100 m/s <sup>2</sup> , 55 Hz to 2000 Hz, 3 axes  |
| <b>Mass</b>                 | Readhead                | 10 g   |
|                             | Ti interface            | 100 g  |
|                             | DOP interface           | 205 g  |
|                             | Standard cable          | 26 g/m   |
|                             | UHV cable               | 14 g/m   |
| <b>Readhead cable</b>       | Standard readhead       | Double-shielded, outside diameter 4.25 ±0.25 mm<br>Flex life > 20 × 10 <sup>6</sup> cycles at 20 mm bend radius<br>UL recognised component   |
|                             | UHV readhead            | Tin coated braided single screen FEP core insulation   |
| <b>Maximum cable length</b> | Readhead to interface   | 10 m   |
|                             | Interface to controller | 25 m (with 40 MHz to 50 MHz clocked output interface)<br>50 m (with < 40 MHz clocked output interface)<br>50 m (with analogue interface)   |

**CAUTION:** Renishaw encoder systems have been designed to the relevant EMC standards, but must be correctly integrated to achieve EMC compliance. In particular, attention to the shielding arrangements is essential. For UHV cables ensure that the cable to UHV connector termination meets the EM requirements defined by IEC 61800-5-2: Annex E second environment.

## RELx20 scale specifications

|   |  |
|---|--|
| <b>Form (height x width)</b>                              | 1.8 mm x 14.9 mm (including adhesive backing tape)   |
| <b>Pitch</b>  | 20 µm  |
| <b>Accuracy (at 20 °C) - includes slope and linearity</b> | Certified to ±1 µm for lengths up to 1 m<br>±1 µm/m for lengths > 1 m to 1.5 m<br>(Calibration traceable to International Standards) |
| <b>Supplied lengths</b>                                   | 20 mm up to 1.5 m (available in increments of 10 mm)   |
| <b>Material</b>   | ZeroMet™. High stability, low-expansion nickel-iron alloy  |
| <b>Mass</b>   | 184 g/m  |
| <b>Coefficient of thermal expansion (at 20 °C)</b>        | 0.75 ±0.35 µm/m/°C   |
| <b>Mounting</b>   | Epoxy datum point and adhesive tape  |

## RSLx20 scale specifications

|   |   |
|---|---|
| <b>Form (height x width)</b>                              | 1.7 mm x 14.9 mm (including adhesive backing tape)  |
| <b>Pitch</b>  | 20 µm   |
| <b>Accuracy (at 20 °C) - includes slope and linearity</b> | ±1.5 µm for lengths up to 1 m<br>±2.25 µm for lengths from 1 m to 2 m<br>±3 µm for lengths from 2 m to 3 m<br>±4 µm for lengths from 3 m to 5 m<br>(Calibration traceable to International Standards) |
| <b>Supplied lengths</b>                                   | 20 mm up to 5 m (available in increments of 10 mm)  |
| <b>Material</b>   | Hardened martensitic stainless steel  |
| <b>Mass</b>   | 172 g/m   |
| <b>Coefficient of thermal expansion (at 20 °C)</b>        | 10.1 ±0.2 µm/m/°C   |
| <b>Mounting</b>   | Epoxy datum point and adhesive tape   |
| <b>Storage</b>  | Lengths over 1.13 m are coiled (> 600 mm diameter)  |

## Reference mark

|                      |   |   |
|----------------------|---|---|
| <b>Type</b>          | <i>IN-TRAC</i> auto-phase optional reference mark, no physical adjustments required                     |   |
| <b>Position</b>      | RELM20  | Single reference mark at the midpoint of the scale length   |
|                      | RELE20  | Single reference mark 20 mm from the end of the scale   |
|                      | RSLM20  | Single reference mark at the midpoint of the scale length   |
|                      | RSLE20  | (Option A) – Single reference mark 20 mm from the end of the scale (for use with 10 mm length limits)           |
|                      | RSLE20  | (Option B) – Single reference mark 70 mm from the end of the scale (for use with 20 mm and 50 mm length limits) |
|                      | RSLC20  | Multiple reference marks every 200 mm <sup>1</sup>  |
| <b>Phasing</b>       | Auto-phased by readhead calibration routine   |   |
| <b>Repeatability</b> | Unit of resolution repeatability (bi-directional) across full system rated speed and temperature ranges |   |



## Limit switches

|                      |  |
|----------------------|--|
| <b>Type</b>          | Magnetic actuators; with dimple triggers Q limit, without dimple triggers P limit (see ' <a href="#">TONiC T3x1x readhead installation drawing</a> ' on page 23) |
| <b>Trigger point</b> | 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   |
| <b>Mounting</b>      | Self-adhesive backing tape. Customer placed at desired locations   |
| <b>Repeatability</b> | < 0.1 mm   |

<sup>1</sup> When using a T1030 readhead, a self-adhesive reference mark selector magnet is required to choose the reference mark that is output.

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