

## SP600 installation and user's guide

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# SP600 installation and user's guide

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## SP600 installation and user's guide

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 ORIGINAL LANGUAGE VERSION

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### Packaging

To aid end user recycling and disposal the materials used in the different components of the packaging are stated here:

Packaging component	Material	94/62/EC code	94/62/EC number
Packing foam	Low density polyethylene	LDPE	04
Outer box	Corrugated fibreboard	PAP	20
Bag	High density polyethylene	HDPE	02

### Patents

Features of the SP600 system and associated products, equipment and techniques are the subjects of one or more of the following patents and patent applications:

EP 1368615	JP 4062515	US 6909983
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# Product compliance

## EU declaration of conformity

Contact Renishaw plc or visit [www.renishaw.com/EUCMM](http://www.renishaw.com/EUCMM) for the full EU declaration.

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## UK declaration of conformity

Contact Renishaw plc or visit [www.renishaw.com/UKCMM](http://www.renishaw.com/UKCMM) for the full UK declaration.

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## EMC conformity

This equipment must be installed and used in accordance with this installation guide. This product is intended for industrial use only and should not be used in a residential area or connected to a low voltage power supply network which supplies buildings used for residential purposes.

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## FCC (USA only)

### Information to user (47 CFR 15.105)

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

### Information to user (47 CFR 15.21)

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

### Equipment label (47 CFR 15.19)

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
  2. This device must accept any interference received, including interference that may cause undesired operation.
-

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### ICES-001 (Canada only)

This ISM device complies with Canadian ICES-001.

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

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### REACH regulation

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

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# Safety



**CAUTION:** Permanent magnets are used in some components of the SP600 / M / Q system. It is important to keep them away from items which may be affected by magnetic fields, e.g. data storage systems, pacemakers and watches etc.

There is no overtravel protection in the +Z axis other than an endstop. Your control system must therefore be able to stop the motion of the machine in the +Z axis of the probe before the endstop is reached. If this is not the case safety glasses must be worn when operating or observing the operation of the SP600M system in the case of stylus breakage.

Machine operators must be trained in the use and application of the products detailed in this guide, in the context of the machine it is fitted to, before being allowed to operate that machine.

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# Introduction

This document is intended as a guide to initial installation, integration and use of the Renishaw SP600 family of analogue measurement probes. It assumes that you will be using the Renishaw AC1 or AC2 analogue counter PC card to interface the probe. If you intend to handle probe interfacing yourself then details of probe signals, power requirements etc. can be found in the pages listed below:

- [SP600 probe signals](#)
- [SP600 cables](#)
- [SP600 in multiple Renishaw probe type installations](#)

This will significantly increase the complexity of the integration process and use of the AC1 or AC2 is strongly recommended.

## Principles of operation

The motion of the SP600 is based on a system of parallel operating springs that support an arrangement of three light emitting diodes (LEDs). The triangular shaped light-box is mounted on, and moves with the motion system. Inside the light box there are three LEDs one for each axis. The light from the LEDs is focused into slits and shine onto three individual position sensitive detectors (PSDs) that are fixed to the body of the probe. The linearity specification of the PSDs used in the probe is better than 0.25%.

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# Product range

## SP600M analogue measurement probe

SP600M is an auto-jointed, multiwired analogue scanning probe suitable for mounting on certain motorised and fixed Renishaw probe heads. The probe body contains the extremely robust parallel operating sensor mechanism. It enables a CMM to gather large amounts of data very rapidly for inspection or digitising purposes. The probe offers 3 axis movement of  $\pm 1$  mm in each direction (X, Y, Z), irrespective of probe orientation. It can carry stylus lengths up to 300 mm and may be re-orientated using a Renishaw PH10M PLUS / PH10MQ PLUS motorised head. The IS1-2 interface selector allows the SP600 to be interchanged with other Renishaw multiwire probe systems and automatically selects the correct interfacing, enabling analogue measurement to be fully integrated into a conventional automatic probing system. Touch-trigger (non-multiwired) probes can be used with a splitter cable. See '[SP600 in multiple Renishaw probe type installations](#)' for further information.

## SP600Q analogue measurement probe

SP600Q is a quill mounted version of the SP600M analogue scanning probe. It can therefore be connected directly to the quill of a CMM and an internal cable carries the probe signal to the interface card. This probe offers exactly the same benefits and operation as the SP600M, with identical integration issues.

## SP600 analogue measurement probe

SP600 is a shank mounted version of the SP600M analogue scanning probe. It can therefore be connected directly to the quill of a CMM and an external cable carries the probe signal to the interface card. This probe offers exactly the same benefits and operation as the SP600M, with identical integration issues.

## SP600 with overtravel unit

The SP600 overtravel unit is a protection device that can be fitted between a SP600 probe and its mounting shank. The overtravel unit contains a switch to indicate when the probe body has suffered a collision and the signal is supported by both the AC1 and AC2 interface cards. It is intended for use when the SP600 probe is used in a machine tool for scanning applications. For CMM usage the size of the overtravel unit make it unsuitable and the low forces applied by a CMM make it unnecessary.

## SH600 stylus holder

The SP600 / M / Q comprises the main body and a detachable stylus holder. The stylus holder is kinematically located onto the probe body to provide repeatable positioning of the stylus, and removes the requirement to re-qualify each stylus arrangement between holder changes. There are two variants of stylus holders in the range, SH600-STD and SH600-EXT. Both of these designs offer the ability to manually or automatically change the stylus on the SP600 probe allowing for stylus optimisation.

Effective crash protection is achieved by either the stylus holder becoming detached during a collision, or by setting a higher stylus deflection to alert the CMM of an unexpected collision. In this event, the robustness of the probe means that a simple re-qualification of the probe and stylus arrangement will enable work to continue.



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### SH600 - STD

This product is fitted to all SP600 and SP600M probes and is compatible with the SP600Q probe. The SH600-STD offers the following capabilities

- M4 stylus compatibility
- M3, M2 stylus compatibility using appropriate adaptors
- Up to 200 mm stylus length can be accommodated.

### SH600 - EXT

This product is fitted to all SP600Q probes and is compatible with SP600 and SP600M probes (manufactured after May 2002). The SH600-EXT offers the following capabilities

- M4 stylus compatibility
- M3, M2 stylus compatibility using appropriate adaptors
- Up to 300 mm stylus length capability

### SCR600 stylus changing rack

The SCR600 is a stylus changing rack for use with the SP600 / M / Q. It does not require any electrical connection for operation. A mechanism in the base provides overtravel protection in the probe entry direction. The rack can house up to four stylus modules and any number of racks can be used in a system.

### SCP600 stylus changing port

The SCP600 is a single stylus changing port, which is a component of a flexible modular stylus changing system. Several ports can be fitted onto a Renishaw modular rack system (MRS / MRS2) at user defined spacing, depending on requirements. SCP600s are particularly suited to the SP600Q probe, where for example star stylus clusters are unable to fit into an SCR600 stylus changing rack.

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### AC1 analogue counter PC card

The Renishaw AC1 PC interface card is simple to install and connects directly to a standard Renishaw multiwire probe signal cable.

- Performs probe management functions
- Communicates status information to the host PC
- Converts each of the three analogue probe outputs (one per axis representing stylus deflection) into 2's complement binary numbers accessible to the PC
- 12-bit resolution giving 1  $\mu\text{m}$  resolution

The AC1 contains a number of registers that are accessible to software using I/O commands.

### AC2 analogue counter PC card

The Renishaw AC2 PC interface has all the functions of the AC1, but in addition has:

- 16-bit resolution giving resolution better than 0.1  $\mu\text{m}$
- Optically isolated PICS interface
- Reading synchronisation using the PICS interface or software commands
- Probe power removal using PICS
- Full ISA bus address decoding
- Optional 16-bit data transfers via the addition ISA 36-way connector
- Interrupts generated on receipt of PICS or software ACQUIRE command
- $\Delta T$  controller compatibility is achieved by the use of option switches

The AC2 contains a number of registers that are accessible to software using I/O commands.

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# Probe dimensions

<p>SP600</p>	<p>SP600M</p>
<p>SP600Q quill mount</p>	<p>SP600Q</p>

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# Technical specification

## Probe

<b>Probe attributes</b>	3 axis measurement (X, Y, Z) Linear and parallel motion in all axes
<b>Measurement range</b>	±1 mm (±0.04 in) in all axes and orientations with a 50 mm (1.97 in) 4.6 g (0.16 oz) stylus
<b>Overtravel range</b>	X, Y and -Z protected by a kinematic joint
<b>Resolution with optional AC2 interface card</b>	0.1 µm (0.000004 in)
<b>Resolution with optional AC1 interface card</b>	1 µm (0.00004 in)
<b>Spring rate</b>	120 gmf/mm nominal (X, Y, Z)
<b>Damping</b>	20% (X, Y, Z) typical
<b>Weight</b>	SP600 probe: 172 g (6.1 oz) (excluding shank) SP600M probe: 216 g (7.6 oz) SP600Q probe: 299 g (10.5 oz)
<b>Power supply</b>	+12 V to -12 V, 5 V (±10%)
<b>Outputs (X, Y, Z)</b>	Analogue proportional Voltage output scaling: 4 V to 8.5 V/mm (dependant on stylus)
<b>Mounting</b>	SP600 adaptors to suit clutch, shank adaptor or CMM shank SP600M autojoint SP600Q is mounted directly to the quill of the CMM

## Interface

<b>Cabling</b>	Refer to appendix 2
<b>Outputs</b>	Analogue proportional

## Voltage output scaling

Axis	Stylus length 50 mm (1.968 in)	Stylus length 100 mm (3.937 in)	Stylus length 150 mm (5.9 in)
X	5.6 V/mm	4.8 V/mm	4.1 V/mm
Y	6.3 V/mm	5.1 V/mm	4.3 V/mm
Z	5 V/mm	5 V/mm	5.3 V/mm

The SP600 is designed to have 5 V/mm @ 100 mm stylus tip.

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# Application - scanning

The probe stylus moves across the surface of the work piece of known or unknown profile by servo control of the CMM with regard to stylus deflection. This is ideal for the inspection or modelling of forms and shapes which are not standard geometric elements, are complex or which require full profile measurement (i.e. cam profiles, turbine blades, moulds etc). Scanning gives much higher data acquisition rates than are possible using conventional probing methods. Large amounts of information about a surface can be collected in a short time, for example hundreds of point around a bore, giving more confidence in measurement results than touch trigger probing in the same period.



**WARNING:** There is no overtravel protection in the +Z axis other than an end stop. Your control system must therefore be able to stop the motion of the machine in the +Z axis of the probe before the end stop is reached. If this is not the case safety glasses must be worn when operating or observing the operation of the SP600M system in case of stylus breakage.

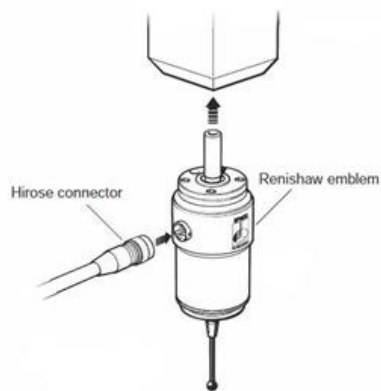
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# Probe installation

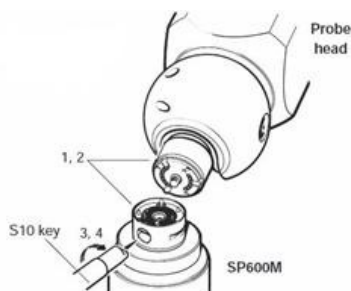
## SP600 probe

The shank mounted SP600 attaches simply and quickly to any CMM providing that the correct shank attachment has been ordered as shown below. The shank is inserted into a mechanical fixing mechanism and tightened into place, with the Renishaw emblem facing the front of the CMM. The probe cable should then be connected to the external Hirose connector on the side of the SP600.



## SP600M probe

The SP600M probe may be mounted on either the PH10M PLUS / PH10MQ PLUS range of motorised probe head or the PH6M fixed probe head by means of the Renishaw autojoint. Locking and unlocking of the autojoint is carried out either manually, using the autojoint key, as shown below, or automatically using the Renishaw autochange rack system. In both cases, the connection repeatability eliminates the need for probe requalification after exchange.



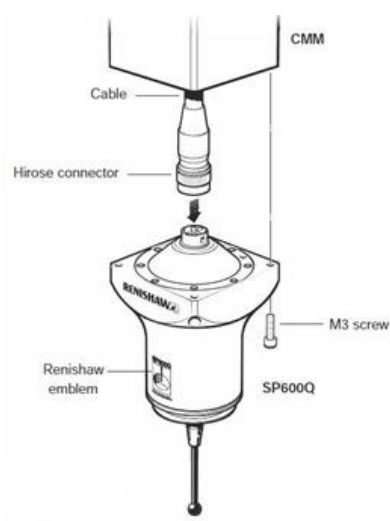
1. Align the black dot on the probe with the black dot on the head.
2. Locate the two halves of the joint together.
3. Insert the S10 key in the slot.
4. Turn the key clockwise until it locks tight.

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### SP600Q probe

The SP600Q is mounted directly onto the quill using four M3 screws as shown below. The cable (PL82V) is connected using a Hirose connector at the probe end. The Renishaw logo must be facing to the front of the CMM.



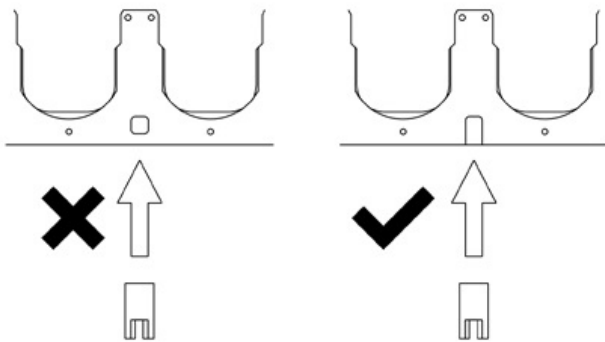
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# SCR600 mounting plate insert

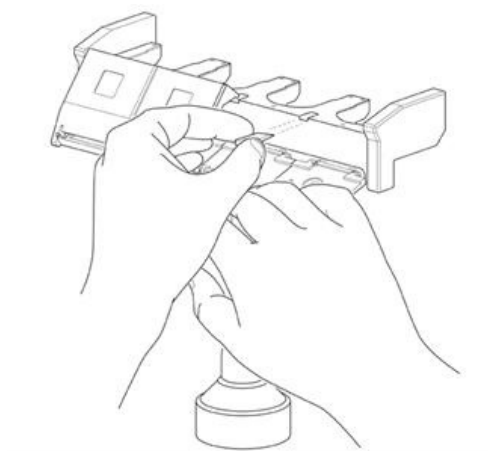
When using SCR600 with any of the range of SP600 probes with an aquablast finish it is necessary to fit these inserts otherwise problems may occur with the port lids staying open after a stylus change.

Any SCR600 manufactured prior to 2000 does not have the slots to allow for this insert to be fitted. If you do have a rack that is pre 2000 then you will need to contact your local Renishaw service centre for an RBE replacement. The image belows shows a top elevation of an SCR600 manufactured before and after 2000.



## Retrofitting SCR600 mounting plate inserts

Hold down port lids 1 and 2 and insert the mounting plate into the slot shown as below. Ensure that the mounting plate is fully inserted into the slot. Hold down port lids 3 and 4 and repeat the process. Please note that the middle slot on the SCR600 does not require a mounting plate to be inserted.





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# SCR600 installation

## Mechanical alignment

This section describes the mounting and physical alignment of the SCR600 stylus rack to a CMM axis.

### Step 1 - Mounting to the CMM

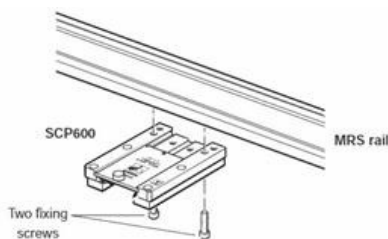
1. Secure the location plate to the CMM table using a suitable mounting screw.
2. Tighten securely.
3. Locate the SCR600 onto the location plate and turn the grub screw clockwise using a 1.5 mm hexagonal key.
4. Do not tighten fully.

### Step 2 - Physical alignment

1. Align the SCR600 to the CMM's X or Y-axis by probing on points one and two (P1 and P2 shown on page '[Datuming SCR600](#)').
2. Adjust the position so that the suggested maximum runout of 0.10 mm (0.0019 in) is achieved between P1 and P2.
3. Carefully tighten the grub screw.
4. The SCR600 is now ready for datuming (see page '[Datuming SCR600](#)').

## SCP600 installation onto MRS / MRS2

It is recommended that the stylus changing port units (SCP600) are attached to the rail using the following procedure where it is assumed that the MRS / MRS2 system is correctly installed. For full details, please refer to the MRS / MRS2 installation and user's guide (Renishaw part number H-1000-5088 / 5255):



1. Insert one of the fixing screws through the SCP600.
2. Offer up the SCP600 to the rail, positioning the fixing screw to the respective 'T' nut within the rail. Finger-tighten the screw.
3. Insert the other fixing screw through the SCP600 port.
4. Position the SCP600 so that the second screw locates into the respective 'T' nut in the rail. Finger-tighten the screw.
5. Using the hexagonal key supplied, hand-tighten the two fixing screws into the 'T' nut.

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# Datuming SCR600

## Software alignment for the SCR600

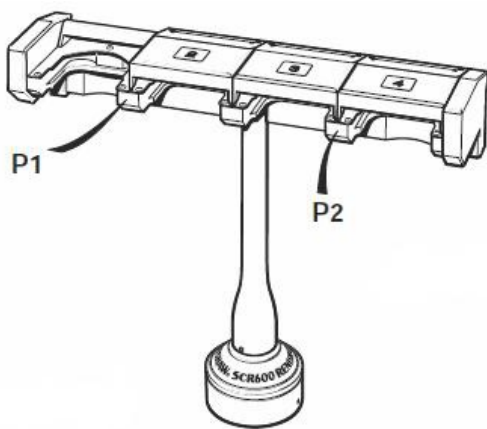
This section describes the suggested software alignment routine to find the positions of the SCR600 ports. These instructions assume that the SCR600 has the X-axis as its docking axis.

Port lids 1 and 4 should be in the retained position, which is achieved by sliding the lids back to the extreme of their travel where a magnet / slot mechanism will hold the lids open.

### Step 1 - Establishing docking depth (X)

- Take points P1 and P2 as shown below.
- To establish the docking depth (X-axis) for all ports, the following calculation should be used:

X position of P1 / P2 + stylus ball radius + 21.5 mm (0.85 in)



### Step 2 - Establishing docking height (Z)

- Take point P3 as shown below.
- To establish the docking height (Z-axis) for all ports, the following calculation should be used:

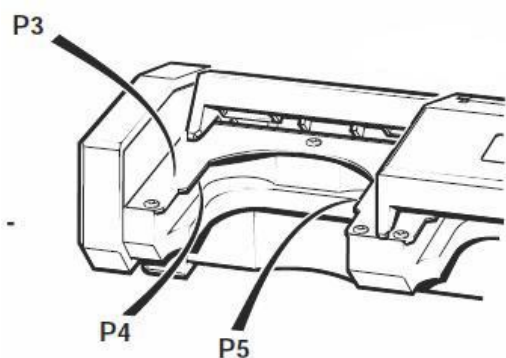
Z position of P3 - stylus ball radius - stylus length - 8.4 mm (0.33 in)

### Step 3 - Establishing docking centre for port 1 (Y1)

- Take points P4 and P5 as shown below.
- Calculate the centre line of these points.

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### Step 4 - Establishing docking centre for ports 2 to 4

- Using the centre of port 1 as a reference, add 53.5 mm (2.11 in) to establish the docking centre for port 2 (Y2)
- Using the centre of port 2 as a reference, add 53.5 mm (2.11 in) to establish the docking centre for port 3 (Y3)
- Using the centre of port 3 as a reference, add 53.5 mm (2.11 in) to establish the docking centre for port 4 (Y4)

### Position of docking target co-ordinates

Port 1 = X, Y1, Z

Port 2 = X, Y2, Z

Port 3 = X, Y3, Z

Port 4 = X, Y4, Z

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# SCR600 pick up / put down routine

## Put down routine for port (N)

The table below shows the steps involved in the put down routine for a stylus module.

Operation	X-axis	Y-axis	Z-axis
Inhibit the probe			
Clearance position	X(s)	Y(n)	0 mm
Move into docking target (SP600 loaded)	X	No change	No change
Detach stylus module	No change	No change	+8 mm (+0.31 in)
Exit port	X(s)	No change	No change



**CAUTION:** When performing a stylus module change with PH10 PLUS and SP600M, always lock and unlock in free space to ensure repeatability.

## Picking up routine for SCR600 port (N)

Operation	X-axis	Y-axis	Z-axis
Clearance position	X(s)	Y(n)	+8 mm (+0.31 in)
Move into docking target (SP600 loaded)	X	No change	No change
Attach stylus module	No change	No change	0 mm
Exit port	X(s)	No change	No change
Activate the probe			

X(s) = Safe position to start change cycle

Y(n) = Y axis position for port n



**CAUTION:** When using a SCR600 always load stylus modules automatically with the CMM and SP600.

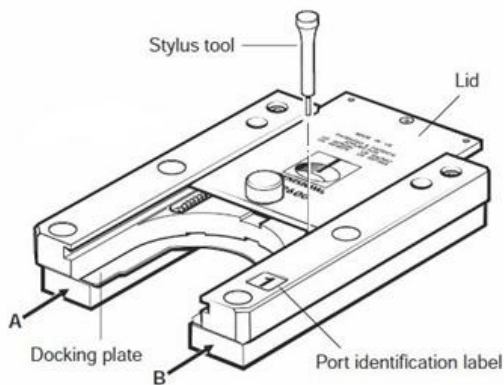
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# Datuming SCP600

**i** **NOTE:** As the SCP600 port is of modular design, it is suggested that the following routine is completed under manual control for each port installed.

The following is the recommended procedure for locating and datuming the SCP600 after it is fitted to the MRS rail, and is in position on the CMM table. The procedure assumes the SCP600 port is aligned to the CMMs axis, with a maximum run out of 0.5 mm across points A and B (instructions for fitting the SCP600 to the rail are given on page 'SCR600 installation').




1. Push the lid of the SCP600 port to the extreme of travel (this assumes that the SCP600 is connected to the MRS / MRS2 system at the time).
2. Place the stylus tool into the retaining hole at the rear of the SCP600 port.
3. Release the SCP600 lid so that the stylus tool holds the lid.
4. Take 4 points on the top face of the docking plate (plane 1).
5. Take 4 points in the circle at the rear of the SCP600 port docking plate (circle 1).
6. Create the datum for this port as follows:  
 X and Y axis origin = circle 1  
 Z axis origin = plane 1 – (stylus length + ½ stylus ball diameter + 8.4 mm)
7. Store this datum as the datum for the port.
8. Identify the port by placing the port identification label into the recess on the front of the port.

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# SCP600 pick up / put down routines

 **NOTE:** The following section assumes that the datum created in 'Datuming the SCP600' is the axis system that the machine is working in.

## Put down routine

The following table lists the recommended procedure for putting down a stylus module on the SCP600. All dimensions are absolute and given in mm.

Operation	X-axis	Y-axis	Z-axis
Inhibit the probe and move to stand-off position	0	50	8
Move into port	0	0	8
Detach stylus	0	0	0
Move to stand-off position	0	50	0

## Pick up routine

The following table lists the recommended procedure for picking up a stylus module from the SCP600. All dimensions are absolute and given in mm.

Operation	X-axis	Y-axis	Z-axis
Move to stand-off position	0	50	8
Move into port	0	0	8
Attach stylus	0	0	0
Move to stand-off position and activate the probe	0	50	0

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# Styli

The SP600 uses standard Renishaw M4 thread styli, that thread into the stylus holder (SH600-STD or SH600-EXT). Styli can be changed manually by screw or by exchange of the kinematic stylus holder using the SCR600 or SCP600 stylus change rack.

Always use the Renishaw stylus spanner provided to change styli to avoid damage to the stylus holder or stylus.

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# Probe measurement range

The measurement range of the probe is dependent on the following parameters:

- Nominal range of the probe
- Mass of the moving structure 50 g (1.94 oz)
- Spring rate of the moving structure 135 g/mm (4.76 oz/mm)
- Mass of the stylus
- Orientation of the probe with respect to gravity

For a vertically orientated probe (e.g. PH10 PLUS at A0°) the effect on the Z-axis measurement range, due to increased stylus mass can be calculated from:

$$\frac{\text{Stylus mass (g)}}{\text{Spring rate (g/mm)}}$$

e.g. for a stylus of 40 g mass:

$$\frac{40 \text{ g (1.76 oz)}}{135 \text{ g/mm (4.76 oz/mm)}} = 0.3 \text{ mm (0.012 in)}$$

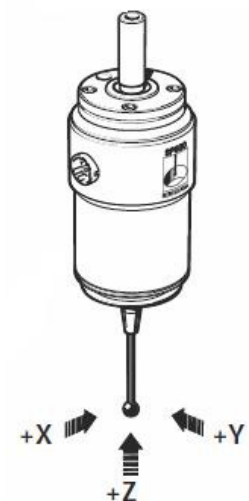
For a horizontally orientated probe (e.g. PH10 PLUS at A90°) the effect on the Y and Z-axes measurement range, due to the re-orientation through 90° can be calculated from:

$$\frac{\text{Mass of moving structure (g) + Stylus mass (g)}}{\text{Spring rate (g/mm)}}$$

e.g. for a stylus of 40 g mass:

$$\frac{50 \text{ g (1.76 oz)} + 40 \text{ g (1.41 oz)}}{135 \text{ g/mm (4.76 oz/mm)}} = 0.7 \text{ mm (0.028 in)}$$

## SP600 probe axes





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### Typical stylus tip measuring range

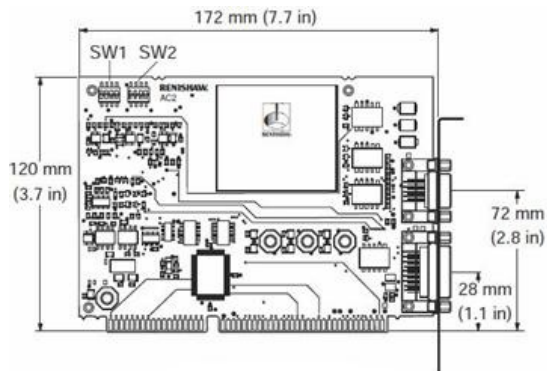
The table below gives an example of a typical probe's measuring range (at the stylus tip) for a range of stylus masses and probe orientations.

Stylus mass	Probe orientation	+X	-X	+Y	-Y	+Z	-Z
4.6 g (0.16 oz)	0°	1.6 mm (0.062 in)	1.6 mm (0.062 in)	1.6 mm (0.062 in)	1.6 mm (0.062 in)	1.8 mm (0.070 in)	1.6 mm (0.062 in)
20 g (0.71 oz)	0°	1.6 mm (0.062 in)	1.6 mm (0.062 in)	1.6 mm (0.062 in)	1.6 mm (0.062 in)	2 mm (0.078 in)	1.4 mm (0.055 in)
50 g (1.76 oz)	0°	1.6 mm (0.062 in)	1.6 mm (0.062 in)	1.6 mm (0.062 in)	1.6 mm (0.062 in)	2.2 mm (0.086 in)	1.2 mm (0.047 in)
4.6 g (0.16 oz)	90°	1.6 mm (0.062 in)	1.6 mm (0.062 in)	1.2 mm (0.047 in)	2 mm (0.078 in)	1.4 mm (0.055 in)	2 mm (0.078 in)
20 g (0.71 oz)	90°	1.6 mm (0.062 in)	1.6 mm (0.062 in)	1 mm (0.039 in)	2.2 mm (0.086 in)	1.4 mm (0.055 in)	2 mm (0.078 in)
50 g (1.76 oz)	90°	1.6 mm (0.062 in)	1.6 mm (0.062 in)	0.8 mm (0.031 in)	2.4 mm (0.094 in)	1.4 mm (0.055 in)	2 mm (0.078 in)

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# AC2 interface card



The AC2 card is a 16-bit ISA expansion card that is designed to fit into one of the 16-bit expansion slots provided in a PC.



The AC2 contains static sensitive components. Observe anti-static handling precautions, including the use of earth straps during handling and installation.

## AC2 I/O space base address

The AC2 is supplied set to I/O base address 0200H 16-bit wide data and ISA bus mode. If the base address is already used, or the PC has difficulty in accessing the card, then the base address can be changed to one of the following by altering the switches on the card as shown below.

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PC function	Address	Switch (SW1) way 1	Switch (SW1) way 2	Switch (SW1) way 3	Switch (SW1) way 4
Games adaptor	0200 <sub>H</sub>	Off	Off	Off	Off
PC expansion port	0210 <sub>H</sub>	On	Off	Off	Off
Prototype adaptor	0280 <sub>H</sub>	Off	On	Off	Off
Prototype adaptor	0300 <sub>H</sub>	On	On	Off	Off
Not defined	0310 <sub>H</sub>	Off	Off	On	Off
Not defined	0320 <sub>H</sub>	On	Off	On	Off
Not defined	0340 <sub>H</sub>	Off	On	On	Off
Not defined	0350 <sub>H</sub>	On	On	On	Off
Not defined	0390 <sub>H</sub>	Off	Off	Off	On
Not defined	03A0 <sub>H</sub>	On	Off	Off	On
Not defined	0480 <sub>H</sub>	Off	On	Off	On
Not defined	0520 <sub>H</sub>	On	On	Off	On
Not defined	0540 <sub>H</sub>	Off	Off	On	On
Not defined	0550 <sub>H</sub>	On	Off	On	On
Not defined	0590 <sub>H</sub>	Off	On	On	On
Not defined	05A0 <sub>H</sub>	On	On	On	On



**NOTE:** All 16 address bits on the PC expansion bus are decoded. Clashes are still possible with the addresses of other adaptor cards if their base addresses are set below 400H and match the lower 10 bits of the AC2 addresses.

## AC2 SW2 settings

The AC2 can operate with 8 or 16-bit wide data and (with a suitable hardware adaptor) support the Delta\_Tau bus used in some CMM controllers. SW2 allows these selections to be made.

	Switch (SW1) way 1	Switch (SW1) way 2	Switch (SW1) way 3	Switch (SW1) way 4
Switch setting	8/16-bit	AUX_SW1	Reserved	Reserved
Off	16-bit	ISA BUS	Future use	Future use
On	8-bit	Delta_Tau BUS	Future use	Future use



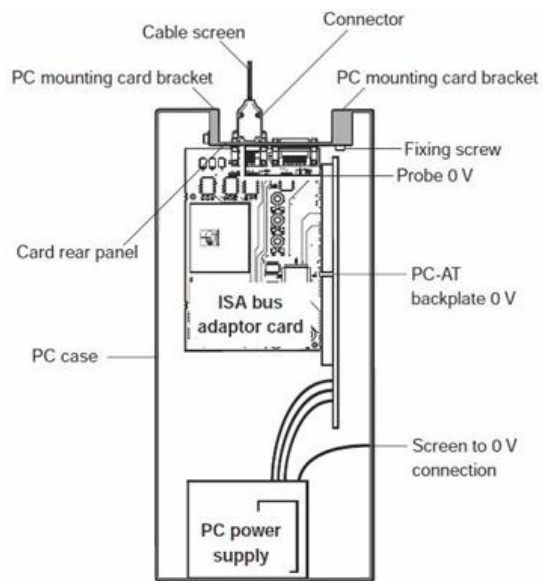
**CAUTION:** SW2 way 2 must be set correctly for ISA bus operation, otherwise damage may be caused either to the AC2 or the host PC.

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# AC2 screening

The AC2 adopt the standard screening arrangement for IBM style PCs, shown below.



If the host PC screening is different to this arrangement, then the accuracy of the SP600 / AC2 system may be impaired.

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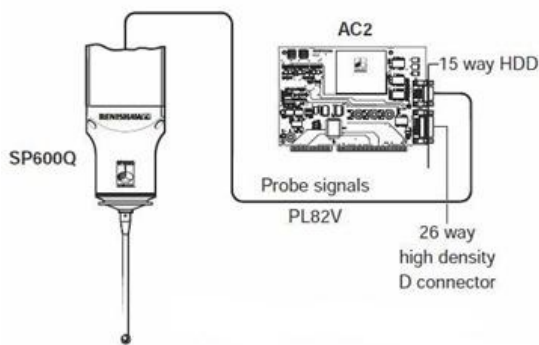
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# System connection

The SP600 probe connects to the AC2 via the PH10M PLUS or PH6M head and standard multiwire cables. This cable connects directly to the PH10M PLUS or PH6M head via a micro 'D' and terminates in a 15-way high-density 'D' which connects directly to the rear panel of the AC2 card.

System connections are as shown in the following illustrations. Ensure all cables are screwed firmly into their sockets. For further information on cables see '[SP600 cables](#)'.

### SP600Q with AC2

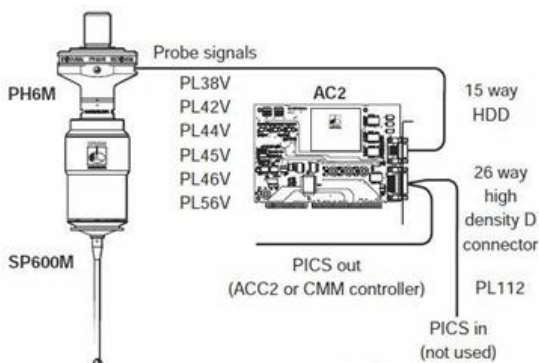


### Overtravel unit

As the overtravel unit cannot be used, one of the following is required:

- Ignore the overtravel bit of the AC2 status byte
- Link pins 17 and 18 of the 26-way high density D connector.

### SP600M and PH6M with AC2



### Overtravel unit

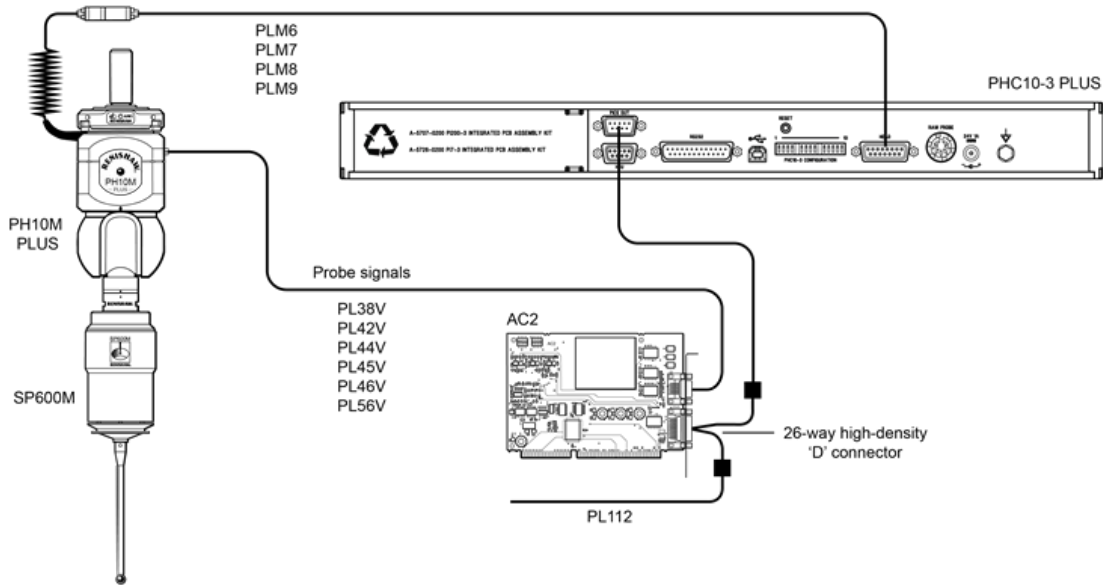
As the overtravel unit cannot be used, one of the following is required:

- Ignore the overtravel bit of the AC2 status byte
- Link pins 17 and 18 of the 26-way high density D connector.

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### SP600M and PH10M PLUS with AC2



### Overtravel unit

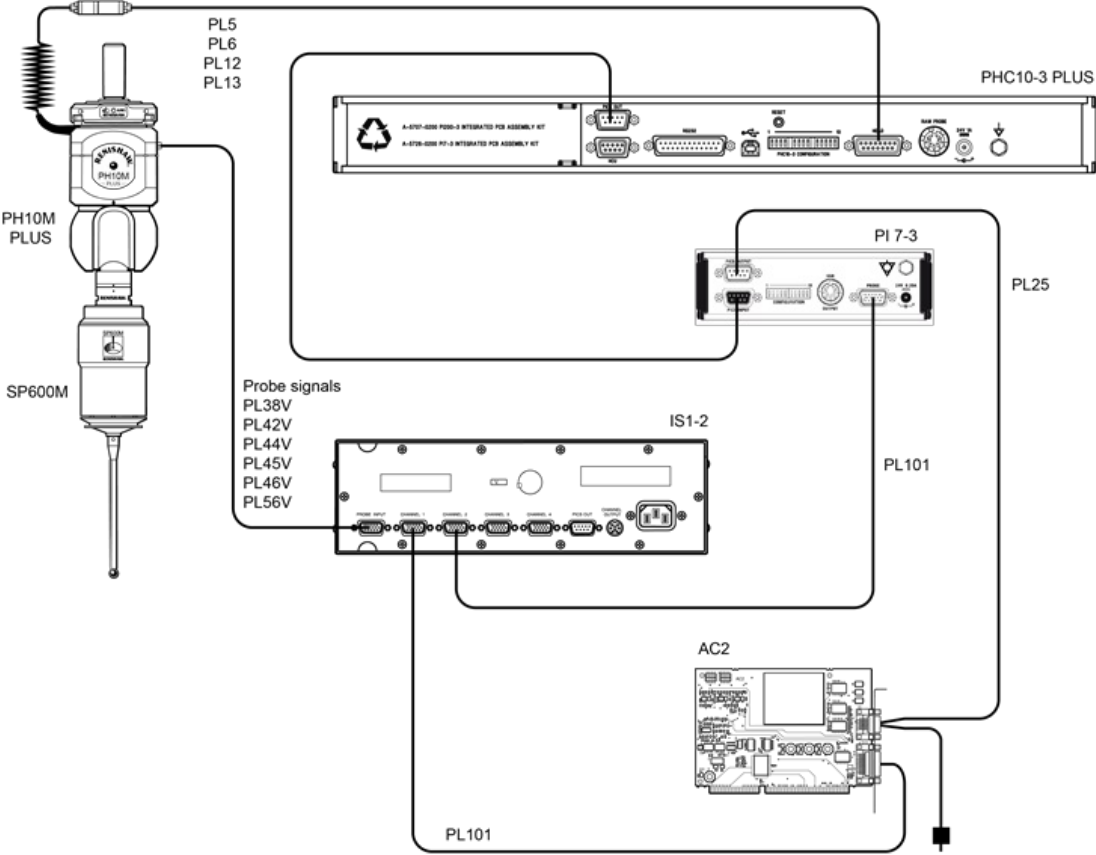
As the overtravel unit cannot be used, one of the following is required :

- Ignore the overtravel bit of the AC2 status byte
- Link pins 17 and 18 of the 26-way high density D connector

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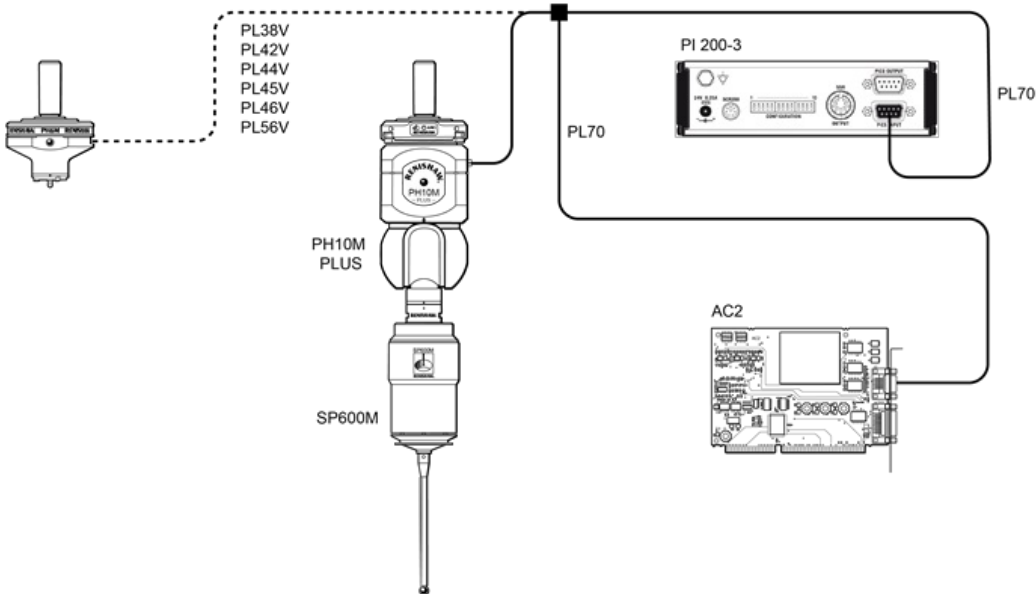
SP600M and PH10M PLUS with AC2, PI 7-3 and IS1-2



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## SP600M with two wire touch-trigger probe





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# Using the AC2 card

The AC2 is completely controllable by software. It also contains a 16 byte register set in I/O space that can be accessed starting from the base address selected in '[AC2 I/O space base address](#)'.

## Features

The AC2 has the same features as the AC1, but in addition has:

- Integral measurement event timer
- Detection of a connected SP600 / M / Q
- Probe power supply protection with failure monitoring
- Interface for the SP600 overtravel unit
- An optional 16-bit or 8-bit ISA bus interface in I/O space
- An option to connect to a Delta Tau controller (customer supplied wiring adaptor required)
- X, Y and Z measurement channels with a resolution of 16 bits
- 6 software selectable operating modes
- Hardware synchronisation of data acquisition in 5 of the operating modes
- ISA bus interrupt on data acquisition (in mode 3)
- Probe power supply protection with resettable fuses
- Paged version identification at the AC2 board identification register

## ISA/ Delta Tau bus interface

The AC2 address space is in I/O space when the ISA bus is selected. Accesses in memory space are not permitted. The bus interface can operate with 8-bit data (bytes) or 16-bit data (words). Selection of the ISA/ ΔT busses, base address and 8/16-bit modes are with selection switches.

## X, Y and Z measurement channels

These have 16-bit resolution. Each time the ACQUIRE bit (bit "11" of register "13") is written to with a "1", or the appropriate synchronisation hardware is activated, the SP600 axis deflections are acquired and presented in registers "5" to "0", and the time latched into registers "7" and "6".

## Integral measurement event timer

This timer has a resolution of 256 microseconds and a maximum value of 16.78 seconds. The timer count register is updated every time the SP600 deflections are acquired. The timer can be reset to zero when the RESET TIMER bit (bit "8" of register "13") is written to with a "1". If the timer reaches its maximum count value of 65536, the TIMER OVERFLOW bit is set to "1". This can be inspected by reading the AC2 status register (bit "5" if register "14"). The TIMER OVERFLOW bit is reset to "0" when the timer is reset.

## Detection of a connected SP600/M/Q

This is carried out automatically by the AC2. When the AC2 recognises that it is connected to an SP600 / M / Q probe, it applies power to the probe. Software can inspect whether a probe is fitted by first writing a "1" to the REQUEST SET PROBE PRESENT bit (bit "10" of register "13"), then reading the PROBE PRESENT bit will be reset to "0" automatically. This feature is included so that software can detect that a probe has been disconnected, then reconnected since the PROBE PRESENT bit was last inspected.

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### Probe power supply protection with failure monitoring

The probe power supplies are protected from overcurrent by self resetting fuses (polysilicon current limiting devices) in each supply line. When an overcurrent occurs, the AC2 automatically removes all power from the probe and sets the appropriate OVERCURRENT bit. Software can inspect the status of these bits by reading the AC2 status register (bits "0", "1" and "2" of register "14").

### Interface for the SP600 overtravel unit

In some applications an SP600 may be fitted with an overtravel unit. Software can inspect whether the probe is not overtravelled by first writing a "1" to the REQUEST RESET OVERTRAVEL bit (bit "9" of register "13"), then reading the OVERTRAVEL STATUS bit in the status register (bit "3" of register "14"). When the SP600 is overtravelled, the OVERTRAVEL bit will be set to "1" automatically. This feature is included so that software can detect that the probe has been overtravelled momentarily since the OVERTRAVEL bit was last inspected.

### AC2 board identification byte

Software is able to read this byte at any time when the page register ("base + 8") is set to 00H, to confirm that the adaptor board fitted at the expected base address is indeed AC2. Upon power up, the page register is set to 00H allowing software to read this identification byte without writing to the board.

The AC2 identification byte varies, depending upon the selected bus width of the AC2. When it is in 8-bit mode, the ident is 0CH. In 16-bit mode, the ident is 0BH. Most Renishaw ISA bus adaptor cards have a unique board identification byte at the address "base + 15".

### AC2 board version number bytes

The AC2 is the first Renishaw ISA bus product to have a software readable, hardware version numbering. The HARDWARE VERSION can be read from "base + 15" when the page register ("base + 8") has been written to with 01H. This number is incremented every time there is a change to the design, whether this is visible to the customer or not.

Often, changes to the hardware are invisible to the customer, such as when a component that is no longer available causes the design to be changed, so changes to the hardware that cause a consequential change to the customer's software cause the SOFTWARE VERSION number to be incremented.

When the page register has been written to with 02H, the SOFTWARE VERSION number can be read from "base + 15". The software version is incremented by Renishaw, when a change has been made to the design that requires a change to the customer's software.

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# AC2 software interface

## Board identification (base address + 15)

This read-only register returns the value 0CH if the board is in 8-bit mode or 0BH if the board is in 16-bit mode.

## Status register (base register + 14)

This read-only register returns the status of the AC2 card. Status bits are as follows:

### Bit 7

Not used.

### Bit 6 - BUSY

This bit is set to "1" when the AC2 has been commanded to acquire data. It is reset to "0" when the data conversion is complete. This takes approximately 15 µs.



**NOTE:** The host PC should not attempt to read the probe deflections or the timer value while the BUSY bit is set to 1. Any data read during this period will be invalid.

### Bit 5 - TIMER OVERFLOW

This bit is set to "1" when the timer has overflowed. It is reset to "0" when the timer has been reset.

### Bit 4 - PROBE PRESENT

This bit is set to "1" if an SP600 / M / Q probe has been connected to the AC2 and the REQUEST SET PROBE PRESENT bit has been written to with a "1" (see '[Detection of a connected SP600 / M / Q section](#)'). If the probe is disconnected from the AC2, then the bit automatically resets to "0".

### Bit 3 - OVERTRAVEL ERROR

This bit is set to "1" if the overtravel unit is overtravelled or not connected. It is set to zero if the overtravel unit is connected, not overtravelled, and the REQUEST RESET OVERTRAVEL bit has been written to with a "1" (see '[Interface for the SP600 overtravel unit](#)').

### Bit 2, 1, 0 - OVERCURRENT STATUS FLAGS

These show the status of the three probe output overcurrent protection devices on the AC2. They are set to "1" when one of the probe supplies has had an overcurrent.

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### AC2 I/O map

Register name	Base address offset	Bit reference	Data	Read / write
X axis LO byte	0	7 to 0	2's complement 12 bit count 8000H to 7FFFH	Read only
X axis HI byte	1	15 to 8	2's complement 12 bit count 8000H to 7FFFH	Read only
Y axis LO byte	2	7 to 0	2's complement 12 bit count 8000H to 7FFFH	Read only
Y axis high byte	3	15 to 8	2's complement 12 bit count 8000H to 7FFFH	Read only
Z axis LO byte	4	7 to 0	2's complement 12 bit count 8000H to 7FFFH	Read only
Z axis HI byte	5	15 to 8	2's complement 12 bit count 8000H to 7FFFH	Read only
Timer LO count	6	7 to 0	16 bit binary count 0000H to FFFFH	Read only
Timer HI count	7	15 to 8	6 bit binary count 0000H to FFFFH	Read only
Page selection	8	N/A	Selects pages 0, 1 or 2	N/A
Not used	9	15 to 8	Reads back 00H	Read only
PICS and interrupt status	10	7 to 0	Bits are set if the condition is true	Read only
Not used	11	15 to 8	Reads back 00H	Read only
Acquisition mode selected	12	7 to 0	Set the bit to command the function	Read / write
Command register	13	15 to 8	Write 1 to the relevant bit to activate	Write only
Status register	14	7 to 0	Bits set to logic 1 if condition true	Read only
AC2 board identification	15	15 to 8	Page 0 returns the value 0BH or 0CH	Read only

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### PICS and interrupt status register definitions

7	Not used (set to logic 1)
6	Not used (set to logic 1)
5	Not used (set to logic 1)
4	Not used (set to logic 1)
3	PICS READ
2	PICS PDAMP
1	PICS PPOFF
0	Interrupt requested

### Command register definitions

7	Not used (set to logic 0)
6	BUSY
5	TIMER OVERFLOW
4	PROBE PRESENT
3	OVERTRAVEL
2	5 V OVERCURRENT
1	-12 V OVERCURRENT
0	+12 V OVERCURRENT

### Acquisition mode register definitions

7	Interrupt line select bit 2
6	Interrupt line select bit 1
5	Interrupt line select bit 0
4	Level / shared interrupt mode selection
3	Not used
2	Acquisition mode select bit 2
1	Acquisition mode select bit 1
0	Acquisition mode select bit 0

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### Command register definitions

15	Not used
14	Not used
13	Not used
12	Not used
11	ACQUIRE data and latch timer count (sets BUSY true until complete)
10	REQUEST SET PROBE PRESENT
9	REQUEST RESET OVERTRAVEL
8	RESET TIMER

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### Command register (base address + 13)

This write-only register allows the software to control the AC2. Functions are commanded by writing a "1" to the appropriate bit. When a "0" is written to a bit, nothing happens. This allows the software to control individual functions by writing to selected bits with a "1", while leaving the other bits set to "0".

The command bits are shown below:

#### Bits 15 to 12

Not used

#### Bit 11 - ACQUIRE data and latch timer count

Writing a "1" to this bit causes the AC2 to acquire the SP600 axis deflections and latch the time stamp. The data is presented in registers "5" to "0", and the time stamp is latched into registers "7" and "6". While the data acquisitions process takes place, its progress can be monitored by inspecting the BUSY bit in the status register. Writing a "1" to this bit can take place in any of the AC2 operating modes and will result in data acquisition.

#### Bit 10 - REQUEST SET PROBE PRESENT

Writing a "1" to this bit causes the AC2 to sample the state of its probe identification circuitry. Upon writing to this bit, the PROBE PRESENT bit in the status register is set to "1" if an SP600/M/Q probe is present.

#### Bit 9 - REQUEST RESET OVERTRAVEL

Writing "1" to this bit causes the AC2 to sample the state of its overtravel circuitry. Upon writing to this bit, the OVERTRAVEL bit in the status register is set to "0" if an overtravel unit is connected and not overtravelled.

#### Bit 8 - RESET TIMER

Writing a "1" to this bit causes the AC2 to reset the AC2 timer to 0000H and resets the TIMER OVERFLOW flag to "0".

### Acquisition mode select register (base address + 12)

This read/write register allows the software to set the AC2 to the required acquisition mode, with a selected interrupt (if required).

The command bits are shown below:

#### Bits 7 to 5 - INTERRUPT SELECTION

Writing the data pattern shown in the table below will select the interrupt shown in the table. Interrupts are valid in acquisition modes 3, 4 and 5. Upon power up, IRQ3 is selected.

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### Interrupt request line

Selection interrupt line bit 765	IRQ	IBM ISA bus definition
000	IRQ3	Serial port 2
001	IRQ5	Parallel port 2
010	IRQ7	Parallel port 1
011	IRQ9	Software
100	IRQ10	Reserved
101	IRQ11	Reserved
110	IRQ12	Reserved
111	IRQ15	Reserved

### Bit 4 - SHARED/LEVEL INTERRUPT MODE SELECTION

Writing a "1" to this bit enables shared interrupt mode. Writing a "0", enables level interrupt mode. Upon power up, level interrupt mode is selected.

### Bit 3

Not used

### Bits 2 to 0 - ACQUISITION MODE

Writing the data pattern shown in the table below will select the acquisition mode in the table. Upon power up, mode 0 is selected.

### Acquisition mode bit select

Acquisition mode bit 210	Mode	Mode type
000	0	ISA bus acquire without PICS SYNC (default)
001	1	ISA bus acquire with PICS SYNC and HALT
010	2	PICS READ without interrupt
011	3	PICS READ with interrupt
100	4	Reversed direction interrupt without PICS SYNC
101	5	Reversed direction interrupt with PICS SYNC
110	0	ISA bus acquire without PICS SYNC (default)
111	0	ISA bus acquire without PICS SYNC (default)



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### DATA ACQUISITION MODES

The AC2 has six modes for acquiring measurement data. These are described below:

#### Mode 0

This is the default mode of operation after power has been applied to the AC2 or a system reset has occurred. AC2 does not respond to the PICS READ command, or reversed direction interrupt, nor generate PICS SYNC or any interrupt. When the user writes a "1" to bit "11" of the command register ("base +13") the timer value is latched, the BUSY bit is set and the conversation of the three measurement channels begins. When the data from the measurement channels is available to be read over the ISA bus, the BUSY flag is lowered and the AC2 is ready for another conversation.

#### Mode 1 ISA bus acquire with PICS SYNC

This mode is identical to mode 0 with additional activity on the PICS interface. During the period that the BUSY bit is set, PICS SYNC is set to its active state.

#### Mode 2 PICS READ without interrupt

In this mode the AC2 responds as in mode 0 when to bit "11" of the command register is written to with a "1". In addition, on the falling edge of the PICS READ signal, the timer value is latched, the BUSY bit is set and the conversation of the three measurement channels begins. The BUSY bit is lowered in the same way as for mode 0.

#### Mode 3 PICS READ with interrupt

This is identical to mode 2, except that when the BUSY bit is lowered at the end of the data acquisition, the interrupt selected by bits "7", "6", "5" and "4" of the acquisition mode selection register becomes active. The interrupt is cleared by reading any AC2 register. This feature has been included so that customers who do not want to bother resetting the interrupt bit can just read the measurement register.

It is essential that any user who wants to read the interrupt bit at address "base +10", reads this address first after the interrupt has occurred. If the user does not, the interrupt will be cleared and the bit in the status register will be reset to "0" before the software has read it.

#### Mode 4 Reversed direction interrupt without PICS SYNC (used by some CMM controllers)

In this mode the AC2 responds as in mode 0 when to bit "11" of the command register is written to with a "1". In addition, when the AC2 sees a rising edge on the interrupt selected by bits "7", "6" and "5" of the acquisition mode selection register, the timer value is latched, the BUSY bit is set and the conversation of the three measurement channels begins. The BUSY bit is lowered in the same way as for mode 0. A second conversion will not occur until after the selected interrupt has gone to logic "0" again. Bit "4" of the acquisition mode register is ignored.

#### Mode 5 Reversed direction interrupt with PICS SYNC

This is identical to mode 4 with additional activity on the PICS interface. During the period that the BUSY bit is set, PICS SYNC is set to its active state for the duration of the BUSY period.

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### Using INTERRUPTS

The AC2 can use any of the following interrupts: IRQ3, IRQ5, IRQ7, IRQ9, IRQ10, IRQ11, IRQ12 and IRQ15. These are selected by bits "7", "6" and "5" of the acquisition mode select register. An interrupt is only generated when acquisition mode 3 is selected.

One of two interrupt methods is selected by bit "4" of the acquisition mode select register. When previously written with a "1", shared interrupt operation will occur. The host PC (bus master) holds the interrupt line high with a passive pull up resistor. When the AC2 requests an interrupt it generates an active low pulse on the interrupt line selected using a driver that generates an active low or high impedance output. This pulse lasts for approximately 500 ns. The bus master determines that the AC2 is the source of the interrupt by polling the PICS and interrupt status register.



**NOTE:** Reading any of the AC2 registers resets the interrupt bit, therefore it is essential that the polling routine reads this register only.

After power on or reset, or after a "0" is written to bit "4" of the acquisition mode select register, level interrupt operation will occur. This is described in the IBM PC-AT technical reference manual. In this mode, the AC2 drives the interrupt line to logic "0" when the interrupt mode has been selected. When an interrupt is needed, the AC2 asserts it by driving the selected interrupt line to logic "1". The interrupt line returns to logic "0" and the interrupt bit is cleared when any register in the AC2 is read by the bus master. All unselected interrupt lines present a high impedance to the ISA bus, except when the ΔT bus interface is selected. When this occurs, all interrupts will be set to logic "0".

In either mode, after an interrupt has occurred, bit "0" of the PICS and interrupt status register is set. This bit is cleared by reading any register in the AC2.

### INTERRUPT TESTING

Simulating the use of interrupts in both modes using the ACQUIRE bit of the command register described in section 4.3.4 is possible. Writing "1" to this register causes the AC2 to respond as though it has received an interrupt signal when the AC2 has been set to acquisition Modes 4 and 5. It causes the acquisition of data and the generation of an interrupt when the AC2 has been set to acquisition mode 3.

### PICS and interrupt status register (base address + 10)

This read only register returns the status of the AC2 card. The status bits are shown below:

#### Bits 7 to 4

Not used

#### Bit 3 - PICS READ

This bit is set to "1" when PICSREAD is asserted (pulled low) by a device connected to the PICS interface. It is reset to "0" when PICSREAD is unasserted.

#### Bit 2 - PICS PDAMP

This bit is set to "1" when PICSDAMP is asserted (pulled low) by a device connected to the PICS interface. It is reset to "0" when PICSDAMP is unasserted.

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### Bit 1 - PICS PPOFF

This bit is set to "1" when PICS PPOFF is asserted (pulled low) by a device connected to the PICS interface. It is reset to "0" when PICS PPOFF is unasserted.

### Bit 0 - INTERRUPT

This bit is set to "1" when the AC2 asserts an interrupt in mode 3, or when the AC2 is receiving an interrupt in modes 4 and 5. It is reset to "0" when the selected interrupt is not asserted.

### Page register (base address + 8)

Writing to this register selects the data that is presented at address base + 15, shown in the following table:

Base + 15	Contents
Page 0	IDENTITY BYTE "0CH" when 8 bit mode is selected or "0BH" when 16-bit mode is selected.
Page 1	HARDWARD VERSION NUMBER. This shows the version of the assembly drawing of the adaptor card. Application software must read and present this number to the customer on request, but the software execution will not depend upon its value.
Page 2	FUNCTIONALITY REVISION NUMBER. This shows the version of the functionality of the adaptor card. This number will be incremented each time a change is made to the adaptor card that changes its functionality. For applications that are safely critical (e.g. motion control, cutting tool enabled, etc) the software must check that it is using a version of the adaptor card for which it was designed. If the software does not contain a device driver for the version of the card, it must generate an error message and not attempt to operate the card.



**CAUTION:** If the FUNCTIONALITY REVISION NUMBER of the AC2 has changed, it is still the software designer's responsibility to ensure that any existing software is still compatible with the new version of the AC2.

### Timer count LO and HI bytes (base address +7 and +6)

These read-only registers return the latched LO and HI byte of the AC2 internal timer. The latched timer value is updated each time axis deflections are required.



**NOTE:** It is possible for the counter to have an offset of up to 1 µs from the time of writing to the RESET TIMER bit.

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### Axis deflection LO and HI bytes (base address +5 through to 0)

These read-only registers return the LO and HI byte of the X, Y and Z axis deflections of the probe. The format of these values is 2's complement 16-bit counts which can take any value between  $8000_{\text{H}}$  and  $7FFF_{\text{H}}$ . The deflections are only updated when an appropriate hardware synchronisation is sent to the AC2 or the acquire bit is written to.

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# SP600 probe connector

## Probe connector signal definitions

The probe connector is a 15-way high density 'D' socket. Its pin-out is shown in the table below.

Connector pin no.	Description	Type
1*	+5 V	Power output
2	N/C	High impedance
3	0 V_POWER	Power return
4*	Y	Signal input
5*	Z	Signal input
6*	+12 V	Power output
7*	-12 V	Power output
8	Probe identification	Signal input
9	N/C	High impedance
10	N/C	High impedance
11*	X	Signal input
12	0 V_REF	Signal input
13	N/C	High impedance
14	Head LED anode	Signal output
15	Head LED cathode	Signal output
Shell	Screen	Protective ground

\* Isolated to >100 kΩ when the probe is disconnected or not recognised as SP600.

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# SP600 overtravel / PICS connector

## Overtravel / PICS connector signal definitions

This 26-pin high-density 'D' type plug replaces the 9-pin 'D' type overtravel connector on the AC1. Adaptor cables are available to allow connection to an existing overtravel cable (PL113) and to standard Renishaw PICS cables (PL112). Its pin-out are shown in the table below:

Connector pin no.	Description	Type
1*	_____ STOP (OUT)	Signal output
2*	_____ PPOFF (OUT)	Signal input
3*	0 V (OUT)	Power return
4	+5 V (OUT)	Power output
5	_____ SYNC (OUT)	Signal output
6	_____ HALT (OUT)	Signal output
7*	_____ PDAMP (OUT)	Signal input
8*	_____ LEDOFF (OUT)	Signal output
9	_____ READ (OUT)	Signal input
10	PROBE RETURN	High impedance
11	N/C	High impedance
12	N/C	High impedance
13	N/C	High impedance
14	N/C	High impedance
15	N/C	High impedance
16	N/C	High impedance
17	O/T RETURN	Power return
18	OVERTRAVEL	Signal input
19*	_____ LEDOFF (IN)	Signal output
20*	_____ PDAMP (IN)	Signal input

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Connector pin no.	Description	Type
21	150R PULL UP	Signal input
22	PROBE SIGNAL	High impedance
23	LEDA (IN)	Signal output
24*	0 V (IN)	Power return
25*	_____ PPOFF (IN)	Signal input
26*	_____ STOP (IN)	Signal output
Shell	Screen	Protective ground

\* Signals connected from the PICS IN to PICS OUT connector.

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# Using the SP600, SP600M and SP600Q

## Qualification

The SP600M family of probes require qualification before they are able to give accurate positional data. Renishaw has extensive experience of scanning, and offers support and advice on scanning algorithms and control software. Please contact your local Renishaw subsidiary for further information.

## Modes of operation

The SP600M is an analogue output measurement probe and may be used in a variety of ways. Principally, these will be as either a single point measurement or a profile measurement/digitising probe.

### Scanning mode

SP600 can be used as a continuous deflection analogue contact scanning probe for profile measurement or for surface digitising purposes. In this case the CMM controller must respond to the deflections of the probe in real time to maintain surface contact, i.e. 6 axes must be controlled simultaneously.

### Single point measurement mode: Extrapolate to zero method

Data is acquired whilst in contact and moving normal to the surface, either on the way in or whilst backing off. This is extrapolated to the zero surface position. It has the advantage that the measurement takes place at zero force, minimising the deflection on probe, stylus and CMM, and additionally that the probe does not need calibration.

### Static point measurement mode: Static averaging method.

SP600 can be used to take single points to give increased accuracy whilst reducing the effects of machine vibration by performing static averaging.

The probe's stylus should be made to contact the workpiece and deflect the stylus to the recommended amount (50 microns). The CMM should be halted and kept nominally stationary.

Whilst the machine is stationary surface position readings should be taken which are then averaged to give one single surface point. The longer the system is kept stationary, the more readings can be gathered, to give a more accurate result and to average out the effect of machine vibration.



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### Single point measurement mode: THRESHOLD METHODS

There are two types of threshold method as described below. Type1 takes data whilst driving the probe onto the part to a pre-set deflection threshold, whilst type 2 takes data whilst backing off to the pre-set deflection threshold.

#### Type 1

A target deflection threshold should be set. The probe is driven onto the part until this target deflection threshold is seen, at which time the controller simultaneously stores all CMM axes together with the probe deflections - this is the data point.

#### Type 2

A target deflection should be set. Additionally, an upper target deflection should be set which will enable a back off move to the target deflection to be executed at a constant velocity. The probe is driven onto the part until the upper target deflection is seen; at which time the motion should halt and a back off move should commence. When the target deflection is seen, the controller simultaneously stores all CMM axes together with the probe deflections - this is the data point. This method is more accurate than type 1 above.

### Probe deflections

±1 mm (0.04 in) is guaranteed in all axes and in all orientations with a 50 mm (1.97 in) 4.6 g (0.16 oz) stylus.

The probe scales give an absolute positional reading. This means that the probe may be switched off and on and used again without the need for recalibration, the scale readings will be in the same positions each time.

### Maximising performance

The optimum deflection (for accuracy) used during calibration is ideally kept to a minimum (i.e. 200 microns).

### Operation limits

The CMM must set operating limits for the probe, these are defined by:

#### Minimum probe deflection

Below which the CMM regards the stylus as not in contact with a surface.

#### Maximum probe deflection

Above which the stylus is beyond the probe's measurement range and is likely to overtravel.

#### Soft limit

A value below the maximum probe deflection. When this deflection is reached, the CMM recognises that the stylus is close to the limits of the probe's range and that it must take action to re-centre the probe. Renishaw recommends that this limit is set 0.25 mm (0.01 in) below the maximum probe deflection, although this may not always be possible and may be altered depending upon the CMM control characteristics, scanning speed etc.

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### Reorientation

The SP600M probe may be used in different orientations when mounted on a Renishaw PH10M PLUS motorised head. The design has been optimised to allow this but it will have some effect on the distribution of the measuring ranges available in each axis.



**NOTE:** When using a SP600 with PH10MQ, a PEM25 extension bar is required to achieve  $A = 97.5^\circ$  or  $A = 105^\circ$  in all B-axis positions.

### Return to zero

The probe has a nominal absolute centre position where the functions of stylus configuration and probe orientation cause it to rest. Because of small amounts of internal friction, when the probe is displaced from this zero point, the stylus will not return to exactly the same point on the scale and the axis deflection readings will show a different value.

This characteristic of probe performance is called RETURN TO ZERO and is a feature of all analogue probes and is not a source of error as the scale system continues to monitor position. Rather it is merely a factor which must be taken into account when designing control software for using the probe. It can be given a value which represents the diameter of a sphere around the nominal zero position within which the probe will return to reset after any displacement.

SP600M has a return to zero value of less than 5 microns after a deflection of 0.5 mm (typically 1 micron). It is important to take this into account as it affects the minimum amount of deflection necessary before the stylus is considered to be in contact with the surface. Because the stylus can return to a value other than the nominal zero, the CMM must recognise the fact that the range of rest positions of the stylus must not cause the machine motion as the stylus is not necessarily in contact with a surface even though it is "deflected".

The CMM software should have a parameter for this minimum probe deflection and only deflections above this amount should be considered as the stylus being in contact with a surface.

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# SP600 fault diagnosis

**If the SP600M probing system fails to function, please contact Renishaw who will provide a test program on disk.**

This program enables the operation of the AC2 card and of each probe axis to be verified:

- Status of the 3 fuses on the AC2 card
- N.B. The OVERTRAVEL ERROR flag will always be set to "1" (error state) as no overtravel unit is connected to the SP600M probe
- PROBE PRESENT verifies that the SP600M is properly connected
- Each probe axis output can be seen

## Probe faults

If the test program works correctly but the probe axis outputs have failed or the probe present signal is not given, check system connections and the probe cable (either by replacement or for continuity). If the fault persists please contact Renishaw, as the system must be returned for repair.

## AC2 faults

If the test program does not communicate with the AC2 card at all, please ensure that the base addresses are selected correctly on the AC2 and in the test program. The user should also check that AC2 is correctly installed in the PC expansion slot. If the base address and AC2 installation is correct, please contact Renishaw for further advice.

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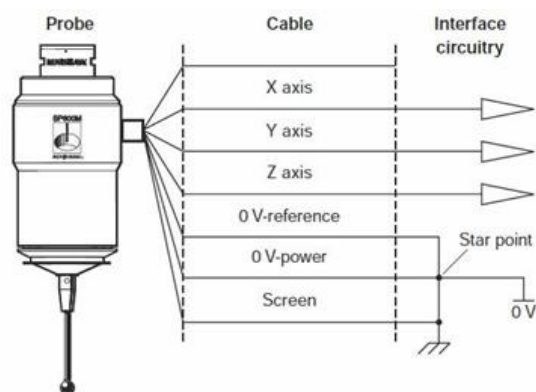
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# Appendix 1 - Probe signals

It is strongly recommended that the Renishaw AC2 card is used to interface the SP600M probe. However, should you wish to attempt to power the probe and deal with its outputs by your own means, the following information is necessary.

## Grounding arrangement

The SP600M has two 0 V connections, 0 V-power and 0 V-reference. It is recommended that they are connected to a star point in the interface and kept separate from the probe screen as shown below. The 0 V-power is used to power the internal circuitry and transducers. The 0 V-reference is a signal from which the outputs are referenced.



## Screening

It is recommended that the screening arrangements are based on the Faraday cage principle, i.e. the screen is continuous throughout the system. The SP600M connector shell is connected to the body of the probe.

## Power supply filtering

The power supply to the probe should be filtered as close to the interface output connector as possible to reduce the output noise to <math><20\text{ mV}</math> RMS in the frequency range 0-7 KHz.

## Measurement signal filtering

The input bandwidth is 700 Hz. The measurement signals should be filtered as close to the interface connector as possible to stop high frequency noise getting into the interface. It is recommended that a first order filter with a 3 dB cut-off frequency of  $\sim 700$  Hz is used.

## Cable terminations

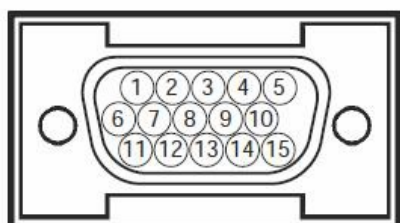
The probe cable terminates at the high-density 'D' plug and carries the following signals:

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HDD pin no.	Wire colour	Signal description	Signal type
11	Orange	X	Analogue signal
4	Violet	Y	Analogue signal
5	Yellow	Z	Analogue signal
6	Red	+ 12 V	Power output
7	Blue	- 12 V	Power output
12	Blue / white	0 V-reference	Power output
1	Brown	+5 V	Power output
3	Green	0 V-power	Power output
10	Coax inner	O/T 1	Signal output (not used)
8	White	Probe identification	Output
14	Black / white	Head LED anode	-
15	Brown / white	Head LED cathode	-
Shell	-	Screen	Grounding

Total number of connections = 13



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# Appendix 2 - Cables

The following are standard Renishaw multiwired probe signal cables suitable for use with the SP600M system between probe head and AC2 card.

Cable	Length (m)	Connectors	Part number
PL38V	25	Micro 'D' 15-way high-density	A-1016-7625
PL42V	15	Micro 'D' 15-way high-density	A-1016-7624
PL44V	8	Micro 'D' 15-way high-density	A-1016-7627
PL45V	1.8	Micro 'D' 15-way high-density	A-1016-7629
PL46V	3.7	Micro 'D' 15-way high-density	A-1016-7628
PL56V	12	Micro 'D' 15-way high-density	A-1016-7626
PL82V	5	Hirose 15-way high-density	A-1016-7648

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# Appendix 3 - Multiple Renishaw probe type installations

For installations using SP600M and other Renishaw probing systems, Renishaw has developed the IS1-2 interface selector system. The unit functions by identifying which probe has been fitted and switches the probe signal / power lines to an appropriate interface.

The system comprises an IS1-2 stand alone or rack mountable selector unit, a separate power supply unit, additional probe connection cables and special output connection cables to combine the various outputs.

The IS1-2 has four separate outputs and is fully compatible with Renishaw's autochange system and motorised heads via the Renishaw product interconnection system (PICS). This allows any combination of the following Renishaw probes:

- SP600M - analogue scanning probe
- TP7M - high precision touch-trigger probe
- TP2 - touch-trigger probe
- TP6 - touch-trigger probe
- TP20 - touch-trigger probe
- TP200 - touch-trigger probe



**NOTE:** Please refer to the IS1-2 user's guide (Renishaw part number H-1000-5085) and the PICS installation guide (Renishaw part number H-1000-5000), or contact Renishaw directly for further information on these systems.

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