



TECHNICAL
NOTES

Optical Encoder Technology



Verapath™ Accuracy

TN-1006 | REV 160624



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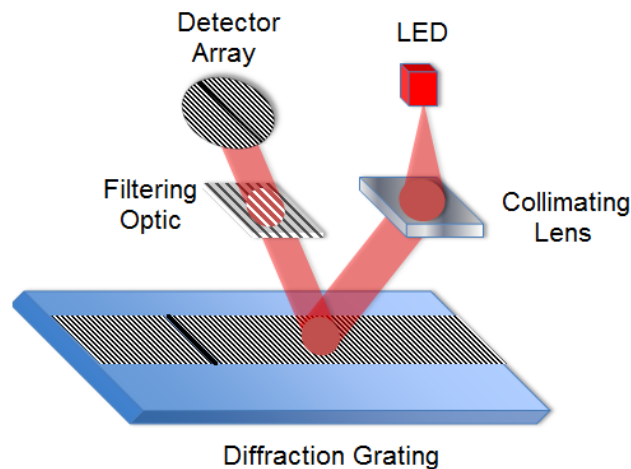
PURPOSE

This document is an overview of the accuracy capabilities of the Veratus™ linear encoder system with Verapath™ optical technology on VILT linear tape scale.



BACKGROUND

Verapath™ optical technology incorporates LED based diffractive optics, a large detector array and advanced signal processing to provide excellent accuracy performance which is insensitive to grating flatness variation and scale contamination.



Reference documents:

TN-1002 "Verapath™ Optical Technology"

TN-1004 "Veratus Advanced Signal Processing"

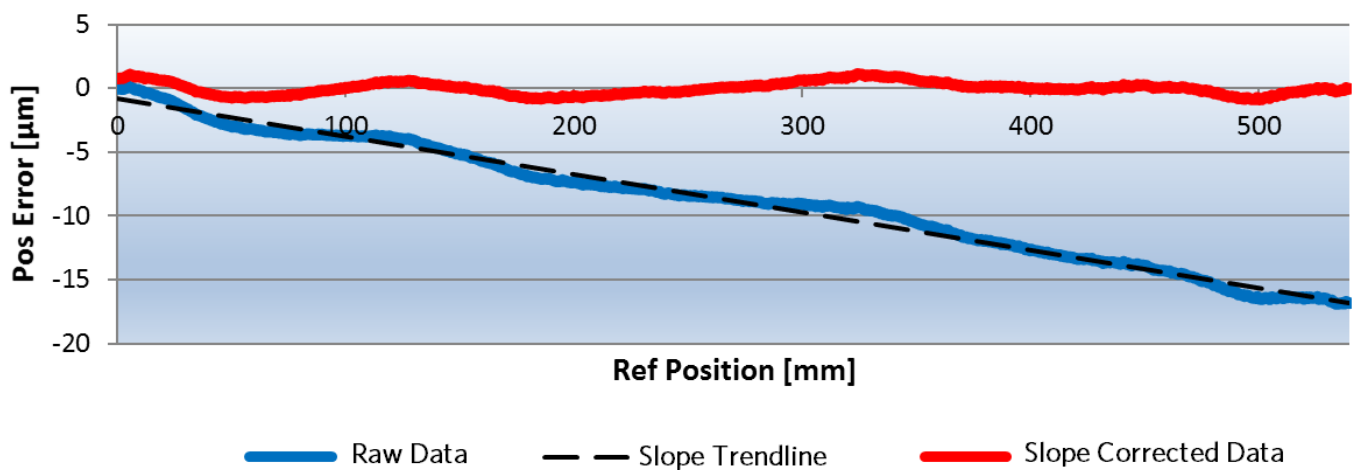
TN-1005 "Resolution, Accuracy and Repeatability"

DEFINITIONS AND VERAPATH PERFORMANCE

Linear encoder accuracy has three major error components:

- **Slope**
 - Long-range error
 - Accumulates across the full range of motion
 - Repeatable to ± 1 LSB
 - Determined by the scale printing process and thermal expansion of the metal substrate. (13ppm/ $^{\circ}$ C for Inconel 625)
 - Typically specified in terms of \pm microns/meter
 - VILT slope specification is $< \pm 50 \mu\text{m}/\text{m}$
 - Example below in Figure 1 shows a slope error of $-29.7 \mu\text{m}/\text{m}$

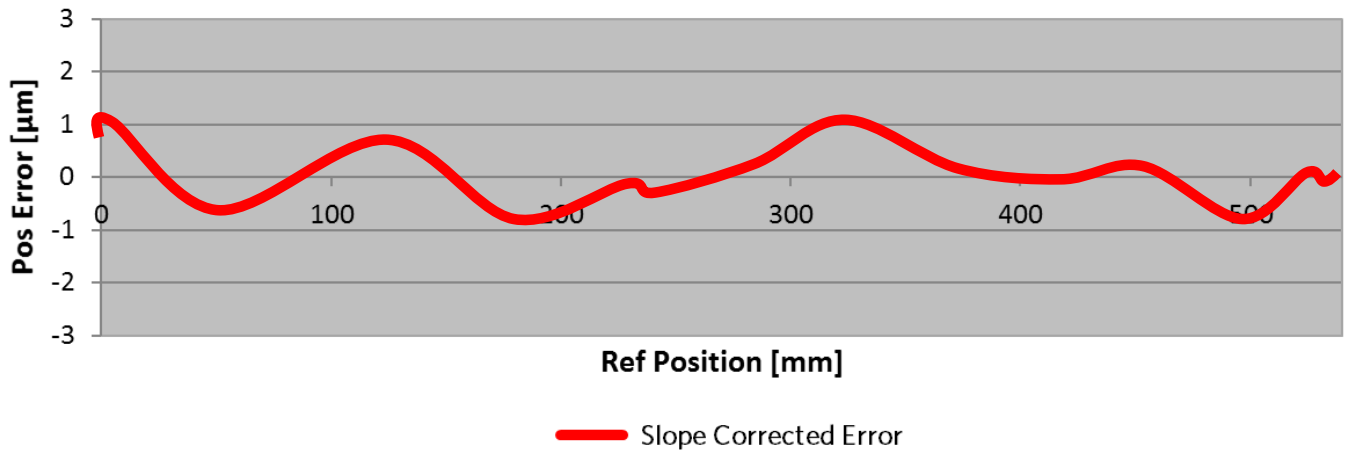
Fig. 1 Slope Error



- Parallelism of the tape installation to the axis of motion can also induce a slope error component known as *cosine error*. Use of the VILT-AT tape scale applicator tool will help minimize cosine error

- **Linearity**
 - Remaining long-range error after Slope is removed
 - Non-accumulating
 - Repeatable to ± 1 LSB
 - Determined by the scale printing process
 - Typically specified in terms of \pm microns
 - VILT linearity specification is $< \pm 3 \mu\text{m}$
 - Example plot below in Figure 2 shows a linearity error of $\pm 1.13 \mu\text{m}$ (same data as Figure 1 but with an expanded vertical axis)

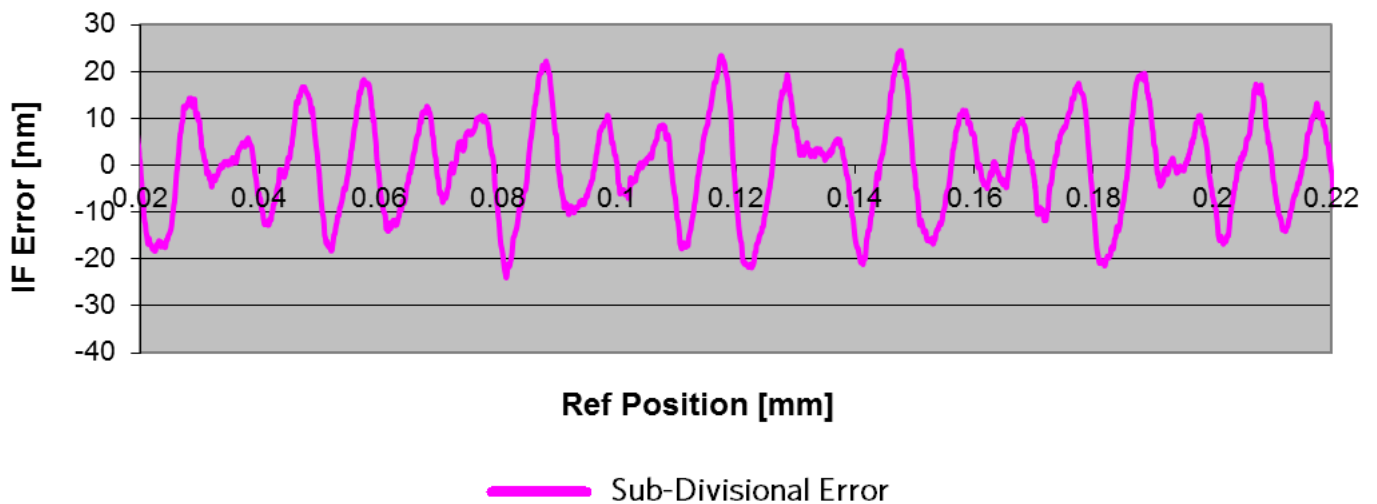
Fig. 2 Linearity Error



- **Sub-Divisional Error (SDE)**

- Short-range error over 20-100 μm
- Repeats with the line pitch of 20 μm
- Repeatable to ± 1 LSB
- Determined by optical and electronic deviations from a perfect sinusoidal signal
- Typically specified in terms of \pm nanometers
- VILT SDE specification is <20nm RMS (root mean squared)
- Example plot below in figure 3 shows a SDE of 10.7nm RMS (± 24.5 nm peak-to-peak)

Fig. 3 Sub-Divisional Error



- The double peaks in this plot every 20 μm indicate the strongest contributor to Veratus SDE is the second harmonic.

SUMMARY

The VeraPath™ optical system uses a collimated, low coherence LED light source to illuminate the multi-track pattern on VILT scales. By using a low coherence light source, foreign items on the scale such as contamination or scratches do not create interference patterns of their own which would produce undesirable modulation on the detector. With VeraPath™ filtering optics, the 20µm period interference fringes are virtually the only influence on the final encoder signal.

Additionally, the detector's interleaved photodiode array samples and averages the fringes over a wide area. The combination of this optical filtering, averaging, and VeraPath™ advanced signal processing produces excellent signal fidelity resulting in high accuracy measurements.

Veratus Series optical encoders deliver the high accuracy made possible by VeraPath optical technology. Veratus is in a class by itself when taking into consideration that all of the electronics are miniaturized and contained inside the encoder sensor. No external signal processing is required and there are no bulky signal processing or interpolation modules at the other end of the cable. Veratus offers truly world class accuracy on metal tape scale in a small, low power consumption, light-weight package.

DO'S & DON'TS:

- Do follow the installation instructions for the Veratus sensor head and scales available on our website.
- Do prepare your mounting surfaces as recommended in the Veratus interface drawings available from our website.
- Do use the VILT-AT tape scale applicator tool especially for tape runs in excess of 300mm.
- Do not attempt to clean the Veratus sensor or scale with abrasives or harsh chemicals.
- Do clean the sensor and scale if necessary with a soft cotton cloth or swab dampened with acetone.

Please contact Celera Motion Applications Engineering group with any questions regarding Veratus encoders or VeraPath technology.

Note: All accuracy data presented was collected using a standard Veratus encoder and VILT. The reference measuring system was a NIST traceable laser interferometer in a temperature, humidity and vibration controlled environment.
