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FORTiS-S™ enclosed encoder system

Specification

Measuring standard	Renishaw stainless-steel scale with single track absolute encoding
Coefficient of thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C
Thermal datum	At centre position (encoder position of 0.5 × measuring length)
Measuring lengths available (mm)	140, 240, 340, 440, 540, 640, 740, 840, 940, 1040, 1140, 1240, 1340, 1440, 1540, 1640, 1740, 1840, 2040, 2240, 2440, 2640, 2840, 3040, 3240
Accuracy grades	High grade: ≤ ±3 µm Standard grade: ≤ ±5 µm
Resolution [1]	0.5 nm, 1 nm, 1.25 nm, 10 nm, 12.5 nm, 25 nm, 50 nm
Sub-Divisional Error (typical)	±40 nm
Jitter (RMS)	10 nm
Absolute position serial interface	BiSS C, FANUC (α/αi), Mitsubishi, Panasonic, Siemens DRIVE-CLiQ (with external interface), Yaskawa
Encoder electrical connection	Cable connector M12 custom (customer configurable exit direction)
Controller electrical connection	8-way M12, FANUC 20-way, 10-way Mitsubishi, 17-way M23, 9-way D-Type, 14-way LEMO, flying lead
Cable length	Up to 100 m (with extension cable)
Power supply	5 V ±10% 1.25 W maximum (250 mA @ 5 V)
Set-up LED	Signal strength indicator LED
Maximum speed	4 m/s
Acceleration (readhead relative to scale)	< 200 m/s² in measuring direction
Moving force (maximum force required to move the readhead through the seals)	< 5 N
Vibration (55 Hz to 2 000 Hz)	Housing: < 300 m/s² to IEC 60068-2-6 Readhead: < 300 m/s² to IEC 60068-2-6
Shock 11 ms half-sine	< 300 m/s² IEC 60068-2-27
Operating temperature	0 °C to 50 °C
Environment protection	IP53 when installed correctly, IP64 with air purge
Air purge requirements	Air supply pressure = 1 bar at encoder At correct supply pressure the supplied air connection fitting restricts the air flow rate to 2 l/min
Weight	0.27 kg + 2.0 kg/m

[1] See page 2.

Resolution per accuracy grade and serial interface – standard options

Accuracy grade	Serial interface	Resolution nm	
		Single	Dual
3 µm	BiSS C, Mitsubishi, Panasonic, Siemens DRIVE-CLiQ, Yaskawa	1	
	FANUC		1 / 0.5
			10 / 1.25
5 µm	BiSS C, Mitsubishi, Panasonic, Siemens DRIVE-CLiQ, Yaskawa	10	
		50	
	FANUC		50 / 12.5
			50 / 25

NOTE: For BiSS C encoders, the standard position word length is 36 bits long. However, to accommodate controllers that require a shorter position word length, versions with 26 bit or 32 bit word length are also available (with standard 5 µm accuracy grade only).

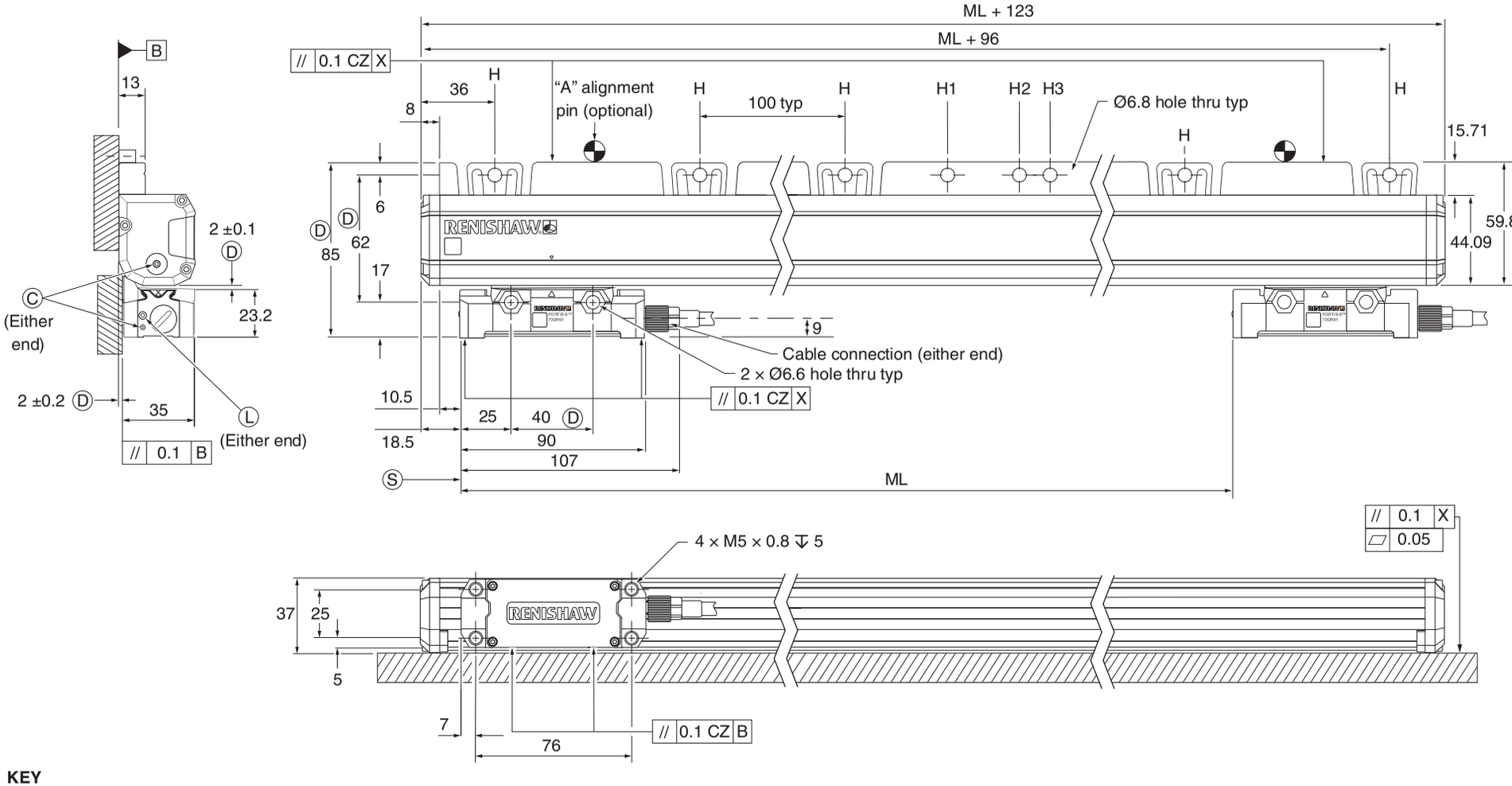
Position word length	Nomenclature code	Accuracy grade	Resolution options (nm)		
			1	10	50
36 bit	36B	3 µm	OK	N/A	N/A
		5 µm	N/A	OK	OK
32 bit	32B		N/A	OK	N/A
26 bit	26B		N/A	N/A	OK

NOTE: For Siemens DRIVE-CLiQ encoders, the position word length is linked to the resolution, which in turn is linked to the accuracy grade. Here are the three options.

Position word length	Nomenclature code	Accuracy grade	Resolution options (nm)
34 bit	34D	3 µm	1
30 bit	30D	5 µm	10
28 bit	28D	5 µm	50

System installation drawing

Dimensions and tolerances in mm



KEY

A = Recommended extrusion alignment pin locations (if required)
Adjacent to first and last flexure holes plus every 300–500 mm

C = Compressed air inlet fitting

D = Required mounting dimensions

H = Flexure mounting holes

H1 = Fixed mounting hole (preferred)

H2 and H3 = Alternative mounting holes (non-preferred)

L = LED set-up illumination

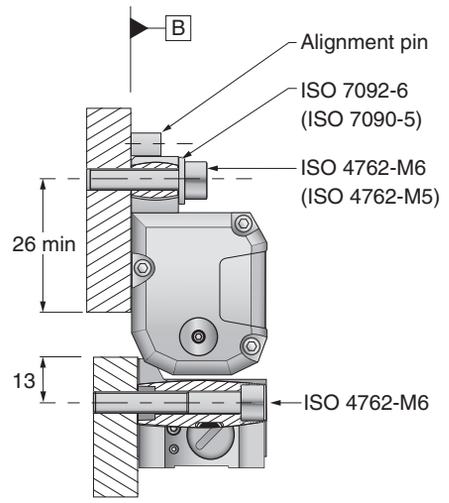
ML = Measuring length

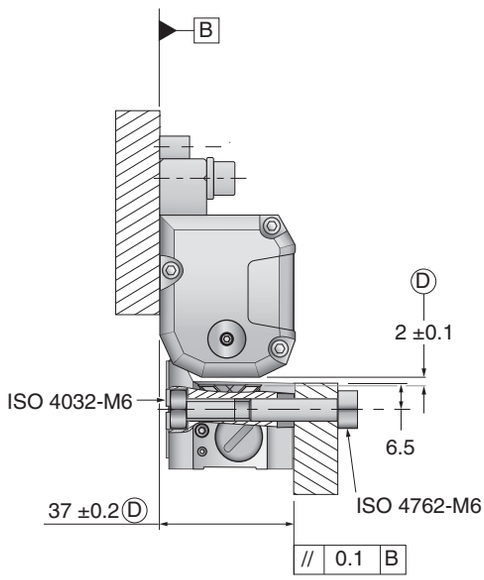
S = Start of measuring length

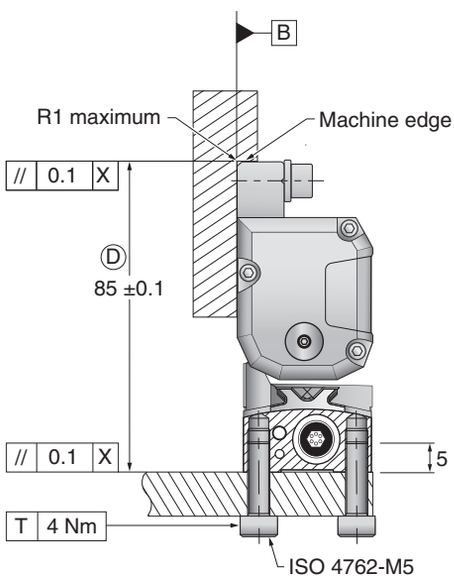
X = Machine guideway/axis datum

Mounting orientations

Dimensions and tolerances in mm







KEY

D = Required mounting dimensions

X = Machine guideway/axis datum

NOTES:

1. Side elevations show alternative mounting orientations.

2. Screws sizes in brackets are permissible alternatives.

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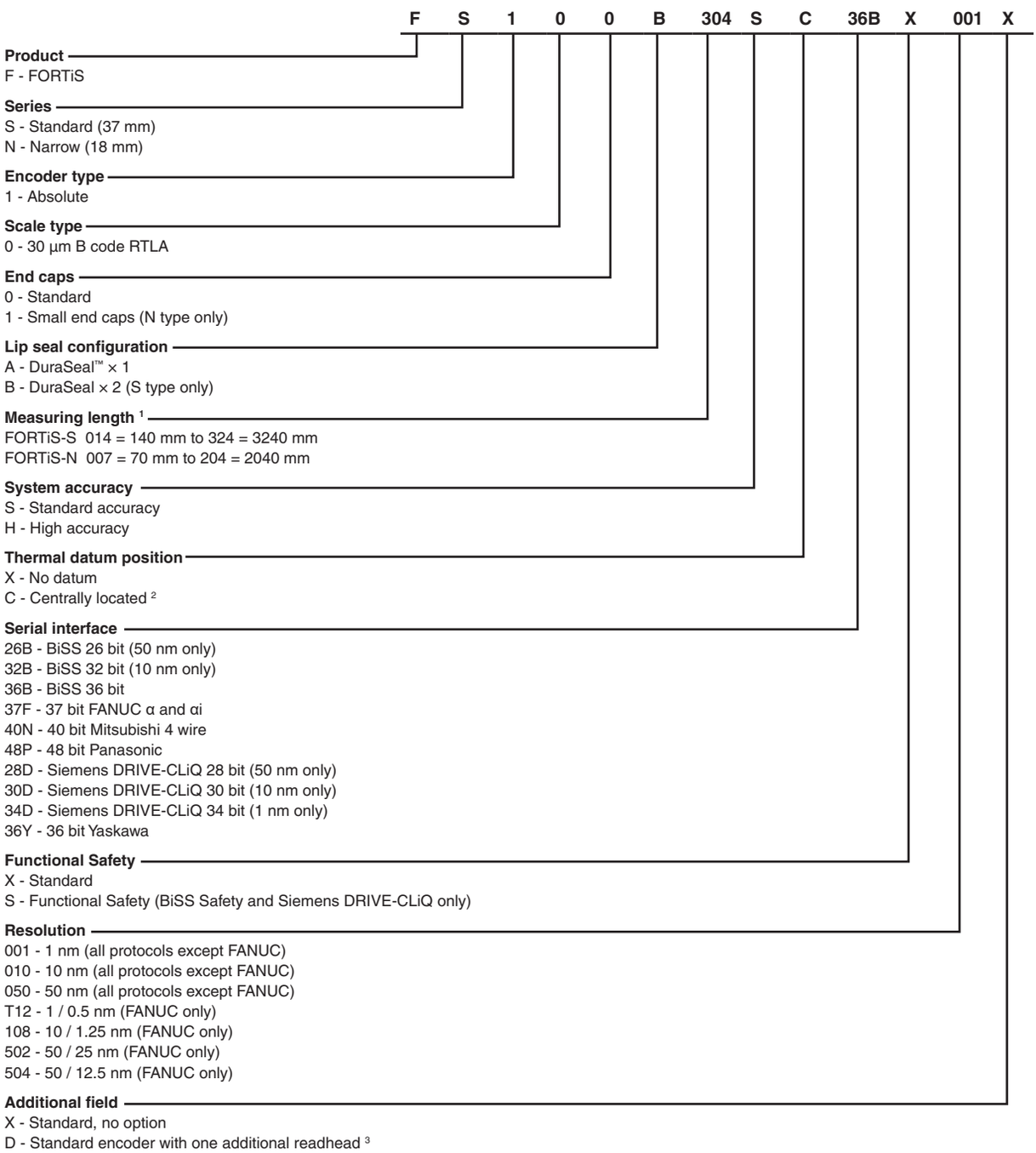
Nomenclature



[1] For all permissible measuring length options refer to specification table.

[2] For other datum requirements contact your local Renishaw representative.

[3] For further information see the manual *FORTiS-S enclosed encoder system with multiple readheads* (Renishaw part no. L-6725-9176).

www.renishaw.com/contact

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Part no.: L-9517-9934-02-B
Issued: 09.2023

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FORTiS-N™ enclosed encoder system

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Specification

Measuring standard	Renishaw stainless steel scale with single track absolute encoding
Coefficient of thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C
Thermal datum	At centre position (encoder position of 0.5 × measuring length)
Measuring lengths available (mm)	70, 120, 170, 220, 270, 320, 370, 420, 470, 520, 570, 620, 670, 720, 770, 820, 920, 1020, 1140, 1240, 1340, 1440, 1540, 1640, 1740, 1840, 2040 (mounting spar available – recommended for > 620 mm length)
Accuracy grades	High grade: ±3 µm Standard grade: ±5 µm
Resolution*	0.5 nm, 1 nm, 1.25 nm, 10 nm, 12.5 nm, 25 nm, 50 nm
Sub-Divisional Error (typical)	±40 nm
Jitter (RMS)	10 nm
Absolute position serial interface	BiSS C, FANUC (α/αi), Mitsubishi, Panasonic, Siemens DRIVE-CLiQ (with external interface)
Encoder electrical connection	Cable connector M12 custom
Controller electrical connection	8-way M12, FANUC 20-way, 10-way Mitsubishi, 17-way M23, 9-way D-Type, 14-way LEMO, flying lead
Cable length	Up to 100 m (with extension cable)
Power supply	5 V ±10% 1.25 W maximum (250 mA @ 5 V)
Set-up LED	Signal strength indicator LED
Maximum speed	4 m/s
Acceleration (readhead relative to scale)	< 200 m/s² in measuring direction
Moving force (maximum force required to move the readhead through the seals)	< 4 N
Vibration (55 Hz to 2000 Hz)	Readhead: < 300 m/s² to IEC 60068-2-6 Housing without mounting spar: < 200 m/s² to IEC 60068-2-6 Housing with mounting spar: < 300 m/s² to IEC 60068-2-6
Shock 11 ms half-sine	< 300 m/s² IEC 60068-2-27
Operating temperature	0 °C to 50 °C
Environment protection	IP53 when installed correctly, IP64 with air purge
Air purge requirements	Air supply pressure = 1 bar at encoder At correct supply pressure the supplied air connection fitting restricts the air flow rate to 2 l/min
Weight	0.11 kg + 0.45 kg/m

* See page 2.

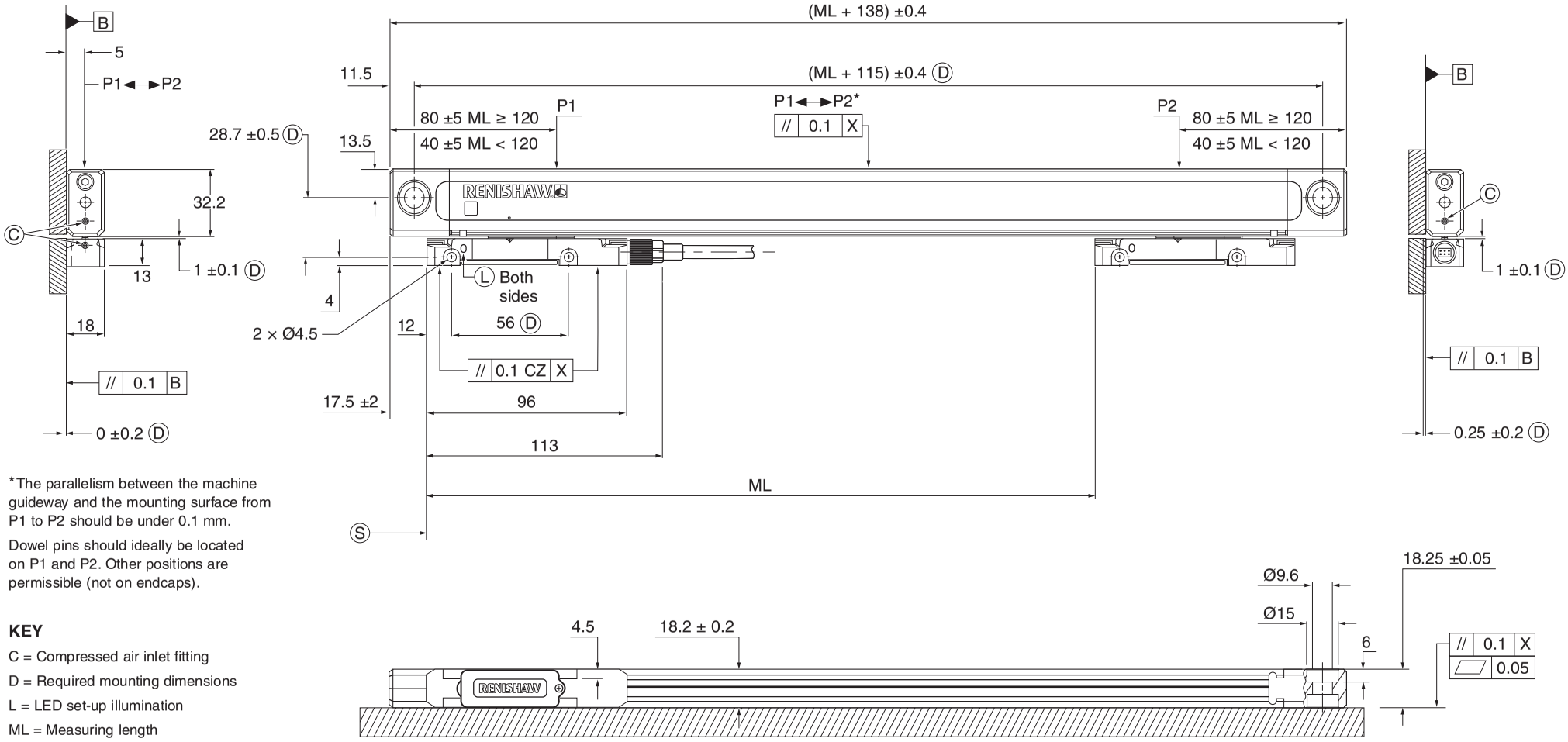
Resolution per accuracy grade and serial interface – standard options

Accuracy grade	Serial interface	Resolution nm	
		Single	Dual
3 µm	BiSS C, Mitsubishi, Panasonic, Siemens DRIVE-CLiQ	1	
	FANUC		1 / 0.5
			10 / 1.25
5 µm	BiSS C, Mitsubishi, Panasonic, Siemens DRIVE-CLiQ	10	
		50	
	FANUC		50 / 12.5
			50 / 25

System installation drawings – standard end caps

(ML 320 mm shown)

Dimensions and tolerances in mm



*The parallelism between the machine guideway and the mounting surface from P1 to P2 should be under 0.1 mm.

Dowel pins should ideally be located on P1 and P2. Other positions are permissible (not on endcaps).

KEY

C = Compressed air inlet fitting

D = Required mounting dimensions

L = LED set-up illumination

ML = Measuring length

P = Gauging points for alignment

S = Start of measuring length

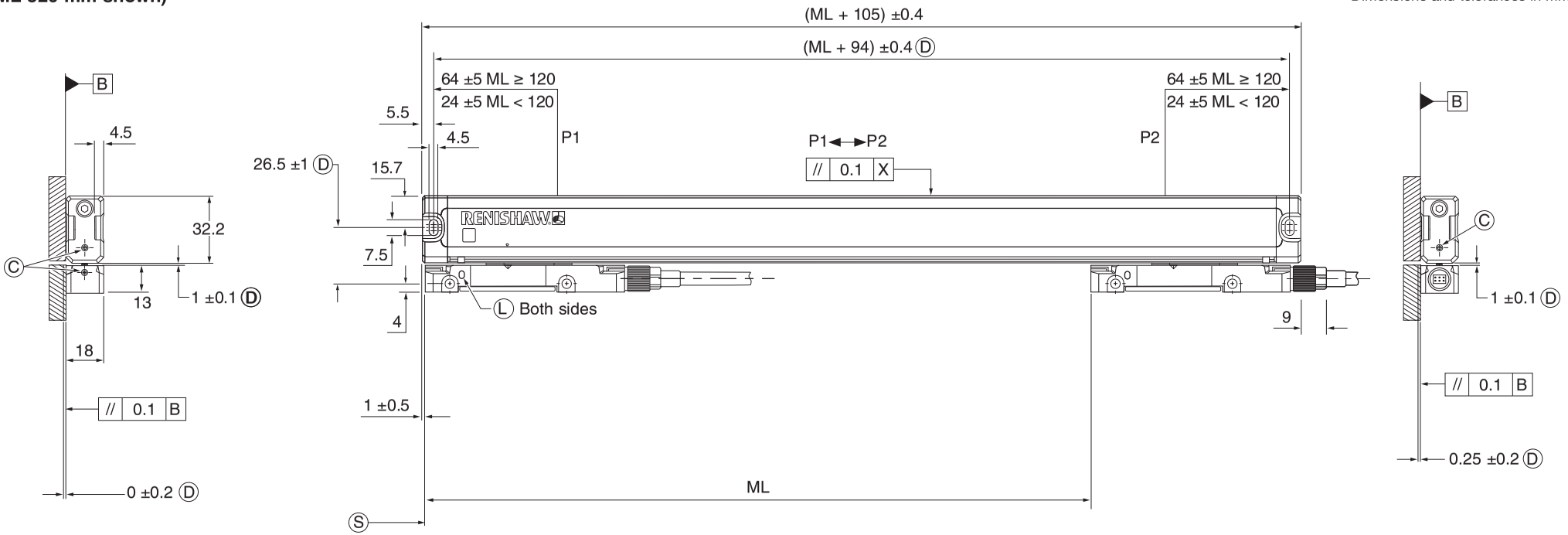
X = Machine guideway/axis datum

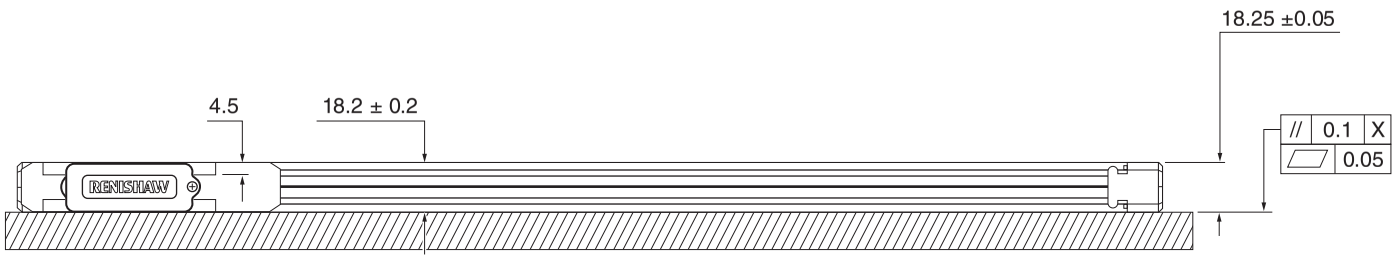
ML	70	120	170	220	270	320	370	420	470	520	570	620	670	720	770	820	920	1020	1140	1240	1340	1440	1540	1640	1740	1840	2040

System installation drawings – short end caps

(ML 320 mm shown)

Dimensions and tolerances in mm





KEY

C = Compressed air inlet fitting

D = Required mounting dimensions

L = LED set-up illumination

ML = Measuring length

P = Gauging points for alignment

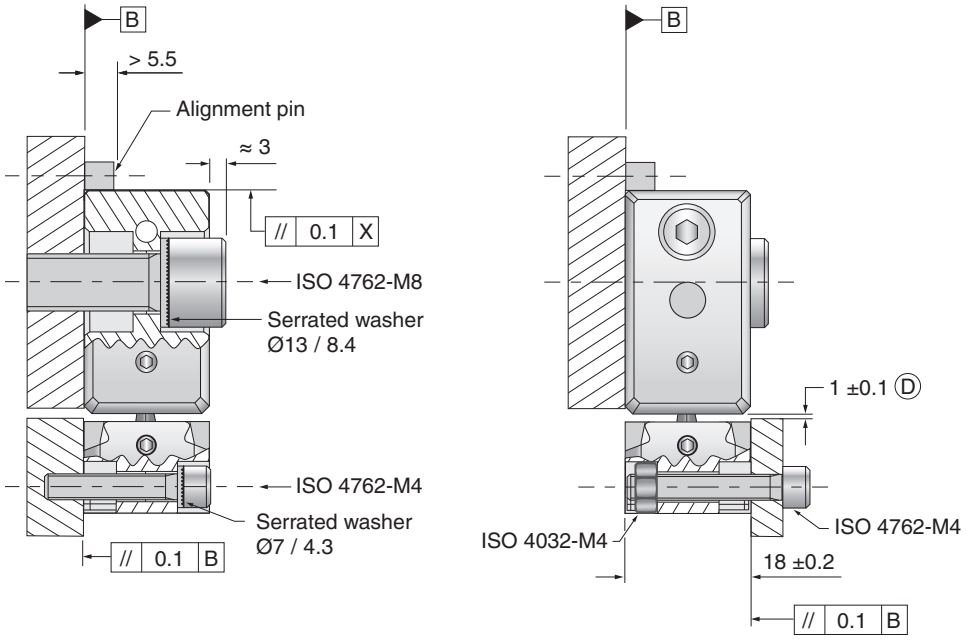
S = Start of measuring length

X = Machine guideway/axis datum

ML	70	120	170	220	270	320	370	420	470	520	570	620	670	720	770	820	920	1020	1140	1240	1340	1440	1540	1640	1740	1840	2040

Mounting orientations – standard end caps

Dimensions and tolerances in mm



KEY

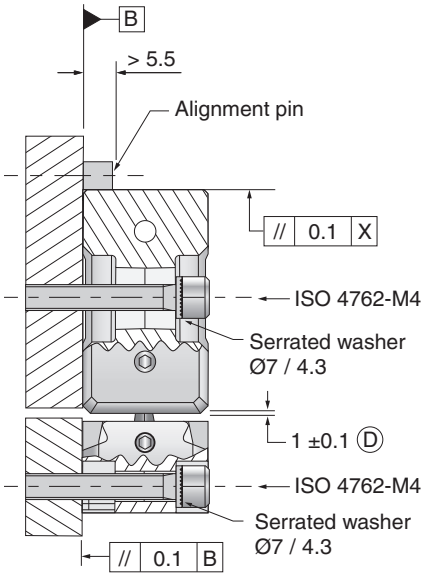
D = Required mounting dimensions

X = Machine guideway/axis datum

NOTES

- Side elevations show alternative mounting orientations.
- Alignment pin and machine edge mounting options to mate directly to the top face of the extrusion.

Mounting orientation – short end caps



KEY

D = Required mounting dimensions

X = Machine guideway/axis datum

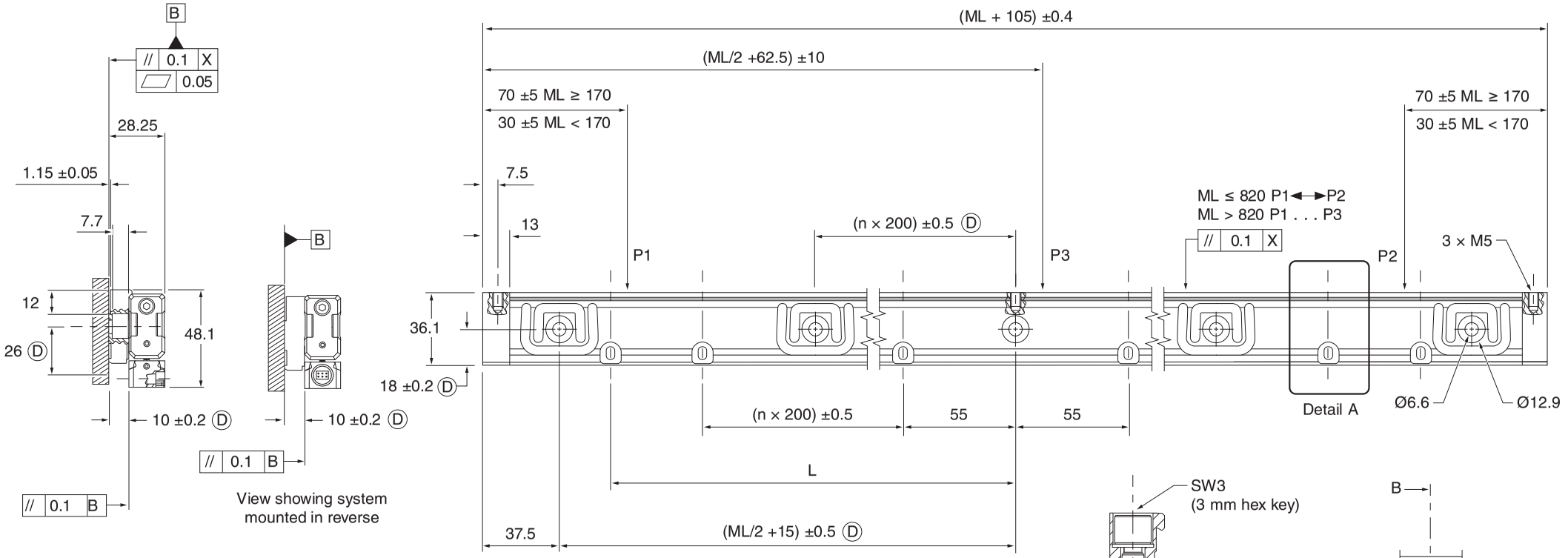
NOTES

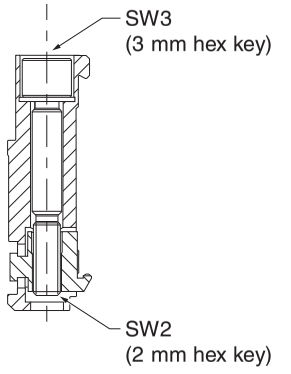
- Side elevation shows alternative mounting orientation.
- Extrusion mounting can be machine edge or dowel pins.

Mounting spar installation drawing

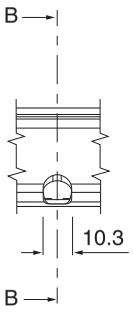
(ML 620 mm shown)

Dimensions and tolerances in mm





Section B–B through the spar



Detail A
Showing clamp installed

KEY

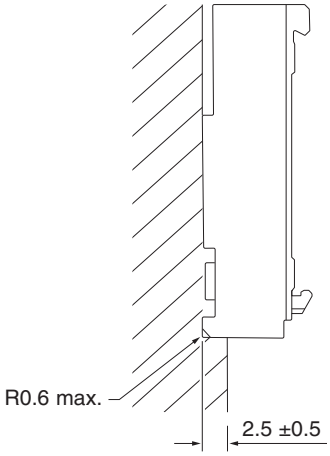
D = Required mounting dimensions
ML = Measuring length
P = Gauging points for alignment
X = Machine guideway/axis datum

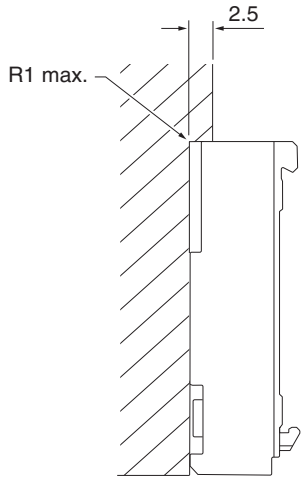
ML	70	120	170	220	270	320	370	420	470	520	570	620	670	720
L	37.5	55	75	100	115	140	175	200	225	250	275	300	325	350
n	-	-	-	-	-	-	-	-	-	-	-	1	1	1

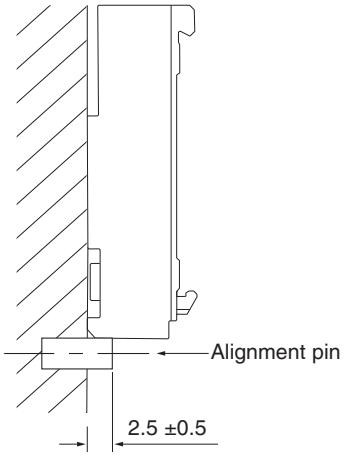
ML	770	820	920	1020	1140	1240	1340	1440	1540	1640	1740	1840	2040
L	375	400	450	500	550	640	655	710	760	810	855	910	1010
n	1	1	1	2	2	2	2	3	3	3	3	4	4

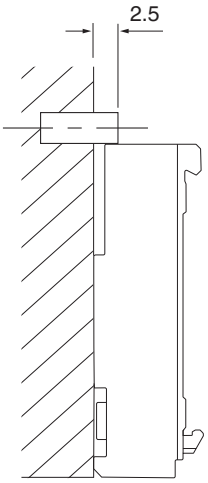
Spar mounting options

Dimensions and tolerances in mm









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Nomenclature

F	N	1	0	0	B	204	S	C	36B	X	001	X

Product
F - FORTiS

Series
S - Standard (37 mm)
N - Narrow (18 mm)

Encoder type
1 - Absolute

Scale type
0 - 30 µm B code RTLA

End caps
0 - Standard
1 - Small end caps (N type only)

Lip seal configuration
A - DuraSeal™ × 1
B - DuraSeal × 2 (S type only)

Measuring length*
FORTiS-S 014 = 140 mm to 304 = 3040 mm
FORTiS-N 007 = 70 mm to 204 = 2040 mm

System accuracy
S - Standard accuracy
H - High accuracy

Thermal datum position
C - Centrally located†

Serial interface
36B - BiSS 36 bit
37F - 37 bit FANUC α and αi
40N - 40 bit Mitsubishi 4 wire
48P - 48 bit Panasonic
28D - Siemens DRIVE-CLiQ 28 bit (50 nm only)
30D - Siemens Drive-CLiQ 30 bit (10 nm only)
34D - Siemens Drive-CLiQ 34 bit (1 nm only)

Functional Safety
X - Standard
S - Functional Safety (BiSS Safety and Siemens DRIVE-CLiQ only)

Resolution
001 - 1 nm (all protocols except FANUC)
010 - 10 nm (all protocols except FANUC)
050 - 50 nm (all protocols except FANUC)
T12 - 1 / 0.5 nm (FANUC only)
108 - 10 / 1.25 nm (FANUC only)
502 - 50 / 25 nm (FANUC only)
504 - 50 / 12.5 nm (FANUC only)

Additional field
X - Standard, no option
D - Standard encoder with one additional readhead

* For all permissible measuring length options refer to specification table.
† For other datum requirements contact your local Renishaw representative.

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

Part no.: L-9517-9946-01-A
Issued: 12.2021

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FORTiS-S™ Functional Safety enclosed encoder system

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Specification

Measuring standard	Renishaw stainless-steel scale with single track absolute encoding
Coefficient of thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C
Thermal datum	At centre position (encoder position of 0.5 × measuring length)
Measuring lengths available (mm)	140, 240, 340, 440, 540, 640, 740, 840, 940, 1040, 1140, 1240, 1340, 1440, 1540, 1640, 1740, 1840, 2040, 2240, 2440, 2640, 2840, 3040
Accuracy grades	High grade: ≤ ±3 µm Standard grade: ≤ ±5 µm
Resolution*	1 nm, 10 nm, 50 nm
Sub-Divisional Error (typical)	±40 nm
Jitter (RMS)	10 nm
Absolute position serial interface	BiSS Safety, Siemens DRIVE-CLiQ (with external interface)
Encoder electrical connection	Cable connector M12 custom (customer configurable exit direction)
Controller electrical connection	8-way M12, 9-way D-type, flying lead
Cable length	Multiple options available
Power supply	Depends on protocol
Set-up LED	Signal strength indicator
Maximum speed	4 m/s
Acceleration (readhead relative to scale)	< 200 m/s² in measuring direction
Moving force (maximum force required to move the readhead through the seals)	< 5 N
Vibration (55 Hz to 2000 Hz)	Housing: < 300 m/s² to IEC 60068-2-6 Readhead: < 300 m/s² to IEC 60068-2-6
Shock 11 ms half-sine	< 300 m/s² IEC 60068-2-27
Operating temperature	0 °C to 50 °C
Storage temperature	–20 °C to 70 °C
Environment protection	IP53 when installed correctly, IP64 with air purge Protection class III Pollution degree II Altitude 2000 m
EMC immunity	IEC 61800-5-2:2016 *Electromagnetic immunity requirement for safety related systems - Annex E, second environment*
Air purge requirements	Air supply pressure = 1 bar at encoder At correct supply pressure the supplied air connection fitting restricts the air flow rate to 2 l/min
Weight	0.27 kg + 2.0 kg/m

* See page 2.

Resolution per accuracy grade and serial interface – standard options

Accuracy grade	Serial interface	Resolution nm
		Single
3 µm	BiSS Safety, Siemens DRIVE-CLiQ	1
5 µm	BiSS Safety, Siemens DRIVE-CLiQ	10
		50

The FORTiS-S FS enclosed encoder system

FORTiS-S FS encoders are for use in Functional Safety applications and are certified to:

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

The FORTiS-S FS enclosed encoder system is suitable for use in a Category 3 performance level d (PLd) application in compliance with ISO 13849-1 and in a safety integrity level 2 (SIL2) application in compliance with IEC 61508 and IEC 61800-5-2.*

The FORTiS-S 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) ≤ 200 m/s^2
- Safe acceleration range (SAR) ≤ 200 m/s^2
- Safe limited speed (SLS) ≤ 4 m/s
- Safe speed range (SSR) ≤ 4 m/s
- Safely limited position (SLP)†
- Safely limited increment (SLI)†
- Safe direction (SDI)
- Safe speed monitor (SSM) ≤ 4 m/s.

For further details see the *FORTiS-S FS enclosed encoder system Functional Safety installation guide and safety manual* (Renishaw part no. M-6725-9016). Available from: **www.renishaw.com/fsencoders**

*The system must be installed and operated in accordance with the instructions defined in the relevant 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.

†See the safety function restrictions for the safe position figure for each FORTiS-S FS encoder system variant.

Functional Safety data declaration

Product identification: FORTiS-S FS with BiSS Safety and Siemens DRIVE-CLiQ serial interfaces

IEC 61508 safety data

Safety integrity level		2
Random hardware failures (per hour) **– BiSS Safety serial interface**		λ_S = 2.60E-07 λ_D = 4.08E-07 λ_{DD} = 3.67E-07 λ_{DU} = 4.08E-08
Random hardware failures (per hour) **– Siemens DRIVE-CLiQ serial interface**		λ_S = 3.46E-07 λ_D = 6.02E-07 λ_{DD} = 5.42E-07 λ_{DU} = 6.02E-08
PFD_{avg}		Not applicable due to continuous demand mode
PFH (per hour) – BiSS Safety serial interface		λ_{DU} = 4.08E-08
PFH (per hour) – Siemens DRIVE-CLiQ serial interface		λ_{DU} = 6.02E-08
Architectural constraints	Type	B
	HFT	0
	SFF	94%
Hardware safety integrity compliance		Route 1H
Systematic safety integrity compliance		Route 1S
Systematic capability		SC 2
Demand mode		Continuous
Proof test interval		Not required for continuous demand mode

ISO 13849 safety data

$MTTF_D$ – BiSS Safety serial interface	292 years
$MTTF_D$ – Siemens DRIVE-CLiQ serial interface	189 years
Diagnostic coverage	Medium (90%)
Category	3
Performance level	d
Lifetime/replacement limits	20 years

Safety function

The FORTiS-S FS encoder shall provide a safe position when requested by the controller.

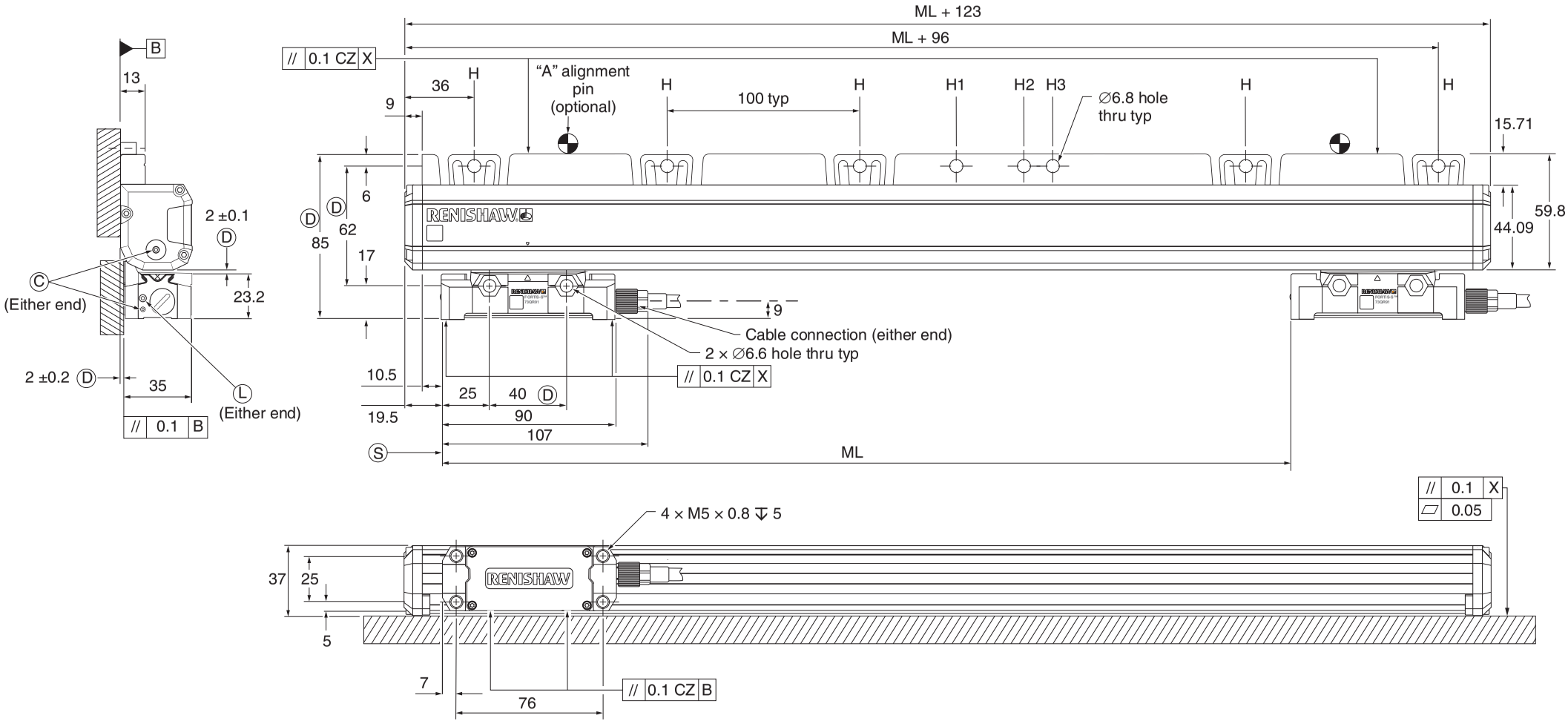
When installed correctly, the FORTiS-S FS encoder has mechanical safe position of ±1 mm.

In addition to any safety requirements defined by the communication protocol, to achieve full system integrity the evaluation unit must continuously monitor the error condition of the FORTiS-S FS encoder system,* and in the case of fault detection place the system into a safe state within the process safety time.

*Maximum request rate supported is 32 kHz.

System installation drawings

Dimensions and tolerances in mm



KEY

A = Recommended extrusion alignment pin locations (if required)
Adjacent to first and last flexure holes plus every 300–500 mm

C = Compressed air inlet fitting

D = Required mounting dimensions

H = Flexure mounting holes

H1 = Fixed mounting hole (preferred)

H2 and H3 = Alternative mounting holes (non-preferred)

L = LED set-up illumination

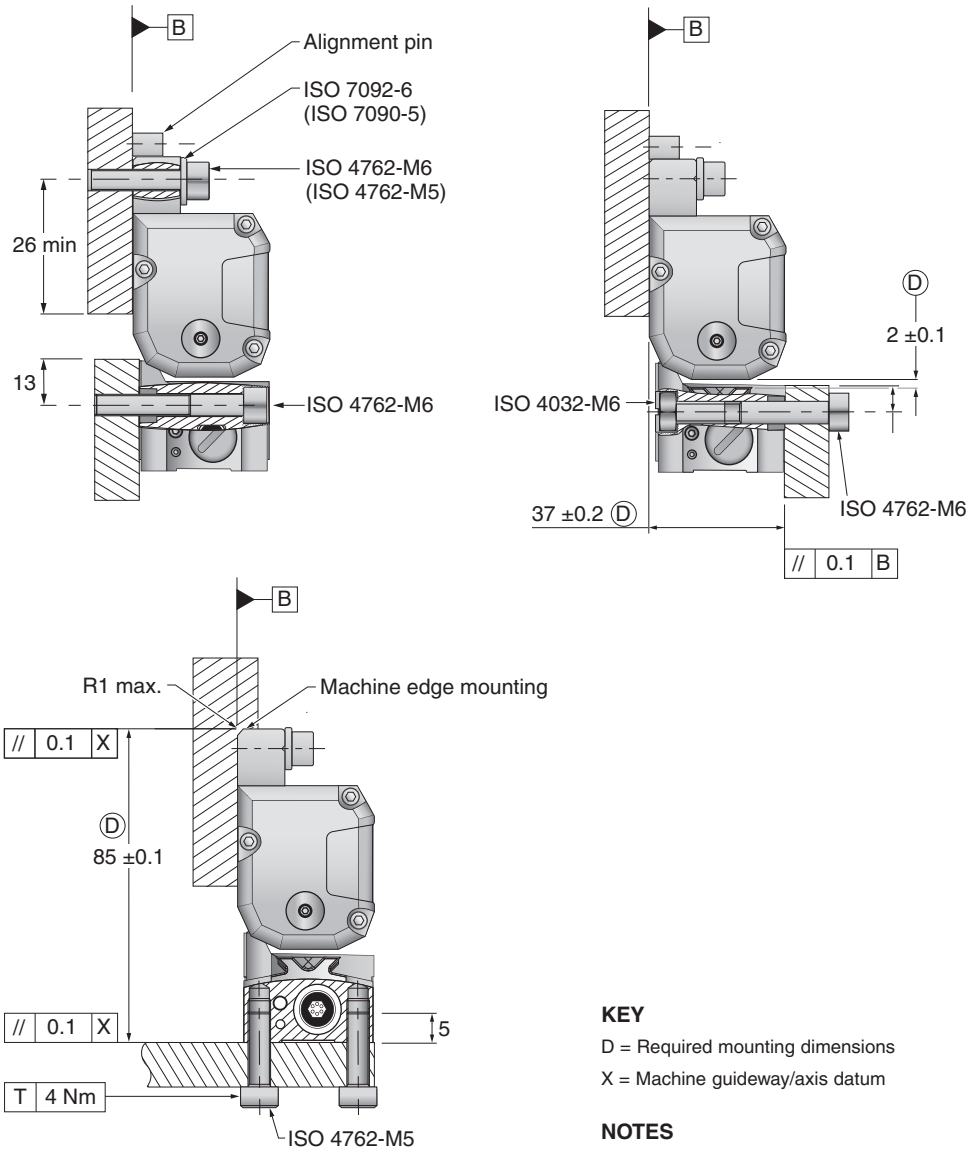
ML = Measuring length

S = Start of measuring length

X = Machine guideway/axis datum

Mounting orientations

Dimensions and tolerances in mm



KEY

D = Required mounting dimensions

X = Machine guideway/axis datum

NOTES

- Side elevations show alternative mounting orientations.
- Screws sizes in brackets are permissible alternatives.

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RENISHAW
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Nomenclature

F	S	1	0	0	B	304	S	C	36B	S	001	X

Product
F - FORTiS

Series
S - Standard (37 mm)
N - Narrow (18 mm)

Encoder type
1 - Absolute

Scale type
0 - 30 µm B code RTLA

End caps
0 - Standard
1 - Small end caps (N type only)

Lip seal configuration
A - DuraSeal™ × 1
B - DuraSeal × 2 (S type only)

Measuring length*
FORTiS-S 014 = 140 mm to 304 = 3040 mm
FORTiS-N 007 = 70 mm to 204 = 2040 mm

System accuracy
S - Standard accuracy
H - High accuracy

Thermal datum position
C - Centrally located†

Serial interface
36B - BiSS 36 bit
37F - 37 bit FANUC α and αi
40N - 40 bit Mitsubishi 4 wire
48P - 48 bit Panasonic
28D - Siemens DRIVE-CLiQ 28 bit (50 nm only)
30D - Siemens Drive-CLiQ 30 bit (10 nm only)
34D - Siemens Drive-CLiQ 34 bit (1 nm only)

Functional Safety
X - Standard
S - Functional Safety (BiSS Safety and Siemens DRIVE-CLiQ only)

Resolution
001 - 1 nm (all protocols except FANUC)
010 - 10 nm (all protocols except FANUC)
050 - 50 nm (all protocols except FANUC)
T12 - 1 / 0.5 nm (FANUC only)
108 - 10 / 1.25 nm (FANUC only)
502 - 50 / 25 nm (FANUC only)
504 - 50 / 12.5 nm (FANUC only)

Additional field
X - Standard, no option
D - Standard encoder with one additional readhead

* For all permissible measuring length options refer to specification table.
† For other datum requirements contact your local Renishaw representative.

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Part no.: L-9517-9958-01-B
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FORTiS-N™ Functional Safety enclosed encoder system

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Specification

Measuring standard	Renishaw stainless steel scale with single track absolute encoding
Coefficient of thermal expansion (at 20 °C)	10.1 ±0.2 µm/m/°C
Thermal datum	At centre position (encoder position of 0.5 × measuring length)
Measuring lengths available (mm)	70, 120, 170, 220, 270, 320, 370, 420, 470, 520, 570, 620, 670, 720, 770, 820, 920, 1020, 1140, 1240, 1340, 1440, 1540, 1640, 1740, 1840, 2040 (mounting spar available – recommended for > 620 mm length)
Accuracy grades	High grade: ≤ ±3 µm Standard grade: ≤ ±5 µm
Resolution*	1 nm, 10 nm, 50 nm
Sub-Divisional Error (typical)	±40 nm
Jitter (RMS)	10 nm
Absolute position serial interface	BiSS Safety, Siemens DRIVE-CLiQ (with external interface)
Encoder electrical connection	Cable connector M12 custom
Controller electrical connection	8-way M12, 9-way D-type, flying lead
Cable length	Multiple options available
Power supply	Depends on protocol
Set-up LED	Signal strength indicator
Maximum speed	4 m/s
Acceleration (readhead relative to scale)	< 200 m/s² in measuring direction
Moving force (maximum force required to move the readhead through the seals)	< 4 N
Vibration (55 Hz to 2000 Hz)	Readhead: < 300 m/s² to IEC 60068-2-6 Housing without mounting spar: < 200 m/s² to IEC 60068-2-6 Housing with mounting spar: < 300 m/s² to IEC 60068-2-6
Shock 11 ms half-sine	< 300 m/s² IEC 60068-2-27
Operating temperature	0 °C to 50 °C
Storage temperature	–20 °C to 70 °C
Environment protection	IP53 when installed correctly, IP64 with air purge Protection class III Pollution degree II Altitude 2000 m
EMC immunity	IEC 61800-5-2:2016 *Electromagnetic immunity requirement for safety related systems - Annex E, second environment*
Air purge requirements	Air supply pressure = 1 bar at encoder At correct supply pressure the supplied air connection fitting restricts the air flow rate to 2 l/min
Weight	0.11 kg + 0.45 kg/m

* See page 2.

Resolution per accuracy grade and serial interface – standard options

Accuracy grade	Serial interface	Resolution nm
		Single
3 µm	BiSS Safety, Siemens DRIVE-CLiQ	1
5 µm	BiSS Safety, Siemens DRIVE-CLiQ	10
		50

The FORTiS-N FS enclosed encoder system

FORTiS-N FS encoders are for use in Functional Safety applications and are certified to:

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

The FORTiS-N FS enclosed encoder system is suitable for use in a Category 3 performance level d (PLd) application in compliance with ISO 13849-1 and in a safety integrity level 2 (SIL2) application in compliance with IEC 61508 and IEC 61800-5-2.*

The FORTiS-N 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) ≤ 200 m/s²
- Safe acceleration range (SAR) ≤ 200 m/s²
- Safe limited speed (SLS) ≤ 4 m/s
- Safe speed range (SSR) ≤ 4 m/s
- Safely limited position (SLP)†
- Safely limited increment (SLI)†
- Safe direction (SDI)
- Safe speed monitor (SSM) ≤ 4 m/s.

For further details see the *FORTiS-N FS enclosed encoder system Functional Safety installation guide and safety manual* (Renishaw part no. M-6725-9026). Available from: **www.renishaw.com/fsencoders**

*The system must be installed and operated in accordance with the instructions defined in the relevant 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.

†See the safety function restrictions for the safe position figure for each FORTiS-N FS encoder system variant.

Functional Safety data declaration

Product identification: FORTiS-N FS with BiSS Safety and Siemens DRIVE-CLiQ serial interfaces.

IEC 61508 safety data

Safety integrity level		2
Random hardware failures (per hour) **– BiSS Safety serial interface**		λ_S = 2.60E-07 λ_D = 4.08E-07 λ_{DD} = 3.67E-07 λ_{DU} = 4.08E-08
Random hardware failures (per hour) **– Siemens DRIVE-CLiQ serial interface**		λ_S = 3.46E-07 λ_D = 6.02E-07 λ_{DD} = 5.42E-07 λ_{DU} = 6.02E-08
PFD_{avg}		Not applicable due to continuous demand mode
PFH (per hour) – BiSS Safety serial interface		λ_{DU} = 4.08E-08
PFH (per hour) – Siemens DRIVE-CLiQ serial interface		λ_{DU} = 6.02E-08
Architectural constraints	Type	B
	HFT	0
	SFF	94%
Hardware safety integrity compliance		Route 1H
Systematic safety integrity compliance		Route 1S
Systematic capability		SC 2
Demand mode		Continuous
Proof test interval		Not required for continuous demand mode

ISO 13849 safety data

$MTTF_D$ – BiSS Safety serial interface	292 years
$MTTF_D$ – Siemens DRIVE-CLiQ serial interface	189 years
Diagnostic coverage	Medium (90%)
Category	3
Performance level	d
Lifetime/replacement limits	20 years

Safety function

The FORTiS-N FS encoder shall provide a safe position when requested by the controller.

When installed correctly, the FORTiS-N FS encoder **without** mounting spar has a mechanical safe position of ±1 mm. When installed correctly, the FORTiS-N FS encoder **with** mounting spar has a mechanical safe position of ±4 mm.

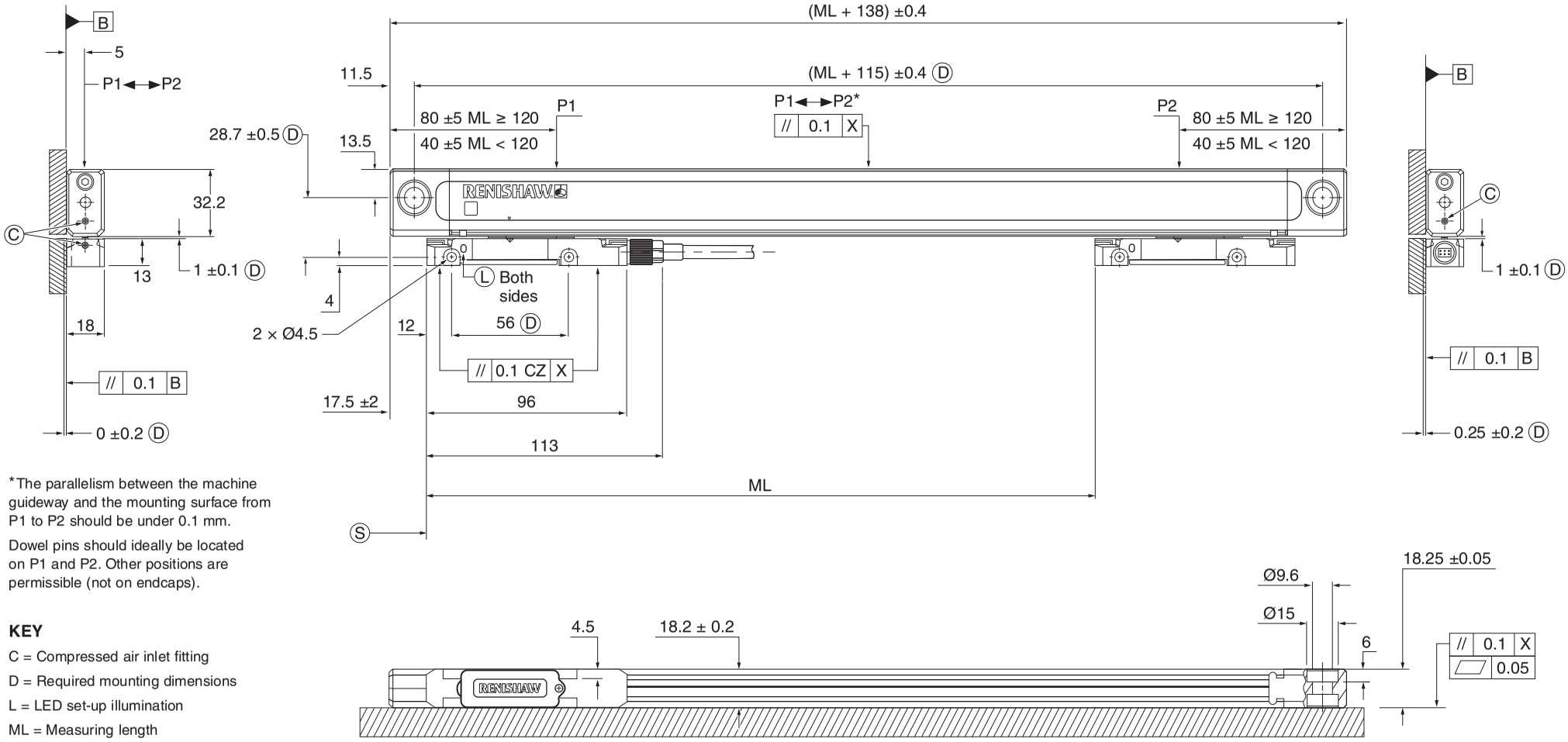
In addition to any safety requirements defined by the communication protocol, to achieve full system integrity the evaluation unit must continuously monitor the error condition of the FORTiS-N FS encoder system*, and in the case of fault detection place the system into a safe state within the process safety time.

*Maximum request rate supported is 32 kHz.

System installation drawings – standard end caps

(ML 320 mm shown)

Dimensions and tolerances in mm



*The parallelism between the machine guideway and the mounting surface from P1 to P2 should be under 0.1 mm.

Dowel pins should ideally be located on P1 and P2. Other positions are permissible (not on endcaps).

KEY

C = Compressed air inlet fitting

D = Required mounting dimensions

L = LED set-up illumination

ML = Measuring length

P = Gauging points for alignment

S = Start of measuring length

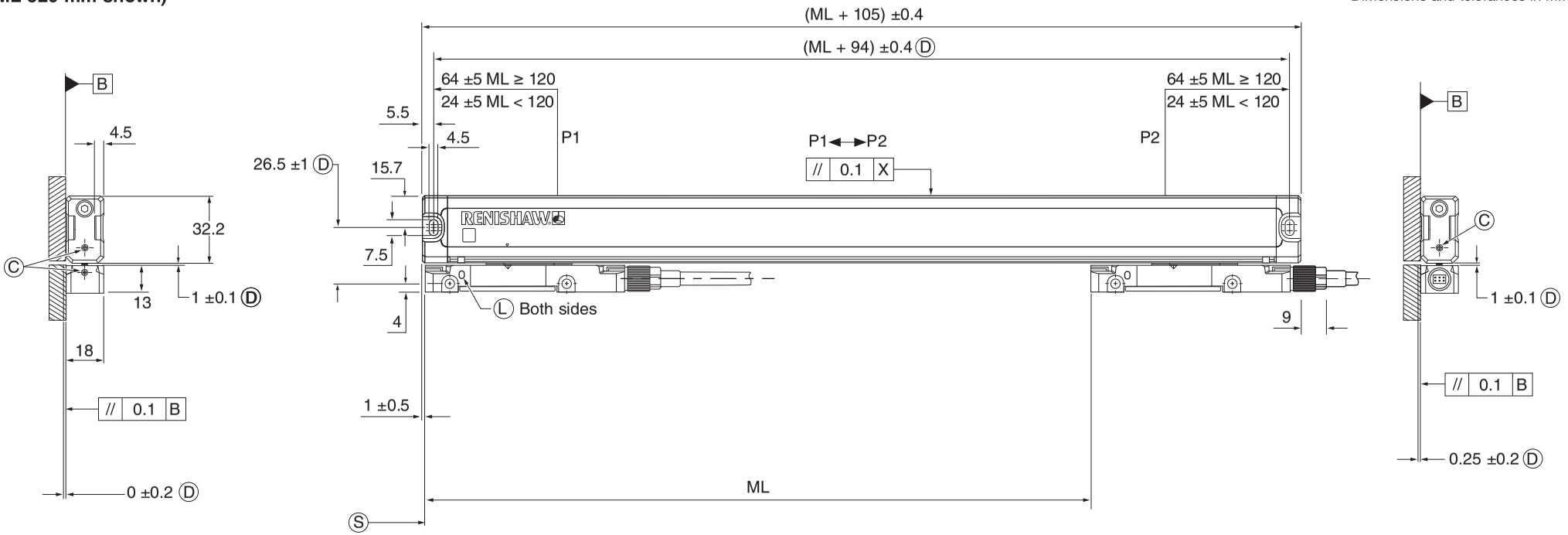
X = Machine guideway/axis datum

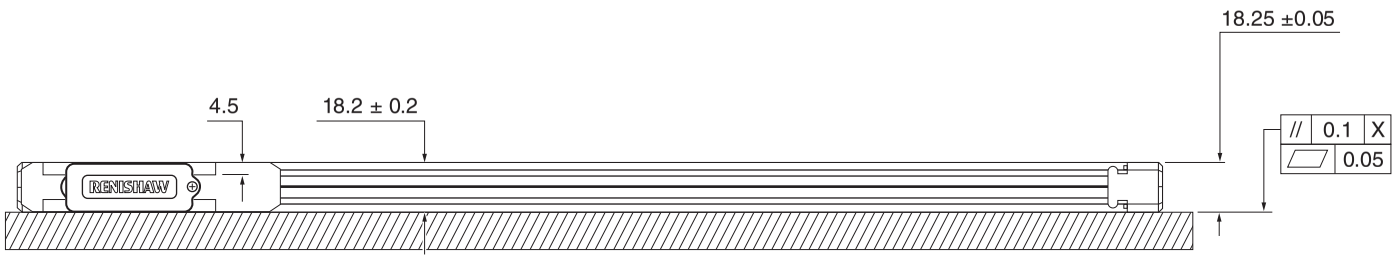
ML	70	120	170	220	270	320	370	420	470	520	570	620	670	720	770	820	920	1020	1140	1240	1340	1440	1540	1640	1740	1840	2040

System installation drawings – short end caps

(ML 320 mm shown)

Dimensions and tolerances in mm





KEY

C = Compressed air inlet fitting

D = Required mounting dimensions

L = LED set-up illumination

ML = Measuring length

P = Gauging points for alignment

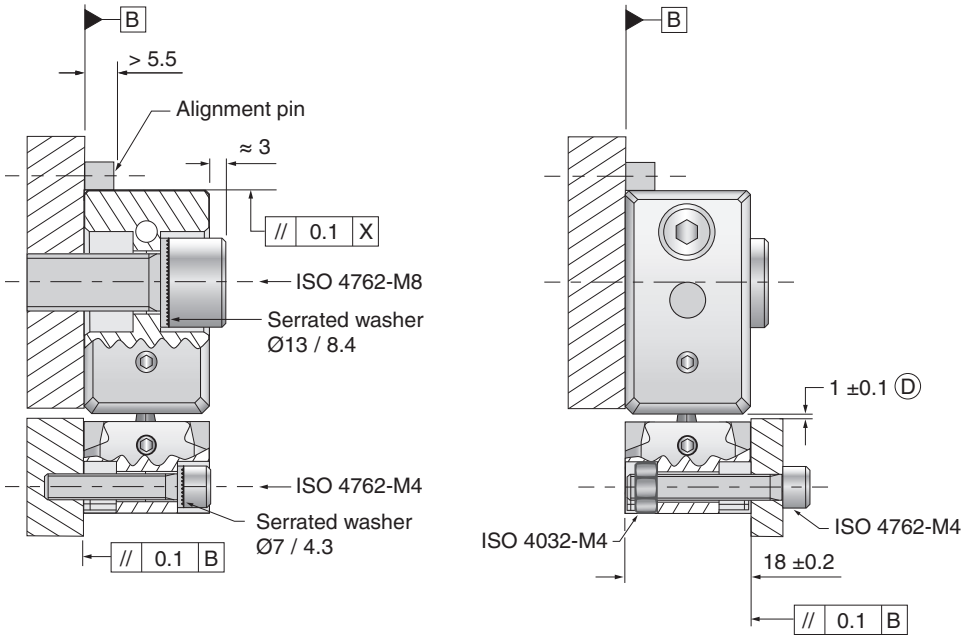
S = Start of measuring length

X = Machine guideway/axis datum

ML	70	120	170	220	270	320	370	420	470	520	570	620	670	720	770	820	920	1020	1140	1240	1340	1440	1540	1640	1740	1840	2040

Mounting orientations – standard end caps

Dimensions and tolerances in mm



KEY

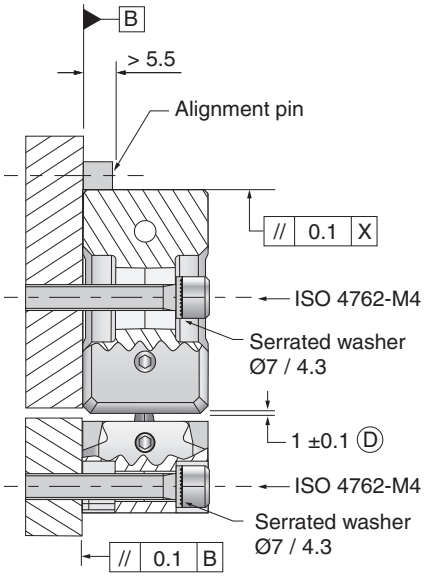
D = Required mounting dimensions

X = Machine guideway/axis datum

NOTES

- Side elevations show alternative mounting orientations.
- Alignment pin and machine edge mounting options to mate directly to the top face of the extrusion.

Mounting orientation – short end caps



KEY

D = Required mounting dimensions

X = Machine guideway/axis datum

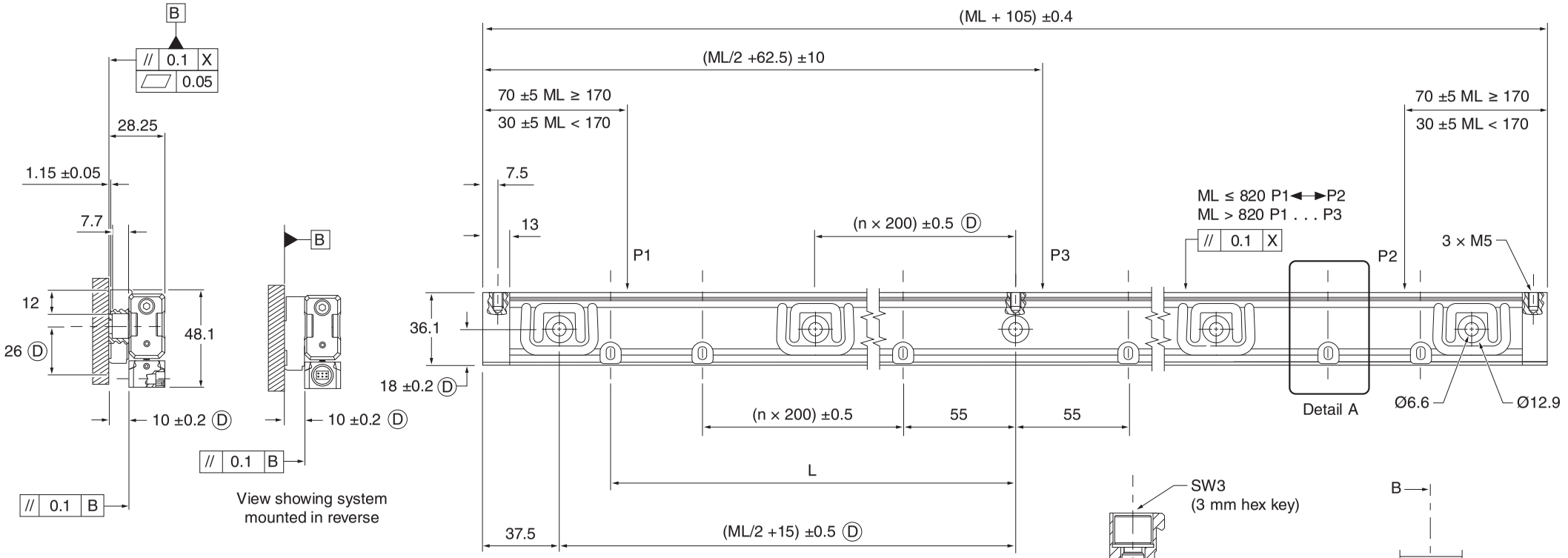
NOTES

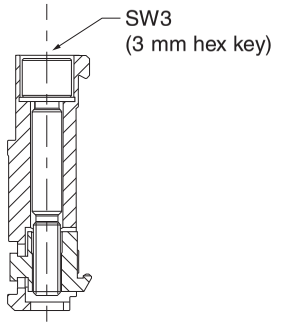
- Side elevation shows alternative mounting orientation.
- Extrusion mounting can be machine edge or dowel pins.

Mounting spar installation drawing

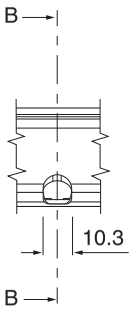
(ML 620 mm shown)

Dimensions and tolerances in mm





Section B–B through the spar



Detail A
Showing clamp installed

KEY

D = Required mounting dimensions

ML = Measuring length

P = Gauging points for alignment

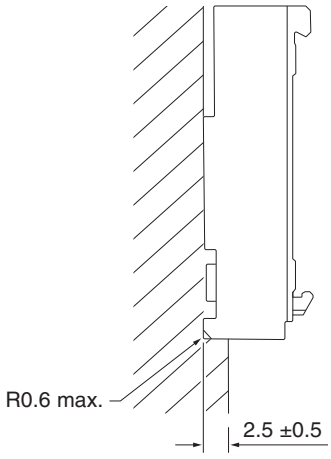
X = Machine guideway/axis datum

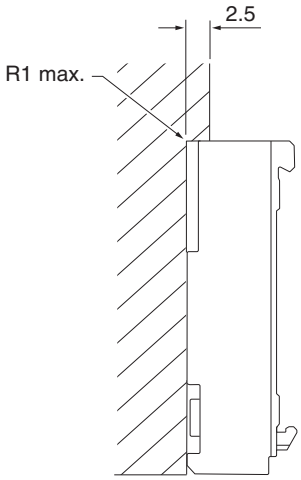
ML	70	120	170	220	270	320	370	420	470	520	570	620	670	720
L	37.5	55	75	100	115	140	175	200	225	250	275	300	325	350
n	-	-	-	-	-	-	-	-	-	-	-	1	1	1

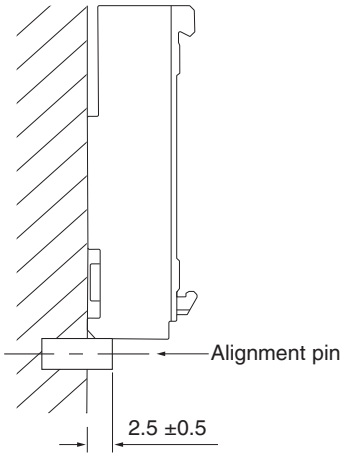
ML	770	820	920	1020	1140	1240	1340	1440	1540	1640	1740	1840	2040
L	375	400	450	500	550	640	655	710	760	810	855	910	1010
n	1	1	1	2	2	2	2	3	3	3	3	4	4

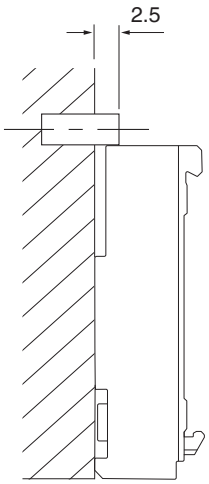
Spar mounting options

Dimensions and tolerances in mm









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Nomenclature

F	N	1	0	0	B	204	S	C	36B	S	001	X

Product
F - FORTiS

Series
S - Standard (37 mm)
N - Narrow (18 mm)

Encoder type
1 - Absolute

Scale type
0 - 30 µm B code RTLA

End caps
0 - Standard
1 - Small end caps (N type only)

Lip seal configuration
A - DuraSeal™ × 1
B - DuraSeal × 2 (S type only)

Measuring length*
FORTiS-S 014 = 140 mm to 304 = 3040 mm
FORTiS-N 007 = 70 mm to 204 = 2040 mm

System accuracy
S - Standard accuracy
H - High accuracy

Thermal datum position
C - Centrally located†

Serial interface
36B - BiSS 36 bit
37F - 37 bit FANUC α and αi
40N - 40 bit Mitsubishi 4 wire
48P - 48 bit Panasonic
28D - Siemens DRIVE-CLiQ 28 bit (50 nm only)
30D - Siemens Drive-CLiQ 30 bit (10 nm only)
34D - Siemens Drive-CLiQ 34 bit (1 nm only)

Functional Safety
X - Standard
S - Functional Safety (BiSS Safety and Siemens DRIVE-CLiQ only)

Resolution
001 - 1 nm (all protocols except FANUC)
010 - 10 nm (all protocols except FANUC)
050 - 50 nm (all protocols except FANUC)
T12 - 1 / 0.5 nm (FANUC only)
108 - 10 / 1.25 nm (FANUC only)
502 - 50 / 25 nm (FANUC only)
504 - 50 / 12.5 nm (FANUC only)

Additional field
X - Standard, no option
D - Standard encoder with one additional readhead

* For all permissible measuring length options refer to specification table.
† For other datum requirements contact your local Renishaw representative.

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Data sheet
L-9517-9884-02-B

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BiSS® Safety for RESOLUTE™ and FORTiS™ encoders

www.renishaw.com/functional-safety

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About Renishaw encoders with BiSS® interface

Renishaw BiSS encoders have options to use the C-mode (unidirectional) BiSS serial interface, (**www.renishaw.com/biss-protocol-support**), or BiSS Safety serial interface. This datasheet describes BiSS Safety interface.

- RESOLUTE rotary encoders are single-turn (with 2^n counts per revolution and no revolution counting).
- RESOLUTE and FORTiS linear encoders are available with a range of different resolutions (and maximum measuring lengths) as specified on the product data sheet.

More information on BiSS serial interfaces is available on the BiSS website: **www.biss-interface.com**.

Description of the BiSS Safety interface

BiSS Safety is a fast synchronous serial interface for acquiring position data from an encoder in applications requiring Functional Safety. RESOLUTE FS and FORTiS FS use BiSS Safety communications and are certified to the following Functional Safety standards:

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

BiSS Safety is a master-slave interface. The master controls the timing of position acquisition and the data transmission speed, and the encoder is the slave. The interface consists of two unidirectional differential pairs of lines:

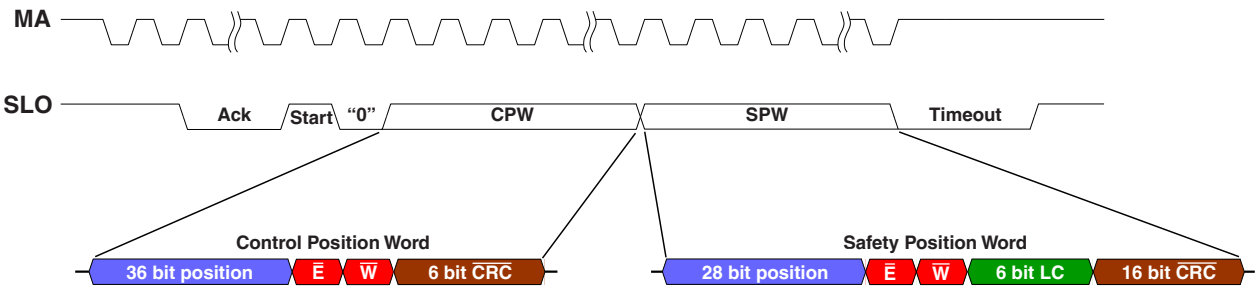
- MA transmits position acquisition requests and timing information (clock) from master to encoder.
- SLO transfers position data from encoder to master, synchronised to MA.

The diagram below shows the data transmitted.

The master-slave signal communication format is RS485/RS422 differential line-driven.

Data format

Example shown for 36 bit control position word (CPW):



A typical request cycle proceeds as follows:

1. When idle, the master holds MA high. The encoder indicates it is ready by holding SLO high.
2. The master requests position acquisition by starting to transmit clock pulses on MA.
3. The encoder responds by setting SLO low on the second rising edge on MA.
4. After the Ack period is complete, the encoder transmits data to the master synchronised with the clock as shown on page 2.
5. When all data has been transferred, the master stops the clock and sets MA high.
6. If the encoder is not yet ready for the next request cycle, it sets SLO low (the Timeout period).
7. When the encoder is ready for the next request cycle, it indicates this to the master by setting SLO high.

Description of data

Ack

This is the period during which the readhead calculates the absolute position. See the timing information table on page 5.

Start and “0” (1 bit each)

The encoder transmits the start bit to signal to the master that it is starting to transmit data. The start bit is always high and the “0” bit is always low.

Control position word (CPW)

The control position word (CPW) is used for motor control, has high resolution and is protected against transmission errors with a standard 6 bit CRC (HD = 3). The control position word comprises:

- **Position (28, 32 or 36 bits)**

  The absolute position data is sent MSB first in binary format. For linear encoders, the LSB is equivalent to one unit of resolution of the encoder, as specified in the data sheet. Lower resolutions may be achieved by ignoring the least significant bit(s) of the position data.

- **Error (1 bit)**

  The error bit is active low: “1” indicates that the transmitted position information has been verified by the readhead’s internal safety checking algorithm and is correct; “0” indicates that the internal check has failed and the position information should not be trusted. The error bit is also set to “0” if the temperature exceeds the maximum specified for the product. The operating temperature limits of Renishaw encoders are specified in the product data sheets.

- **Warning (1 bit)**

  The warning bit is active low: “0” indicates that the encoder scale (and/or reading window) should be cleaned.

  NOTE: The warning bit is not an indication of the trustworthiness of the position data. Only the error bit should be used for this purpose.

- **CRC for position data (6 bit)**

  The CRC polynomial for position, error and warning data is: 0x43. The CRC start value is 0x00. It is transmitted MSB first and inverted. The start bit and “0” bit are omitted from the CRC calculation.

Safety position word (SPW)

The safety position word (SPW) is strongly protected with a safety capable 16 bit CRC (HD = 6). The SPW brings an additional integrated 6 bit sign-of-life counter to detect missing or reordered position values. The SPW may have lower resolution than the control word. The purpose of the SPW is to ensure the validity of the control word. The safety position word comprises:

- **Position (24, 28 or 32 bits)**

  The absolute position data is sent MSB first in binary format. The position data in SPW in linear applications is shorter than the position data in CPW, so the resolution of the SPW is also lower (for 28 bit CPW and 24 bit SPW, it is 16 times lower; for 36 bit CPW and 28 bit SPW, it is 256 times lower).

- **Error (1 bit)**

  The error bit is active low: “1” indicates that the transmitted position information has been verified by the readhead’s internal safety checking algorithm and is correct; “0” indicates that the internal check has failed and the position information should not be trusted. The error bit is also set to “0” if the temperature exceeds the maximum specified for the product. The operating temperature limits of Renishaw encoders are specified in the product data sheets.

- **Warning (1 bit)**

  The warning bit is active low: “0” indicates that the encoder scale (and/or reading window) should be cleaned.

  NOTE: The warning bit is not an indication of the trustworthiness of the position data. Only the error bit should be used for this purpose.

- **LC Sign-of-Life (6 bit)**

  The sign-of-life counter represents a uniquely consecutive number within 63 SCD frames. The sign-of-life counter with its consecutive number can be used to detect unwanted repetition, wrong sequencing, loss and insertion. The sign-of-life counter's first value will be 0x01 and once the maximum value of 0x3F (decimal value = 63) is reached, the counter rolls over to 0x01.

- **CRC for position data (16 bit)**

  The SPW CRC polynomial is: 0x190D9. The CRC start value is 0x00. It is transmitted MSB first and inverted.

		Control position word (CPW)				Safety position word (SPW)			
Encoder type	**BiSS Safety configuration type** [1]	**Resolution of position**	**Number of position bits**	**CRC length**	**CRC polynomial**	**Resolution of position**	**Number of position bits**	**CRC length**	**CRC polynomial**
RESOLUTE rotary	LMM	0.0003 arc seconds	32	6 bits	0x43	0.0003 arc seconds	32	16 bits	0x190D9
RESOLUTE linear	RSM	50 nm	28	6 bits	0x43	800 nm	24	16 bits	0x190D9
RESOLUTE linear	RSH	1 nm	36	6 bits	0x43	256 nm	28	16 bits	0x190D9
FORTiS linear	RSH	10 nm	36	6 bits	0x43	2560 nm	28	16 bits	0x190D9
FORTiS linear	RSH	1 nm	36	6 bits	0x43	256 nm	28	16 bits	0x190D9

Timeout

RESOLUTE and FORTiS encoders are capable of acquiring a new position reading every 31.25 µs (a maximum request cycle rate of 32 kHz). Therefore 31.25 µs must elapse between the start of one request cycle and the start of the next. However, it is possible for data transmission to be complete before 31.25 µs have elapsed. In this case, the encoder signals this to the master by holding the SLO line low until 31.25 µs have elapsed. This is the timeout period.

[1] BiSS Safety configuration types are defined in the BiSS Safety concept document from iC-Haus.

Line-delay compensation

Signals travelling between master and encoder experience a time delay due to the cable length and signal propagation delays within the master and encoder. The time delay has no effect at low clock speeds (where the time delay is much shorter than the clock period). However, for high clock speeds, it is necessary for the master to implement line-delay compensation.

The master determines the round-trip time delay by measuring the time between transmitting the second rising edge on MA and receiving the falling edge of Ack on SLO.

MA clock speed	Maximum cable length	
	Without line-delay compensation	With line-delay compensation
250 kHz	95 m	100 m
1 MHz	20 m	100 m
2 MHz	8 m	100 m
5 MHz	0.5 m	100 m
10 MHz	-	50 m

NOTES: All figures relate to installations using original Renishaw readhead and extension cables. See the relevant product data sheet for details of options and limitations.

Care should be taken to ensure supply voltage is maintained within 5 V ±10% at the readhead connector.

Great care should be taken with cables to ensure signal integrity. For cable lengths greater than 50 m, contact Renishaw for recommendations.

This table makes no allowance for propagation delays within the master.

Timing information

	Minimum	Typical	Maximum	Units	Notes
Ack time	-	-	16	µs	The Ack period always ends on a rising edge of MA. Therefore at low MA clock frequencies, the Ack time may exceed 16 µs.
MA clock frequency	0.25	-	10	MHz	Within any one request cycle, the MA clock frequency must be constant. The duty cycle should be 1:1.
Request cycle rate	-	-	32	kHz	32 kHz is not achievable for all MA clock frequencies (because data transmission takes too long).
Sampling moment	3.225	3.250	3.275	µs	Timed from the first rising edge on MA.
RESOLUTE/FORTiS internal line-delay	-	-	42.5	ns	This is the internal propagation delay (MA-SLO) within RESOLUTE/FORTiS encoders.
Line-delay due to cable length	-	10	-	ns/m	This is the round-trip delay experienced by signal travelling through the cable (that is, from master to encoder and back to master again).

For information on the actions required for safe integration of the RESOLUTE or FORTiS Functional Safety encoder with BiSS Safety into a functionally safe system, refer to the product installation guide and safety manual.

IMPORTANT: 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.

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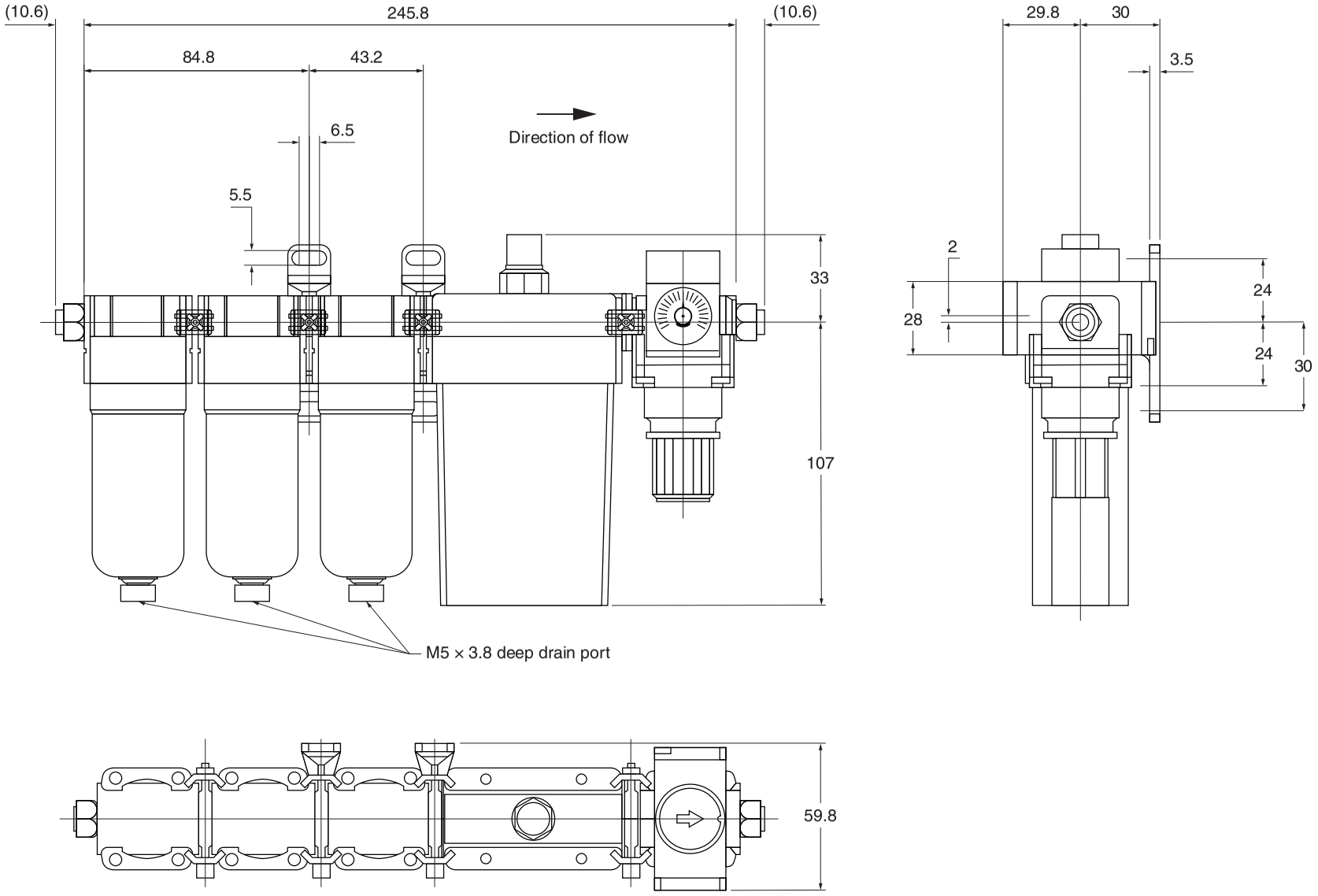
Air filtration systems for use with FORTiS™ encoders

Specification

	Full-size air filter	Reduced-size air filter
		
Part number	A-9768-4353	A-9768-4354
Design	System for cleaning and regulating compressed air for purge of FORTiS™ encoders. A-9768-4353 adds prefilter for longest-life performance when connected to a particularly dirty air supply.	
Connectable encoders	Up to 10 FORTiS linear encoders	
Set-up	• Prefilter: for particle sizes down to 5 µm, automatic condensate drain • Mist separator for dust, oil and water with particle sizes as fine as 0.3 µm, automatic condensate drain • Micro mist separator for particle sizes as fine as 0.01 µm and oil to 0.01 mg/m³ with automatic condensate drain • Dryer to suppress moisture content to a pressure dew point of +3 °C • Pressure regulator for adjusting the output pressure	• Mist separator for dust, oil and water with particle sizes as fine as 0.3 µm, automatic condensate drain • Micro mist separator for particle sizes as fine as 0.01 µm and oil to 0.01 mg/m³ with automatic condensate drain • Dryer to suppress moisture content to a pressure dew point of +3 °C • Pressure regulator for adjusting the output pressure
Overpressure	Operating pressure range: Rating 0.7 MPa Maximum 1.0 MPa Minimum 0.3 MPa	
Purity classes	Airflow in: Class 7:9:4 (ISO 8573-1: 2010) Airflow out: Class 1:4:2 (ISO 8573-1: 2010)	Airflow in: Class 6:8:4 (ISO 8573-1: 2010) Airflow out: Class 1:4:2 (ISO 8573-1: 2010)
Output overpressure	Output pressure can be adjusted from 0.05 MPa to 0.3 MPa and should be set to ensure each encoder has an input pressure of 0.1 MPa (1 bar). See *FORTiS air filter assembly mounting instructions* Installation guide (Renishaw part no. M-9768-9492) for details.	
Operating temperature	Operating temperature range: –5 °C to +50 °C	
Flow rate	Filter flow rate: maximum 100 l/min @ 0.7 MPa	
Connections	Inlet and outlet ports G1/4 inch Auto drain: M5 × 0.8	
Maintenance	Filter change Up to three encoders connected: two years Up to ten encoders connected: annually	
Mass (approximate)	0.78 kg	0.66 kg

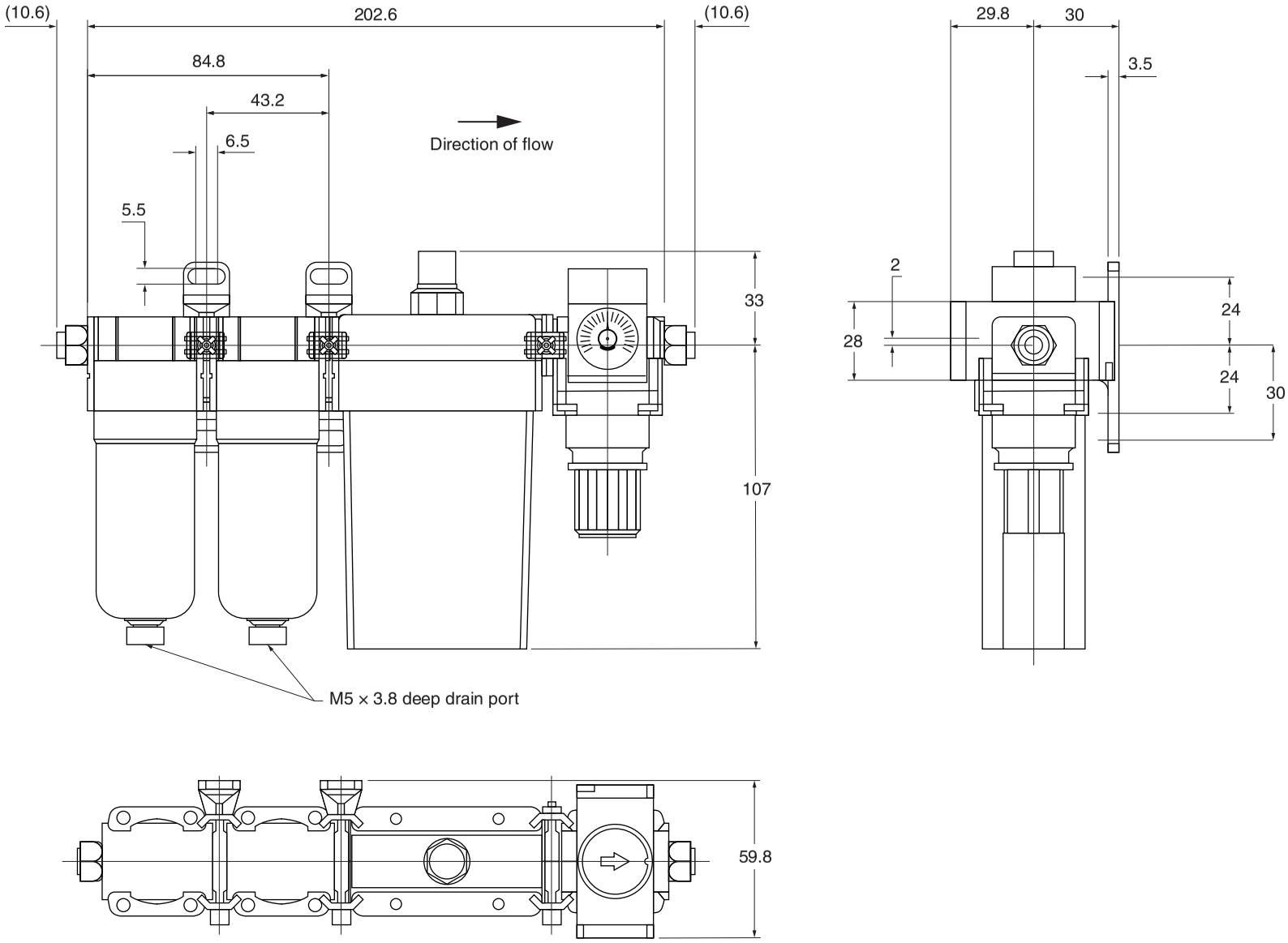
Full-size air filter drawing (A-9768-4353)

Dimensions and tolerances in mm



Reduced-size air filter drawing (A-9768-4354)

Dimensions and tolerances in mm



Extender kits

For users of NC4 tool setting systems and FORTiS encoders on the same machine, it is possible to use the FORTiS air filter (A-9768-4353 or A-9768-4354) and add an extender kit, so a second regulated output is provided for the NC4. Similarly, there is an extender kit to add a second regulated output for FORTiS to the NC4 air filter (A-6435-4000).

EXTENDER KITS	
A-9768-4355	A-9768-4356
Extender kit to add an output for **NC4** to the **FORTiS** air filter	Extender kit to add an output for **FORTiS** to the **NC4** air filter
	

ACCESSORIES, SPARES AND SERVICE PARTS		
	Universal elbow (turns air flow direction 90 degrees)	A-9768-4391 (MOQ = 10)
	180 degree air turn assembly	A-9768-4416
	Air filter service kit for full-size air filter	A-9768-4385
	Air filter service kit for reduced-size air filter	A-9768-4386
	Black PU tubing 6 mm OD, per metre*	A-9768-4388
	One-touch straight union	A-9768-4400 (MOQ = 10)
	One-touch tee union	A-9768-4406 (MOQ = 10)
	PSI gauge kit	A-9768-4387

* To order a 20 metre length of tubing, place an order for quantity 20 of A-9768-4388.

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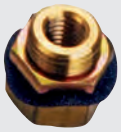
SPARES AND SERVICE PARTS		
	One-touch connector	A-9768-4389 (MOQ = 10)
	T-type spacer	A-9768-4390
	Spacer with bracket	A-9768-4381
	Spacer	A-9768-4384
	FORTiS low pressure regulator	A-9768-4377
	Pressure gauge assembly	A-9768-4409
	Tube cutter	A-9768-4392

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

L-9517-9982-01

Part no.: L-9517-9982-01-B
Issued: 10.2022

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Cables for FORTiS™ absolute encoders

www.renishaw.com/fortisdownloads

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Contents

Introduction

Renishaw offers a range of cables for use with the FORTiS™ absolute linear encoder. The cables are offered to fit a variety of applications, with cable runs falling into three categories:

1. **Readhead cables**
Uninterrupted cables that run from the FORTiS connector to plug directly into the drive/controller. For details on cable length limitations see 'Maximum readhead cable length (no extension cable)' on page 9.

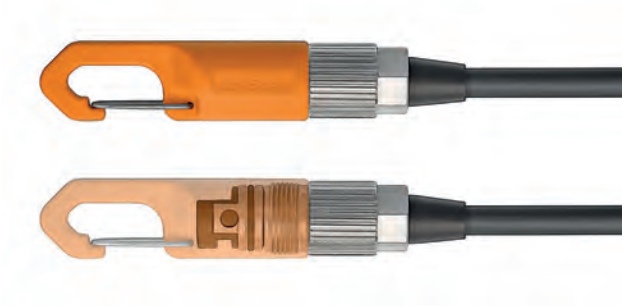
2. **Extension cables**
For use with shorter readhead cables to extend the maximum cable length. For details on cable length limitations see 'Maximum readhead and extension cable length' on page 9.

3. **ADTa-100 cables**
The optional Advanced Diagnostic Tool (ADTa-100), in conjunction with the ADT View software, provides comprehensive, real-time feedback from the FORTiS encoder. It can be connected directly to the encoder, or to the interconnector, or to the plug at the drive/controller. The ADTa-100 is fitted with a 9-way female D-type input connector.
See 'ADTa-100 adaptor cables' on page 32 for adaptor cable part numbers.

Renishaw FORTiS connector

The readhead connector (R termination) that plugs directly into the FORTiS encoder is a bespoke over-moulded connector made to a Renishaw design. It is supplied with an orange dust-cap with an integral clip to aid cable feed-through. The connector is not available as a field-wireable part. However, for custom applications, cables are available with the FORTiS connector (R termination) at one end and flying leads at the other; see the relevant protocol section for the part numbers.

A pack of 10 spare dust-caps is available to order: Renishaw part no. A-9768-2255.

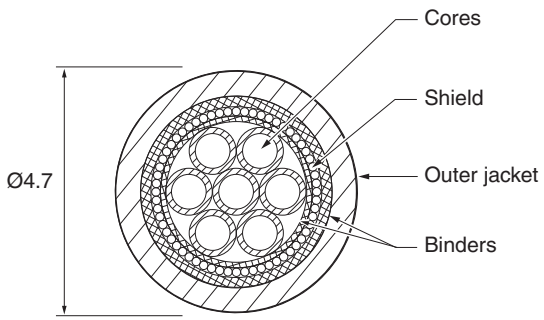


Cable types

Renishaw offers four cable types for FORTiS depending upon the requirements of the application. All cables are designed to provide toughness, excellent EMI immunity and long-term reliability in the harshest industrial conditions.

Cable types			
Cable type	**Readhead cable**	**Extension cable**	**Details**
A	✓	✗	High flex life, 20 mm dynamic bend radius, maximum readhead cable length 9 m. Ideal for applications that require a short readhead cable combined with a longer extension cable. For more details see 'Type A cable' on page 5.
B	✓	✓	High flex life, > 63 mm dynamic bend radius, maximum readhead cable length 25 m. Ideal for applications that require a long readhead cable that runs all the way to the controller or as an extension cable. For more details see 'Type B cable' on page 6.
C	✗	✓	Normally used on long cable lengths over 25 m. Supplied on a reel unterminated as standard (Renishaw part number M-9553-0414). For more details see 'Type C cable' on page 7.
D	✓	✗	Armoured cable, high flex life, 75 mm dynamic bend radius, maximum readhead cable length 9 m. Used in applications where the readhead cable is directly exposed to the risk of physical damage. For more details see 'Type D cable' on page 8.

Type A cable (4.7 mm diameter, black)



Description

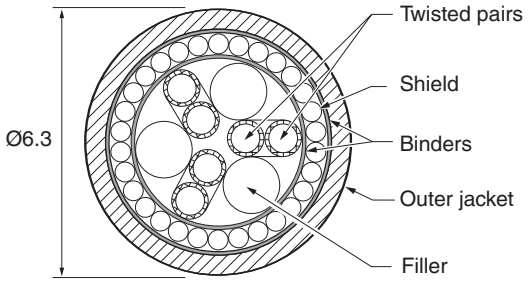
UL recognised, RoHS compatible, high-flex screened cable with 7 × 0.081 mm² (28 AWG) cores, 4.7 ±0.2 mm outside diameter. Excellent EMC properties, hydrolysis and micro-organism resistant, with low-friction surface finish.

Common applications

Use with FORTiS encoders on applications where the readhead is the moving element. Type A cable provides high flex life and low bending force. Often used in applications that require a short readhead cable combined with a longer extension cable.

Specifications	
Physical characteristics	
Outer jacket material	Black extruded polyurethane PUR (halogen free)
Usable in drag chains	Yes
Shield	Tinned and annealed copper wire, 40 AWG, to ASTM B33, optical coverage > 96% ±3%, nominal 40° braid angle
Flex life	> 20 × 10^6 cycles at 20 mm bend radius
Static bend radius	10 mm at 90° (internal radius), 15 mm at 180° (internal radius)
Dynamic bend radius	20 mm (to centre of cable)
Mass	26 kg/km
Operating temperature	–40 °C to +80 °C (UL rating)
Electrical characteristics	
Number of cores and conductor size	7 off 0.081 mm² (28 AWG)
Conductor material	Multi-strand, tinned and annealed copper wire
Voltage rating	30 V RMS
Conductor resistance at 20 °C	< 220 ohms/km
Shield resistance at 20 °C	< 50 ohms/km
Insulation resistance at 20 °C	> 10 000 megohms/km (with 500 Vdc)
Insulation breakdown at 20 °C (2.8 kVdc for 5 seconds)	Core to core > 2 000 V Core to screen > 1 000 V
Approvals	UL approval AWM Style 20236 80 °C 30 V RoHS approved

Type B cable (6.3 mm diameter, green)



Description

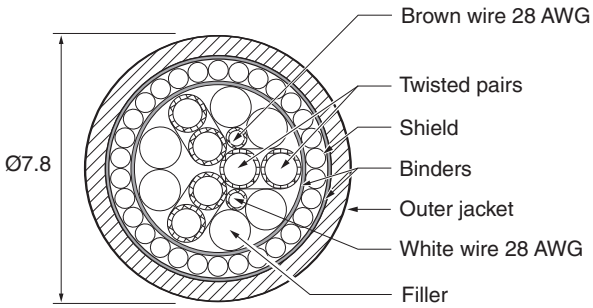
UL recognised, RoHS compatible, extra-rugged screened cable with 6 × 0.25 mm² (23 AWG) cores arranged as three twisted pairs, 6.3 ±0.2 mm outside diameter. Excellent EMC properties, hydrolysis and micro-organism resistant, with low-friction surface finish.

Common applications

Use with FORTiS encoders on applications where the scale/extrusion is the moving element. Type B cable provides high flex life, but the bending force is higher than Type A. Often used in applications that require a long readhead cable that runs all the way to the controller. Also often used as an extension cable.

Specifications	
Physical characteristics	
Outer jacket material	Green extruded polyurethane PUR (halogen free)
Usable in drag chains	Yes
Shield	Tinned and annealed copper wire, 38 AWG, to ASTM B33, optical coverage > 85%, nominal 35° braid angle
Flex life	> 20 × 10^6 cycles at 75 mm bend radius
Static bend radius	31.5 mm (internal radius)
Dynamic bend radius	> 63 mm (to centre of cable)
Mass	52 kg/km
Operating temperature	–20 °C to +80 °C (UL rating)
Electrical characteristics	
Number of cores and conductor size	3 off (2 × 0.25 mm²) (23 AWG)
Conductor material	Multi-strand, tinned and annealed copper wire
Voltage rating	30 V RMS
Conductor resistance at 20 °C	< 80 ohms/km
Shield resistance at 20 °C	< 50 ohms/km
Insulation resistance at 20 °C	> 500 megohms/km (with 500 Vdc)
Insulation breakdown at 20 °C (2.8 kVdc for 5 seconds)	Core to core > 2 000 V Core to screen > 1 000 V
Approvals	UL approval AWM Style 20554 80 °C 30 V CSA approval 75 °C – 30 V Flame resistant IEC 60332-1-2 FT2 RoHS approved

Type C cable (7.8 mm diameter, green)



Description

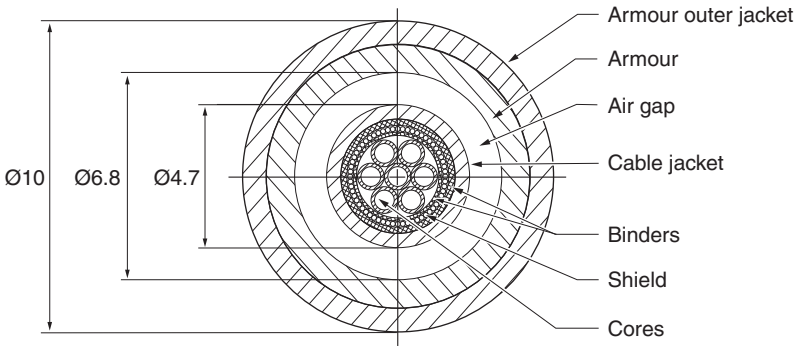
UL recognised, RoHS compatible, extra-rugged screened cable for long-length applications, with 2 off 28 AWG cores (2 × 0.08 mm²), 4 off 23 AWG cores arranged as twisted pairs (2 off (2 × 0.25 mm²)) and 2 of 20 AWG cores arranged as a twisted pair (1 off (2 × 0.5 mm²)). 7.8 ±0.3 mm outside diameter. Excellent EMC properties, hydrolysis and micro-organism resistant, with low-friction surface finish.

Common applications

Extension cable for use with FORTiS encoders on applications requiring very long cable runs. The 2 × 0.5 mm² power cores provide low voltage drop, making this cable suitable for use in cable runs up to 57 metres. It is recommended that this cable be used as an extension cable, with an interconnect to a cable with lower bend stiffness, such as Renishaw Type A cable.

Specifications	
Physical characteristics	
Outer jacket material	Green extruded polyurethane PUR (halogen free)
Usable in drag chains	Yes
Shield	Tinned and annealed copper wire, 38 AWG, to ASTM B33, optical coverage > 85%, nominal 35° braid angle
Flex life	> 20 × 10⁶ cycles at 75 mm bend radius
Static bend radius	50 mm at 90° (internal radius); 58 mm at 180° (internal radius)
Dynamic bend radius	75 mm (to centre of cable)
Mass	74 kg/km
Operating temperature	–20 °C to +80 °C (UL rating)
Electrical characteristics	
Number of cores and conductor size	2 × (2 × 0.25 mm²) + 1 × (2 × 0.5 mm²) + 2 × (0.081 mm²)
Conductor material	Multi-strand, tinned and annealed copper wire
Voltage rating	30 V RMS
Conductor resistance at 20 °C	< 39 ohms/km on 0.5 mm² (20 AWG) cores < 80 ohms/km on 0.25 mm² (23 AWG) cores < 220 ohms/km on 0.081 mm² (28 AWG) cores
Shield resistance at 20 °C	< 50 ohms/km
Insulation resistance at 20 °C	> 10 000 megohms/km (with 500 Vdc) on 0.5 mm² and 0.081 mm² cores > 500 megohms/km (with 500 Vdc) on 0.25 mm² cores
Insulation breakdown at 20 °C (1 kVac for 1 minute)	Core to core > 2 000 V Core to screen > 1 000 V
Approvals	UL approval AWM Style 20554 80 °C 30V CSA approval 75 °C – 30 V Flame resistant IEC 60332-1-2 FT2 RoHS approved

Type D cable (10 mm diameter, black)



Description

UL recognised, RoHS compatible, high-flex screened cable with 7 × 0.081 mm² (28 AWG) cores, 10 ±0.5 mm outside diameter. Excellent EMC properties, hydrolysis and micro-organism resistant, high flex life, 75 mm dynamic bend radius, maximum readhead cable length 9 m.

Common applications

Used in applications where the readhead cable is directly exposed to the risk of physical damage.

Specifications	
Physical characteristics	
Outer jacket material	UL recognised cable within galvanised steel conduit with PVC jacket
Usable in drag chains	Yes
Shield	Tinned and annealed copper wire, 40 AWG, to ASTM B33, optical coverage > 96 ±3%, nominal 40° braid angle
Flex life	> 20 × 10^6 cycles at 75 mm internal radius
Static bend radius	25 mm internal radius
Dynamic bend radius	75 mm internal radius
Mass	165 kg/km
Operating temperature	–5 °C to +70 °C (UL rating)
Crush strength at 23 °C (IEC 61386-1)	< 25% crush > 90% recovery: > 1250N
Electrical characteristics	
Number of cores and conductor size	7 off 0.081 mm² (28 AWG)
Conductor material	Multi-strand, tinned and annealed copper wire
Voltage rating	30 V RMS
Conductor resistance at 20 °C	< 220 ohms/km
Shield resistance at 20 °C	< 50 ohms/km
Insulation resistance at 20 °C	> 10 000 megohms/km (with 500 Vdc)
Insulation breakdown at 20 °C (2.8 kVac for 5 seconds)	Core to core > 2 000 V Core to screen > 1 000 V
Approvals	UL approval AWM Style 20236 80 °C 30V RoHS approved

Maximum cable lengths

Maximum readhead cable length (no extension cable)

The maximum length for a cable run consisting of only one type of cable (readhead cable direct to the controller, no extension cable used) depends upon the cable type:

- Type A cable: 9 metres
- Type B cable: 25 metres
- Type D cable: 9 metres

Maximum readhead and extension cable length

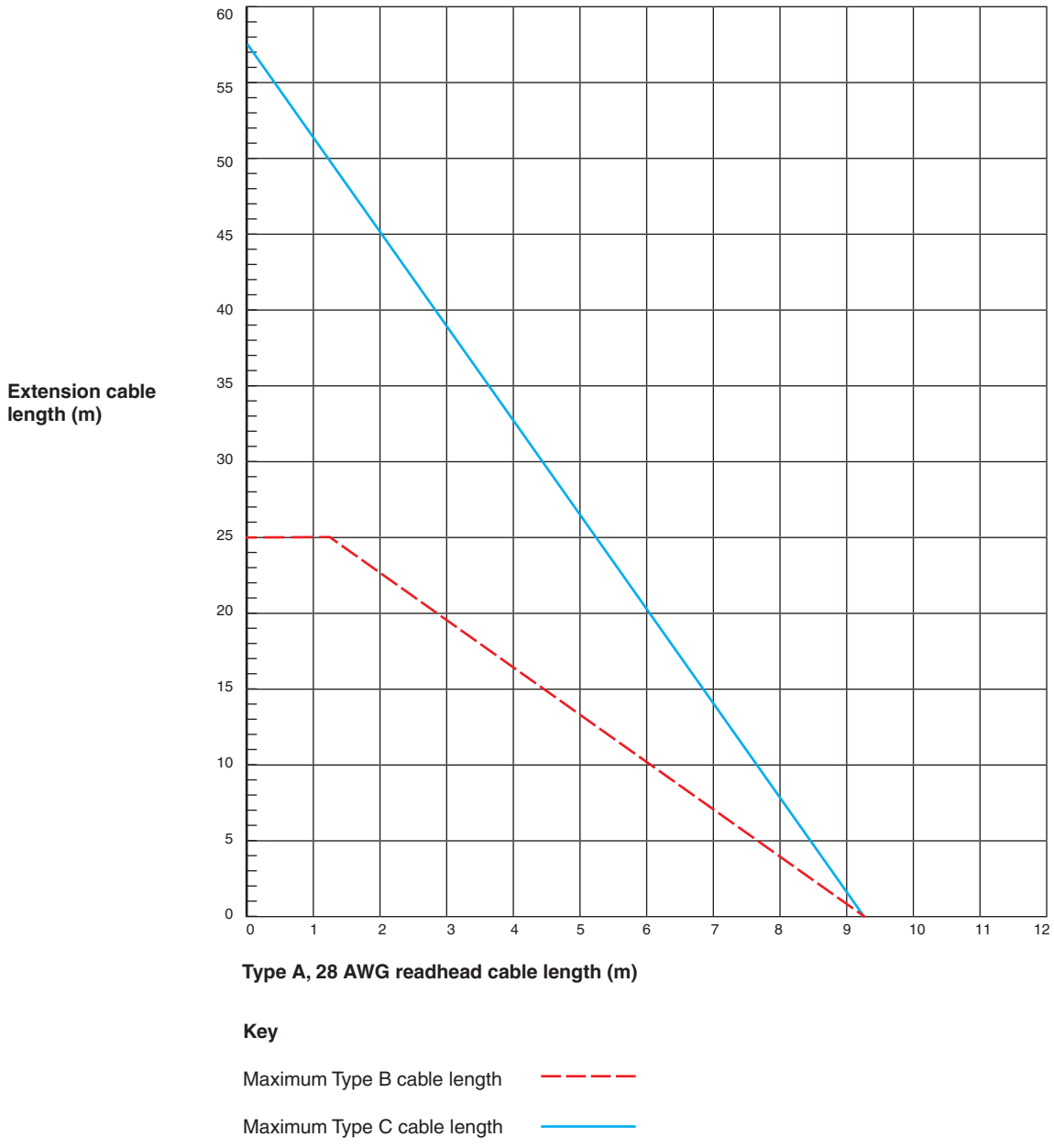
The maximum total cable length when using an extension cable depends upon several factors:

- Readhead cable type
- Readhead cable length
- Type of extension cable

To work out the maximum cable length possible for Type A readhead cables see 'Type A readhead cable combined with an extension cable' on page 10, and for Type B readhead cables see 'Type B readhead cable combined with an extension cable' on page 11.

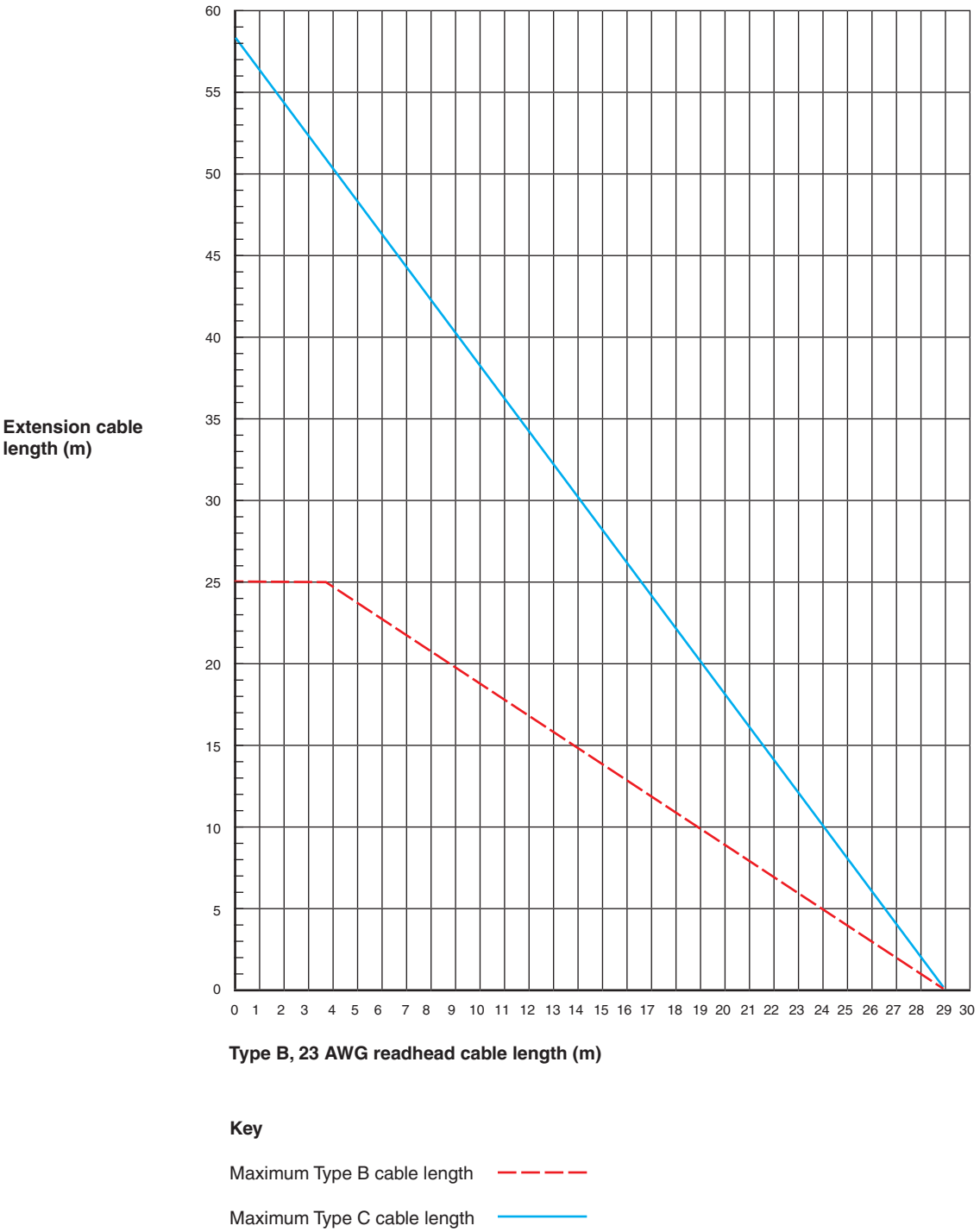
Type A readhead cable combined with an extension cable

The following graph shows the maximum length for a cable run when a combination of Type A readhead cable and either Type B or Type C extension cable is used. To read this graph, find the length of readhead cable on the *x* axis, then the *y* axis will indicate the maximum extension cable length for each type of extension cable.



Type B readhead cable combined with an extension cable

The following graph shows the maximum length for a cable run when a combination of Type B readhead cable and either Type B or Type C extension cable is used. To read this graph, find the length of readhead cable on the *x* axis, then the *y* axis will indicate the maximum extension cable length for each type of extension cable.



BiSS C and BiSS Safety

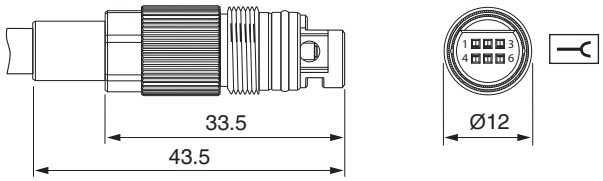
BiSS C and BiSS Safety are available with either Renishaw standard termination (see 'Termination options' below) or iC-Haus termination (see 'Cables with iC-Haus standard pin-out' on page 15).

Cables with Renishaw standard termination

Termination options

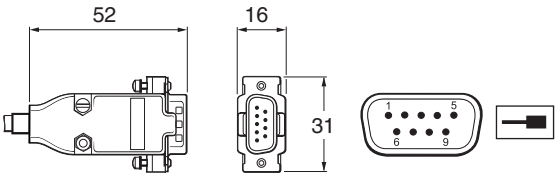
Readhead connector

Dimensions in mm

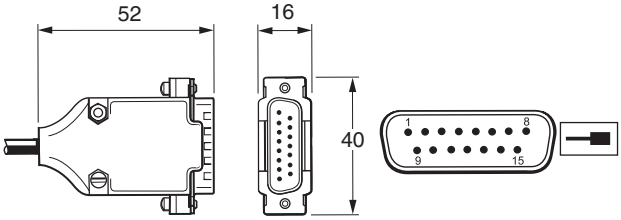


Controller connector

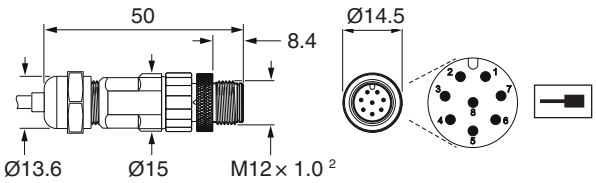
9-way D-type plug



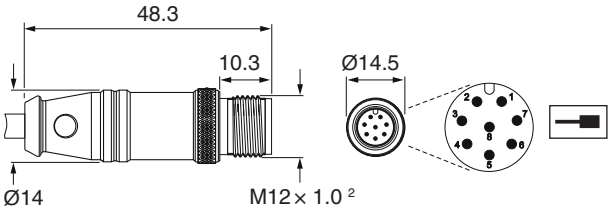
15-way D-type plug



8-way M12 plug [1]

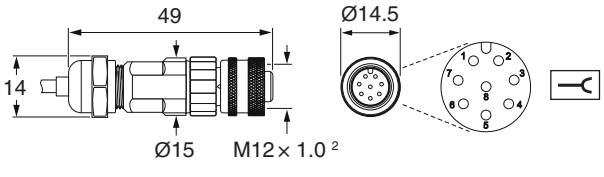


8-way M12 plug – overmoulded version

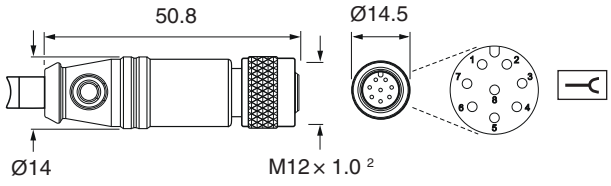


In-line connector

8-way M12 socket [1]



8-way M12 socket – overmoulded version



[1] Subject to availability, may be supplied with overmoulded version.

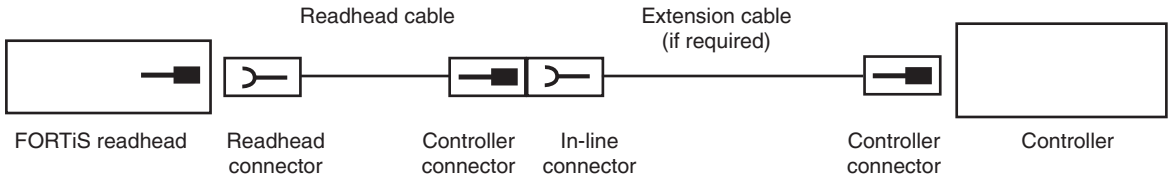
[2] The recommended tightening torque is 4 Nm.

Output signals

Function	Signal	Flying lead wire colour (F)	Pin-out		
			9-way D-type (A)	8-way M12 (S)	15-way D-type (D)
Power	5 V	Brown	4, 5	2	4, 12
	0 V	White	8, 9	5, 8	2, 10
Serial interface	MA+	Violet	2	3	8
	MA–	Yellow	3	4	15
	SLO+	Grey	6	7	5
	SLO–	Pink	7	6	13
Shield	Shield	Shield	Case	Case	Case

Nomenclature

IMPORTANT: Maximum cable length depends upon the readhead cable length and cable type. For maximum total cable lengths see 'Maximum cable lengths' on page 9.



Readhead cable

A A - 0300 - R S X

Category
A - Absolute encoder cable

Cable type
A - 4.7 mm diameter black encoder cable
B - 6.3 mm diameter green encoder cable
D - 10 mm diameter armoured encoder cable

Length

0050 - 0.5 m	0600 - 6 m
0100 - 1 m	0900 - 9 m
0300 - 3 m	1200 - 12 m (Cable Type B only)

Readhead connector
R - FORTiS readhead connector

Controller connector
A - 9-way D-type (Renishaw)
D - 15-way D-type (Beckhoff)
F - Flying lead
S - 8-way M12 (Renishaw) [1]

Other
X - Standard

[1] Recommended options for use with extension cables.

Extension cable

A B - 0600 - S A X

Category
A - Absolute encoder cable

Cable type
B - 6.3 mm diameter green encoder cable

Length

0100 - 1 m	1200 - 12 m
0300 - 3 m	1500 - 15 m
0600 - 6 m	2000 - 20 m

In-line connector
S - 8-way M12 (Renishaw)

Controller connector
A - 9-way D-type (Renishaw)
D - 15-way D-type (Beckhoff)
F - Flying lead
S - 8-way M12 (Renishaw)

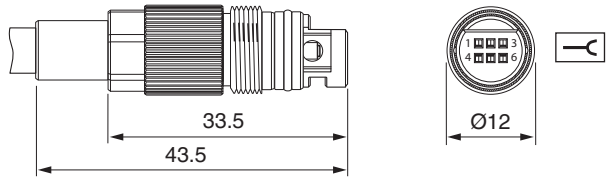
Other
X - Standard

Cables with iC-Haus standard pin-out

Termination options

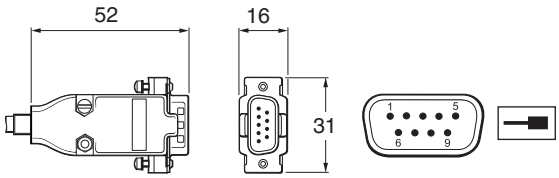
Readhead connector

Dimensions in mm

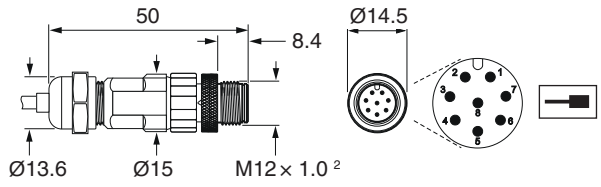


Controller connector

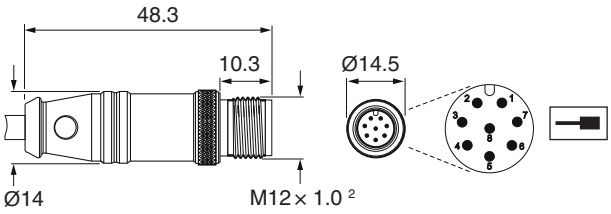
9-way D-type plug



8-way M12 plug [1]

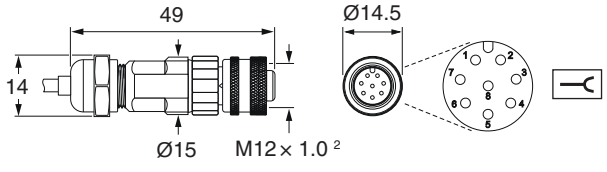


8-way M12 plug – overmoulded version

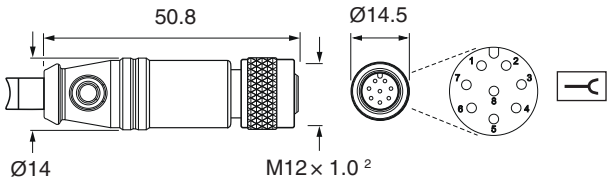


In-line connector

8-way M12 socket [1]



8-way M12 socket – overmoulded version



[1] Subject to availability, may be supplied with overmoulded version.

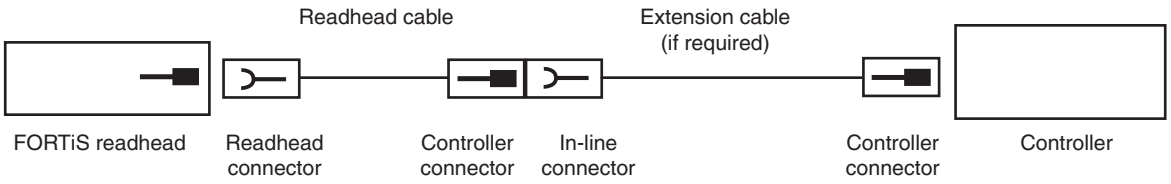
[2] The recommended tightening torque is 4 Nm.

Output signals

Function	Signal	Flying lead wire colour (F)	Pin-out	
			9-way D-type (G)	8-way M12 (U)
Power	5 V	Brown	4	1
	0 V	White	6	2
Serial interface	MA+	Violet	2	6
	MA–	Yellow	3	4
	SLO+	Grey	7	5
	SLO–	Pink	8	8
Shield	Shield	Shield	Case	Case

Nomenclature

IMPORTANT: Maximum cable length depends upon the readhead cable length and cable type. For maximum total cable lengths see 'Maximum cable lengths' on page 9.



Readhead cable

A A - 0300 - R G X

Category
A - Absolute encoder cable

Cable type
A - 4.7 mm diameter black encoder cable
B - 6.3 mm diameter green encoder cable
D - 10 mm diameter armoured encoder cable

Length

0050 - 0.5 m	0600 - 6 m
0100 - 1 m	0900 - 9 m
0300 - 3 m	1200 - 12 m (Cable Type B only)

Readhead connector
R - FORTiS readhead connector

Controller connector
F - Flying lead
G - 9-way D-type
U - 8-way M12 (iC-Haus) [1]

Other
X - Standard

[1] Recommended option for use with extension cables.

Extension cable

A B - 0600 - U G X

Category
A - Absolute encoder cable

Cable type
B - 6.3 mm diameter green encoder cable

Length

0100 - 1 m	1200 - 12 m
0300 - 3 m	1500 - 15 m
0600 - 6 m	2000 - 20 m

In-line connector
U - 8-way M12 (iC-Haus)

Controller connector
F - Flying lead
G - 9-way D-type

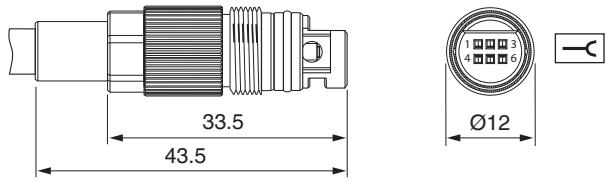
Other
X - Standard

FANUC

Termination options

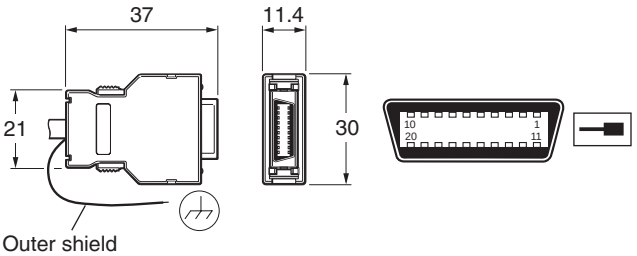
Readhead connector

Dimensions in mm

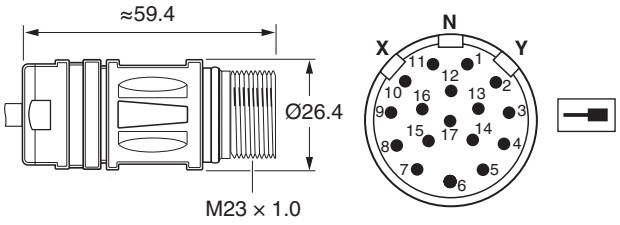


Controller connector

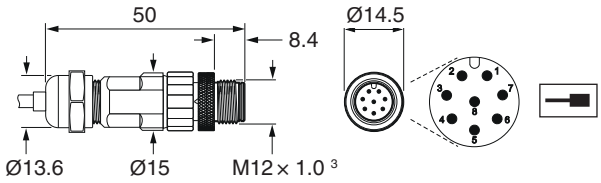
20-way plug [1]



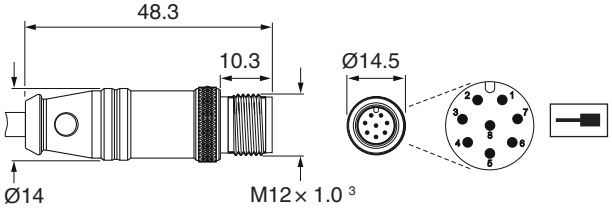
17-way M23 plug



8-way M12 plug [2]

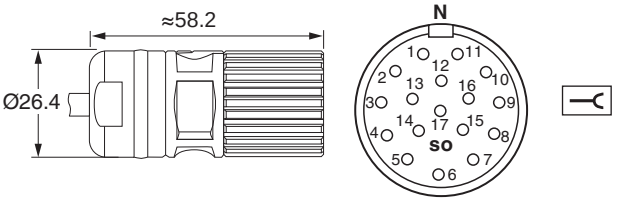


8-way M12 plug – overmoulded version

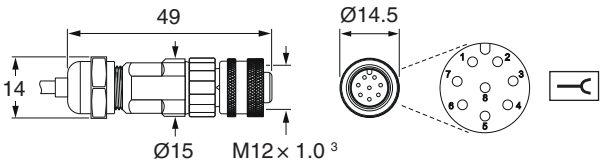


In-line connector

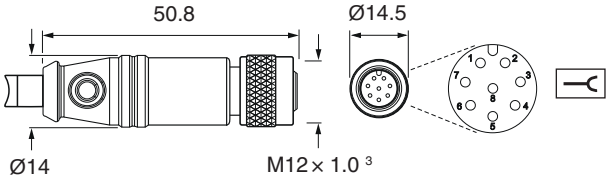
17-way M23 socket



8-way M12 socket [2]



8-way M12 socket – overmoulded version



[1] Only Fanuc-approved controller connectors are supplied. However, the cosmetic appearance of the connector supplied may differ from the illustration, depending on the approved supplier used.

[2] Subject to availability, may be supplied with overmoulded version.

[3] The recommended tightening torque is 4 Nm.

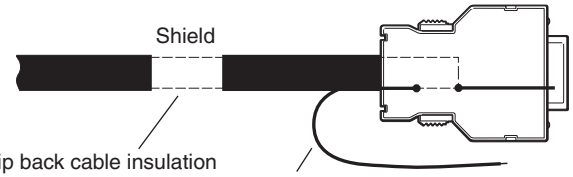
Output signals

Function	Signal		Flying lead wire colour (F)	Pin-out			
	FANUC α	FANUC αi		20-way plug (H)	8-way M12 (S)	8-way M12 (T)	17-way M23 (C)
Power	5 V	5 V	Brown	9, 20	2	8	1, 7
	0 V	0 V	White	12, 14	5, 8	5	4, 10
Serial interface	REQ+	REQ+ / SD+	Violet	5	3	7	8
	REQ–	REQ– / SD–	Yellow	6	4	6	9
	SD+	Do not connect	Grey	1	7	3	14
	SD–		Pink	2	6	4	17
Shield	Shield	Shield	Cable braid	16, External	Case	Case	Case

Connecting the cable screen on H terminations

⚠ The following arrangement should be applied to FANUC versions only.

The cable is supplied with the shield connected to pin 16 inside the connector, making the required connection to the FANUC equipment. The shield must also be connected to machine Earth, either by using the external Earth wire provided, or by cutting back the cable insulation to expose the shield and clamping that to machine Earth.

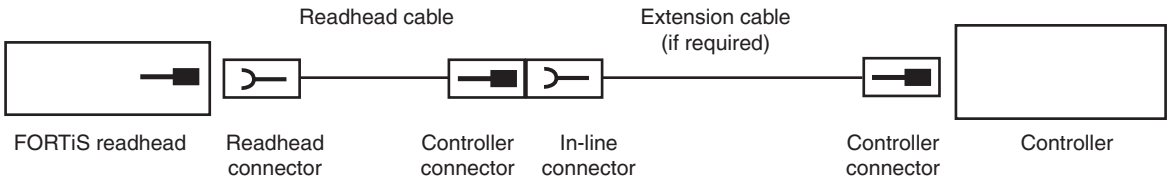


Option 2: Strip back cable insulation to expose the braided shield and clamp to machine Earth.

Option 1: Connect external Earth wire to machine Earth.

Nomenclature

IMPORTANT: Maximum cable length depends upon the readhead cable length and cable type. For maximum total cable lengths see 'Maximum cable lengths' on page 9.



Readhead cable

A A - 0300 - R H X

Category
A - Absolute encoder cable

Cable type
A - 4.7 mm diameter black encoder cable
B - 6.3 mm diameter green encoder cable
D - 10 mm diameter armoured encoder cable

Length

0050 - 0.5 m	0600 - 6 m
0100 - 1 m	0900 - 9 m
0300 - 3 m	1200 - 12 m (Cable Type B only)

Readhead connector
R - FORTiS readhead connector

Controller connector
C - 17-way M23 [1]
F - Flying lead
H - H-20 way Honda/Hirose (FANUC)
S - 8-way M12 (Renishaw) [1]
T - 8-way M12 (alternative pin-out) [1]

Other
X - Standard

[1] Recommended options for use with extension cables.

Extension cable

A B - 0600 - S H X

Category
A - Absolute encoder cable

Cable type
B - 6.3 mm diameter green encoder cable

Length

0100 - 1 m	1200 - 12 m
0300 - 3 m	1500 - 15 m
0600 - 6 m	2000 - 20 m

In-line connector
C - 17-way M23
S - 8-way M12 (Renishaw)
T - 8-way M12 (alternative pin-out)

Controller connector
H - 20-way Honda (FANUC)

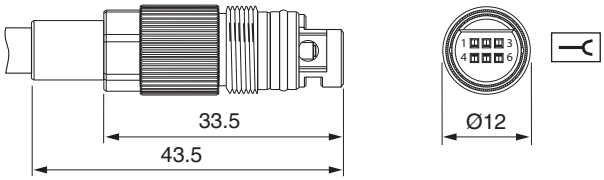
Other
X - Standard

Mitsubishi

Termination options

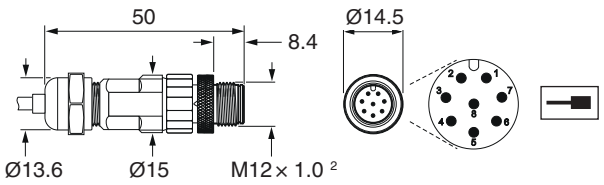
Readhead connector

Dimensions in mm

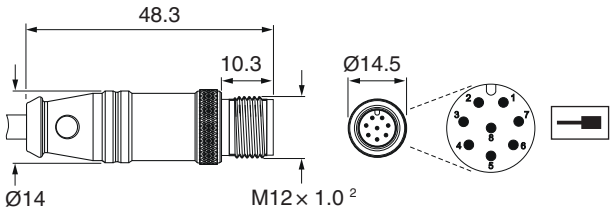


Controller connector

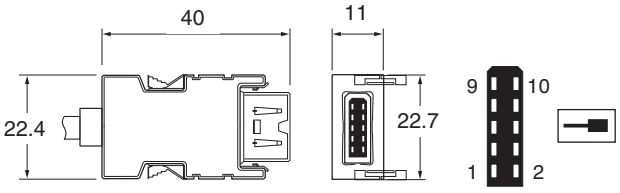
8-way M12 plug [1]



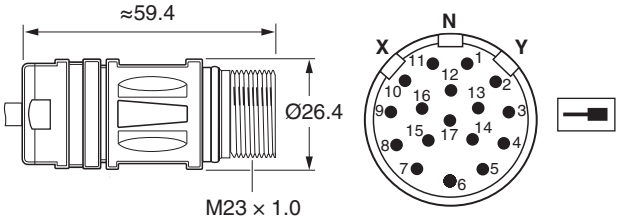
8-way M12 plug – overmoulded version



10-way plug [3]

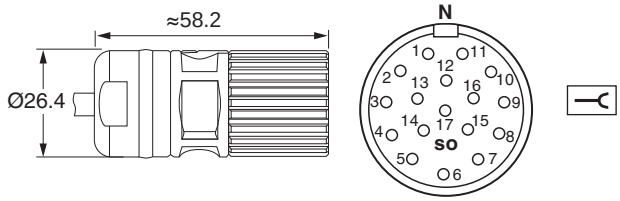


17-way M23 plug

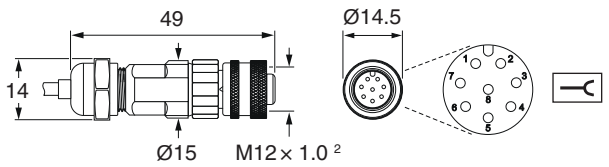


In-line connector

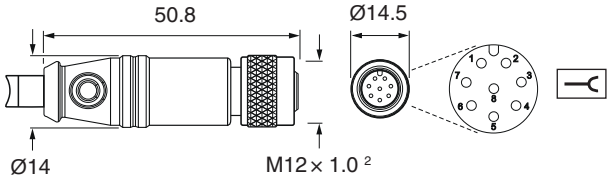
17-way M23 socket



8-way M12 socket [1]



8-way M12 socket – overmoulded version



[1] Subject to availability, may be supplied with overmoulded version.

[2] The recommended tightening torque is 4 Nm.

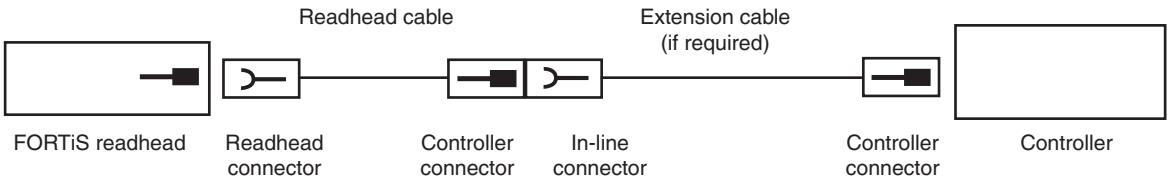
[3] Only Mitsubishi-approved controller connectors are supplied. However, the cosmetic appearance of the connector supplied may differ from the illustration, depending on the approved supplier used.

Output signals

Function	Signal	Flying lead wire colour (F)	Pin-out		
			10-way 3M (P)	8-way M12 (S)	8-way M12 (T)
Power	5 V	Brown	1	2	8
	0 V	White	2	5, 8	5
Serial interface	MR	Violet	3	3	7
	MRR	Yellow	4	4	6
	MD	Grey	7	7	3
	MDR	Pink	8	6	4
Shield	Shield	Shield	Case	Case	Case

Nomenclature

IMPORTANT: Maximum cable length depends upon the readhead cable length and cable type. For maximum total cable lengths see 'Maximum cable lengths' on page 9.



Readhead cable

A A - 0300 - R P X

Category
A - Absolute encoder cable

Cable type
A - 4.7 mm diameter black encoder cable
B - 6.3 mm diameter green encoder cable
D - 10 mm diameter armoured encoder cable

Length

0050 - 0.5 m	0600 - 6 m
0100 - 1 m	0900 - 9 m
0300 - 3 m	1200 - 12 m (Cable Type B only)

Readhead connector
R - FORTiS readhead connector

Controller connector
C - 17-way M23 [1]
F - Flying lead
P - 10-way 3M/Molex (Mitsubishi)
S - 8-way M12 (Renishaw) [1]
T - 8-way M12 (alternative pin-out) [1]

Other
X - Standard

[1] Recommended options for use with extension cables.

Extension cable

A B - 0600 - S P X

Category
A - Absolute encoder cable

Cable type
B - 6.3 mm diameter green encoder cable

Length

0100 - 1 m	1200 - 12 m
0300 - 3 m	1500 - 15 m
0600 - 6 m	2000 - 20 m

In-line connector
C - 17-way M23
S - 8-way M12 (Renishaw)
T - 8-way M12 (alternative pin-out)

Controller connector
P - 10-way 3M/Molex (Mitsubishi)

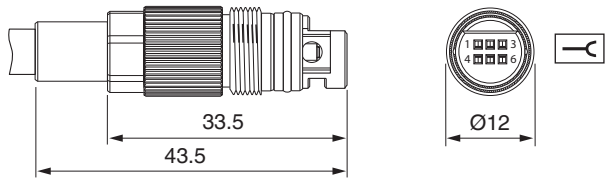
Other
X - Standard

Panasonic

Termination options

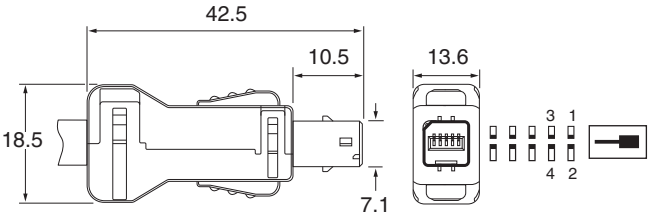
Readhead connector

Dimensions in mm

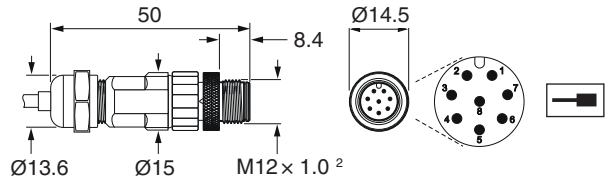


Controller connector

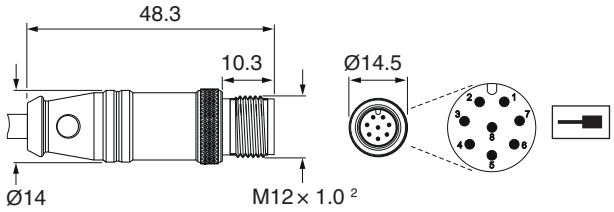
10-way plug



8-way M12 plug [1]

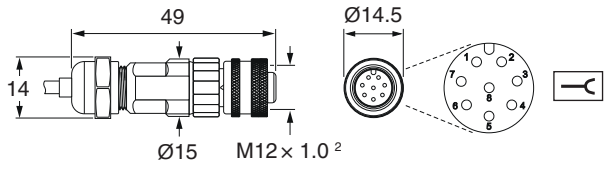


8-way M12 plug – overmoulded version

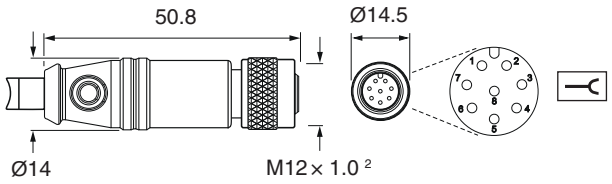


In-line connector

8-way M12 socket [1]



8-way M12 socket – overmoulded version



[1] Subject to availability, may be supplied with overmoulded version.

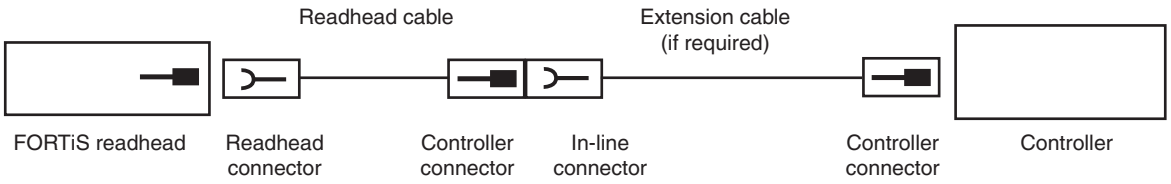
[2] The recommended tightening torque is 4 Nm.

Output signals

Function	Signal	Flying lead wire colour (F)	Pin-out	
			8-way M12 (S)	10-way (J)
Power	5 V	Brown	2	1
	0 V	White	5, 8	2
		Green		-
Serial interface	PS	Violet	3	3
	$\overline{\text{PS}}$	Yellow	4	4
Reserved	Do not connect	Grey	7	-
		Pink	6	-
Shield	Shield	Shield	Case	Case

Nomenclature

IMPORTANT: Maximum cable length depends upon the readhead cable length and cable type. For maximum total cable lengths see 'Maximum cable lengths' on page 9.



Readhead cable

A A - 0300 - R S X

Category
A - Absolute encoder cable

Cable type
A - 4.7 mm diameter black encoder cable
B - 6.3 mm diameter green encoder cable
D - 10 mm diameter armoured encoder cable

Length

0050 - 0.5 m	0600 - 6 m
0100 - 1 m	0900 - 9 m
0300 - 3 m	1200 - 12 m (Cable Type B only)

Readhead connector
R - FORTiS readhead connector

Controller connector
F - Flying lead
J - 10-way
S - 8-way M12 (Renishaw)

Other
X - Standard

Extension cable

A B - 0600 - S S X

Category
A - Absolute encoder cable

Cable type
B - 6.3 mm diameter green encoder cable

Length

0100 - 1 m	1200 - 12 m
0300 - 3 m	1500 - 15 m
0600 - 6 m	2000 - 20 m

In-line connector
S - 8-way M12 (Renishaw)

Controller connector
F - Flying lead
S - 8-way M12 (Renishaw)

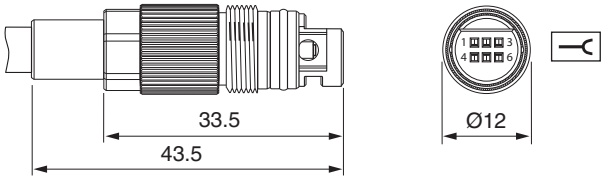
Other
X - Standard

Siemens

Termination options

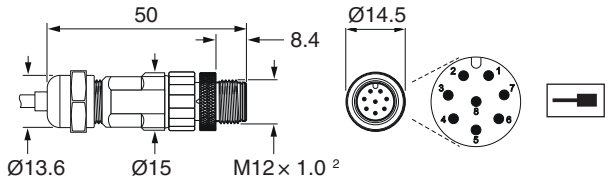
Readhead connector

Dimensions in mm

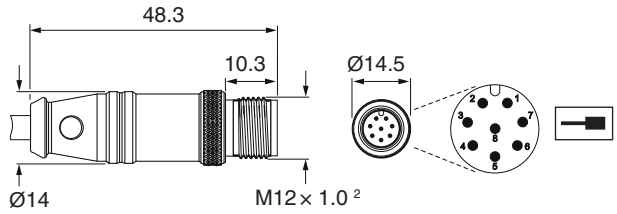


Drive-CLiQ interface connector

8-way M12 plug [1]

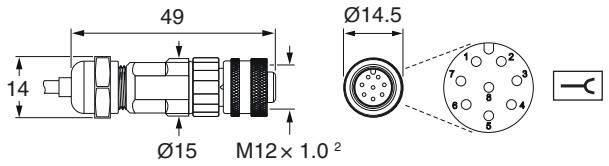


8-way M12 plug – overmoulded version

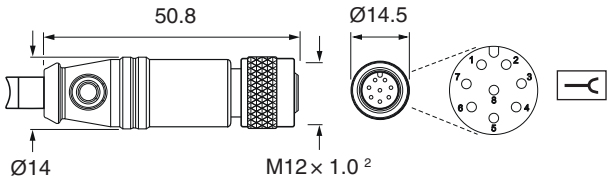


In-line connector

8-way M12 socket [1]



8-way M12 socket – overmoulded version



[1] Subject to availability, may be supplied with overmoulded version.

[2] The recommended tightening torque is 4 Nm.

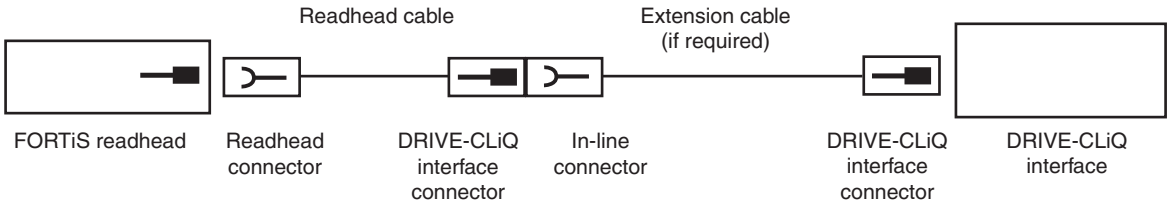
Output signals

Function	Signal	Wire colour	Pin-out
			8-way M12 (S)
Power	5 V	Brown	2
	0 V	White	5, 8
Serial interface	A+	Violet	3
	A–	Yellow	4
Reserved	Do not connect	Grey	7
		Pink	6
Shield	Shield	Shield	Case

Extension cables from the FORTiS DRIVE-CLiQ interface to controller should be sourced directly from Siemens.

Nomenclature

IMPORTANT: Maximum cable length depends upon the readhead cable length and cable type. For maximum total cable lengths see 'Maximum cable lengths' on page 9.



Readhead cable

A A - 0300 - R S X

Category
A - Absolute encoder cable

Cable type
A - 4.7 mm diameter black encoder cable
B - 6.3 mm diameter green encoder cable
D - 10 mm diameter armoured encoder cable

Length

0050 - 0.5 m	0600 - 6 m
0100 - 1 m	0900 - 9 m
0300 - 3 m	1200 - 12 m (Cable Type B only)

Readhead connector
R - FORTiS readhead connector

DRIVE-CLiQ interface connector
S - 8-way M12 (Renishaw)

Other
X - Standard

Extension cable

A B - 0600 - S S X

Category
A - Absolute encoder cable

Cable type
B - 6.3 mm diameter green encoder cable

Length

0100 - 1 m	1200 - 12 m
0300 - 3 m	1500 - 15 m
0600 - 6 m	2000 - 20 m

In-line connector
S - 8-way M12 (Renishaw)

DRIVE-CLiQ interface connector
S - 8-way M12 (Renishaw)

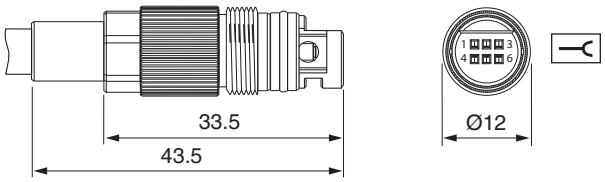
Other
X - Standard

Yaskawa

Termination options

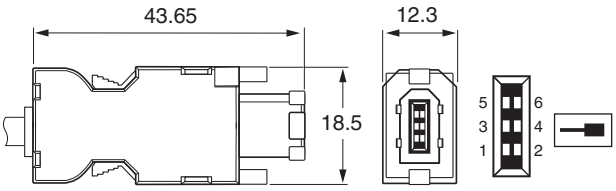
Readhead connector

Dimensions in mm

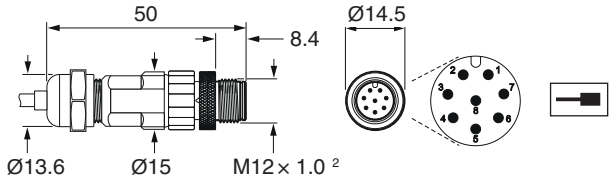


Controller connector

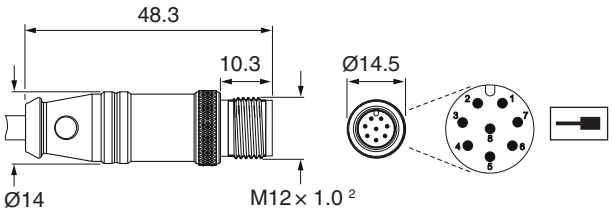
6-way plug



8-way M12 plug [1]

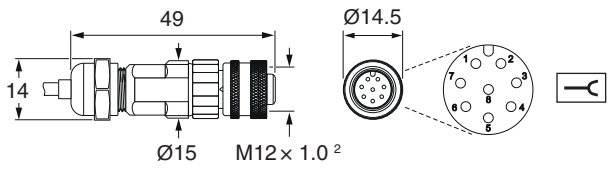


8-way M12 plug – overmoulded version

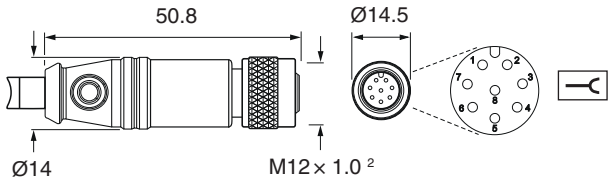


In-line connector

8-way M12 socket [1]



8-way M12 socket – overmoulded version



[1] Subject to availability, may be supplied with overmoulded version.

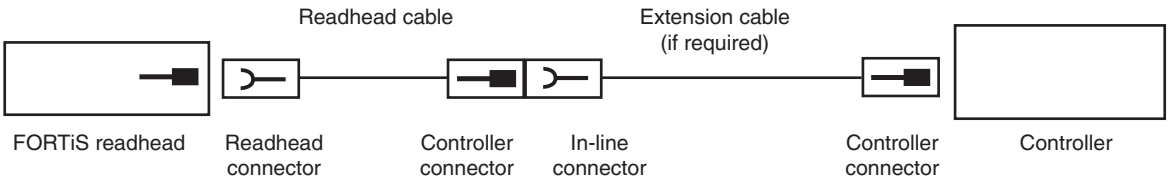
[2] The recommended tightening torque is 4 Nm.

Output signals

Function	Signal	Flying lead wire colour (F)	Pin-out	
			6-way Molex (Y)	8-way M12 (S)
Power	5 V	Brown	1	2
	0 V	White	2	5, 8
		Green	Not connected	
Serial interface	S	Violet	5	3
	$\overline{S}$	Yellow	6	4
Reserved	Do not connect	Grey	-	7
		Pink	-	6
Shield	Shield	Shield	Case	Case

Nomenclature

IMPORTANT: Maximum cable length depends upon the readhead cable length and cable type. For maximum total cable lengths see 'Maximum cable lengths' on page 9.



Readhead cable

A A - 0300 - R S X

Category
A - Absolute encoder cable

Cable type
A - 4.7 mm diameter black encoder cable
B - 6.3 mm diameter green encoder cable
D - 10 mm diameter armoured encoder cable

Length

0050 - 0.5 m	0600 - 6 m
0100 - 1 m	0900 - 9 m
0300 - 3 m	1200 - 12 m (Cable Type B only)

Readhead connector
R - FORTiS readhead connector

Controller connector
F - Flying lead
S - 8-way M12 (Renishaw) [1]
Y - 6-way Molex (Yaskawa)

Other
X - Standard

[1] Recommended option for use with extension cables.

Extension cable

A B - 0600 - S Y X

Category
A - Absolute encoder cable

Cable type
B - 6.3 mm diameter green encoder cable

Length

0100 - 1 m	1200 - 12 m
0300 - 3 m	1500 - 15 m
0600 - 6 m	2000 - 20 m

In-line connector
S - 8-way M12 (Renishaw)

Controller connector
Y - 6-way Molex (Yaskawa)

Other
X - Standard

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ADTa-100 adaptor cables

The ADTa-100 diagnostic tool has a standard 9-way female D-type input connector. For alternative pin-outs and connector options adaptor cables are required.

A A - 0100 - R A X

Category
A - Absolute encoder cable

Cable type
A - 4.7 mm diameter black encoder cable

Length [1]
0100 - 1 m
0300 - 3 m

In-line connector
A - 9-way D-type (Renishaw)
C - 17-way M23
D - 15-way D-type (Beckhoff)
F - Flying lead
G - 9-way D-type (iC-Haus)
H - 20-way Honda/Hirose (FANUC)
P - 10-way 3M/Molex (Mitsubishi)
R - FORTiS readhead connector
S - 8-way M12 (Renishaw)
T - 8-way M12 (alternative pin-out)
U - 8-way M12 (iC-Haus)
Y - 6-way Molex (Yaskawa)

ADT connector
A - 9-way D-type

Other
X - Standard

[1] When using a 9 metre Type A (4.7 mm diameter, black) or Type D (10 mm diameter, armoured) readhead cable, the 1 metre ADTa-100 adaptor cable should be selected.