# Technicle White Paper

Zettlex
Precision in the Extreme

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## Incremental versus Absolute Sensors

***Most engineers still specify incremental position sensors because they think absolute versions are too costly. But the market has changed in recent years. Mark Howard, General Manager of Zettlex Ltd provides an up-to-date review of the relative merits of incremental versus absolute approaches.***

**Incremental versus absolute position sensors**

If you've never really understood the difference between incremental and absolute measurement, don't worry – you're not alone. Plenty of engineers have never really got to grips with this terminology. Furthermore, sensor manufacturers have confused matters by claiming absolute measurement when what they really offer is incremental.

Some definitions may help. First, we will use the generic term 'sensor' to cover encoders, transducers and detectors. The distinguishing feature of an incremental position sensor is that it reports an incremental *change* in position. In other words, when an incremental sensor is powered up, it does not report its position until it is provided with a reference point from which it can measure.

An absolute sensor unambiguously reports its position within a scale or range. In other words, when an absolute sensor is powered up it will report its position without the need for any reference information. 'What happens on power up?' is a good acid test to differentiate the two types of sensor. If the sensor has to go through some form of calibration step – it's incremental; if it doesn't – it's absolute.

Some sensor manufacturers claim absolute measurement performance because a battery stores position information from the incremental sensor when power is lost. All very well – but what happens when the battery runs out? Similarly, some sensor manufacturers claim absolute measurement performance when an incremental sensor needs to move only a small amount at power up to gain the reference information.  These are incremental sensors, marketed and priced as absolute sensors.

Potentiometers are still the most common form of position sensor, but over the past 25 years the use of non-contact sensors has grown significantly. This continuing trend towards non-contact devices is due to the problems associated with potentiometer wear and reliability – especially in harsh environments (notably vibration) or extended life-times. Potentiometers are almost always absolute but a common form of non-contact sensor is the optical encoder. These devices work by shining a light through or onto an optical grating and calculating position from the intensity of the returned light. Most optical devices are incremental. Typically, the position information is delivered using a series of pulses – usually in phase quadrature, so that direction of travel can be determined. These are usually referred to as A/B pulses. A separate pulse train, typically referred to as the Z reference, provides one pulse per revolution to act as a reference mark.

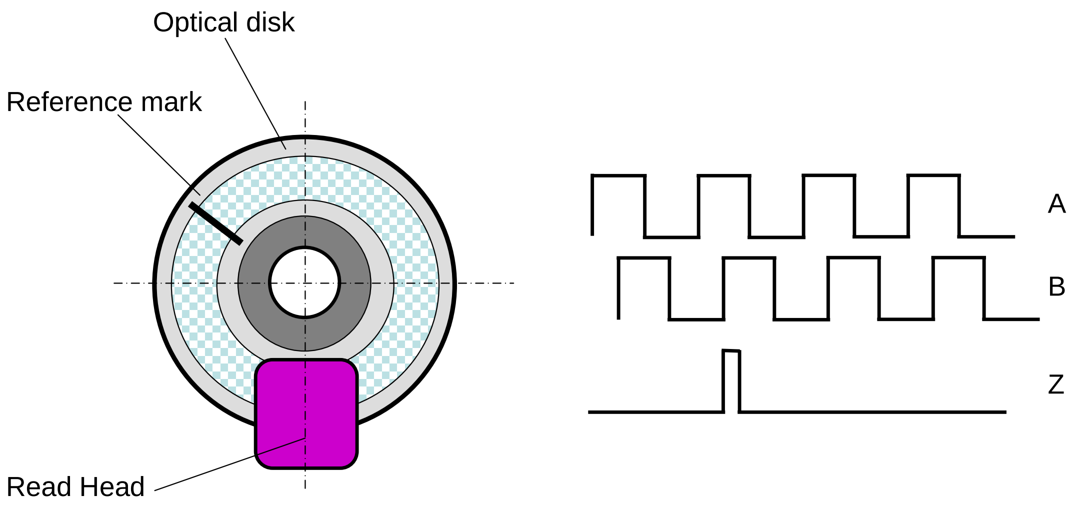
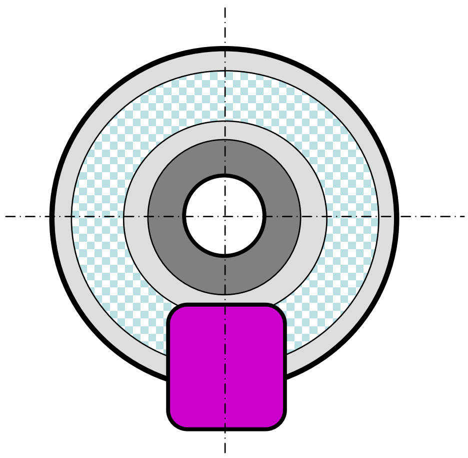



Fig. 1 – Schematic of an incremental optical sensor with a reference pulse.

The absolute optical device is similar but uses a different kind of scale, whereby absolute position is determined at power up – without the need for a reference mark.  Typically, these sensors have a digital output and their resolution is defined by the number of bits in the output. A 10-bit device will offer 1,024 counts; an 11-bit device will offer 2,048 counts and so on.



| Digital Output |
|---|
| 0000000000 |
| 0000000001 |
| 0000000010 |
| - |
| - |
| 1111111101 |
| 1111111110 |
| 1111111111 |

Fig. 2 – Schematic of a 10 bit absolute sensor with a digital output.

Approximately three times as many incremental sensors are sold as absolute sensors.  A major reason for this is an incremental sensor is usually cheaper than an absolute sensor of otherwise comparable performance.

Things change and nowadays absolute sensors are not as expensive as many might believe. A change to (non-contact) absolute position measurement can offer better performance, better accuracy and lower overall costs. This is because there can be practical problems with the incremental sensor approach. The most obvious one is that every time power is lost the system must perform a calibration step, which slows system performance and may have safety implications if power is lost suddenly.

Secondly, position is calculated by counting from a reference mark.  In some instances – notably voltage supply variation or high speed position changes – count can be lost.  This has a potentially catastrophic effect on operation which, if unchecked, can lead to prolonged out-of-synch operation.   Most incremental sensors are optical and in order to provide high resolution readings, very fine features on the optical grating must be used – sometimes the features measure just a few microns across. Whilst such fine features increase sensitivity, it also means that they become more delicate and susceptible to foreign matter. Moisture, grease or dirt can cause an optical device to stop working – or, worse still, produce incorrect readings.

The price differential between absolute and incremental sensors has reduced in recent years partly because of the greater use of absolute sensors but, more importantly, the introduction of new, absolute sensing techniques. Whilst optical sensors still remain the automatic choice for some engineers, new generation inductive devices now offer accurate, absolute position sensors that are unaffected by harsh environments.

Rather than a grating and optical sensor, these inductive devices use printed, laminar windings and their fundamental operating principles are similar to those of a transformer or resolver. The fundamental physics enables absolute, compact, lightweight, high resolution sensors, which are not dependent on optical features passing a light source. As well as being fundamentally absolute, they also have other advantages over optical sensors. First, they are unaffected by foreign matter such as dirt or moisture.  Second, their measurement performance is generally unaffected by offsets or generous mounting tolerances. This means that they do not require their own precision housings or bearing assemblies but can be simply fixed to the host system's mechanical parts e.g. a motor or gearbox housing. In turn, this enables radical simplification, size and weight reduction of the surrounding mechanical parts through eradication of bearings, shafts, couplings, seals.  Advantageously these new generation inductive devices can be arranged with a generously sized through bore to allow the passage of the host equipment's shaft, cables or slip-rings. From the design engineer's perspective this new approach means that absolute measurement performance to be offered at roughly the same price as a traditional incremental device.

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Fig 3 – New Generation Inductive Devices are increasing the use of absolute rather than incremental sensors

For more information on Zettlex's new generation of inductive position sensors, please telephone Zettlex UK Ltd on 01223 874 444 or visit the website at www.zettlex.com or email info@zettlex.com .

**--- ENDS ---** [1, 057 words]

**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.

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