Precision in the Extreme

TECHNICAL NOTES

ZETTLEX SENSORS

Version 8.3

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Precision in the Extreme

Summary

This document aims to inform engineers about the principles, design rules and applications for Zettlex Technology.

Zettlex Technology is a non-contact technique to measure displacement and/or velocity. The technique is inductive. Specifically, the technique uses the phenomenon of mutual inductance between a conductive Target and a Stator.

Traditional inductive sensors - such as resolvers or linear transformers - have a well deserved reputation for accuracy and reliability in demanding applications. They also have a reputation for being bulky, heavy and expensive. **Zettlex Sensors offer all the advantages of traditional inductive sensors but at a fraction of the volume, weight and cost.**

In a Zettlex position sensor, a Stator containing a planar array of conductors (usually tracks on a printed circuit board) is supplied with power. An electromagnetic field forms near the Stator. Typically, the field extends just a few mm – sometimes a few cm – from the Stator's surface. When a passive, conductive Target enters the Stator's field, the Target causes an electromagnetic signal which is detected by the Stator. This signal uniquely indicates the Target's identity and position relative to the Stator. The identify and position of multiple Targets can be sensed by one Stator at any given time.

Inductive sensors have been used in safety critical applications for >50years in the aerospace, defence, medical & automotive sectors. Zettlex technology applies the same fundamental physics to provide a sensing technique which is extremely stable and repeatable, irrespective of the physical environment. This makes the technique especially good for accurate measurement in harsh environments – hence our company motto **'Precision in the Extreme'.** Zettlex Sensors are in daily use in demanding applications with demanding organizations such as the Royal Navy, British Army, Royal Air Force as well as a myriad of industrial users.

Zettlex sensors are often used in safety critical applications such as primary flight controls and gunnery systems as well as intrinsically safe applications such as petrochemical valve & actuator controls.

Harsh environments might include extreme temperatures, vibration, shock, aggressive chemicals, water, long term immersion, aggressive duty cycles, electromagnetic noise, dirt, foreign matter, tight space or weight constraints. Most of the physical threats can be thwarted by simply coating or encapsulating the sensor's main parts. Extreme temperatures can be accommodated by locating the electronics in more benign environments away from aggressive environments near the sensing area. Harsh electromagnetic environments do not cause mis-reads because of the inherent design features of the Target, Stator and Sensor Electronics.

Zettlex Technology is suited to lots of sensing geometries including rotary, linear, curvi-linear, 2D & 3D. Size ranges are typically from 1mm to 10m. There is also a wide variety of applications including displacement sensors, user interfaces, servo & motor controls.

Zettlex design and make standard products – such as IncOder & LINTRAN ranges – as well as a wide variety of custom designs. >80% of our production is customized to some extent.

Precision in the Extreme

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1. Introduction

Zettlex exploits proprietary, non-contact position and velocity sensing technology in a wide variety of applications and sectors. We offer robust, reliable, accurate sensing at affordable prices. We design and make some standard products – such as our IncOder and LINTRAN ranges – but much of our production is OEM devices which have been designed to suit specific customer applications. Low tooling and engineering costs for the sensor's main components (printed circuits) makes custom designs a highly cost effective option for even modest volumes. Our customers are typically original equipment manufacturers (OEMs) or system integrators to whom we sell sensors, sensor sub-assemblies, sensor components (notably pre-programmed chips) and application engineering projects.

2. Aim

This document aims to inform technologists about the operating principles, design rules and potential applications for Zettlex sensors.

Any data presented in this document should not be taken as defining maximum or minimum design parameters.

3. Terminology

In this document we use the term **'sensor'**. A more scientifically accurate term would be transducer. Some people might also use the term encoder, measuring device, detector or instrument. In this document you may assume that sensor encompasses all such terms.

Similarly, in this document we use the term **'position'**. The more scientifically accurate term would be displacement. Some people might also use the term location or distance. For rotational geometries angle, angular displacement or rotation are used. In this document you may assume that position encompasses all such terms.

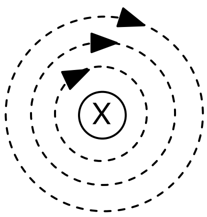
4. Background Science

If you're an experienced electrical engineer or physicist you can skip this section and go directly to Section 5. The physical principles behind Zettlex Technology are well established and covered by some fundamental physical laws:

4.1. Magnetic Field Due To An Electric Current

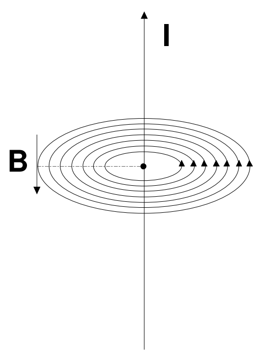
When a conductor carries a current, a magnetic field is produced around that conductor – a phenomenon discovered by Oersted at Copenhagen in 1820. He found that when a wire carrying an electric current was placed above a magnetic needle, the needle was deflected clockwise or anticlockwise depending on the direction of the current.

If we were to look along a conductor and a current is flowing away from us, as shown by the cross inside the conductor in the diagram below, the magnetic field has a clockwise direction and the lines of magnetic flux can be represented by circles around the wire.



4.2. Magnetic Field Strength

Ampere's Law, states that the magnetic field strength in free space, H, at distance r from an infinitely long straight wire carrying a current I is given by the equation:



$$H = \frac{I}{2\pi r}$$

The field produced by an infinitely long conductor is easy to understand. When the conductor is wound in to a loop or series of loops the field pattern is more complex. The field around a loop can be generally classified in to 3 areas:

- **Wire Field** – very close to the surface of the conductor. This field has high field strength and the pattern is predominantly that of an infinitely long straight conductor irrespective of the conductor's actual shape. This field – given its tiny distance from the conductor's surface - is generally not considered when discussing Zettlex technology.

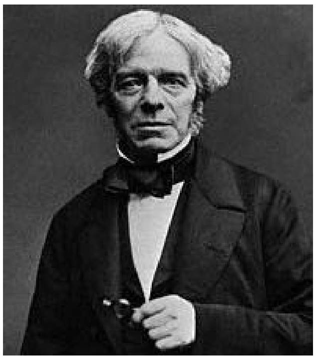
- **Near Field** – the Near Field is the most important of all three areas for us to consider when considering Zettlex Technology. It is of relatively uniform field strength. The Near Field for a current carrying conductor formed in to a circular loop of radius r would typically extend to a maximum limit above and below the loop of 0.5r

- **Far Field** – away from the conductor. The far field is that region beyond the Near Field and extends to infinity. The field strength drops off according to the square of the distance from the current carrying conductor arranged in a simple loop.

If a current carrying conductor is wound to form a loop, the field from any such circuit is increased by the number of circuits or turns, N, in any such loop. The field from the coil is proportional to N and the current in the coil; the product NI is often referred to as the 'amp-turns' in the circuit.

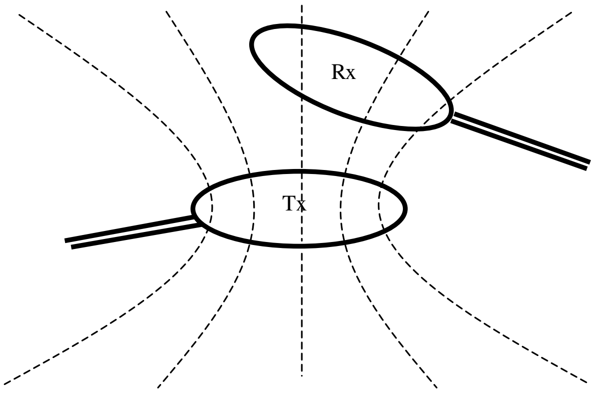
4.3. Electromagnetic Induction

In 1831, Michael Faraday discovered electromagnetic induction, namely a method of obtaining an electric current with the aid of magnetic flux. He wound two coils on an iron ring and found that when a switch was closed to allow current to flow in the first coil a deflection was obtained in a galvanometer in the second coil. Further, when the switch was opened the galvanometer was deflected in the reverse direction. He proposed that one current was ***inducing*** a current to flow in the second.



In a separate experiment, he found that when a permanent magnet was moved relative to a coil, a galvanometer was deflected in one direction and in the opposite direction when the magnet was moved away from the coil. It was this experiment that convinced Faraday that electric current could be produced by the movement of a magnetic flux relative to a coil. Faraday also showed that the magnitude of the induced electro-motive force (e.m.f.) is proportional to the rate at which the magnetic flux passing through the coil is varied.

If we consider two coils - a transmit coil (T_x) and a receive (R_x) coil – then we can see that the following equation would apply:-



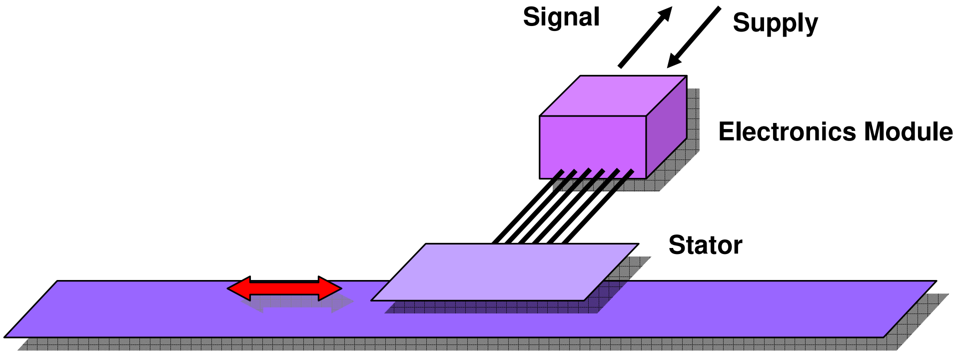
$$V_{RX} = -K \frac{dI_{TX}}{dt}$$

Where:

- V_{RX} is the voltage induced in the Receive coil
- K is the mutual inductance coupling factor depending on the coils relative areas, geometry, distance, and relative number of Circuits.
- dI_{TX}/dt is the rate of change of current in the Transmit coil.

5. Zettlex Sensor Operating Principles

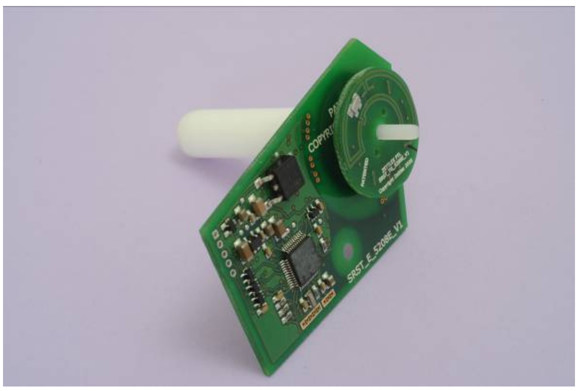
For this we may consider a simple example of a linear Zettlex Sensor. A Zettlex Sensor comprises three main operating elements: Target, Stator and Electronics Module:



The Target is a passive, conductive device usually (but not always) made from a piece of printed circuit board (PCB) and requires no electrical connection.

The Stator is a planar array of conductors which are arranged as transmit and receive circuits along and across a measurement axis. In this instance the axis is linear but in another instance it could be curvi-linear, rotary, 2D or 3D. Usually (but not always) the conductors are tracks on a printed circuit board. As explained in earlier sections, the physical principle is the phenomenon of mutual inductance. Consequently, for any given sensing geometry it can either be the Stator or the Target that extends along the measurement path. Similarly, the moving object need not necessarily be the passive element.

The Electronics Module receives power, feeds a signal to the Stator, receives the return/perturbation signal, processes it and outputs an electrical signal indicating the position of the Target relative to the Stator along the measurement axis. In the image below the measurement axis is rotary.



When energized with an AC signal, the Stator generates a local electromagnetic field. When the Target enters the field, it causes a perturbation which, in turn, is sensed by the Stator. This perturbation signal is processed by the Electronics Module. The Electronics Module then outputs a signal analogous to the position of the Target along the Stator's measurement axis.

A number of Targets may be sensed at any one time from a single Stator. Whilst in theory there is no maximum number, 8 is a reasonable practical maximum.

Within limits, Zettlex's measurement technique ignores all displacements of the Target other than that in the measurement axis. This is key to allowing high precision position measurement without high precision, high cost mechanical engineering. This means, for example, that if the gap between Target and Stator were to increase from say 3mm to 3,3mm there would be only a negligible effect on measured position. However, if the relative position of Target and Stator changed so that there was some component of the relative displacement which was along the measurement axis, then the measured displacement would change by an amount equivalent to the resolved component.

The upper limit of the Target's movement normal to the measurement axis is equivalent to the limit of the Near Field generated by the Stator. For example, in the linear sensor in the photograph above, if we consider the Stator as 15mm wide (measured orthogonally to the measurement axis) then the Near Field would extend by a maximum of 7,5mm above the Stator's surface. That means that the Target could be placed anywhere within that 7,5mm high volume and its position would be measureable. Usually a nominal or design height of <50% of the maximum height is specified in a sensor design.

6. Main Component Descriptions

6.1 Target

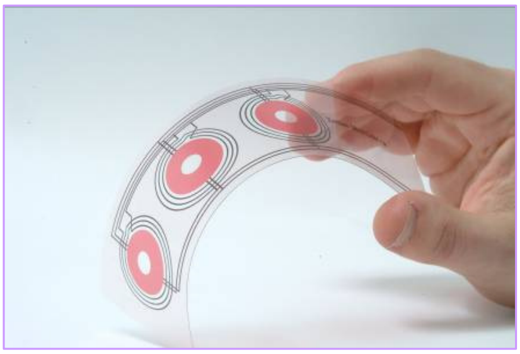
The Target is a passive, electrically conductive circuit formed by a simple winding or a set of tracks on a printed circuit board.

Targets can be conformally coated (varnished), potted or insert moulded in to an injection moulding if environmental conditions necessitate.

Typically, Targets are attached to a host component with screws, dowels, clips or adhesive.

Targets vary in size and shape from a few mm to several metres. Targets may be short relative to the Stator or may be longer than the Stator.

6.2 Stator



The Stator is typically a planar arrangement of conductors which form transmit and receive circuits. The circuits are arranged along and across the measurement axis of the Stator.

Typically the circuits are embodied as tracks on a printed circuit board – most usually but not always multi-layer FR4 grade PCB. The picture on the left shows a Stator, which has been printed using electrically conductive ink on a polyester flexible circuit. Most substrates can be used providing they are non-conducting. Ceramic or polyimide substrates are especially good for extreme temperatures.

Simple wire windings or printed conductive ink can also be used to produce Stators.

Stators vary in size from a few mm to several 100mm. The largest printed Stators are up to A0 sheet size in area or up to 2700mm long. Larger sizes can be made using wire forms. Such wire form constructions do not require a substrate and can be made by winding conductive wire around an arrangement of pegs. Such constructions are well suited to either high temperature applications or inexpensive (but lower accuracy) windings.

6.3 Electronics Module

The Electronics Module comprises a power supply, over voltage & reverse polarity protection (if required), a Transmit circuit (including an oscillator), a receive circuit, a microcontroller and an electrical output. An example with a Zettlex application specific integrated circuit is shown here on the right. Typical power supplies are 3.3, 5, 10, 12, 24 and 28V.

Power consumption is proportional to measurement frequency. For example, the power consumption of a device reading 1000 times per second might be 50milliwatts whereas a unit reading once per second might be 50 microwatts. 2 wire 4…20mA power supplies are a common requirement and Zettlex manufacture several such devices.

The Electronics Module is typically located on the same circuit board as the Stator (as shown above). Alternatively, the Electronics Module can be located away from the Stator and an interconnection made using wires or flexi-rigid PCB construction. Remote location of the Electronics Module is advantageous in 2 cases:

- multiple Stators – controlled by a centralized Electronics Module which multiplexes across the various Stators
- harsh environments - where it is advantageous to locate the Electronics Module in a more benign environment than the Stator and/or Target.

The distance between Electronics Module and Stator may be a few mm or several metres. The maximum distance is determined by 4 factors:-

- size of the Stator and Target
- coupling between Stator and Target
- electromagnetic environment
- specification of the interconnecting wires

The larger the Stator and Target, the larger the practical distance between Stator and Electronics Module. The better the coupling (due to gap or physical geometry), the larger the distance. The more benign the electromagnetic environment, the larger the distance. If the interconnecting wires are protected from the electromagnetic environment – for example, with twisted pairs, shielded or run in conduit - then the larger the distance.

A variety of electrical outputs are possible. Analogue outputs include 0-5V, 0-10V, 4…20mA (2 or 3 wire), PWM, HART protocol and sin/cos 1V peak to peak. Digital outputs include RS232, RS485, SPI, SSI, A/B Pulses, Gray Code, MODBus, CANBus.

ATEX (intrinsically safe) versions of the Electronics Module are readily available.

ITAR free (even US component free) versions of the Electronics Module are readily available.

7. Functional Performance

The functional performance of most position sensors is typically characterised by three main parameters:

- Resolution
- Repeatability
- Linearity
- Measurement frequency
- Temperature Stability.

As a general rule the greater the resolution, linearity and measurement frequency, the higher the cost of any position sensor. This is also true for Zettlex Sensors.

Zettlex offers OEMs a range of sensor designs which can be readily tailored to *exactly* meet the application's requirements – no more and no less – so that costs are minimized.

Resolution. Typically, Zettlex sensors measure absolutely with 10-24bits (1k-16M points) resolution over full-scale. Theoretically, there is no minimum or maximum resolution, since the limit is only set by the analogue to digital converter in either the Zettlex Electronics Module or the host system. Zettlex have produced multi-turn rotary devices with 32 bits of resolution and a 2" rotary device with 24 bits of digital resolution. The most frequently requested resolutions are 10-20bits.

Repeatability. A key feature of Zettlex technology is that there is no hysteresis. Unlike many magnetic sensors, where significant hysteresis effects arise in the B-H curve, there is no such mechanism for hysteresis in a Zettlex device. Consequently, the repeatability is always +/-1 least significant bit of the quoted resolution.

Linearity. For reasons of technical clarity we should differentiate between **'raw linearity'** and **'calibrated linearity'**. Calibrated linearity refers to the linearity of the sensor after it has been calibrated in-situ with its host equipment. – so that the effect of any mechanical mounting variation is cancelled out. Raw linearity refers to the linearity that the Zettlex device will attain provided that the Target and Stator are mounted within certain mechanical tolerances.

For linear devices, a typical raw linearity is:-

- 0,1% of each 5mm of full-scale if the Target and Stator are mounted for smooth, tightly controlled relative motion (e.g. tolerances of the host mechanical components are typically <0,1mm). For example, if a linear sensor had a full-scale of 50mm and the Target and Stator were attached to a smooth running linear slide bearing say, then we would expect the raw linearity of the Zettlex sensor to be 0,01% of full-scale
- 0,25% of each 5mm of full-scale if the Target and Stator are mounted for only moderately controlled relative motion (e.g. mechanical mounting tolerances are typically 0,25mm). For example, if such a linear sensor had a full-scale of 50mm and the Target and Stator were attached to a smooth

running linear slide bearing say, then we would expect the raw linearity of the Zettlex sensor to be 0,025% of full-scale

- ≤0,5% of full-scale if the Target and Stator are mounted such that relative motion along the measurement axis is relatively unconstrained.

For rotary or curvi-linear sensor, similar principles apply but the quoted dimension is typically each 5mm of the effective length of the Stator or Target. Typically this is calculated in the same way that a circumference or arc-length is calculated in which the radius is taken as the mean of the outer radius and inner radius of the Stator's or Target's outermost and innermost windings respectively.

If Zettlex sensors are calibrated after being fixed in place, using a reference device (such as a high precision optical encoder or co-ordinate measuring machine) then the 'calibrated linearity' would be:-

- With about 10 points of calibration, we might expect the raw linearity to reduce by a factor of 2
- With about 1000 points of calibration we might expect the raw linearity to reduce by a factor of 10

As may be seen from the above data, the longer the length of a Zettlex linear sensor, the greater its linearity. Similarly, the greater the diameter of a Zettlex rotary sensor, the greater its linearity.

As a general rule the greatest linearity is achieved with Stator and Targets mounted for smooth, repeatable mechanical displacement and with an Electronic Module which outputs digital data e.g. RS485, SSI, SPI etc.

Temperature Stability

This refers to the stability of sensor readings in relation to changes in temperature. It can be helpful to consider this as the variation in output from a position sensor at fixed position over a variation in temperature.

Zettlex sensors use an inherently stable measurement algorithm and as a consequence are able to claim extremely low temperature coefficients compared to say Hall effect or magnetostrictive devices.

For example, the Zettlex IncOder range, has a temperature coefficient of <0,25ppm/K. In other words, if the IncOder were measuring a stationary point at 20Celsius then without any physical displacement the reading would apparently drift by 2,5ppm when the temperature changed to 30Celsius. This is roughly equivalent to 3 arc-seconds. By way of comparison, the thermal coefficient expansion of aluminium is 20ppm/K.

Thermal coefficients of rotary devices are less than for linear devices – because the thermal expansion of the main parts is mostly radial and hence common.

Thermal coefficients of devices with digital data outputs is typically >5x less than those with analogue outputs due to inherent characterisers of the necessary analogue electronic components.

8. Environmental Performance

8.1 Electromagnetic Emissions

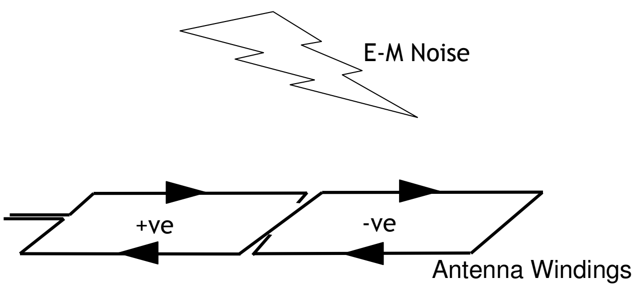
Due to their fundamental nature, Zettlex Sensors do produce electromagnetic emissions. In practice, the transmitted power is small. Stators are purposefully designed as only a near field transmitter. Consequently, any emissions are invisible in the Far Field due to the natural, rapid fall off ($1/r^3$) of the field after the Near Field. Given the low emission levels, Zettlex Sensors are suitable for automotive or defence applications where permissible emissions are particularly stringent. A common requirement is for emissions from Zettlex Sensors not to interfere with nearby, delicate direction finding or electro-optic equipment and we find that such demands are readily met.

8.2 Electromagnetic Susceptibility

Perhaps surprisingly to the newcomer, Zettlex Sensors are ideally suited to noisy electromagnetic environments. The fundamental sensor technology has been specifically engineered for robust operation in noisy environments. By way of illustration, >30% of commercial applications require Zettlex Sensors to be located either in close proximity (<10mm away) from a motor or directly next to motor windings.

Zettlex Sensors are not susceptible to electromagnetic noise due to a number of factors. The Sensors are designed to

- use a specific frequency to closely match the Target's natural frequency and only receive signals at that specific frequency
- receive signals only within minimum and maximum amplitude limits
- receive signals only in anti-phase to the transmit phase
- negate any incoming electromagnetic noise by arranging the conductors in the Stator array in balanced dipoles (conceptually, this is similar to a planar twisted pair). Accordingly, when incoming electromagnetic energy or noise induces a current to flow in one part of the Stator winding an equal and opposite current is induced to flow in the other – thus cancelling the effect. This feature is the most important and the other 3 features are typically used as a redundant safety net.



Stator Windings

In some extreme cases (e.g. in front of military radar installations or inside MRI scanners) where very high field strengths are common, it is usual that *any* electrical system will suffer from electromagnetic saturation if it is not shielded. In such instances, a separate electrical enclosure may not be needed for a Zettlex Sensor to operate reliably. Zettlex Sensors can be fabricated so that the external faces of the Stator and Target carry a thin layer of copper. This acts as an imperfect but effective (and inexpensive) Faraday cage, shielding the Sensors from the strong fields. Such constructions can also be used to minimize any emissions from a Zettlex Sensor. Note – the IncOder range is packaged in aluminium housing and therefore extremely immune to the EMC environment.

8.3 Temperature

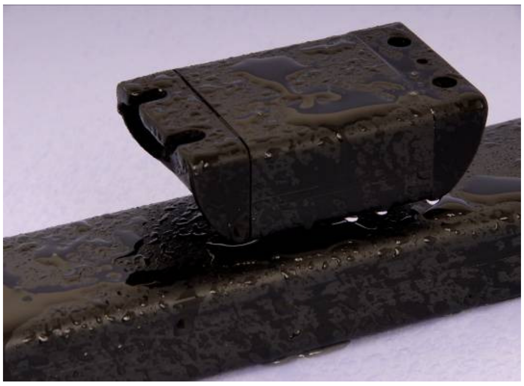
The operating principles of Zettlex technology are not sensitive to temperature variation. Whilst the conductivity of the tracks in the Stator, and so signal strength, will vary with temperature, the array of conductors in the Stator is arranged so that any variation is self cancelling and so does not effect the measured value. This means Zettlex Sensors can operate accurately and reliably in low, high or varying temperature environments.

The materials, from which the Sensor's components are produced, limit the operating & storage temperatures. At a first level, the effective temperature range can be limited by the Sensor's electronic components to a range of –40 to 85 or 125 Celsius (i.e. industrial or automotive ranges). This limit can be overcome by mounting the Sensor's electronics away from the Stator. This allows the Sensors to be arranged so that only the Stator and Target are in the extreme environment, whereas the Electronics Module can be situated in a more benign environment. A distance of a few inches might mean a temperature difference of >100Celsius – particularly if the Electronics Module is located behind a thermal barrier.

With remote Electronics Modules, more extreme temperatures at the Stator and Target can be accommodated by using suitable substrates for the Stator and Targets. Such substrates include ceramic, polyimide or glass. Zettlex Sensors with an upper limit of 230Celsius are common. Similarly, Zettlex Sensors for airborne applications at -55Celsius are common.

The technique's insensitivity to temperature is evidenced by the low thermal coefficients quoted in sensor specifications. Maximum thermal coefficients for linear sensors are typically <20ppm/K of full-scale. Such coefficients are comparable with the effects caused by the thermal expansion of the circuit board substrates – which is low, compared to thermal expansion coefficients of steel or aluminium. Thermal coefficients for rotary sensors are typically <1ppm/K of full-scale. The coefficient is lower than linear because the Target and Stator will expand or contract at similar rates. Electronics Modules with digital outputs exhibit lower temperature coefficients than those with analogue outputs.

8.4 Humidity & Moisture



The fundamental operating principles of Zettlex Technology are not sensitive to moisture and humidity (unlike capacitive techniques). It can be demonstrated that there is typically no variation in measured value compared to humidity levels or even submersion in low conductivity fluids (for these purposes, sea water is classed as a low conductivity fluid). This means Zettlex Sensors can reliably operate accurately and reliably in 0%RH, 100%RH or in submersion.

Practically, the materials, which package or enclose the Sensor, determine resilience to liquids. Most frequently, the Sensor components are conformally coated with varnish. Conformal coatings are recommended for occasional, temporary exposure to fluids. If exposure to fluids is common, prolonged or constant then the Sensor components can be epoxy encapsulated or insert moulded.

Submersion in salt water, fresh water, steam, oil, diesel, petrol does not affect the Sensor's measurement performance.

8.5 Chemical Resilience

The fundamental operating principles are not affected by any chemicals. That means Zettlex Sensors can operate in relatively harsh chemical environments. Practically, the materials, which package or enclose the Sensor, determine resilience to liquids. Most frequently, the Sensor components are conformally coated with varnish. Alternatively, the Sensor components can be epoxy encapsulated or insert moulded. In extreme environments, the Sensor components can be completely housed in stainless steel housing.

8.6 Life-time

The lifetime of a Zettlex Sensor is typically determined by the lifetime of the components carrying the Target and Stator. Duty cycle has either no or negligible effect on life-time.

In some extreme temperature applications the life-time of some of the components *may* be reduced when exposed to temperature extremes for extended periods.

Zettlex Sensors are used in several applications with a 20 year life-time requirement.

Importantly, there is typically no requirement for periodic inspection, service or maintenance due to the non-contact nature of the technology.

8.5 Shock & Vibration

The performance of a Zettlex Sensor with vibration or shock is determined by the performance of the components carrying the Target and Stator.

In some extreme shock or vibration applications, the Sensor's components are encapsulated in hard and/or soft epoxy. Zettlex Sensors are successfully used in one application with a shock of 1000g over 10msec.

Airborne or armoured land vehicle vibration and shock regimes are readily met by most Zettlex Sensor constructions.

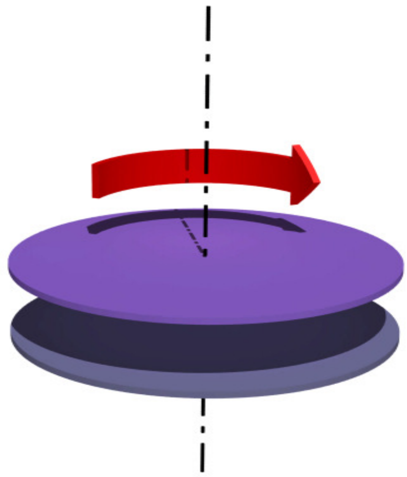
Typically, the most vulnerable parts of any electrical system in harsh vibration or shock environments are connectors. Generally, Zettlex Sensors tend to eradicate or minimize the number of connectors by using either hard wired connections or flexi-rigid circuit constructions.

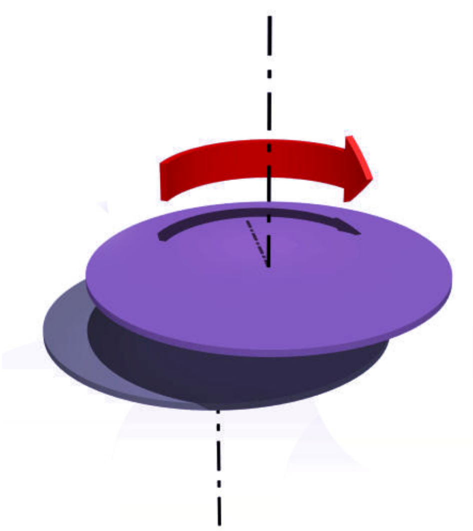
9. Sensing Geometries

There is a myriad of sensor shapes and sizes. The following provides an overview of some of the most common Zettlex Sensor geometries.

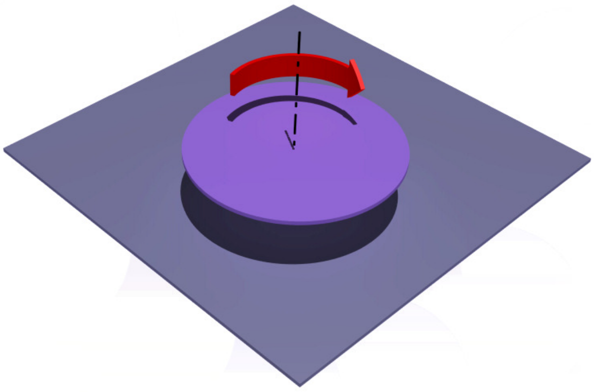
In all instances position measurement is absolute. If required, the Sensors can be configured to provide incremental signals.

Rotary Sensor - Co-Axial Target & Stator. The maximum stand off distance between Target and Stator is about ¼ of the effective (electrical) diameter of the Stator or Target. The Sensor may be constructed in an annular form with a through shaft (of conductive or non-conductive material) or in an 'end of shaft' arrangement with no through shaft. Position measurement is absolute from 0 to 360 degrees with no measurement 'blips' at crossover from 0 to 360 degrees. Typical application: through shaft rotary encoder for BLDC motor commutation and position control.



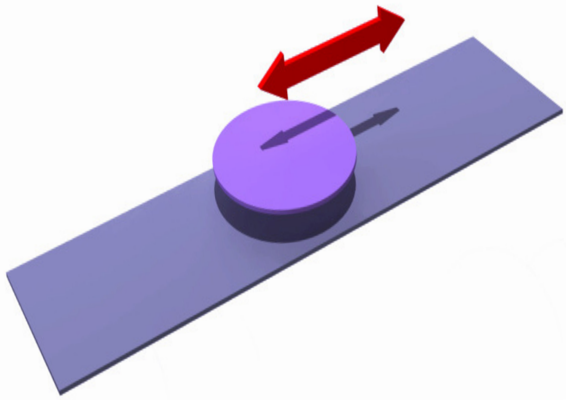


Rotary Sensor - (Slightly) Non-Co-Axial Target & Stator. The maximum stand off distance between Target and Stator is about ¼ of the effective diameter of the Stator or Target. The maximum axial offset depend on a number of factors but generally, may be taken as varying between 0-10% of the diameter of the Stator or Target without significantly affecting measurement performance. Position measurement is absolute from 0 to 360 degrees with no measurement 'blips' at crossover from 0 to 360 degrees. Typical application: end of shaft rotary encoder for roller drive whose centre-line has a variable position.

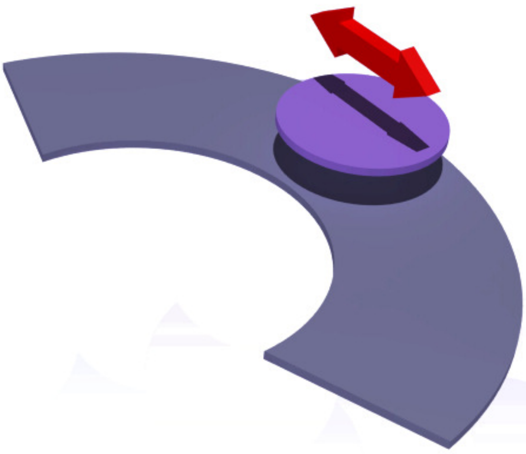


Rotary Sensor - (Grossly) Non-Co-Axial Target & Stator. The maximum stand off distance between Target and Stator is about ¼ the diameter of the effective diameter of the Target. The centre of rotation of the Target may vary within the limits of the Stator such that the Target's circumference does not approach the periphery of the Stator. Position measurement is absolute from 0 to 360 degrees with no measurement 'blips' at crossover from 0 to 360 degrees. Typical application: end of shaft rotary sensor for suspended or sprung shafts.

Linear Sensor. The maximum stand off distance between Target and Stator is about 1/2 of the effective width of the Stator or Target. The maximum offset of the Target at right angles to the measurement axis (but coplanar with Stator) depends on a number of factors but may be taken as varying between 0-10% of the width of the Stator or Target without affecting measurement performance. Position measurement is absolute but, preferably, should be limited to <80% of the length of the Stator to avoid end affects. Typical application: machine element position sensing.

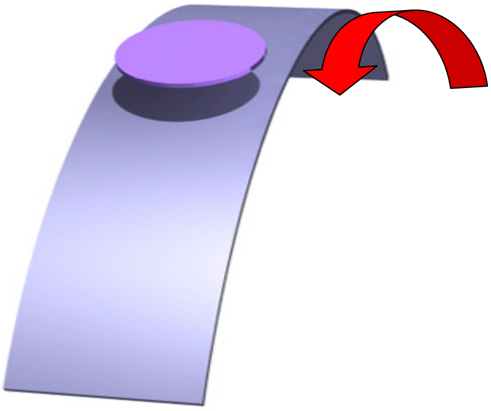


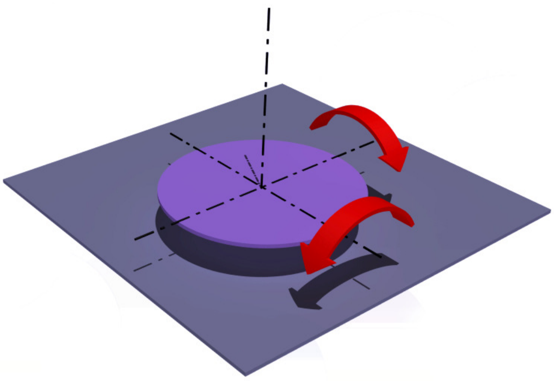
Note that in the example above, the geometry may be changed over so the Stator is the shorter unit and the Target extends along the measurement axis. Typical application: measuring the position of a powered carriage along a track.



Curvi-Linear Sensor [A]. The maximum stand off distance between Target and Stator is about 1/2 the width of the effective width of the Stator or Target. The maximum offset of the Target at right angles to the measurement axis (but coplanar with Stator) depends on a number of factors but may be taken as varying between 0-10% of the width of the Stator or Target without affecting measurement performance. Position measurement is absolute but should be limited to <80% of the effective length of the Stator so that end affects are avoided. The Sensor can curve a full 360 degrees if required wherein no measurement blip will occur at 0 to 360 degree transition. Note the Sensor's output can be parameterised so as to give distance or angle of rotation from the centre point of the Stator's curve. Typical application: accurate angle measurement on large radii such as gun turrets or radar Stator.

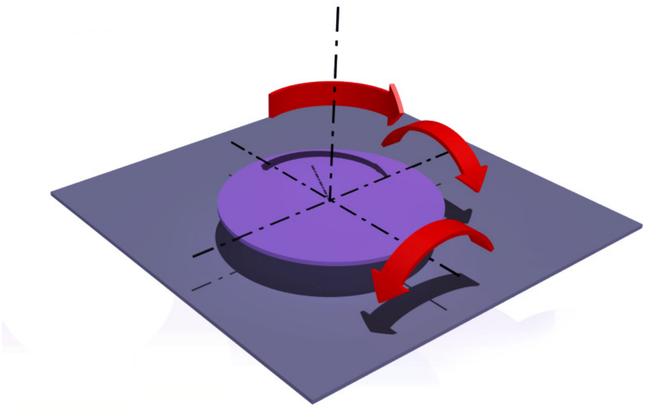
Curvi-Linear Sensor [B]. The maximum stand off distance between Target and Stator is about 1/2 of the effective width of the Stator or Target. The maximum offset of the Target at right angles to the measurement axis (but coplanar with Stator) depends on a number of factors but may be taken as varying between 0-10% of the width of the Stator or Target without affecting measurement performance. The Sensor can curve a full 360 degrees if required, wherein no measurement blip will occur at 0 to 360-degree transition. Position measurement is absolute but should be limited to <80% of the effective length of the Stator so that end affects are avoided (except when in full 360 degree operation). Note the Sensor's output can be parameterised so as to give distance or angle of rotation from the centre point of the Stator's curve. Typical application: accurate angle measurement on large radii around a shaft.

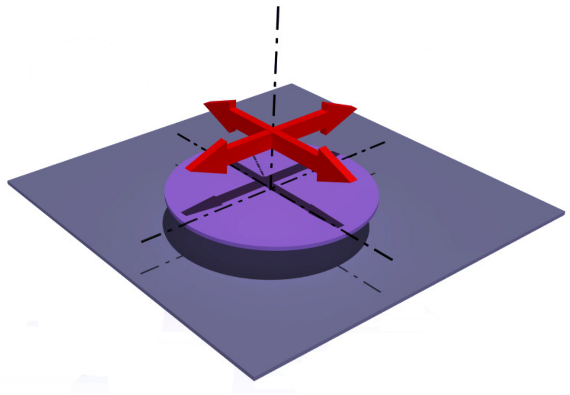




Roll & Pitch Sensor. The maximum stand off distance between Target and Stator is about 1/3 the width of the effective width of the Target. This limit therefore affects the typical measurement range from 0 to +/-45 degrees for each rotational axis. Position measurement is absolute. Typical application: joysticks.

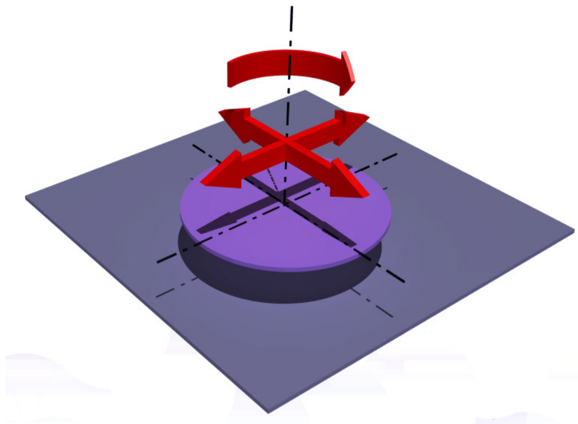
Roll, Pitch & Yaw Sensor. The maximum stand off distance between Target and Stator is about 1/3 of the effective width of the Target. This limit therefore affects the typical measurement range from 0 to +/-45 degrees for each rotational axis. Position measurement is absolute. Typical application: Tilt measurement.





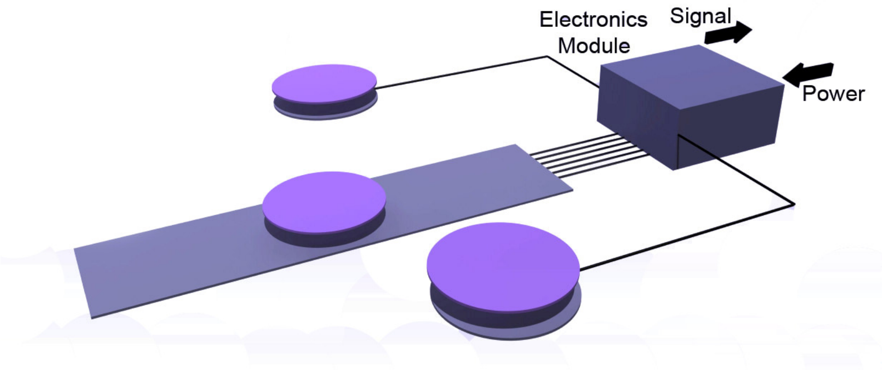
2D Sensor. The maximum stand off distance between Target and Stator is about 1/2 of the effective width of the Target. Position measurement is absolute but should be limited to <90% of the effective length or width of the Stator so that edge affects are avoided. Typical application: joysticks, games and pen input devices.

2D + Rotation Sensor. The maximum stand off distance between Target and Stator is about 1/4 of the effective width of the Target. Position measurement is absolute but should be limited to <80% of the effective length or width of the Stator so that edge affects are avoided. Typical application: joysticks.



10. Multi Sensor Systems

Zettlex Electronic Modules can be designed to multiplex across a number of Sensors. More traditional techniques such as Hall affect or capacitive sensors do not permit this because the required electronic processing (i.e. the silicon) has to be positioned adjacent to the sensing point. With Zettlex Technology, however, it is possible to position the Electronics Module away from individual Stator and Targets. This is because the received signals have relatively high amplitudes and the subsequent signal processing is robust. In turn, this permits multiple Sensors to be energised from, and supply signals to, a central Electronics Module.



Since Targets and Stator are relatively inexpensive to produce, it makes good economic sense to multiplex the Electronics Module. This amortises the Module's cost across multiple Sensors, thus bringing the costs/Sensor down to its lowest possible level.

The Sensors shown here on the right are a pair of rotary sensors controlled by a single Electronics Module located on the same PCB as the first Stator. Such a construction is particularly advantageous in gimbal systems for cameras, radar dishes and weapons systems. In this instance the interconnection between the second Stator and the Electronic Module is twisted pair wires.

Note that there are various inexpensive ways to make the interconnections between Sensors & Electronics Module. Typically the interconnections are either tracks on a PCB, a flexi-PCB interconnect, CAT 5 cable or flexible tracks in flexi-rigid hybrid PCB.

The maximum number of Sensors per Electronics Module is determined by the maximum permissible response time from a given Sensor input. If we consider the example of a system with a measurement cycle time of say 1 milliseconds per Sensor and a maximum permissible response time of 25 milliseconds, then the maximum number of Sensors per Electronics Module is 25. This limit can be increased by the use of more sophisticated multiplexing algorithms – for example, sampling the most frequently used Sensor inputs more frequently and vice versa.

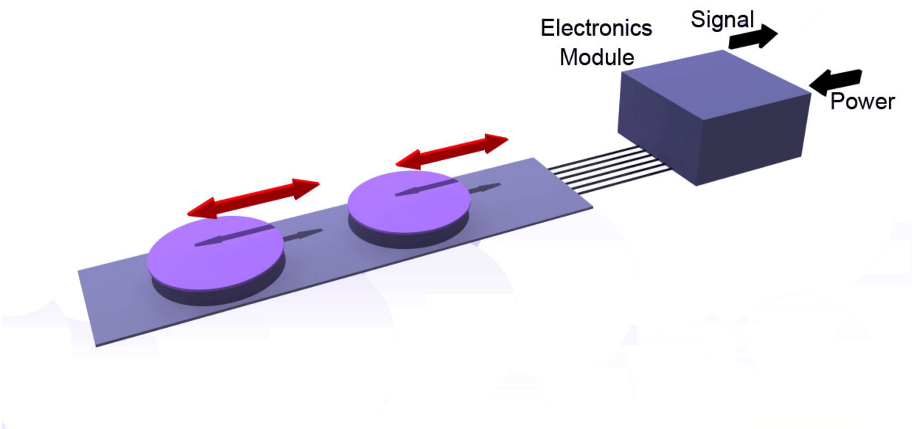
The maximum distance that an Stator can be displaced from the Electronics Module is determined by 3 main factors:

- Physical size of the Stator & Target,
- Coupling factor between Target & Stator,
- EMC/regulatory environment.

Generally, if the Target and Stator are large with a relatively low stand off distance (and hence good coupling factor) then distances between Sensor and Electronics Module of several metres are permissible.

EMC issues on long cable or interconnect lengths can be mitigated by the use of shielded, twisted pair cable and connectors. A further option is to route any interconnections in earthed metal conduit. Of course, it is preferable to avoid the use of shielded cables etc. due to the additional costs. By way of example, a 2m long unshielded CAT5 cable is acceptable within a consumer electronics environment regulated by EN68000, for example.

A requirement to measure the position of multiple Targets does not necessarily require the use of multiple Stators. It should be noted that a single Stator can track multiple Targets. 8 targets per Stator is a sensible limit without a step change in the complexity or cost of an Electronics Module.

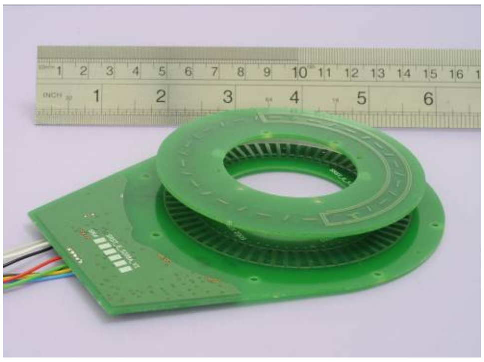


A Zettlex system containing multiple targets with one Stator plus further additional Target and Stator pairs is permissible.

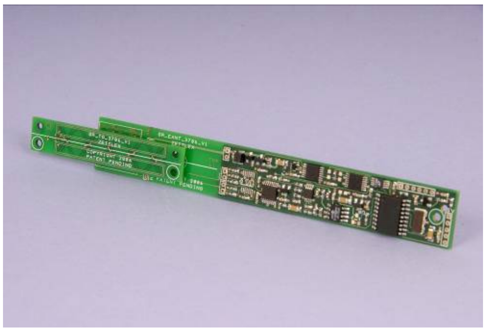
When multiple Sensors or Targets or Stator are controlled by a central Electronics Module it is, of course, beneficial to consider the use of a digital data stream output - rather than multiple 0-5V DC or PWM outputs – so as to minimise electronics, connector and cabling costs.

11. Example Specifications

The following should be taken as examples only rather than limits:-



Sensor geometry = annular (flat ring)
Measurement = absolute angle
Full-scale = ≤360 degrees
Resolution = 16 bits (65,536 counts per rev)
Repeatability = +/1 LSB or 1 count
Raw Linearity = ≤0,05 degrees
Calibrated Linearity = ≤0,005 degrees
Measurement frequency = 2000Hz

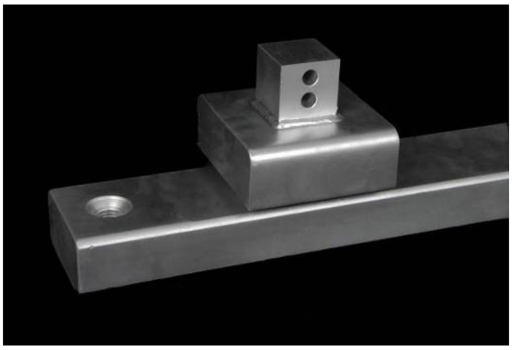


Sensor geometry = linear
Measurement = absolute distance
Full-scale = ≤15mm
Resolution = ≤5microns
Repeatability = +/1 LSB or 1 count
Linearity = ≤0,25% full-scale
Measurement frequency = 1000Hz

Sensor geometry = rotary 25mm diameter
Measurement = absolute angle
Full-scale = 360 degrees
Resolution = 16 bits (65,536 counts per rev)
Repeatability = +/1 LSB or 1 count
Raw Linearity = ≤0,18 degrees
Calibrated Linearity = ≤0,018 degrees
Measurement frequency = 2000Hz

Sensor geometry = curvilinear
Measurement = absolute (programmable)
Full-scale = ≤100 degrees
Resolution = 10 bits over full-scale
Repeatability = +/1 LSB or 1 count
Raw Linearity = programmable against non-linear flow device
Measurement frequency = 20Hz
Note - 2 wire 4…20mA device. ATEX version also in production.

Sensor geometry = pair of rotaries 50mm diam.
Measurement = absolute (programmable)
Full-scale = ≤360 degrees azimuth & elevation
Resolution = 14 bits over full-scale
Repeatability = +/1 LSB or 1 count
Raw Linearity = <0,05% of full-scale
Measurement frequency = 400Hz



Sensor geometry = harsh environment linear
Measurement = absolute
Full-scale = 1000mm
Resolution = 1mm
Repeatability = +/1mm
Raw Linearity = <3mm
Measurement frequency = 100Hz
Operating Temperature = 230Celsius
Shock Rating = 1000g in 10msecs

Sensor geometry = through bore precision rotary
Measurement = absolute
Full-scale = 360°
Resolution = 19 bits
Repeatability = +/-1bit
Raw Linearity = <40 arc-seconds
Measurement frequency = 1000Hz
Operating Temperature = -40 to 85Celsius

12. Design Guidelines

If you plan to use standard Zettlex sensors, such as LINTRAN or IncOder, the corresponding data sheets provide all necessary data. If you plan to use a custom Zettlex Sensor, the following should help you define the technical requirements:-

- **Dynamic range** – measurement geometry and distance should be specified. If it's a linear, curvi-linear or 2D Sensor, allow the Stator to extend beyond the measurement limits by at least 10% of the dynamic range at either end.

- **Resolution** – fineness of measurement should be specified. You can specify this as the physical fineness (e.g. $\leq$1 micron) or bits (e.g. 16 bits = 65,536 counts).

- **Repeatability & Linearity** – generally, the repeatability of a Zettlex sensor is the same as 1 count of resolution.

- **Absolute or incremental** – if the host system requires position measurement at power up, without stepping to known positions, then absolute measurement should be specified.

- **Assembly calibration** – remember to consider the first time the Sensor is used. If there's a fair degree of assembly tolerance with the host, then it is worth considering an in-situ cal step. This may simply be setting the 0% of scale point.

- **Electrical output** – the required electrical output should be specified e.g. 0-5V, PWM, RS232, CAN Bus, RS485, 4…20mA, I^2C. The least expensive and most accurate output is a serial data link such as I^2C or RS232.

- **Presence of metal objects** – (Not applicable to LINTRAN or IncOder ranges) if metal objects are located very near the Sensor (e.g. <10mm), consult Zettlex. Preferably, space the Stator away from any metal objects and ensure no metal directly between Target & Stator unless absolutely necessary. If the metal is a through shaft on a rotary sensor this will have no effect on sensor performance.

- **Distance between Target & Stator** – measurement accuracy is generally not affected by slight variation in stand off distance between Target & Stator, as long as the Target never leaves the Near Field.

- **Temperature range** – consider the temperature range for storage and operation. If the temperatures are extreme at the sensing point, consider placing the electronics away from the Sensor to a more benign environment.

- **Humidity and moisture** – if there is high humidity, condensation or submersion then sealing or encapsulation should be considered

- **Distance of Sensors from Electronics** – Generally, the shorter the distance, the less problematic any EMC issues. At any distance >300mm, EMC issues must be considered with possible solutions of multiple frequency Sensors, twisted pair cables, screened cables, screened connectors, metal enclosures, metal conduit etc.

13. Comparison with Other Technologies

The following table gives a ***rough*** comparison of Zettlex Technology with other technologies – it is not intended as an exhaustive discussion:

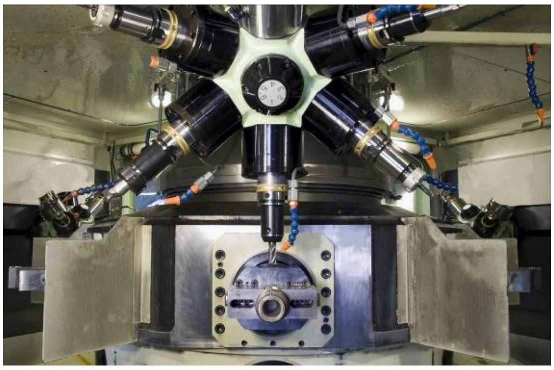
	Multiple/Complex Geometries	Insensitive to Moisture/Dirt	Wide Temperature Range	Absolute Measurement	Analogue Measurement	Shock/Vibration Insensitive	Identification functionality	Multiple Targets per Sensor	Typical Measurement Range	Mechanical offset insensitive	Long Life	Typical volume price range [$]
Capacitive	Yes	No	No	Yes	Yes	Yes	No	No	0 to 1m	No	Yes	50 to 1000
Contacting Switches	No	No	Yes	Yes	No	No	No	No	0 to 10mm	Yes	No	0,1 to 100
Giant Magnetoresistive	Yes	Yes	No	Yes	Yes	Yes	No	No[1]	0 to 10m	Yes	Yes	50 to 1000
Hall Effect	No	Yes[2]	No	Yes[3]	Yes	Yes	No	No	0 to 10mm	No	Yes	1 to 100
Inductive Proximity	No	Yes	Yes	No	No	Yes	Yes[4]	No	0 to 50mm	Yes	Yes	5 to 100
Inductosyn	No	Yes	Yes	Yes	Yes	Yes	No	No	0 to 10m	No	Yes	1000 to 10000
LVDT & RVDT	No	Yes	Yes	Yes	Yes	Yes	No	No	0 to 2m	No	Yes	100 to 1000
Optical	No	No	No	Yes	Yes	No	No	No	0 to 2m	No	Yes[5]	10 to 5000
Potentiometer	No	No[6]	No	Yes	Yes	Yes[7]	No	No	0 to 1m	No	No	0,5 to 100
Reed Switch	No	Yes	No	Yes[8]	No	No	No	No	0 to 10m	Yes	Yes	0,5 to 5
Resolvers & Synchros	No	Yes	Yes	Yes	Yes	Yes	No	No	0 to 0,5m	No	Yes	100 to 1000
Zettlex	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0 to 10m	Yes	Yes	see Note 9

Notes
1. Requires powered target
2. Dirt must be non-magnetic
3. Requires multiple sensors
4. Requires multiple sensors
5. Lifetime limits apply
6. Gaiters can be applied
7. Wear caused by vibration
8. Requires multiple sensors
9. General rule is that a Zettlex sensor will cost <50% of comparable resolver, synchro or LVDT installation

14. Applications

14.1 General Attributes

Zettlex Sensors are not intended to be universally applicable. In some instances a simple switch will provide the design engineer with the optimal cost/performance solution. Nevertheless, in many other instances Zettlex Sensors are more suitable to a given application than other technologies such as Hall affect, optical Sensors, etc.



Zettlex Sensors have a number of unusual attributes:-

- they are extremely robust in harsh environmental conditions in terms of moisture, foreign matter or temperature extremes
- they are accurate
- they offer high resolution and excellent repeatability
- multiple Sensors can be controlled by a single set of electronics
- they are extremely robust in harsh environmental conditions in terms of moisture, foreign matter or temperature extremes
- they are insensitive to AC/DC fields
- they are tolerant of mechanical offsets and tolerances
- they provide absolute rather than incremental position measurement
- they can identify a number of different targets and measure their position independently and concurrently
- they are suitable for unusual or complex sensing geometries
- they have long-life.

Typically, Zettlex Sensors are to be used when two or more of the above attributes are applicable to a sensing project facing a design engineer.

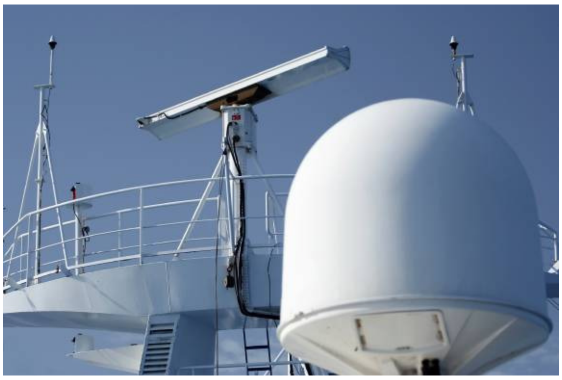
14.2 Specific Applications Examples

Actuators
Aileron controls
Analogue gauges
Angle sensors
Stator tracking
Anti-counterfeit devices
Audio controls
Automatic teller machines
Automation equipment
Ball screws
Boilers
Brake sensors
Brake wear sensors
Brake wear sensors
Burners
Climate controls
Cockpit controls
Component ID
Consumer electronics
Cookers
Cooking ranges
Cooktops
Dials
Dial indicators
Direction indicators
Dishwashers
Displacement sensors
Door travel sensors
Elevators
End of shaft encoders
Fitness equipment
Flow sensors
Food mixers
Fuel level sensors
Fuel metering
Games
Gauges
GMR sensor replacements
Guided vehicle tracking
Gunnery sights
Hall Effect replacements
Headlamp level controls
HVAC sensors
Hydraulic actuators
Hydraulic valves
ID tags
Inclinometers
Inductosyn replacements
Industrial control panels
Joysticks
Kitchen goods
Lifts
Lighting controls
Limit switch replacements
Linear actuators
Liquid level sensors
Load sensors
LVDT replacements
Machine tools
Magnetostrictive replacements
Mining equipment
Missile guidance
Motion controllers
Motor encoders
Odometers
Packaging equipment
Palletisers
Paper thickness sensors
Pedal sensors
Pen sensing
Petrochemical sensors
Plotter controls
Pneumatic actuators
Pneumatic valves
Pressure sensors
Printer write heads
PRNDL sensors
Proximity sensors
Push buttons
Radar controls
Ride height sensors
Robots
Roll & pitch sensors
Roll, pitch & yaw sensors
Roller separation sensors
Rotary encoders
RVDT replacements
Safety switches
Seating instrumentation
Security tags
Servo motors
Servo motors
Shaft encoders
Sheet feeders
Skis
Sliders
Speed sensors
Sports equipment
Steering angle sensor
Steering column controls
Steering torque sensors
Stepper motors
Strain measurement
Suspension dampers
Suspension sensors
Tachometers
Tamper evident devices
Throttle controls
Tilt sensors
Torque sensors
Toys
Traction control
Transmission sensors
User interface elements
Utility meters
Valves
Valve Actuators
Velocity sensors
Vibration sensors
Washing machines
Windscreen wipers
Weight sensors
Wheel sensors
Workpiece ID

15. Frequently Asked Questions

What emissions do Zettlex Sensors produce?
By their fundamental nature Zettlex Sensors do produce electromagnetic emissions. In practice these emissions are small. Stators are specifically designed to be only a near field transmitter. In practice, any emissions are invisible in the Far Field due to the natural, rapid fall off ($1/r^3$) after the Near Field.

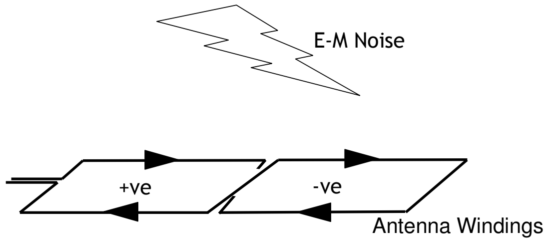
Given the low emissions levels Zettlex Sensors are suitable for automotive or defence applications where permissible emission levels are particularly stringent. A common requirement is for sensor emissions not to interfere with nearby, delicate direction finding, radio or electro-optic equipment and we find that such demands are readily met.



Are Zettlex Sensors susceptible to electro-magnetic noise?
Perhaps surprisingly to some, Zettlex Sensors are ideally suited to noisy environments. The fundamental design of Zettlex Sensors has been specifically engineered for robust and reliable operation in noisy electromagnetic environments. By way of illustrating this point, >30% of Zettlex's commercial applications require Zettlex sensors to be located either in close proximity (<1" away) from a brushed or brushed motor or directly next to motor windings.

Zettlex Sensors are not susceptible to emissions from other sources because they:-

- use a specific frequency to match the Target's natural frequency and only receive signals at that frequency
- receive signals only within minimum and maximum amplitude limits
- receive signals only in anti-phase to the transmit phase
- negate any incoming electromagnetic noise by arranging the conductors in the Stator array in balanced dipoles (conceptually, this is similar to a planar twisted pair). Accordingly, when incoming electromagnetic energy or noise induces a current to flow in one part of the Stator winding an equal and opposite current is induced to flow in the other – thus cancelling the effect. This feature is the most important and the other 3 features are typically used as a 'safety net'.



In some extreme cases (e.g. in front of radar installations or inside MRI scanners) where field strengths of >>100V/m are common, it is usual that *any* electrical system will suffer from electromagnetic saturation if it is not shielded. In such instances, a separate electrical enclosure may not be needed for a Zettlex Sensor to operate reliably. Zettlex Sensors are sometimes fabricated so that the external faces of the Stator and Target carry a thin layer of copper. This acts as an imperfect but effective (and inexpensive) Faraday cage, shielding the Sensors from the strong fields. Such constructions can also be used to negate any emissions from a Zettlex Sensor.

How far can a Target be away from the Stator?
The Near Field produced by the Stator's Transmit circuit determines the limit. As an example, if a linear Stator is 300mm long by 30mm wide, then the Near Field extends to a maximum distance of 15mm from the plane of the Stator. A sensible design limit would be to specify a distance of Target from Stator of <12mm and preferably <5mm. A constant gap between Stator and Target is not necessary for accurate position measurement.

Can a Zettlex Sensor operate through a metal shield?
In principle, a metal shield can be inserted between a Sensor's Target and an Stator. Generally, such an arrangement is not preferred due to the heavy signal losses caused by such an arrangement. The skin depth through which the excitation signals can permeate limits the thickness of the metal shield. The lower the excitation frequency, the greater the thickness of permissible metal. The maximum thickness of metal depends on the actual metal. If a metal shield is to be used then non-magnetic stainless steel is most preferred with aluminium, steel, copper or brass least preferred. Practically, metal thicknesses of <2mm are necessary.

How many identities can a Target carry?
In theory, a Target can carry an infinite number of identities. Practically, a Target is limited to about 8 frequencies and hence 8 identities. However, an object can carry multiple Targets of differing frequency - hence multiplying the possible number of identities. Furthermore, the relative distance and orientation of the Targets can be sensed by an Stator, thus multiplying the number of identities still further.

What maximum temperature can a Zettlex Sensor cope with?

The fundamental operating principles of Zettlex technology are not sensitive to temperature variation. Whilst the conductivity of the tracks in the Stator, and hence signal strength, will vary with temperature, the array of conductors in the Stator is arranged so that any variation is self cancelling and so does not effect the measured value. This means Zettlex Sensors can reliably operate accurately and reliably in low, high or varying temperature environments. Practically, the materials, from which the Sensor's components are produced, limit the operating and storage temperatures. At a first level, the effective temperature range can be limited by the sensor's electronic components to a range of –40 to 85 or 125 Celsius (i.e. industrial or automotive ranges). This limit can be overcome by mounting the Sensor's electronics away from the Stator. This allows the Sensors to be arranged so that only the Stator and Target are in the extreme temperature environment, whereas the Electronics Module can be situated in a more benign environment. A distance of a few inches might mean a temperature difference of >100Celsius – particularly if the Electronics Module is located behind a thermal barrier such as an insulated housing.

With remote Electronics Modules, more extreme temperatures at the Stator and Target can be accommodated by using suitable substrates for the Stator and Targets. Such substrates include ceramic, polyimide or glass. Zettlex Sensors with an upper limit of 230Celsius are common. Similarly, Zettlex Sensors for airborne applications at -55Celsius are common. The technique's insensitivity to temperature is evidenced by the low thermal coefficients quoted in sensor specifications.

How far can the Electronics be away from the Stator?

The maximum distance between Electronics and Stator is determined by two main factors – the coupling factor between Target & Stator and the application's electromagnetic environment or EMC requirements. The greater the signal amplitudes in the Stator's Receive circuits and the more relaxed the EMC environment, the greater the permissible displacement between Electronics and Stator. The use of EMC shielded cable between Stator and Electronics increases the maximum permissible distance. In consumer electronics applications a distance of 2m is achievable without the use of shielded cable between Electronics and Stator. Zettlex can advise on maximum distances given a particular Sensor geometry, size and relevant EMC data.

Do magnets affect Zettlex Sensors?
Generally, Zettlex are unaffected by DC magnetic fields. However, if the magnets are within the Sensor's Near Field then they will tend to distort the Stator's field by providing an 'easy route' for the magnetic flux. This can be accommodated in the design of the Sensor by modifying the arrangement of the Stator and/or Target.

Do metal objects affect Zettlex Sensors?
Metal objects outside the Sensor's Near Field have no affect on the Sensor. However, metal objects within the Near Field tend to distort the Magnetic pattern. Again, as with magnets these can be accommodated in the design of the Stator. Distortion affects are minimal if the metal objects are symmetrical e.g. a metal shaft through the centre of the Sensor.

How much power does a Zettlex Sensor need?
A typical power requirement is 5V and <20mA - but this is at 100% duty cycle. Power usage can be reduced (e.g. for purposes of extending battery life) by the use of a sleep cycle – thus reducing the effective duty cycle. A sleep cycle can be implemented by, for example, using an algorithm which measures displacement once every 10 seconds (equivalent to a 0,1% duty cycle) and reverting to 100% duty cycle should the displacement have changed. In turn, the Sensors can then revert to sleep mode if the displacement does not change again for a period of say, 10 seconds. Zettlex Sensors often operate on a 2 wire 4…20mA current loop.

How many Sensors can a Zettlex Electronics Module handle?
The maximum number of Sensors per set of electronics is determined by the maximum permissible response time per Sensor. If we consider the example of a Zettlex Sensor taking 1 milliseconds per measurement and a maximum response time of 25 milliseconds then with a simple multiplexing scheme the maximum number of Sensors is 25. This number can be increased with a more sophisticated multiplexing algorithm, for example, sampling the less frequently used or less important Sensors less frequently. A Zettlex Electronics Module can also handle inputs from other elements such as switches, thermocouples, user interfaces etc.

How fast can Zettlex sensors measure?
Measurement speed or update rate is determined by a number of factors including power consumption, measurement performance and output signal. When current consumption is constrained to <3mA (for example in a 24VDC 4..20mA 2-wire loop device) update rates of <50Hz are typical whereas in a Zettlex encoder for BLDC control with A/B pulses or 1V sin/cos outputs then update rates of up to 200kHz are feasible, with 20kHz typical for most applications.

Can Zettlex sensors of different geometries be controlled by a single set of electronics?
Yes. The standard Zettlex software can be parameterised to control multiple Sensors of various geometries.

What quality accreditations does Zettlex carry?
Zettlex is ISO9001 accredited for the manufacture of electromagnetic sensors and associated technical services. Zettlex is also BS EN 13980 accredited for the manufacture of ATEX (intrinsically safe) sensors.

Are Zettlex Sensors ITAR listed?
No.

Do Zettlex Sensors contain ITAR listed components?
No. Where necessary, Zettlex Sensors can be supplied with no US components.

Is Zettlex Technology patented?
Yes. The technology is covered by various granted and pending patents in UK and internationally.

Does Zettlex licence the technology?
No. We sell sensors and sensor components.

Who else makes Zettlex Sensors?
Nobody. Competition comes from the traditional manufacturers of potentiometers, Hall Effect devices, optical encoders, capacitive devices, resolvers and LVDTs. We regularly compete against optical encoders, resolvers and LVDTs where typically we offer a superior technical solution at less cost than traditional manufacturers.

What happens if we design a Zettlex Sensor in to our product and, for whatever reason, Zettlex cannot supply?
In many OEM applications a design file containing all the technical information necessary to manufacture the Sensors can be placed in to escrow which our client can access should Zettlex be unable to supply.