Renishaw Metrology

Installation Guide
SP2-1

H-2000-5110-02-A

Care of equipment
Renishaw probes and associated equipment are precision tools used for obtaining precise measurements and must therefore be treated with care.

Changes to renishaw products
Renishaw reserves the right to improve, change or modify its hardware or software without incurring any obligation to make changes to Renishaw equipment previously sold.

Warranty
Renishaw Metrology Ltd warrants its equipment for a limited period (as set out in our Standard Terms and Conditions of Sale) provided that it is installed exactly as defined in associaed Renishaw documentation.

Prior consent must be obtained from Renishaw if non-Renishaw equipment (e.g. interfaces) and/or cabling is to be used or substituted. Failure to comply with this will invalidate the Renishaw warranty.

Claims under warranty must be made from authorised Service Centres only, which may be advised by the supplier or distributor.

Patents
Features of Renishaw's Scanning Probe and of other, related, equipment are the subjects of the patents and patent applications listed below -

GB 144597
IT 1003537
JP 1266244
CH 584884
JP 1388652
GB 1447613
CH 594230
US 4153998
US 4270275
GB 1589297
FR 7739015
DE 2757453
IT 1088539
JP 1684609
JP 125702/86
SE 7714205-1
JP 502608/1991
US 5088208

CH 617881
US 4288925
US 4360973
US 4397093
US 44451988
US 4473955
CA 1091326
GB 1531209
AU 510631
AR 219719
FR 7729458
IT 1987326
US 4136458
JP1368748
GB 2025073B
FR 7917568
EP 0407489
EP 037669

DE 2927525
IT 1162557
JP 3242/88
SE 450418
CH 639309
US 4339714
GB 22108715
DE 3234241
JP 82649/83
US 4542467
US 4636960
EP 108521
US 4599524
JP 501874/84A
EP 0283486
US 4899094
JP 500701/1989

CONTENTS

1.0
INTRODUCTION

Within this guide is the relevant information to enable a system integrator to design an interface for the SP2-1 Scanning Probe.

The information is of value to software and electronics designers and may also be used for Controlled User Documentation provided by Machine Tool Control Systems builders.

1.1 Title

The basic title of the product is the Scanning Probe 2 Derivative 1 (SP2-1). The four versions are designated by using the basic title plus an extension as follows -

Standard Stylus Rate, Side Exit	SP2-1 SS
Standard Stylus Rate, Rear Exit	SP2-1 SR
Low Stylus Rate, Side Exit	SP2-1 LS
Low Stylus Rate, Rear Exit	SP2-1 LR

1.2 Type

The product is a 3 axis incremental measuring probe.

2.0
APPLICATION

The probe is designed to be used for copy milling and digitising on machining centres and dedicated digitisers.

As the probe measurement outputs are count signals and not absolute positions, if the probe is used as an input device to the machine servo system then features should be incorporated into the machine to check the integrity of the probe outputs and ensure safe operation.

3.0
SIZE

The dimensions of the probe are -

Overall length	121mm
Outside diameter (not including connector)	92mm

The external dimensions of the probe with standard 35mm and 50mm shank adaptors are shown in Figures 4 and 5 (Appendix B).

3.1 Probe mass

The probe mass, without stylus, is as follows -

Side Exit:	915g
Rear Exit	970g

3.2 Probe traceability

The probe displays a unique serial number.

3.3 Probe identification

The product is identified by its basic product title: SP2-1, on a label mounted on the Electronic Module housing.

The Low and High Rate version probes are visibly distinguishable by the use of the different identification labels. The Low Rate probe has "SP2-1L" on the front label instead of "SP2-1" for the Standard Rate probe.

3.4 Test certificate

A test certificate is provided which shows the probes' major performance parameters. These include -

a) overall static volumetric accuracy
   - i) linearity
   - ii) straightness
   - iii) orthogonality

b) return to zero value

The probe serial number and version are shown together with the test date on the certificate. The certificate is shipped with the probe, inside the presentation box.

3.5 Styling and finish

The probe has a uniform soft black anodised appearance. The external appearance has a minimum number of hard edged features. There are three labels mounted in recesses of the same dimensions.

3.6 Packaging

3.6.1 Kit 1

The kit comprises -

a) Probe (including insulating washer and mounting screws)
b) Certificate
c) Stylus Spanners (2)
d) Box
e) User Guide
f) Polythene Bag for b) & e) above

Accessories -

Stylus	A-5000-9420
Shank	up to 50mm diameter
Connector	MIL-C 26482 G Series 1 plug, shell size 14, 19 pins, orientation X with a screened backshell
Stylus Adapter	A-5000-9303

The box supports the probe for transport purposes, and is suitable for the storage of the probe by the user site in the form in which the probe is used.

3.6.2 Kit 2

Kit 2 has been designed as the Service Unit kit. No provision is made for accessories within the box apart from the repair notes.

The kit comprises -

a) Probe (including insulating washer and mounting screws)
b) Repair Notes
c) Certificate
d) Box
e) Polythene Bag for b) & c) above

3.7 External packaging

The presentation box is protected during transport by a cardboard sleeve.

For the separate shipment of accessories, packaging is supplied to protect the items during transport.

4.0 PROBE INTERFACES

4.1 Structural

4.1.1 Probe Mount

The probe is mounted to an adapter using 3 M4 screws on a 71mm PCD. The thread depth is greater than 10mm. The screws hole alignment relative to the X axis is ± 0.8°.

Adaptors can be provided according to the requirements of the user.

The orientation, with respect to the probe axis, of the mounting features is specified in Figure 1 (page 9).

4.1.2 Stylus Mount

The probe provides an M5 screw mount for attaching styli with the following specification -

Mounting Face	17mm diameter
Hole Depth	> 5.8mm
Material	Steel
Surface Finish	Flat Ground to less than 0.4 μm
Parallelism	< 5μm over 17mm diameter relative to probe mounting face

The following adaptors are available upon request -

M5 - M4
M5 - ϕ8
M5 - ϕ10
M5 - ϕ12

Stylus changing is by means of a manual spanner.

4.2 Thermal

The structural interface with the user is of low thermal resistance through the insulating (electrical only) washer provided. The thermal design of the probe assumes no heat transfer through this interface.

4.3 Mechanical

4.3.1 Spring Rate

The effective spring rate of the probe with stylus A-5002-0057-MA is as follows -

Standard Rate Version
X, Y, Z axes 350g/mm ± 20%

Low Rate Version (with 100mm stylus)
X, Y, Z axes 170g/mm ± 50%

Variation between axes ±10%

4.3.2 Measurement Range

The maximum stylus travel, from probe centre in each axis is -

Stylus pointing downward

Standard Rate
X,Y ± 4.5mm
Z 5.5mm into the probe, 3.5mm out of the probe

Low Rate
X,Y ± 4.5mm
Z 7.0mm into the probe, 2.0mm out of the probe

Stylus pointing horizontally

Standard Rate
X,Y ± 3.5mm
Z ± 4.5mm

Low Rate
X,Y ± 2.0mm
Z 3.7mm into the probe, 5.3mm out of the probe

4.3.3 Overtravel

The displacement of the stylus tip, in addition to the measurement range is as follows -

Standard Rate
XY Plane 18mm with 100mm stylus
Z Plane 5mm minimum

Low Rate
XY Plane 18mm with 100mm stylus
Z Plane 5mm minimum

4.3.3 Overtravel continued

An overtravel condition occurs when the following forces are applied to the tip of a 100mm stylus -

Standard Rate	
XY Plane	20N to 65N
Z axis	400N to 600N
Low Rate	
XY Plane	15N to 35N
Z axis	200N to 400N

The axis range (XY) before an overtravel condition occurs for a 150mm stylus is -

Standard Rate	> 3.5mm.
Low Rate	full travel

4.4 Electrical

All electrical connections are carried by the probe connector.

4.4.1 Probe conector

4.4.1.1Type

The connector is a MIL-C 26482 G, size 14, 19 pin receptacle with an X orientation.

4.4.1.2 Pin Definitions

The pin definitions are as follows -

PIN	DESCRIPTION	TYPE
N	X A	EIA-422-A Output
S	$\overline{X A}$	EIA-422-A Output
E	X B	EIA-422-A Output
D	$\overline{X B}$	EIA-422-A Output
G	YA	EIA-422-A Output
F	$\overline{Y A}$	EIA-422-A Output
C	Y B	EIA-422-A Output
P	$\overline{Y B}$	EIA-422-A Output
M	Z A	EIA-422-A Output
L	$\overline{Z A}$	EIA-422-A Output
H	Z B	EIA-422-A Output
T	$\overline{Z B}$	EIA-422-A Output
K	OVERTRAVEL 1	O C T
V	OVERTRAVEL 2	O C T
J	SWITCH	O C T
U	ERROR	O C T
B	+V	Power Input
A	0V	Power Return
R	Screen	Grounding

Total number of connections = 19

Pin R is for connection of the screen drain wire or a section of the braid. The body of the probe is connected to the probe chassis.

4.4.1.3 Position

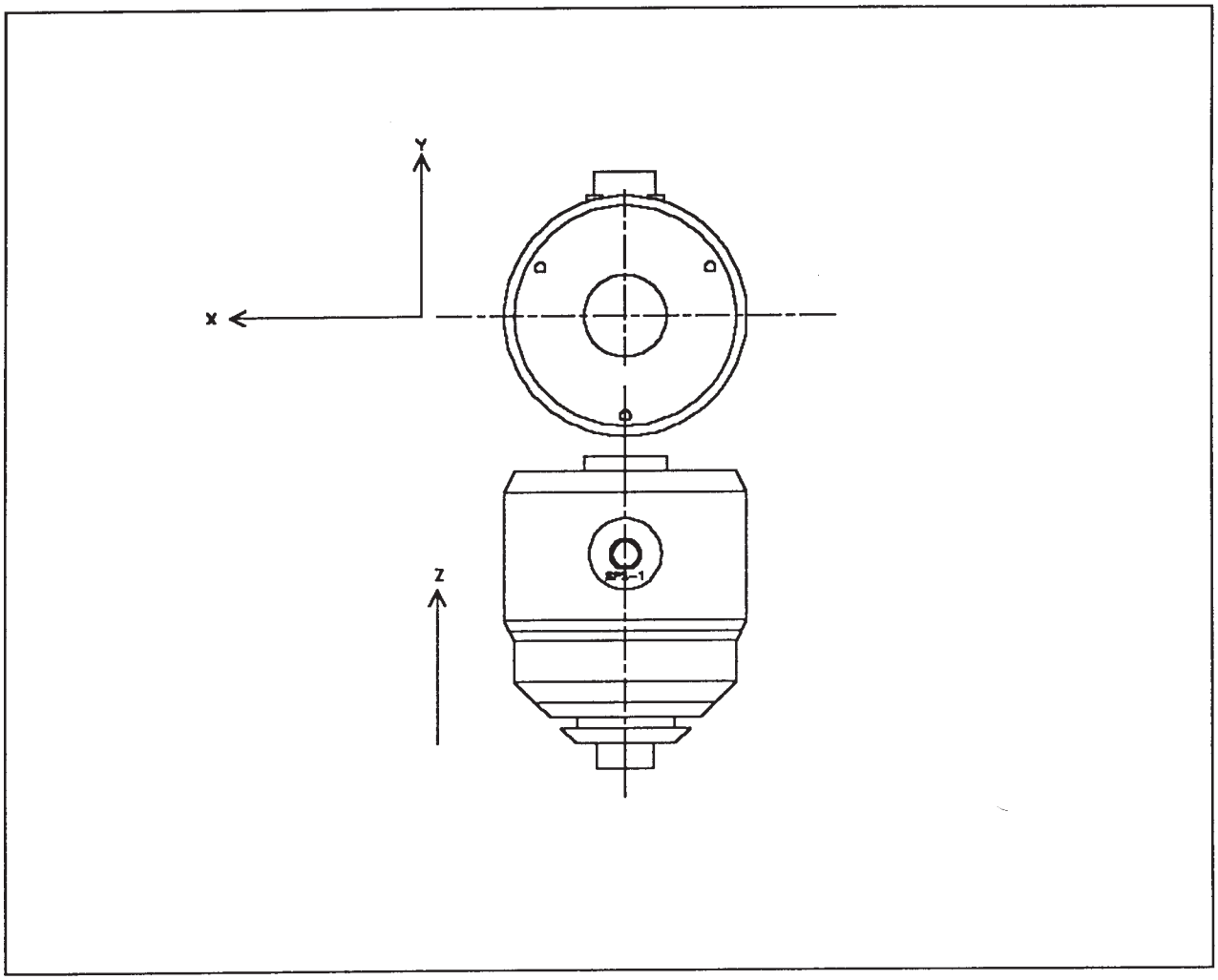
4.4.1.3.1 Side version

The connector is mounted on the side of the Electronic Module Housing.

4.4.1.3.2 Rear version

The connector is mounted on the Electronic Module Housing at the rear of the probe. This arrangement permits the use of a 50mm diameter adaptor.

Figure 1, Probe orientation



4.4.2 Power supply

The probe functions when supplied with power as specified below -

Voltage (V)	+ 9.1V to + 13.2V at the probe conector
Ripple	< 100mV @ < 1kHz
Noise	< 100mV @ > 1kHz

The current consumption of the probe is 124mA maximum without any D.C. load on the measurement signals output. The current consumption must not exceed 150mA when the measurement signals are D.C. loaded .

The Probe will not be damaged if powered up/down by connecting the machine cable.

4.4.3 Measurement signals

4.4.3.1 Format

The form of the probe output measurement signals is quadrature (A & B) square waves for each axis. The A and B signal definition are, for stylus movement in each axis, as shown in Figure 1, output A leads B.

The output signals are in accordance with the EIA-422-A line driver standard. If the signals are terminated to minimise signal overshoot then this must be done capacitively only. DC loading the outputs will increase the power dissipation in the probe giving thermal growth errors.

N.B. The total DC current sourced from the probe outputs must not exceed 40mA.

These outputs are short circuit protected such that no damage will occur for a continuous short circuit current of 150mA from one output at a time. The devices, though, can be damaged if their outputs are forced above +5V or below 0V.

4.4.3.2 Resolution

The resolution of the quadrature output signals is 1μm nominal. The output signal edge separation is between 0.4μm to 1.6μm for all operating conditions within the life of the probe.

4.4.3.3 Minimum edge separation

The minimum edge separation between any two edges of an axis quadrature output is 1μs. This minimum separation will occur at times other than when the stylus is moved at its maximum slew rate. For example, if the stylus is held stationary at a position where the interpolator is at a transition the probe may output a stream of up/down counts at the above minimum edge separation due to machine vibration or signal noise. Providing that the machine counters can function with this edge separation then the resultant count will be 0 or 1.

4.4.4 Overtravel output

The overtravel output is a pair of normally closed OCT compatible Open Drain MOSFET signals. Two signals are provided to ensure a high level of reliability of this protection function. Recommendations for the use of these signals are given in Appendix A.

The overtravel outputs have the following specification -

Contact rating	30V DC, 16mA maximum
Open Circuit leakage current	27.5mA (@ 26.4V)
Closed Circuit voltage drop	85mV (@ 8.5mA)

The contacts are normally closed in the absence of an overtravel condition. When an overtravel occurs both outputs change to the open OCT state.

THE OVERTRAVEL OUTPUT MUST NOT BE CONNECTED TO THE MACHINE EMERGENCY STOP SYSTEM AS IT DOES NOT CONFORM TO THE APPLICABLE REGULATIONS FOR EMERGENCY STOPS

4.4.5 ERROR output

4.4.5.1 ERROR output format

The error output is of an OCT compatible Open Drain MOSFET format with the following specifica tions -

Contact rating	30Vdc 16mA maximum
Open Circuit leakage current	27.5mA (@ 26.4V)
Closed Circuit voltage drop	85mV (@ 8.5mA)

The contacts are normally closed in the absence of an error condition.

4.4.5.2 Fault detection

A fault will be reported if the measurement system is corrupted such that the measurement systemsignal amplitude is less than a defined acceptable level. As the most likely failure is the loss of a read head signal as a result of a wire or joint failure or debris on the optical components, this detection system will report the majority of potential failures. There will be failure modes, however, which cannot be detected by this system (see Section 11.3 Application).

4.4.5.3 Fault report

A fault condition is reported by an open OCT output pulse on the ERROR signal.

The fualt report pulse duration is the duration of the error condition plus 120mS to 776mS. The probe resets on power up after 120mS to 776ms.

4.4.6 User function switch

A signal is provided to indicate the status of the User Function Switch. The SWITCH output is of an OCT compatible Open Drain MOSFET format with the following specification -

Contact rating	30V DC, 16mA maximum
Open Circuit leakage current	27.5mA (@ 26.4V)
Closed Circuit voltage drop	85mV (@ 8.5mA)

The contacts are normally open in the absence of a switch press condition.

A closed OCT level SWITCH signal will be sent when the switch is pressed.

4.4.7 Output cable drive capacity

The Probe outputs will function with cable lengths up to 50m providing that the power supply requirements are still met.

4.4.8 Electrical isolation/grounding

The cable connector backshell should be screened such that the cable screen is connected to the probe chassis through the connector body. The EMC performance of the probe is based on this arrangement.

For cases when a screened back shell is not used, a cable screen pin is provided, within the output connector, which is connected to the probe chassis. This latter arrangement does provide the optimum screening against electromagnetic interference and it will be necessary to carry out EMC testing on the complete installation to ensure the required level of immunity.

The probe 0V is connected to the probe chassis via a 100nF capacitor to reduce the effect of high frequency noise pick-up.

In order to avoid earth loops and electrical interference the probe is isolated from the machine at its mounting interface, by the use of the washer provided, and at the stylus.

5.0
FUNCTIONAL DESCRIPTION

5.1 Speed
The probe operates, according to its interface, functional and performance requirements, at a stylus slew speed, relative to the probe body, of ≤250mm/s in any direction.

5.2 Probe orientation
The probe functions, according to its interface, functional and performance requirements, when used vertically, but as orientation to any angle is required in some applications the effect of this is included in the relevant sections.

5.3 Probe calibration
The relationship between the stylus movement and the axis output (commonly called the 'gain' or 'scaling' factor) must be determined by the user for the particular stylus configuration in use. The stated performance of the probe can only be obtained if the gains are determined and applied by the user.

5.4 Protection
Protection for the machine, workpiece, stylus and probe mechanism is provided by an overtravel device at the stylus mount. This overtravel device operates in all directions apart from the movement of the stylus out of the probe. The protection is such that an overtravel is indicated when there is an attempt to exceed the mechanism travel design limits. With a 150mm stylus a Standard Rate probe overtravel could occur before these design limits are reached in the XY plane.

THE OVERTRAVEL FUNCTION SHOULD NOT BE USED TO PROTECT THE OPERATOR. HIGH FORCES ARE REQUIRED TO ACTIVATE THE DETECTION DEVICE IN THE Z AXIS

5.5 Stylus weight adjustment
The probe has no stylus weight adjustment but relies on sufficient probe travel to cope with the range of styli specified. Above this weight, the axes ranges will be reduced below the stated values.

5.6 Stylus size
The probe functions according to the functional requirements when fitted with styli with the following specification -

Maximum Length for full stylus travel	
Standard Rate	120mm
Low Rate	150mm
Maximum Stylus Mass	100g
Tip Diameters	1mm to 40mm

5.7 Zero set of axes
The outputs are incremental only. There are no zero references for axis positions. Mid-range positions are defined as being the stylus free position for the particular stylus mass and probe orientation.

5.8 Axis motions
The probe axis motions are nominally parallel so that parallel sided styli can be used. Structural and stylus bending always give some angular error at the stylus tip. The value of this error depends on the stylus length and stiffness.

5.9 Indicators
The probe has a visible POWER ON indicator that is ON when the probe is powered.

5.10 User function switch

A press switch is mounted on the probe body which allows the OEM to provide a signal for a user definable function. The switch is accessible to the operator, and resistant to coolant. The switch has a positive tactile feel for feedback to the operator.

6.0 PERFORMANCE

The following performance is stated for all probe versions with 80mm long, 50g stylus (A-5002-0057-MA). Where a detail is different for one version this is specified.

6.1 Accuracy

The static volumetric accuracy for a 6 mm dia sphere centred on the static resting position is < 20µm (95%).

6.2 Parallelism of motion

The angular stiffness of the probe is 1059Nm rad^{-1}.

The maximum angle, in arc minutes, between the stylus mounting face and the probe mounting face is as follows for different axis displacements in the XY plane -

Stylus Length Axis Position (mm)	50mm	100 mm	150 mm
0	1.0	1.0	1.0
1	2.3	2.9	3.4
4	8.2	11.3	14.3

6.3 Dynamic performance

6.3.1 Standard rate

The first structural resonance frequency of the probe in each axis with a 100mm, 6mm diameter steel stylus is as follows -

X	> 70Hz
Y	> 80Hz
Z	> 80Hz

The natural undamped frequency of the probe in each axis with a 50g stylus calculated from the structure masses and minimum spring rates is -

X	> 15Hz
Y	> 16Hz
Z	> 12Hz

6.3.2 Low rate

The first structural resonance frequency of the probe in each axis with a 100mm, 6mm diameter steel stylus is as follows -

X	> 70Hz
Y	> 80Hz
Z	> 80Hz

6.3.2 Low rate continued

The natural undamped frequency of the probe in each axis with a 50g stylus calculated from the structure masses and minimum spring rates is -

X	> 15Hz
Y	> 16Hz
Z	> 9Hz

6.4 Axis alignment

In addition to the volumetric accuracy, the alignment of the axes with respect to the perpendicular to the mounting plate and the appropriate component of one horizontal axis is -

X	0.17° (mean + 3σ)
Y	0.42° (mean + 3σ)
Z	0.34° (mean + 3σ)

6.5 Damping

The damping factors (% of critical) for a standard rate probe at ambient and at the extremes of the operating temperature range are -

5°C to 40°C	40% to 100%
23°C	50% to 85%

The damping factors (% of critical) for a low rate probe at ambient and at the extremes of the operating temperature range are -

5°C to 40°C:	25% to 50%
23°C	35% typical

6.6 Return to zero

The maximum measured return to zero values of the probe are as follows -

Standard Rate	
X	± 26µm
Y	± 28µm
Z	± 26µm
Low Rate	
X	± 200µm
Y	± 200µm
Z	± 200µm

6.7 Measurement stability

The measurement drift of the probe, after warm-up, at a fixed temperature in the specified operating range with the stylus constrained and unconstrained is as follows -

Constrained	≤ 5µm
Unconstrained	≤ 5µm

6.8 Temperature stability

The measurement drift of the probe from power up to a stabilised condition is as follows -

Constrained	6µm

6.8 Temperature stability continued

The time for an unmounted probe to stabilise, to within 2μm of final measurement value, after power-up is less than 0.5hrs

6.9 Overtravel

6.9.1 Force limit

The maximum forces that can be applied to the tip of a 100mm stylus before damaging the probe are -

Standard Rate	
XY Plane	100N
Z axis	1000N
Low Rate	
XY Plane	65N
Z axis	750N

6.9.2 Repeatability

The tip of a 50mm stylus will return to within the value below of its initial position after overtravel to limit of range -

Standard Rate	50μm
Low Rate	50μm

6.9.3 Hysteresis

The hysteresis at the tip of a 50 mm stylus over a range of ± 3mm is -

Standard Rate	< 3μm
Low Rate	< 3μm

7.0 AVAILABILITY

7.1 Life

The probe has a design life of 5,000 hours continuous operation over five year period. At the end of this period the probe will perform with no more than double the quoted volumetric errors. The quoted specification will be maintained for the one year warranty period.

Any overtravel device will meet its performance criteria after 100 operations.

The switch has a design life of >100,000 operations.

The probe connector has a mechanical life of greater than 500 mating cycles

8.0
MAINTAINABILITY

8.1 Design for repair
The Electronics and Mechanical Modules have been designed to be replaceable in a service environment.

9.0
ENVIRONMENT

9.1 Operating temperature range
The Probe will maintain its specified performance over the temperature range of 5°C to 40°C.

9.2 Storage temperature range
The Probe surface or performance is not impaired when soaked for 16 hours at the extremes of -10°C and + 70°C.

9.3 Humidity
The probe performs to specification and does not become degraded in appearance after being subjected to the humidity tests specified by BS2011:Part 2.1 Test Db whilst unpowered.

The probe performs to specification whilst subjected to 95% RH (Non-condensing) for up to one month whilst operating.

9.4 EMC/RFI
The probe conforms to the following standards -

Radiated and conducted emissions	FCC Reg. 47 CFR, part 15, subpart J, class A limits. BS 6527: Class A limits.
Radiated susceptibility	IEC 801.3 Severity level 2 and 3.
Conducted susceptibility	IEC 801.4 Severity 2.5kV

9.5 Electrostatic discharge
The probe functions according to its specification when subjected to the test specified in IEC 801.2 [Severity level 3 - 8 kV] whilst operating.

The probe is not damaged when subjected to the test specified in IEC 801.2 [Severity level 3 - 8 kV] whilst operating.

9.6 Shock and vibration
The probe function and performance is not degraded after being subjected to the drop test as specified by BS 2011 Part 2.1 [100mm drop height].

The probe function and performance is not degraded after being subjected to the impact test as specified by IPXX1 with an impact of 0.225 joules.

9.7 Corrosion
The probe external surfaces, function or performance is not degraded when subjected to the range of coolants and cutting oils as specified in Renishaw Test Document (904DS335).

9.8 Sealing

Because the internal volume of the probe changes when the stylus is moved, the probe is vented to minimise air pressure variations inside the probe which could stress the diaphragm. The venting action also ensures that the probe rest position is not sensitive to temperature and atmospheric changes.

The probe is not fully sealed against the ingress of fluid but is in accordance with IP65 (See 904DS335 for conditions). Ingress of fluid is likely to cause the loss of the measurement function which will be reported by the ERROR signal.

The Probe is not suitable for use in the presence of cutting fluids as in the cutting/milling operation of the machine.

The probe function and performance is not degraded when operated in the presence of swarf and dirt.

10.0 TRANSPORT/HANDLING

The Probe has been designed to be transported by the usual means in standard protective materials. To protect the mechanism during transportation its movement is limited by an 'O' ring.

11.0 SAFETY

11.1 Electrical

The probe is electrically safe when operated in accordance with the documentation provided.

11.2 Mechanical

The probe is mechanically safe when operated in accordance with the documentation provided. As the probe will be fitted to the spindle of a machine and it has a connecting cable, a clear warning label is fixed to the probe indicating that it must not be rotated under any circumstances.

BREAK JOINTS MUST NOT BE USED WITH THIS PROBE APPLICATION

11.3 Application

Although the probe has been designed to the highest standards of reliability there are potential failure modes within the probe that could cause a loss of function of the probe (i.e. the stylus movement and count outputs do not relate as specified). The function most likely to suffer failures is the measurement transducer system as it involves moving parts. Therefore, a fault detection function has been included in the probe to monitor the health of the measurement transducer system.

As the potential for other faults within the probe (or machine) to occur is finite an overtravel device is included in the probe. This is intended to be used as a protection device for the work piece, probe and machine.

Where a machine operation involves manual intervention the overtravel function must not be relied upon to protect the operator as the activation forces could be as high as 600N.

THE OVERTRAVEL FUNCTION MUST NOT BE INCORPORATED INTO THE MACHINE EMERGENCY STOP SYSTEM AS IT DOES NOT CONFORM TO THE APPLICABLE REGULATIONS.

In this case, other safety features should be incorporated into the machine to ensure safe operation (e.g., an accessible emergency stop button or a probe function integrity check).

APPENDIX A: RECOMMENDED ELECTRICAL INTERFACING

CONNECTOR

The connector should be MIL-C 26482 G Series 1 plug, shell size 14, 19 pins, orientation X with a screened backshell (i.e. a cable screen connection should be incorporated in the backshell to connect the cable screen to the backshell and hence to the probe chassis).

CABLE

The cable should have 9 twisted pairs and an overall braided screen and an outer sheath which is resistant to coolants. The characteristic impedance of each pair should be 100Ω nom. The specified supply voltage of the probe must be maintained at the probe connector with the maximum current of 150mA.

TERMINATION

The EIA-422-A signal termination must represent an AC load only to meet the probe accuracy specifications. The total DC load from the probe EIA-422-A outputs must be less than 40 mA. A recommended arrangement is shown in Figure 2. The EIA-422-A receiver specified (26LS32AC) is recommended because it indicates a high state on its outputs when the inputs are tristate. Therefore the machine will not interpret noise as real count signals if the probe is not connected, not powered or has shut down due to thermal overload.

The control signals should be connected as shown. The output driver will be in an open state if power is not applied to the probe. The value of R2 can be other than specified, but the maximum output current must not be exceeded. Exceeding the maximum specified current will cause damage to the driver.

The complete probe electrical interface is shown in Figure 3.

Both overtravel signals should be used such that if either indicate an overtravel condition then action should be taken.

THESE SIGNALS MUST NOT BE CONNECTED TO THE MACHINE EMERGENCY STOP SYSTEM AS THEY DO NOT CONFORM TO THE APPLICABLE REGULATIONS

Figure 2, Interface

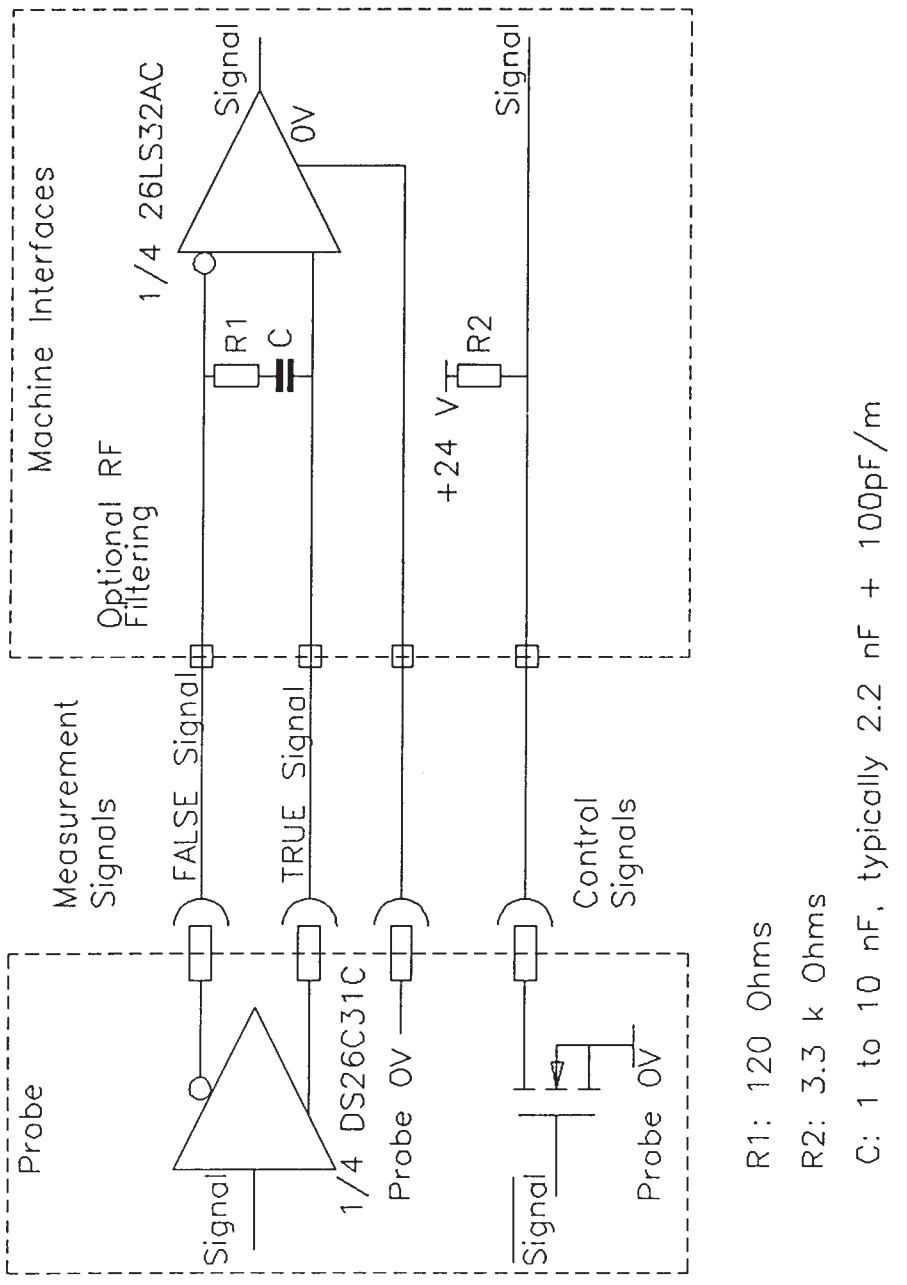
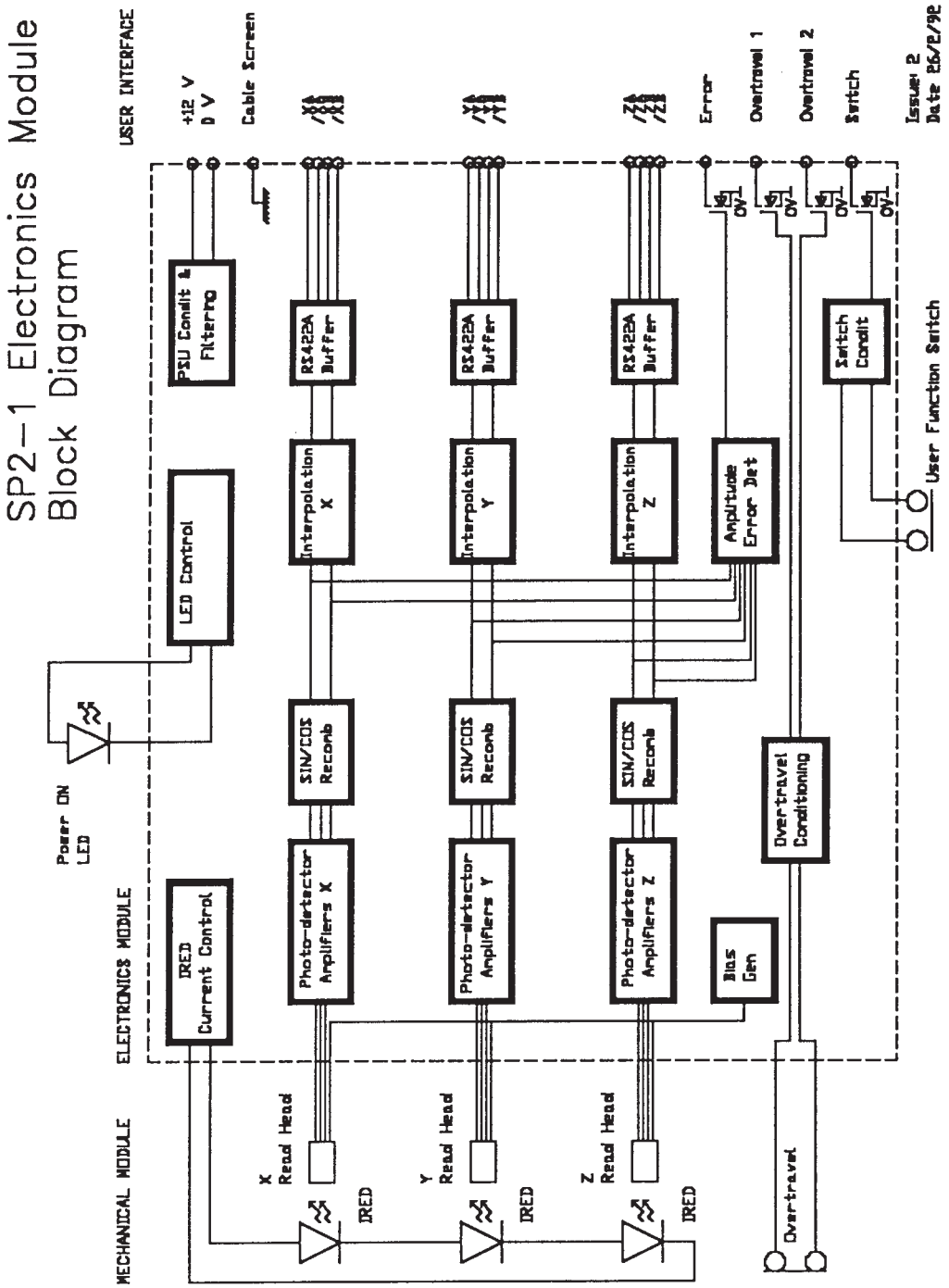
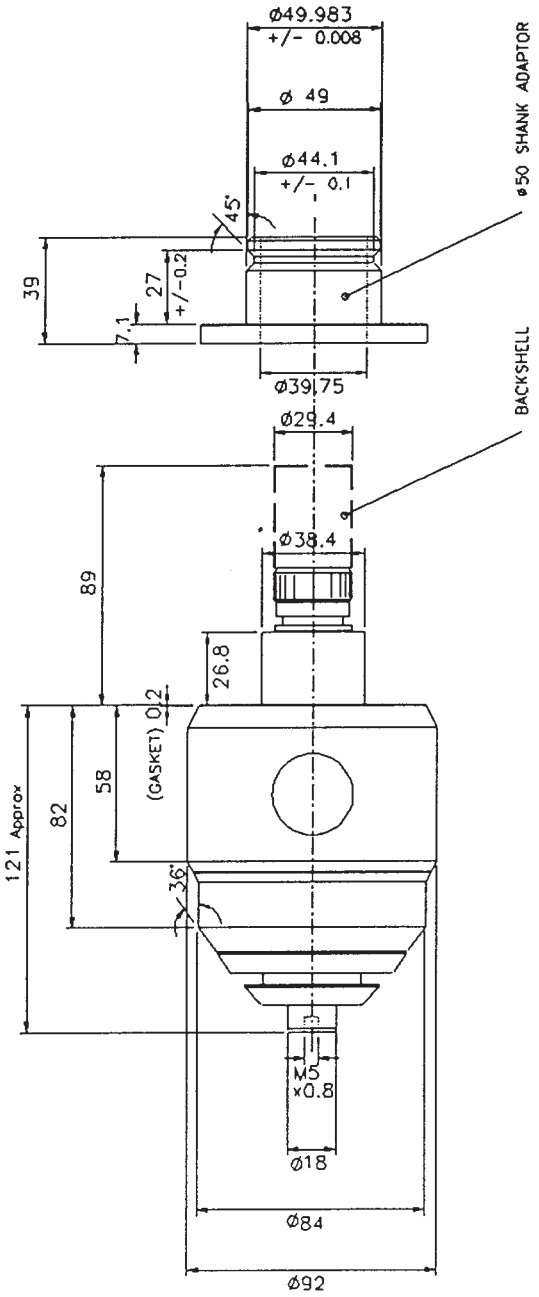


Figure 3, SP2-1 Function diagram



APPENDIX B:
EXTERNAL
DIMENSIONS OF PROBE

Figure 4, Rear exit probe dimensions (mm)



APPENDIX B:
EXTERNAL
DIMENSIONS OF PROBE
continued

Figure 5, Side exit probe dimensions (mm)