

## Optical Encoders - as accurate as you think?

Zettlex encoders have recently been tested against what were, on paper, more accurate optical encoders. Here's what we found:-

Firstly some definitions:- **Accuracy** is the degree of veracity while **precision** is the degree of reproducibility.

We can explain the difference between accuracy and precision using the analogy of an arrow fired at a target. Accuracy describes the closeness of an arrow to the bullseye.

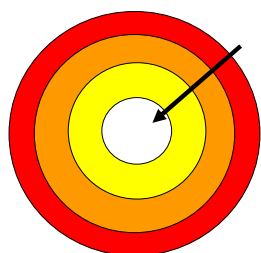


Fig. 1 An accurate shot

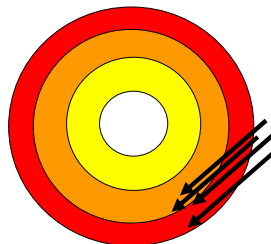


Fig. 2 Precise shots – not necessarily accurate

If many arrows were shot, precision equates to the size of the cluster. When all arrows are grouped together, the cluster is considered precise.

### Optical Encoder Accuracy

Optical encoders work by shining a light source on to or through an optical element - usually a glass disk. The light is either blocked or passes through the disk's gratings and a signal, analogous to position, is generated.

The glass disks are amazing - with tiny features which allow manufacturers to claim high precision. What is often not explicit is what happens if these tiny features are obscured by dust, dirt, grease etc. For purposes of this paper, we will ignore the issues of obscuration, fragility of the glass, optoelectronics life and temperature limits since these problems are well known. What is less well known is the issue of accuracy in optical encoders and optical encoder kits in particular.

Consider an optical device using a 1" nominal disk with a resolution of 18 bits. Typically the claimed accuracy for such a device might be +/-10 arc-seconds. **However, what should be in big bold print (but never is on optical encoder data sheets) is that the stated accuracy**

assumes that the disk rotates perfectly relative to the read head and that temperature is constant.

If we consider a more realistic example, the disk is mounted slightly eccentrically by 0.001" (0.025mm)

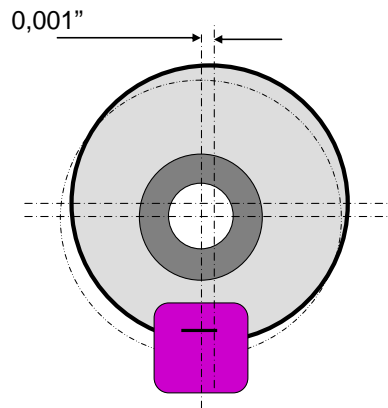


Fig. 4 – Imperfectly mounted rotor

Eccentricity comes from several sources and the following is a list of just some:-

- concentricity of the glass disk on its hub
- concentricity of the hub's through bore relative to the optical disk
- perpendicularity of the hub relative to the plane of the optical disk
- parallelism of the optical disk face with the plane of the read head
- concentricity of the shaft on which the hub is mounted
- clearances in the bearings and bearing mounts which support the main shaft
- imperfect alignment of the bearings
- roundness of the shaft and roundness of the hub's through bore
- locating method (*typically a grub-screw will pull the hub to one side*)
- displacements due to stresses or strain from forces on the shaft's bearings
- thermal effects
- etc. etc.

A perfectly mounted optical disk requires such fine engineering that cost becomes prohibitive. In reality, there is a measurement error because the optical disk is not where the read head thinks it is. If we consider a mounting error of say 0.001" then the measurement error is equivalent to the angle subtended by 0.001" at the optical track radius. To make the maths easy let's assume that the tracks are at a radius of 0,5".

The equates to an error of 2 milliradians or 412 arc-seconds. **In other words, the device with a specification accuracy of 10 arc-seconds is more than 40 times less accurate than its data sheet.**

**From experience we can advise that if you get an optical disk to be positioned accurately to within 0.001" of an inch you are doing really well. Realistically, you're more likely to**



Precision in the Extreme

be in the range 2-10 thousandths of an inch so the actual accuracy will be 80-400 times worse than you might have originally calculated.

### Zettlex Encoder Accuracy

The measurement principle of a Zettlex encoder is fundamentally different. Measurement is based on the mutual inductance between the faces of the rotor (the disk) and the stator (reader). Rather than calculating position from readings taken at a point, measurements are generated over the full face of both the stator and rotor. Consequently, discrepancies caused by non-concentricity in one part of the device are negated by opposing effects at the opposite part of the device.

Accuracies quoted by Zettlex are not quoted based on perfect alignment of rotor and stator. Realistically achievable tolerances - typically +/-0,2mm - are accounted for in any quoted resolutions, repeatabilities and accuracies.

Further, stated performance for Zettlex encoders are not subject to variation due to foreign matter, humidity, life-time, bearing wear or vibration.

### Summary:-

If you're thinking about using an optical encoder - and optical encoder kits, in particular:-

1. Read the spec. sheet very carefully
2. If your project has any of the following:
  - o mechanical assembly tolerances
  - o shock and vibration
  - o temperature variability
  - o potential ingress of liquids or foreign matter

then give Zettlex a call for a competitive quote and a no-nonsense spec.

For more information on new generation inductive position sensors, please contact Zettlex UK Ltd on 01223 874 444 or visit the website at [www.zettlex.com](http://www.zettlex.com) or email [info@zettlex.com](mailto:info@zettlex.com) .

--- ENDS ---

[1, 461 words]



Precision in the Extreme

**Editor's Notes:**

**About Zettlex UK Ltd:**

Zettlex is a sensors company. The company's range of sensors measure position or speed accurately and reliably, even in harsh conditions.

Zettlex designs and manufactures sensors; supplies sensor components and integrated circuits. The company offers bespoke sensor design and development for specific customer applications.

Unique technology and laminar, printed designs, enables Zettlex to manufacture sensors that have no contacts, no bearings, no delicate parts and zero maintenance.

Zettlex sells directly to OEMs and system integrators across a broad range of industry sectors. Applications include position measurement, servos, motor controls, and user interfaces. Around 50 per cent of the company's business is safety-related or safety-critical. Zettlex is ISO 9001 and BS EN 13980 certified for the manufacture of electromagnetic sensors, including sensors for intrinsically safe (ATEX) environments.

**Zettlex UK Ltd contact information:**

Mark Howard,  
General Manager,  
Zettlex UK Ltd  
Newton Court,  
Town Street,  
Newton, Cambridge  
CB22 7PE  
UK  
T: +44 (0) 1223 874 444  
F: +44 (0) 1223 874 111  
E: [info@zettlex.com](mailto:info@zettlex.com)  
W: [www.zettlex.com](http://www.zettlex.com)

To download high resolution images to accompany this article, visit [www.silverbulletpr.co.uk](http://www.silverbulletpr.co.uk) and go to the "Press Area". Alternatively, images and further information can be requested by contacting:

**Press Release issued by:**

Dean Palmer,  
Director,  
SilverBullet PR Ltd,  
The Grey House, 3 Broad Street, Stamford, Lincolnshire PE9 1PG  
T: +44 (0) 1780 753 000  
Mobile: +44 (0) 7703 023771  
E-mail: [dean@silverbulletpr.co.uk](mailto:dean@silverbulletpr.co.uk)  
[www.silverbulletpr.co.uk](http://www.silverbulletpr.co.uk)