Merlin Systems Corp. Ltd

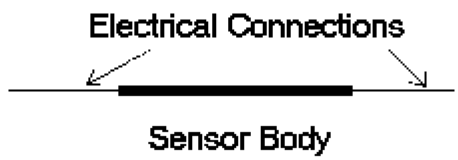
Merlin Stretch Sensor™

Application Note #1
V1.0a

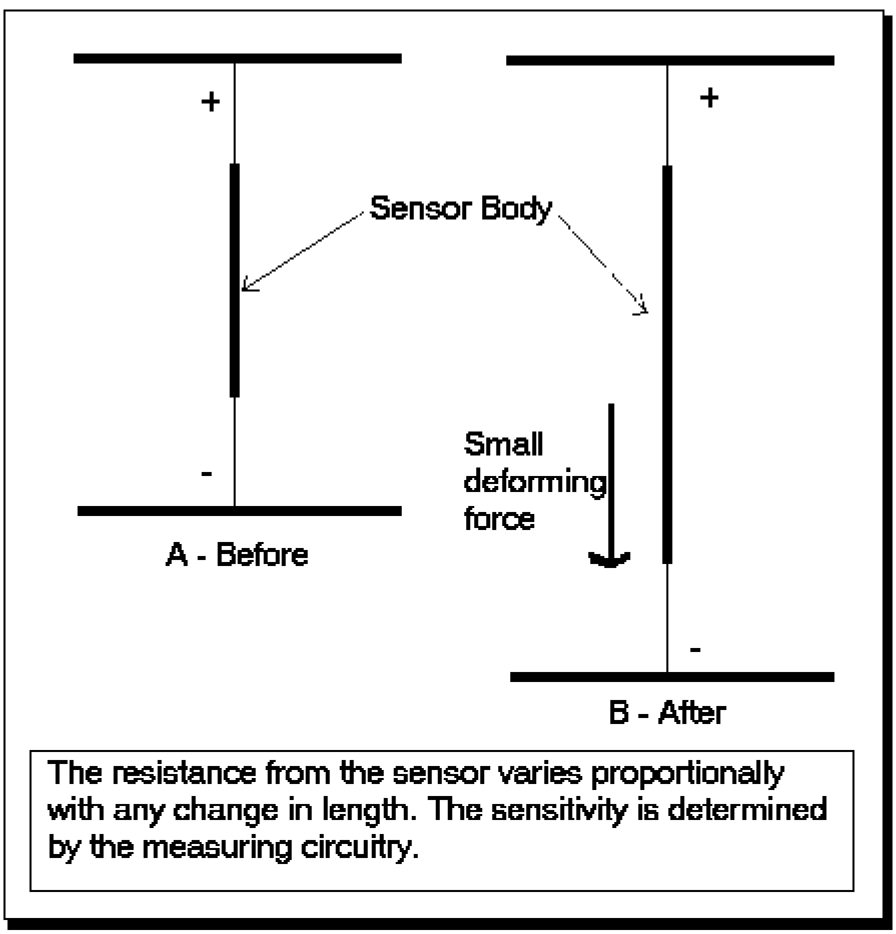
Stretch Sensor

Introduction

Stretch Sensors provide a unique method of making displacement measurements. The Stretch Sensor (SS) is small, flexible and easy to use.



Stretch Sensors are like resistors, the more you stretch the higher the resistance, release the tension and the sensor will return to the resting resistance value.

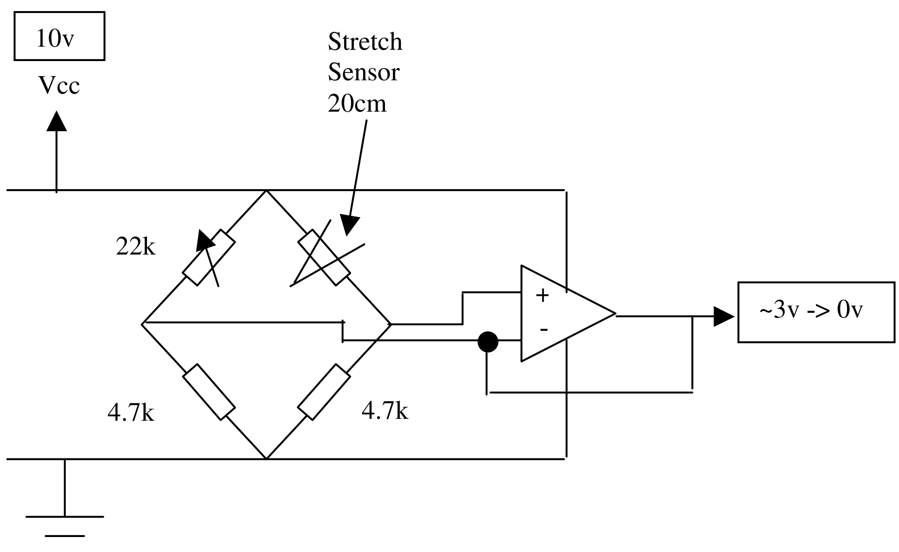


Application Note Introduction

The purpose of this application note is to give an introduction into taking measurements from a Stretch Sensor and to give data regarding the expected performance. In terms of measurements circuits this guide is not definitive and there are numerous other designs that are equally suitable.

Simple Bridge Circuit

The following circuit demonstrates a bridge configuration that can be used to take measurements from a stretch sensor. This is not a high precision configuration as the base resistors on the bridge have been selected to give a reasonable span of 3v without further amplification (normally these resistors should be proportionally high compared to the resistance value that is changing). The opamp (LM662) is configured as a voltage following and has rail-to-rail inputs and outputs. The purpose is to make the output compatible with a->d inputs (select high GBP). The bridge should be balanced using potentiometer (22k) to give a maximum deflection when the sensor is relaxed, this will drop to near zero when extended to 100% of the resting length.
This circuit is convenient because you do not need to worry about virtual earth's or bipolar supplies that a precision configuration would need to account for. The potentiometer should be selected to have a similar range to the stretch sensor (resistance) being measured.



We supply a complete evaluation board, which implements this circuit and outputs data in a format readily readable by a PC via a serial port.

Test Apparatus

The IAI Systems actuator and an intelligent controller were used as the basic actuation mechanism to precisely stretch the sensor through a series of displacements. The actuator has a specified repeatability/resolution of better than +-0.02mm.

A bespoke PC application was developed to drive the actuator through test sequences and to log readings from the A/D subsystem. The application streamed the output into a flat file for later analysis using Microsoft Excel 97.

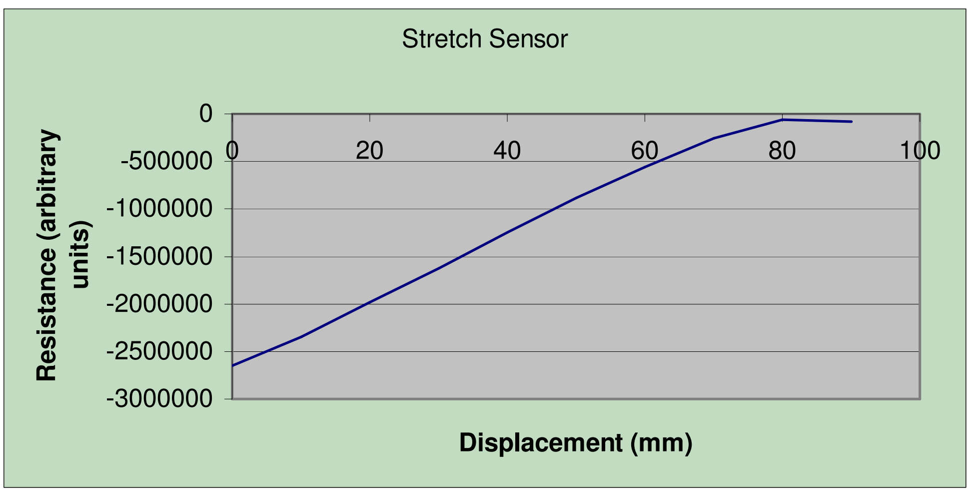
The A/D was set at a 2kHz sample rate and some tests averaged multiple samples for better noise immunity. The quoted resolution of the A/D is 24bits, but the effective resolution after noise, resolution and linearity is around 18bits. The output from the above circuit only achieved a 3v span further reducing the effective resolution. However, the expected precision of the stretch sensor is well within these specifications.

Test Results

Relative Displacements

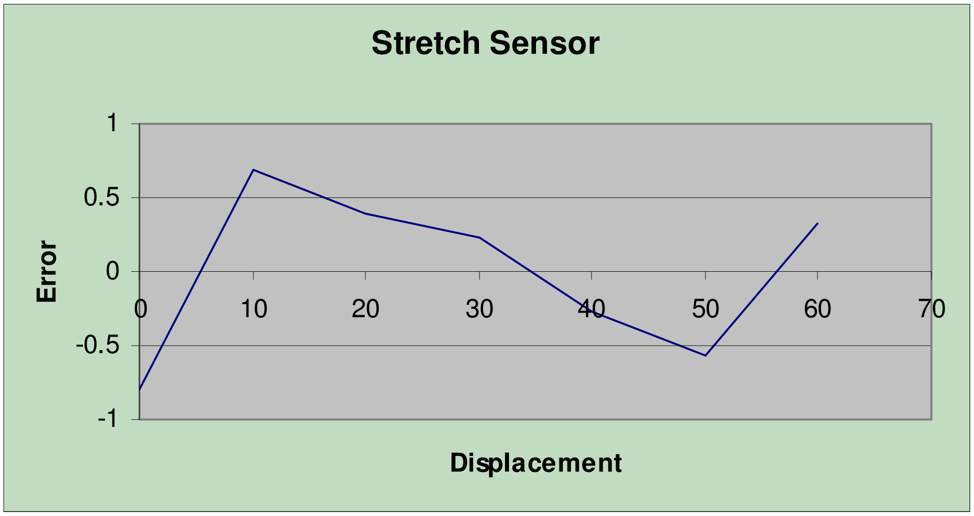
The following tests were all conducted using a 21cm stretch sensor. The resting resistance was 9kOhms, and when extended by 100mm the resistance was 14.5kOhms. At rest this works out at 428 Ohms/cm and extended 467 ohms/cm. The sensor was extended to 147% of the resting length.

The displacements were recorded relative to a 100mm extended position, returning to this position after each required displacement. Movements were made at a fixed velocity of 100mm/s. Thirty two samples were averaged at each point to improve noise immunity. A reading is taken at a reference position and then at the displacement position. The difference between these two values is plotted on the y axis. The units are linearly related to change in resistance but the exact correlation will depend upon the setup of the a/d (reference voltage), the exact units are therefore not given.

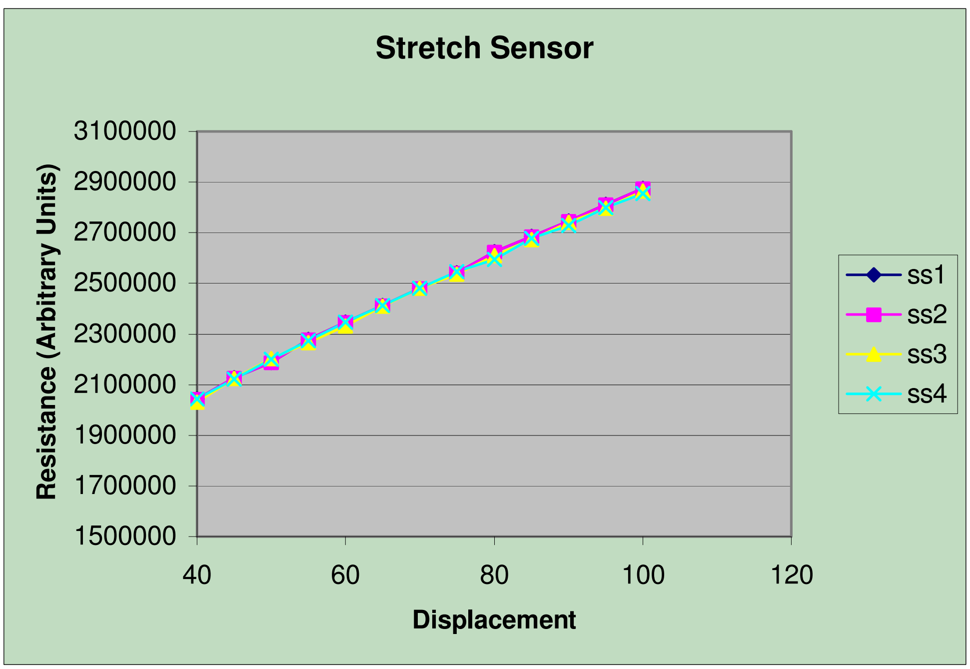


The results indicate a linearity of +- 0.8mm for displacements in the range 0-60mm 9 (see below). The displacements were measured from the opposite end to the zero position (at 100mm). Displacements were made in steps of 10mm from the extended end e.g. 90mm,100mm,80mm,100mm,70mm,100mm etc..

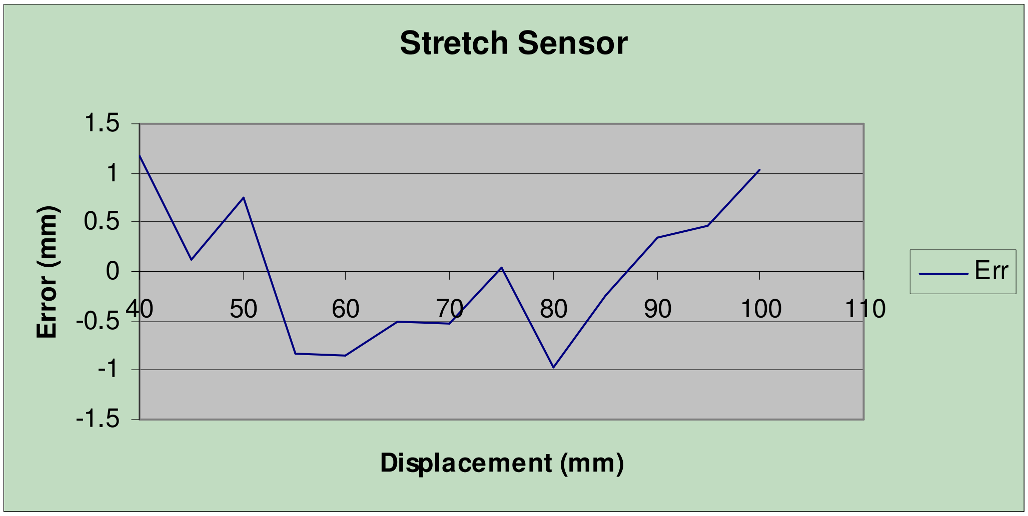
The linear region (0->60mm) was plotted against a best straight line to generate a measure of linearity. The following chart shows the recorded errors for each displacement.



When the zero position is moved to zero the linear region is at the opposite end (40mm->100mm). Test run with 5mm steps. Test run 4 times.



The linearity is not as good but is almost +-1mm.

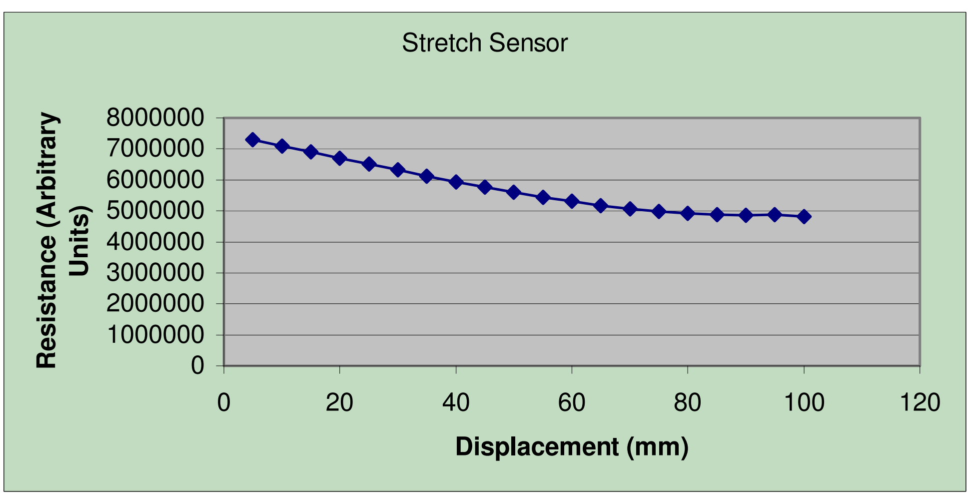


Summary

Similar velocity displacements relative to one end or the other produce the best results. If a movement is made relative to an extended position the best results are achieved with a linearity of +-0.8mm. The linear region is 60% of the extension region and is at the opposite end to the reference position.

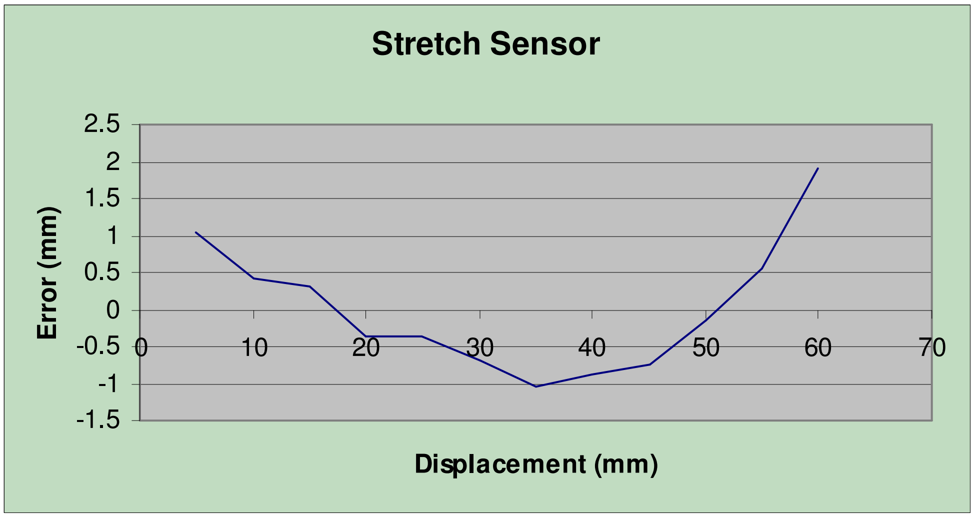
Step Displacements

The following series recorded a series of steps starting at 100mm moving toward 0mm in 5mm steps at a fixed velocity.

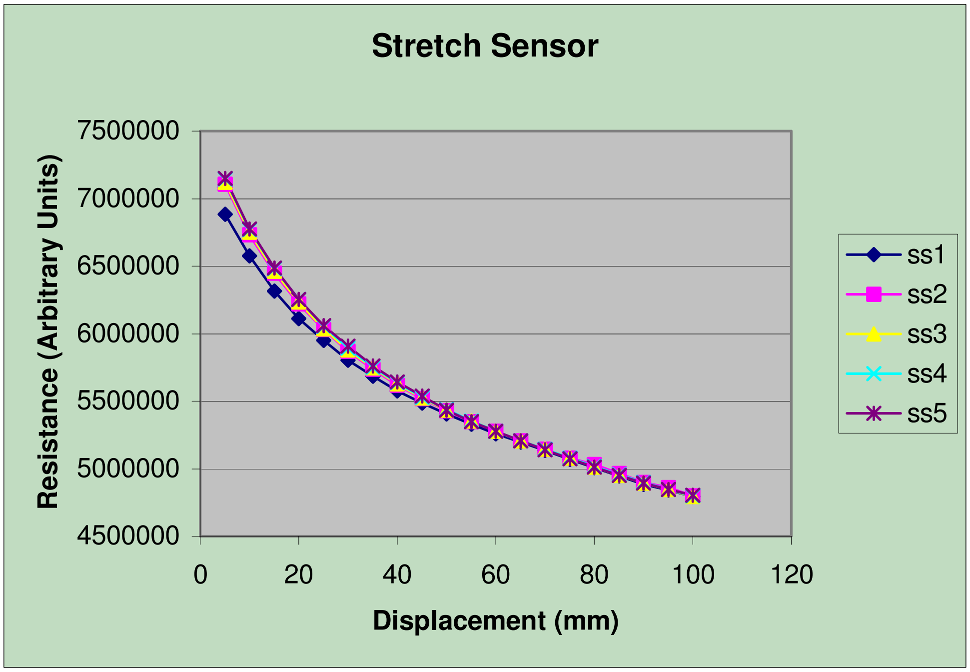


The graph below shows the error relative to a generated best straight line.

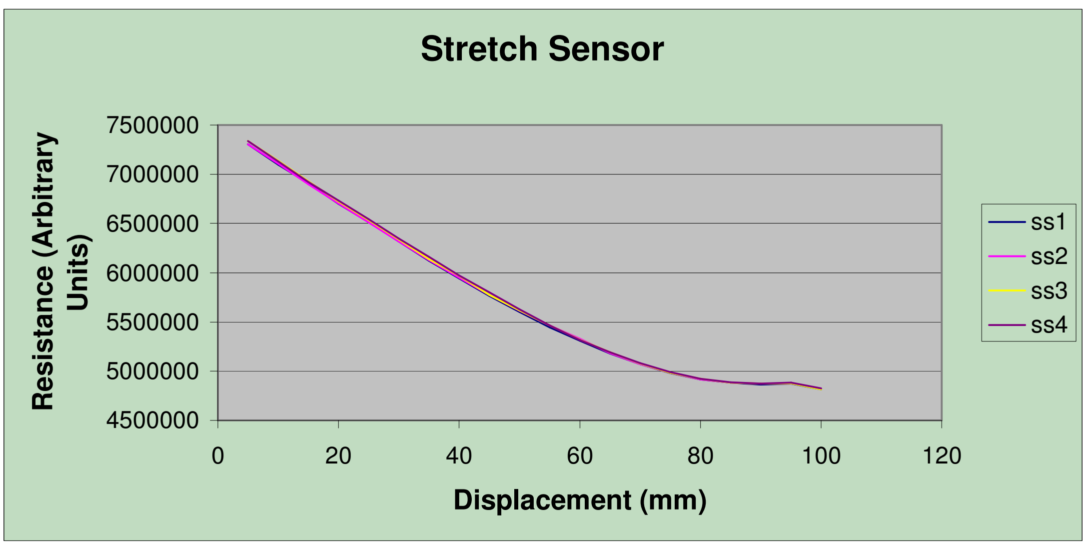
The error plot indicates +-1mm linearity in the region 0->55mm.



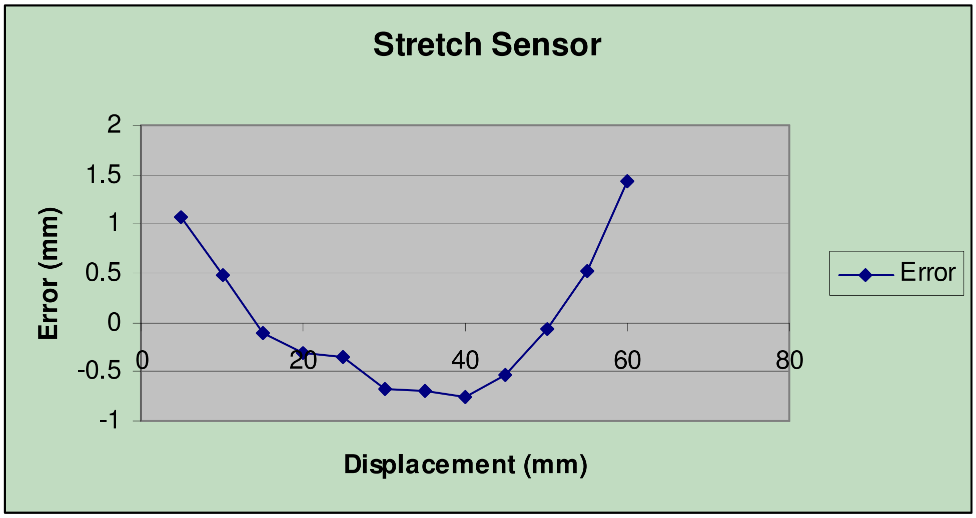
A series of tests run in the opposite direction are shown in the graph below. In this case the linear region is from 55mm to 100mm, but the actual linearity is again not as good as tests run from the tension end.



A similar sequence produced in the opposite direction produced the graph below.



The best line in the series has the following error profile against a best-fit straight line.

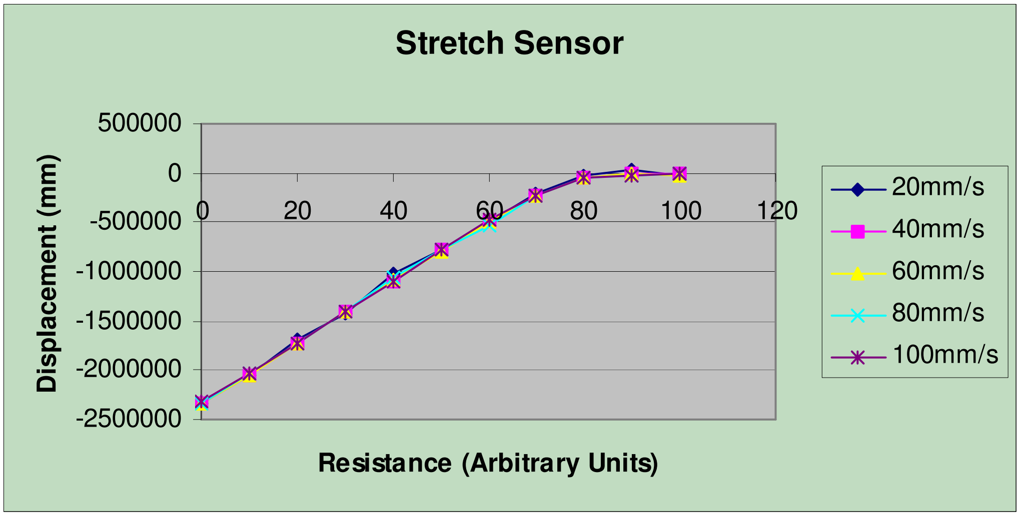


Summary

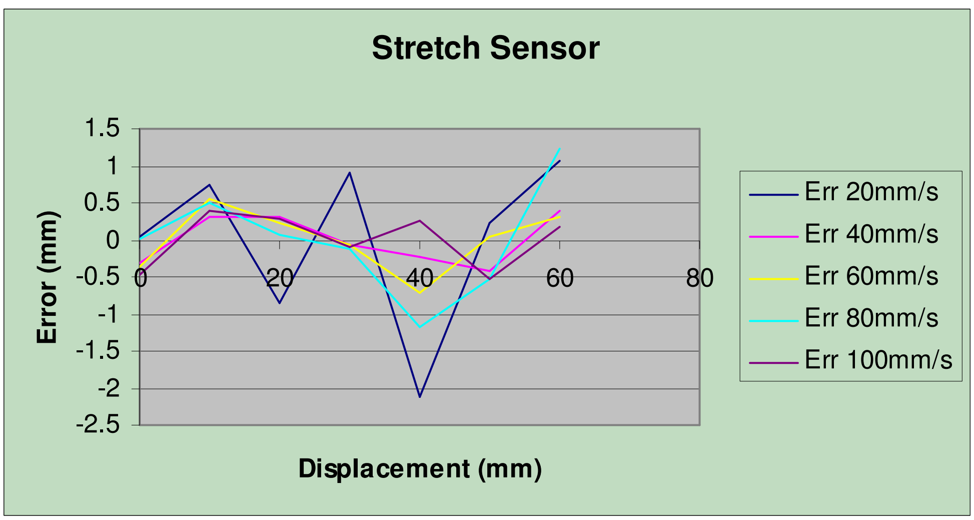
The results shown above indicate linearity of approx +-1mm for a sequence of movements made in one direction. The linear region for these displacements is always at the opposite end to the start point for the movement.

Relative displacements at different velocities

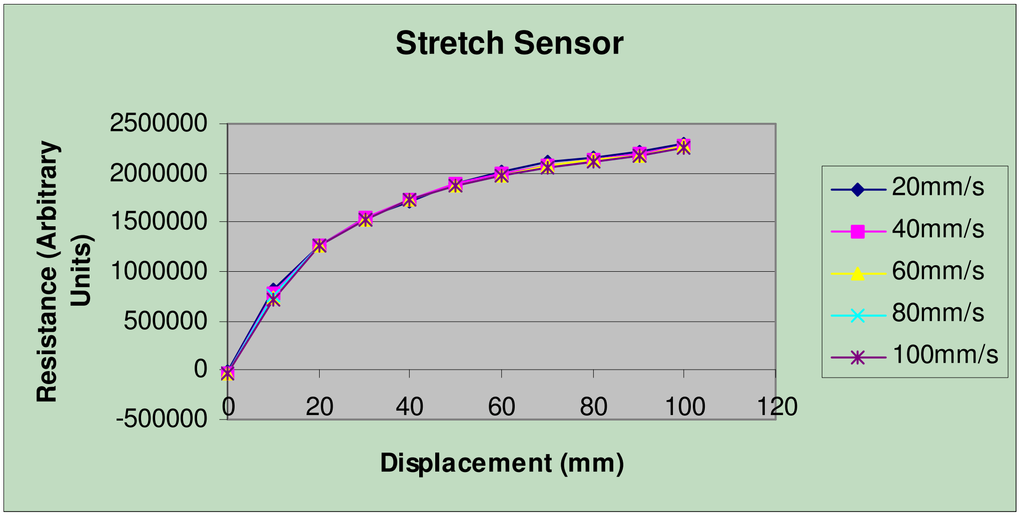
The following are a series of tests for displacements made relative to a known reference position at either 0mm or 100mm but at a range of velocities from 20mm/s to 100mm/s.



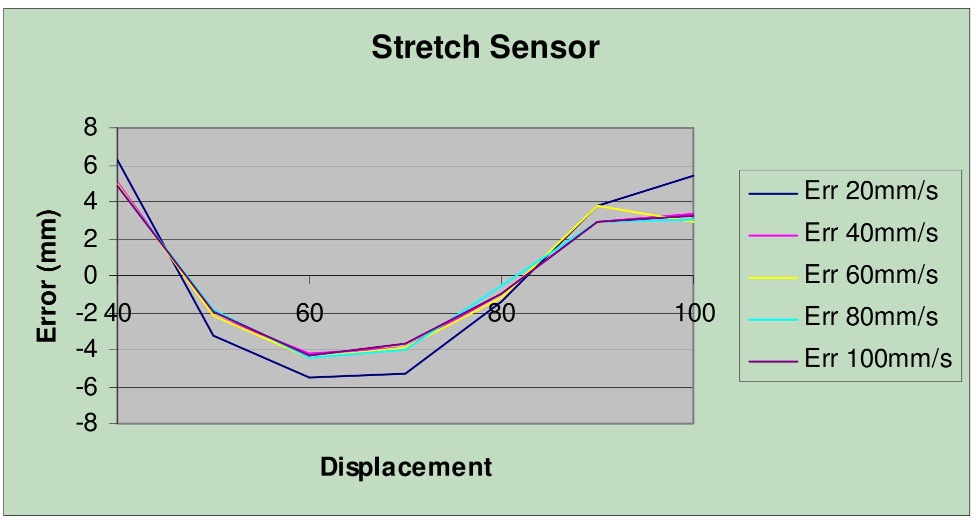
The error profiles plotted against a best-fit straight line are as follows:



The above results were taken starting at the extended end moving toward zero, in the opposite direction the results are not as good.



As expected the linear region is between 40mm and 100mm, but the error profiles indicate poor linearity with velocity.



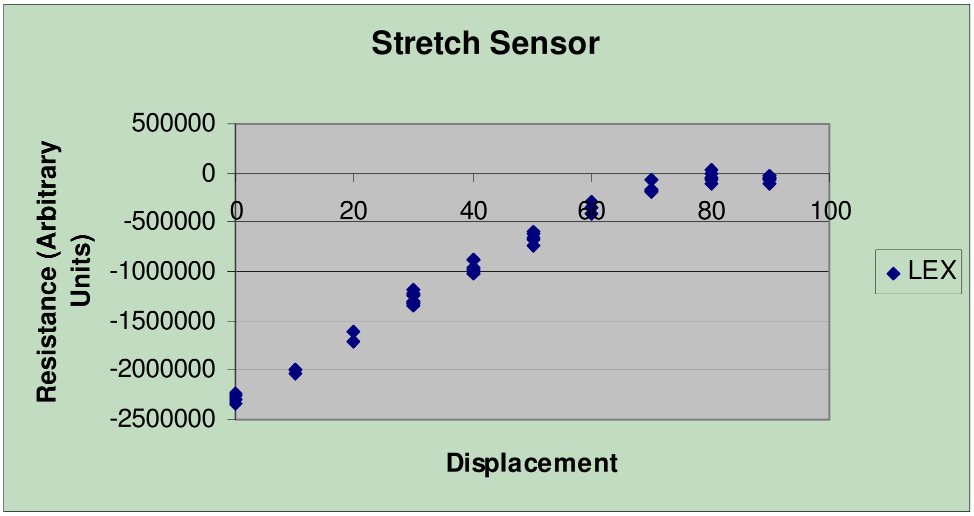
The signals appear to be repeatable for velocities above 20mm/s but linearity is only +-6mm.

Summary

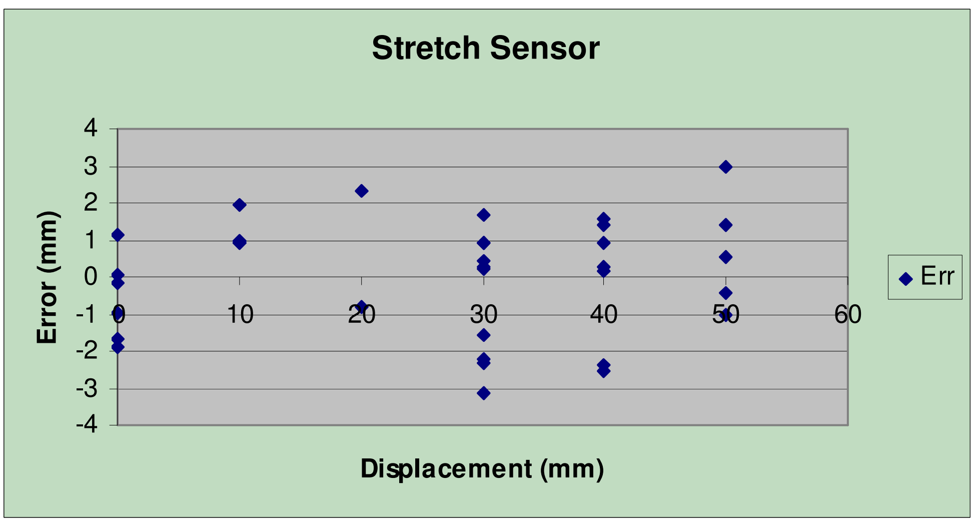
Movements made at different velocities should only be made from an extended reference point. The results are only likely to be similar for movements at similar velocities, and errors are likely to increase with the range of velocities being measured.

Random Displacements

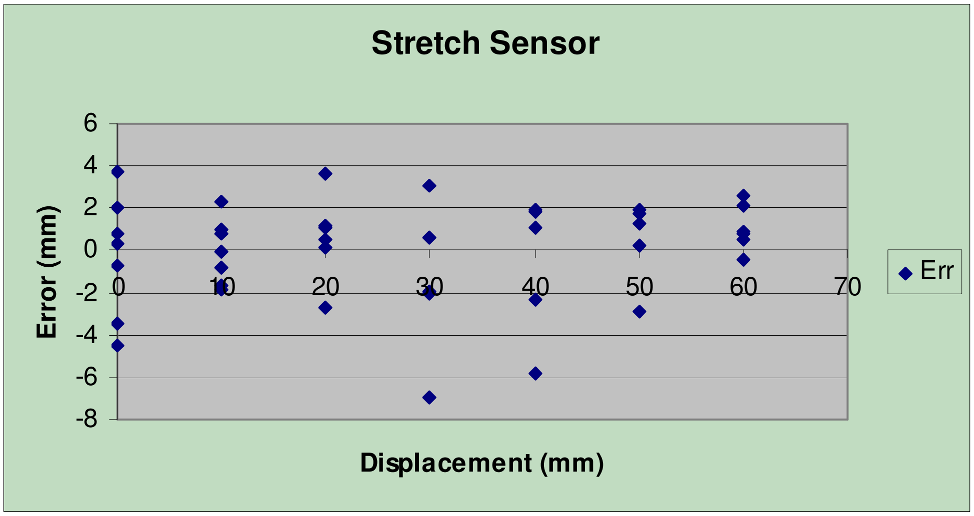
The following graph shows a series of random displacements made from fixed extended reference point at the same velocity.



A clear characteristic is shown between 0mm and 60mm as expected. The error plot indicates a linearity of +-3mm.



A similar test run with random velocities between 20mm/s and 120mm/s is shown below.



The results indicate increasing errors with velocity, in particular the errors outside the +-4mm band were at the velocity extremes.

Conclusion

The Stretch Sensor has an exponential decay that varies with displacement and velocity. The above results indicate that for certain types of relative displacements the sensor is able to perform well giving a best case linearity of +-0.8mm. For random displacements made relative to a fixed end point, position errors within +-3mm are achievable.