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TECHNICAL PAPER

SP25M

The world's most compact and versatile scanning probe system …

SP25M product overview

At only 25mm in diameter, and with a range of modules for high performance scanning and touch trigger probing, Renishaw's innovative SP25M is **"the world's most compact and versatile scanning probe system"**. Indeed, it is being seen as setting the new product standard and class in the scanning probe marketplace.

The SP25M is actually two sensors in one, enabling scanning and touch trigger probing (TTP) in a single probe system. SP25M gives highly accurate scanning performance with stylus lengths from 20 mm to 200 mm, using a M3 stylus range. In addition, the ability to carry Renishaw's TP20 range of touch trigger stylus modules mean that the SP25M system enables the user to always deploy an optimised measurement solution to exactly suit the application. To understand this major benefit further, it is necessary to explain the need for the two probing methods…

TTP, where discrete points are taken around a part, is traditionally the most common method of measurement on co-ordinate measuring machines (CMMs). However, a limited amount of point data are acquired which only enables basic feature size and position to be determined with varying levels of certainty. With scanning, a constant stream of data points are captured as the stylus travels continuously over the part's surface, providing a large amount of surface information from which the feature form can be accurately determined. Scanning is therefore ideally suited when functional fits between parts must be maintained, such as engine cylinder bores, whereas TTP is best for simple non-critical features such as clearance holes. In many cases, both measurement methods will apply to a particular part to be measured and SP25M therefore provides a most cost effective dual-sensor solution.

The SP25M's compact size and Renishaw 'autojoint' mounting make it compatible with the industry standard Renishaw PH10M/MQ articulating motorised probe heads and also probe extension bars, thus providing excellent reach and access to part features.

SP25M champions many new and innovative Renishaw design concepts. These include a patented pivoting spring motion system, which achieves excellent dynamic performance, and the highly modular system approach that sees three scanning modules which provide exceptional high accuracy across the wide stylus length range. Together with the high-resolution transducer that incorporates Renishaw's 'isolated optical metrology' design principles, these design features allow SP25M to remarkably counter most of the traditional deterioration in performance seen in other types of scanning probe as stylus length increases (see key innovations below).

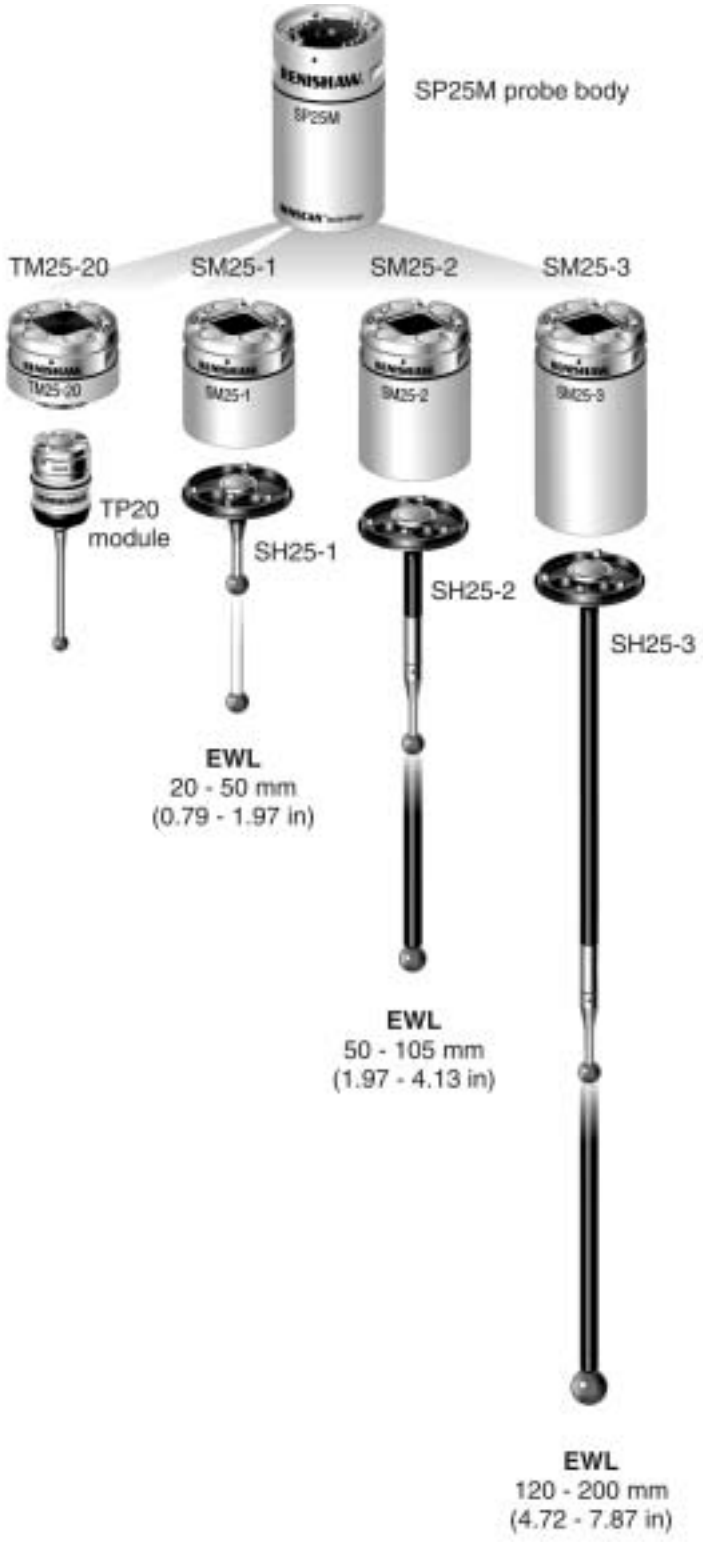
User flexibility and being cost effective was at the core of the product design brief. The result is a modular product that is available as a low cost 'entry level' scanning kit but which can be readily expanded later - right up to a complete system with the full scope of scanning measurement range and dual sensor functionality. Add to this the productivity gains which are possible when fully automating the inspection process via rapid interchange between stylus configurations using the flexible change rack system, it is clear to see why SP25M should bring 'scanning to the masses'.

This aspiration is further assured since SP25M is compact enough to be suited to small CMMs and for the first time, Vision CMMs too - market sectors that prior to SP25M, had severely restricted contact scanning probe options.

SP25M system elements

Before detailing the various elements of the system (probe body/modules/stylus holders, change rack etc), it should be emphasised that the system is highly modular, allowing rapid interchange between elements, with the express purpose of enabling the optimum measurement solution to always be deployed.

This family tree illustrates the SP25M probe system elements.



The joints between the elements are highly repeatable, thus eliminating the need to re-qualify (re-calibrate) after interchange. They work on proven kinematic location principles with simple magnetic attraction.

The EWL (effective working length) range of the scanning stylus is shown for each of the three scanning modules.

SP25M probe body

The SP25M probe body houses the probe electronics and part of the 'isolated optical metrology' transducer system.

At the top is the Renishaw autojoint for repeatable attachment to a 'multiwired' probe head (eg PH10M/MQ). The autojoint also makes it possible to couple the SP25M onto a probe extension bar for additional reach, as well as interchange with other types of sensor in a Renishaw probe autochange system (i.e. ACR1/3).

At the bottom of the body is a kinematic mount which allows repeatable interchange between the different modules for scanning (SM25-1/2/3) and the adaptor module for touch probing (TM25-20).

Scanning modules

There are three scanning modules provided (SM25-1/2/3), which are individually optimised for peak performance over a specific stylus length range. They attach to the SP25M probe body at one end, and at the other carry the stylus holder (SH25-1/2/3).

The scanning module houses the other part of the 'isolated optical metrology' transducer system, which is an integral part of the motion system.

The patented, pivoting motion system features two diaphragm springs. One spring allows movement in all directions whilst the other (pivot) spring is stiff in (probe) X & Y but allows movement in Z. The three scanning modules are of different lengths to accommodate the optimised positioning of, and pitch between, the spring arrangement. This will be explained in more detail in 'key innovations' below.

Stylus holders

Three stylus holders (SH25-1/2/3), matched to the corresponding scanning modules (SM25-1/2/3), directly carry the scanning stylus mounted via an M3 thread.

To maximise rigidity and accuracy, SH25-2 and SH25-3 feature a fixed carbon fibre (Renishaw GF) extension, thereby requiring only relatively short styli to be used to achieve a longer reach. For example, SM25-3 + SH25-3 + 100 mm long stylus actually has a reach of 200 mm.

TTP adaptor module

This mounts to the probe body in an identical way to the SM25-# and then provides attachment for the full range of TP20 probe touch trigger modules.

Automation using the FCR25 flexible change rack

The full potential of the SP25M system can be realised when the measurement routine is automated using the highly cost effective FCR25 flexible change rack, a passive triple-ported unit capable of storing any of the system elements.

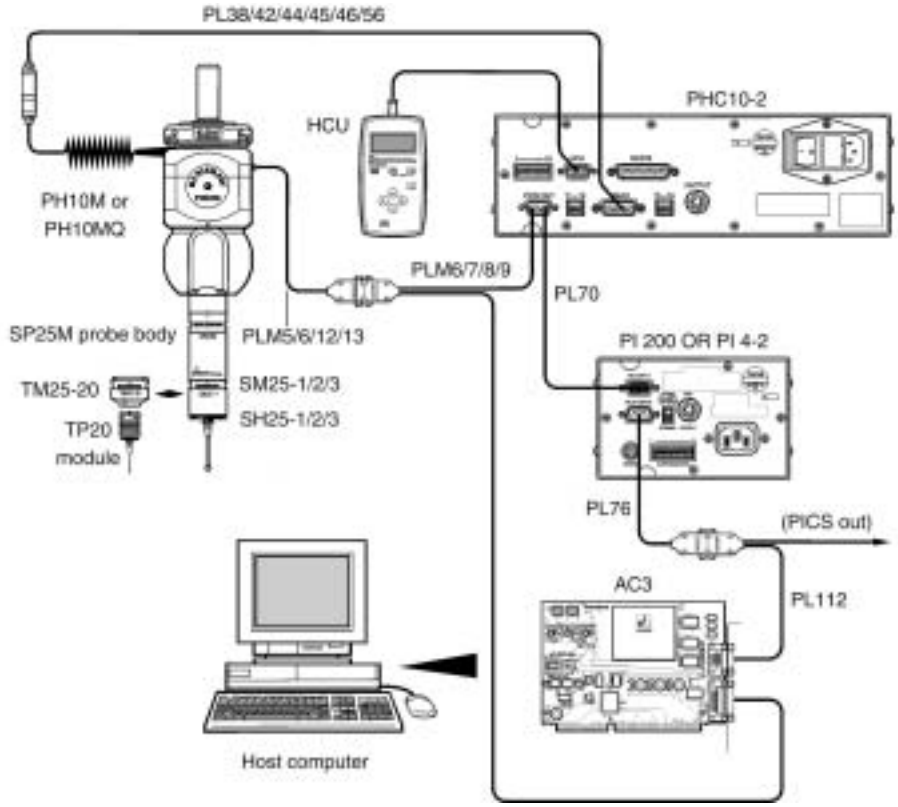
The ports in the FCR25 store the SM25-# and TM25-20 modules, but can quickly be configured to store the SH25-# stylus holders or TP20 modules by use of the appropriate port adaptor insert: PA25-SH (for SH25-#) or PA25-20 (for TP20).

The FCR25 mounts directly on Renishaw's MRS modular rack system thus providing flexible multiple port solutions (3,6,9,12,15 etc). Alternatively, there is FCR25-L3 (3 port) and FCR25-L6 (6 port) stand-alone rack variants which are ideal where machine space is limited such as on a vision CMM.

Interfacing the SP25M with the CMM controller

SP25M is fully compatible with Renishaw's universal CMM controller (UCC) which gives the user the benefit of sophisticated in-built scanning cycles to simplify measurement routines.

Alternatively, where the CMM is fitted with an OEM's controller, the Renishaw AC3 interface card has been produced to handle the probe's outputs and make integration easy. A typical integration with AC3 is illustrated below…



Maximising the SP25M/CMM system accuracy

A characteristic of SP25M is that probe outputs are non-linear and therefore Renishaw has developed, and provides, an advanced calibration method together with software to maximise probe performance.

SP25M is calibrated using Renishaw's non-linear method utilising a third-order polynomial equation and by taking specified scan paths (including bi-directional) over the datum sphere

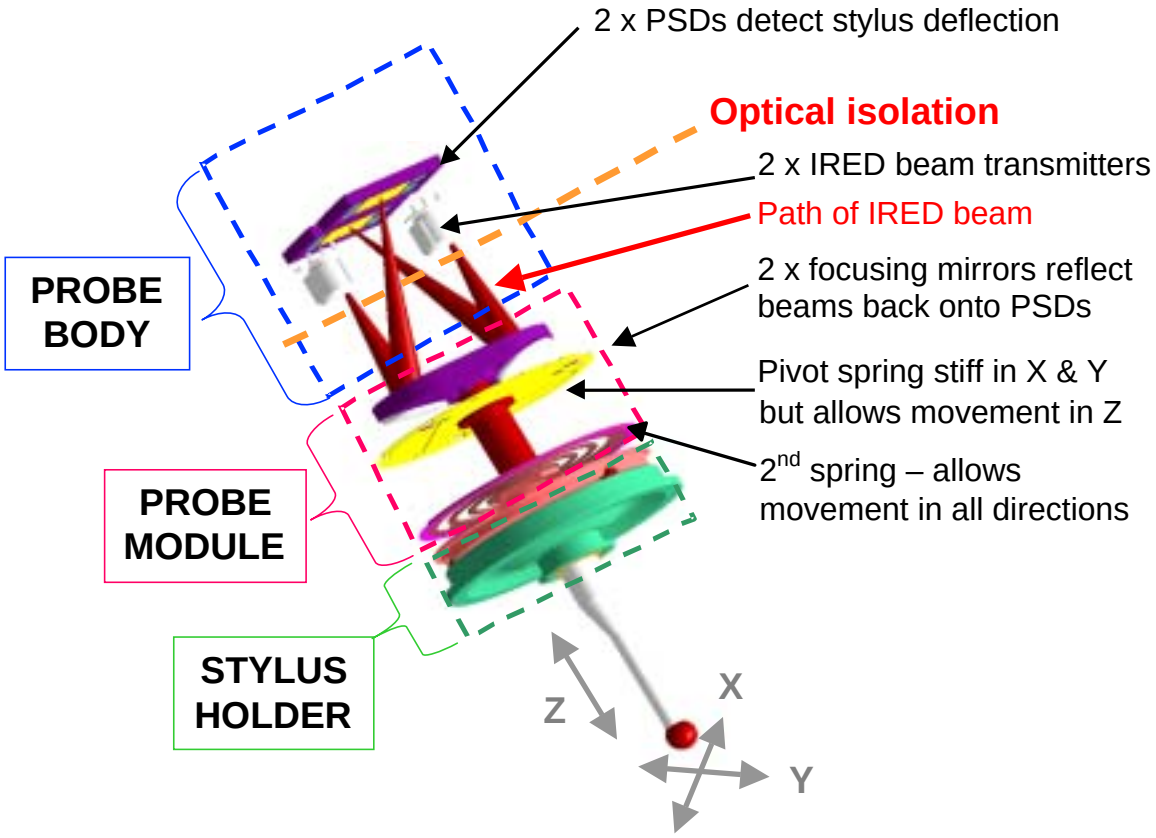
SP25M key innovations

Without doubt, SP25M stands apart from other probes available due to its high scanning accuracy, even with long styli. Incorporation of Renishaw's 'isolated optical metrology' design principles allows SP25M to remarkably counter most of the traditional deterioration in performance seen in other types of scanning probe as stylus length increases (see plot towards end).

The key innovations, which achieve this, will now be described whilst the diagram below illustrates the general internal arrangement of parts.

The probe body houses the probe electronics and two of the three components which comprise the **'isolated optical metrology' transducer system**, these being a pair of **infrared beam sources (IREDs)** and a pair of **light sensitive position sensing devices (PSDs).**

The scanning module houses the remaining components of the isolated optical metrology system which are a **patented pivot spring motion system with an integral pair of reflective concave mirrors.**



The pivoting motion system comprises **two diaphragm springs** and a **ferrofluid damping system**. One spring allows movement in all directions whilst the other (pivot) spring is stiff in (probe) X & Y but allows movement in Z. The reflective mirrors are integrally mounted to the motion system and therefore move directly with stylus deflection.

In operation, the IRED beams, originated in the probe body, are directed onto the mirrors inside the scanning module. These beams are then focussed and reflected back onto the PSDs in the probe body and can then be translated into spatial measurement co-ordinates.

The physical arrangement of the motion and optical system has been carefully designed to ensure **SP25M achieves maximised transducer gain** (i.e. best IRED beam utilisation of the PSD area) as the stylus deflects (pivots) within its operating range.

This is a crucial part of SP25M's design principle and is the reason for having three dedicated scanning modules. To explain further…

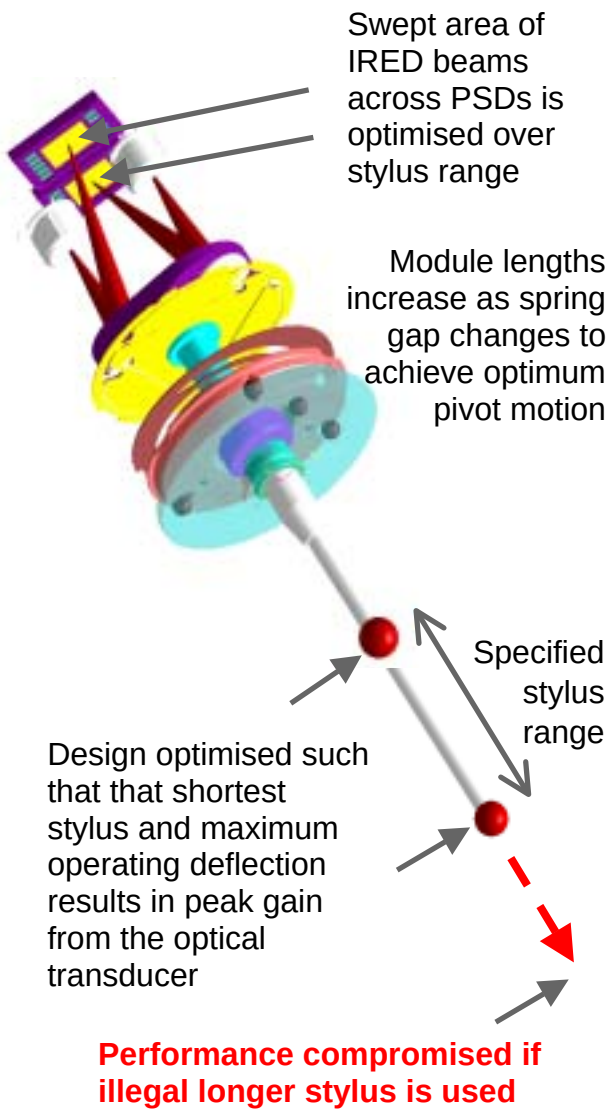
What if just one module was used (say SM25-2 with its 50-105 mm design range) and an attempt was made to use an excessive stylus length of say 150 mm? For a given stylus deflection (say the maximum of 0.5 mm) the result would be that the swept area of the IRED beams across the PSD reduces and directly affects transducer gain, significantly compromising accuracy. This is due to the increased length from tip to pivot spring which decreases the relative pivot angle.

Conversely, if an attempt was made to use too short a stylus on the same module, say just 25 mm? The same deflection would result in excessive pivot motion which may over-travel the operating range of the PSDs, and may also cause breakout of the stylus holder kinematic joint. Again, the affect on accuracy would be disastrous!

The three modules have therefore been designed specifically such that with the shortest specified stylus the larger angular rotation will give peak transducer performance. Also, by limiting the maximum stylus length that can be used, **performance is always maintained within an optimum zone.**

The operating range of each module is at least 0.5 mm radius in all directions, in all orientations, (i.e. this is the range if using heaviest recommended stylus configuration).

Low stylus contact forces are achieved and this is related to the actual stylus length used within the specified module range - for example ~0.2 N/mm when using shortest stylus up to ~0.6 N/mm when using longest.

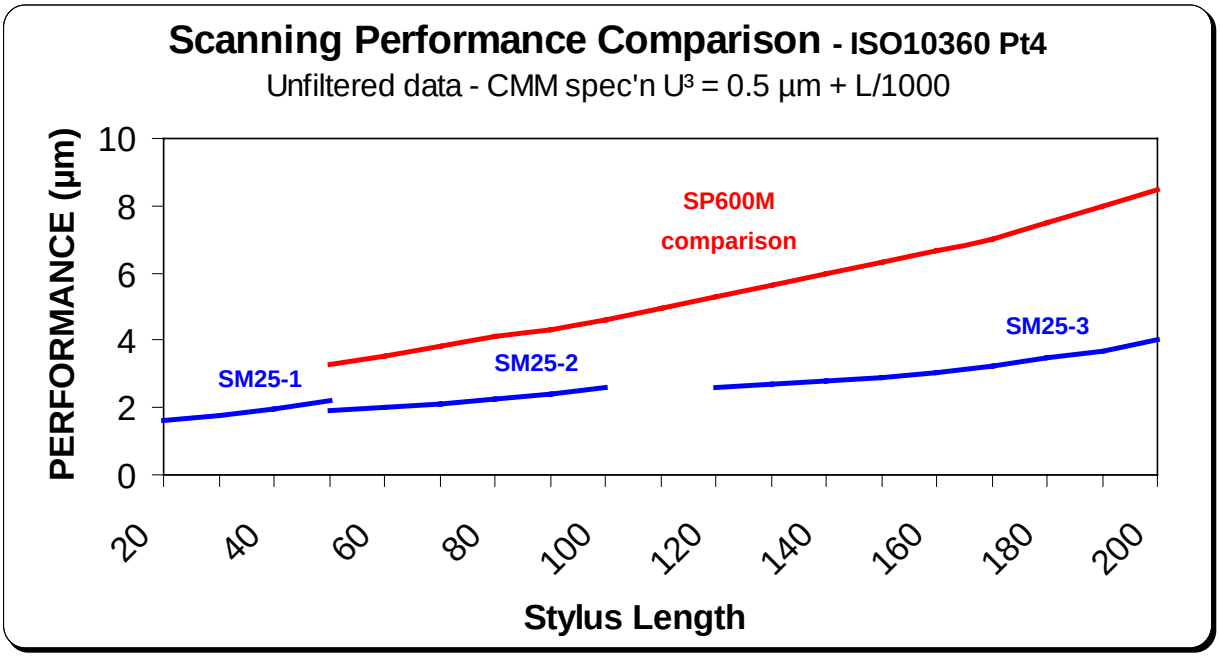


The **low probe mass** allows a low spring rate whilst retaining improved dynamic response over traditional scanning probe designs. The improved dynamics of **SP25M allows faster scanning measurements to be taken.**

Additionally when combined with **'Renscan DC'** (a machine dynamics compensation algorithm available with UCC), tests at Renishaw have shown that **cycle times on powertrain component measurements can be reduced by a factor of four.**

SP25M performance

The plot below shows the SP25M's **remarkable ability to counter most of the traditional deterioration in performance** seen in other types of scanning probe **as stylus length increases.** A comparison with Renishaw's highly successful SP600M scanning probe (launched in 1995) is shown to illustrate the technology leap made with SP25M whilst also achieving the many benefits from its compactness.



Summary

SP25M is set to become a volume selling product in the competitive scanning sector. The unrivalled system flexibility and exceptional accuracy with long styli, together with its affordability, define this probe as setting the new product standard and class in the scanning probe marketplace