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Linear Encoder

Technical Overview

ULTRA PRECISION TECHNOLOGIES

Application Note
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Issue 3

Linear Encoder Operation

The principal of operation of Solartron's Linear Encoders is that light from an infra red LED passes through a 10 µm pitch grating, producing interference fringes at the same pitch as the grating. The scale is fixed to the shaft of the Linear Encoder so that as the probe tip is moved, the interference fringes also move. The fringes are observed by a second grating (the index piece) and a set of photodiodes. As the probe tip is moved, the fringes are counted to determine the actual displacement to within 10 µm.

To achieve 50 nm (0.05 µm) resolution, the signals from the photodiodes are interpolated by a factor of 200. The signals from the photodiodes vary in a sinusoidal manner with displacement of the probe tip. The sine wave has a period equal to the grating pitch, i.e.10 µm. The index piece and photodiode array produce two such sine waves, phase shifted by 2.5 mm or 90° (the sine and the cosine). The arctangent is calculated and the exact position to within 1/200th of the grating pitch (50 nm) is then determined from a look up table.

Linear Encoder Terminology

Accuracy: The specified accuracy of the Linear Encoder is ± 0.5 µm. The maximum difference between any two calibration points on the calibration certificate supplied with each Linear Encoder is therefore 0.5 µm.

Example:
Use an LE25 mounted in a gauge stand and connected to a DR600 to measure a gauge block that is exactly 20 mm. Zero the reading when the probe tip is in contact with the base of the stand. Now place the gauge block on the stand and measure it. Ignoring any errors in the gauge block itself and assuming that it is perfectly in contact with the base of the stand, the DR600 will display the size of the gauge block as measured by the Linear Encoder. This will be within the range 19.9995 mm to 20.0005 mm, i.e. 20 mm ±0.5 µm.

Repeatability:

LE12 and LE25	0.15 µm (±2 sigma)
LE50	0.20 µm (±2 sigma)

Resolution: The resolution of all Solartron Digital Linear Encoders is 0.05 µm. The DR600 and DR700 have the ability to reduce the resolution displayed, if required.

Calibration Equipment Description

The diagram is a schematic of the calibration equipment. The Linear Encoder is mounted at the end of a rigid single axis slide way. The probe tip contacts a precision anvil. The slide way and hence probe tip position is driven by the lead screw.

The laser interferometer system is based on the Renishaw ML10 laser system. The Renishaw ML10 laser system, including the EC10 environmental compensation module, is calibrated and traceable to NPL (National Physical Laboratory) Standards.

The Verification system has been designed taking into account all appropriate errors (such as environment, interpolation, pitch, yaw and Abbe errors).

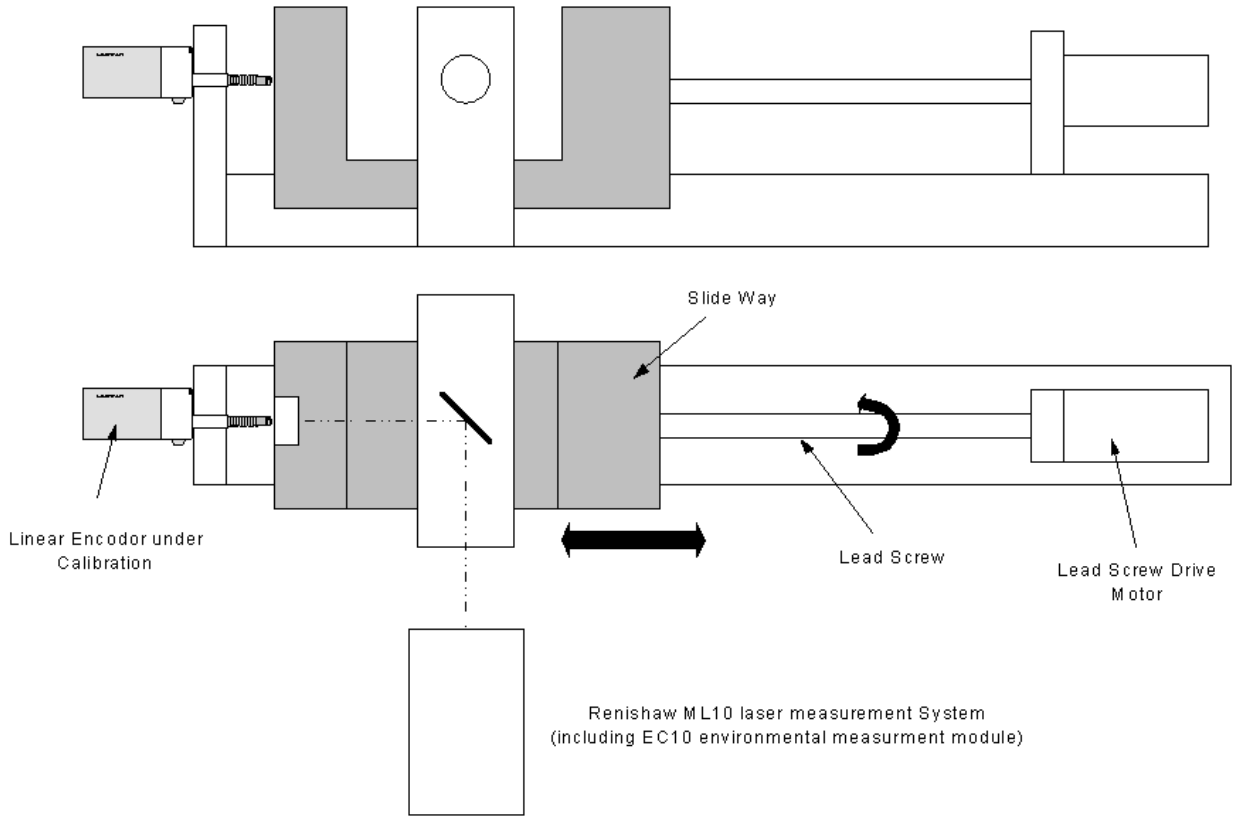
Verification Process

The Verification system is operated in a temperature controlled environment allowing a maximum change in temperature of ± 0.1 °C during the verification process.

Linear Encoders are loaded onto the fixture and allowed to rest. This allows thermal effects due to handling to dissipate.

Each probe is moved from the fully out (-extended) position in predefined steps to the fully in (-retracted) position. At each position a reading from the Linear Encoder and the reference laser is taken.

This process is repeated several times to verify different aspects of probe performance. Data from the final measurement cycle is plotted and presented as the Certificate of Calibration. This is a single run in one direction only.



Linear Encoder Laser Interferometer Calibration System