# 78mm Type 3.2 Axial Sensor

## Description

A resonant inductive position sensor for measuring linear position over a range of 78mm. The sensor works with targets having an axis of symmetry running along the measuring axis, which means they can rotate freely ("Axial Sensor").

A large gap is possible between sensor and target. This allows each of the parts to be located inside its own separate housing, with each part separately encapsulated where needed.

The sensor works with CambridgeIC's Central CAM312 Tracking Unit (CTU) chip with Type 3 circuitry. This performs measurements and provides high-quality position data to a host device.

The sensor includes four coils. Two are used to excite the resonator inside the target. All four are then used to detect signals coming back from the resonator, for processing by the CAM312 IC.

## Features

- Full absolute linear sensing
- 78mm Measuring Length
- 8-layer PCB process
- Works with a wide range of target designs
- 5 wire connection possible

## Performance (depends on target)

- Linearity Error <±0.2%
- Noise Free Resolution > 10 bits
- Gap up to 10mm

| Product identification | |
|---|---|
| **Part no.** | **Description** |
| 013-0057 | Assembled sensor |
| 013-6001 | Compatible sensor cable |
| 013-1033 | L20 Rod Target Sample |
| 013-5034 | CAM312 Development Board |
| 010-0145 | Sensor Blueprint |

## Applications

- Valve position sensing
- Actuator position feedback
- Liquid level sensing by detecting float height
- Electronic reading of variable area flow meters
- Syringe fill level sensing

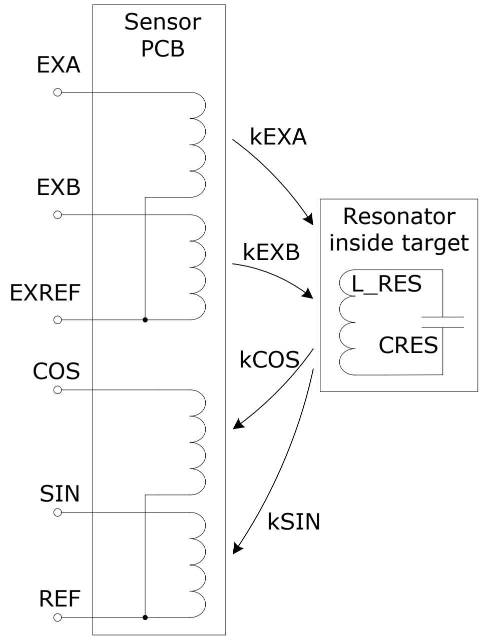


**Figure 1 equivalent circuit**

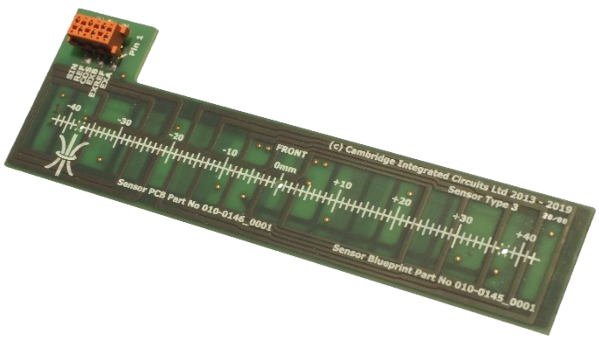

**Figure 2 78mm Type 3.2 Sensor Assembly**

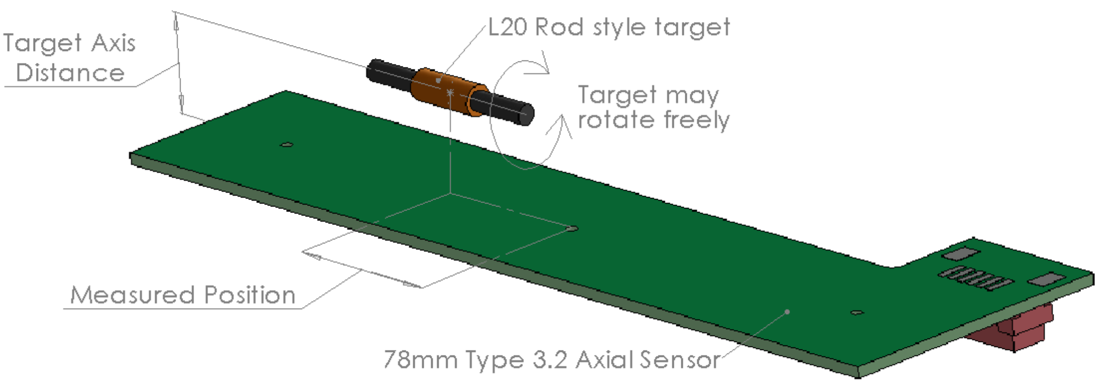


**Figure 3 Sensor Assembly illustrated with L20 Rod style target**

# 1 Assembled Sensor Mechanical Design

The 78mm Type 3.2 Axial Sensor is available as an assembled PCBs including connector. An image of its FRONT side is shown in Figure 2. Figure 4 is a mechanical drawing with dimensions in mm.

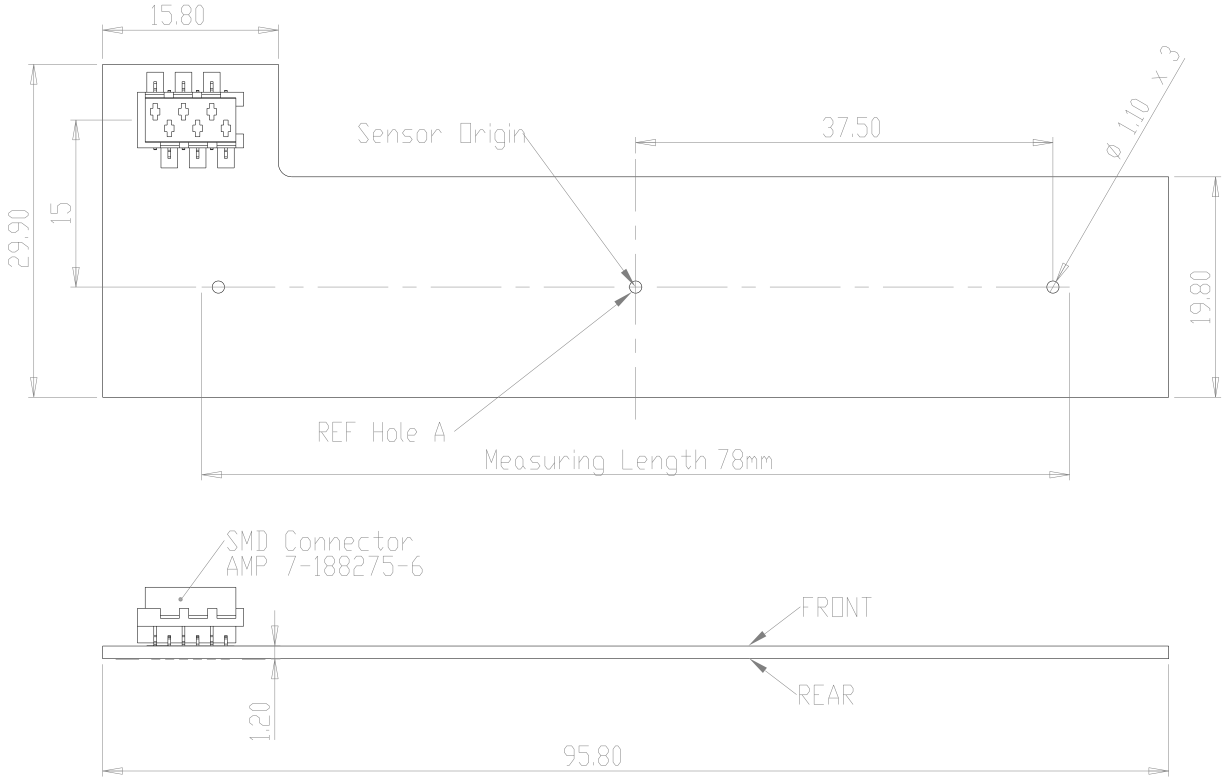


**Figure 4 Mechanical drawing, sensor PCB assembly 013-0057**

The FRONT of the sensor PCB is fitted with an SM connector AMP-7-188275-6. The REAR includes pads for SM connector MOLEX 53261-0671, which is not fitted. The pinout for both is shown in Table 1.

**Table 1 Sensor PCB electrical connections**

| Pin no | Signal name |
|---|---|
| 1 | EXA |
| 2 | EXREF |
| 3 | EXB |
| 4 | COS |
| 5 | REF |
| 6 | SIN |

The target may be adjacent either the FRONT or REAR surface of the sensor PCB.

The sensor measures Actual Position relative to the Sensor Origin. The nominal location of the Sensor Origin is REF Hole A, as drawn in Figure 4. Its actual position is the origin of the coil pattern. The resulting Offset Error is on the order of ±0.2mm (section 3.4).

# 2 Target Design Illustrations

The 78mm Type 3.2 Axial Sensor may be used with a variety of different styles and sizes of target. This allows a customer to select the style and size best suited to their application. Typical selection criteria include the performance required, space envelope available, distance from sensor to the target axis and whether the application requires the presence of metal along the axis.

The designs in this section are to illustrate the range of design possibilities. Section 4 provides performance measurement for each one, used with the 78mm Type 3.2 Axial Sensor. The design details in this section may be used as a starting point for production designs. Please contact CambridgeIC for assistance with detailed design when required.

For more information on centering a target's resonant frequency to suit the CTU chip please refer to the Resonant Frequency Centering white paper.

## 2.1 L20 Rod

This option includes a wound ferrite rod. The rod concentrates magnetic field along its axis. This allows the part to be physically small, while also operating with substantial gap between the target and sensor.

Figure 5 shows the rod and its winding. The winding is connected to a resonating capacitor (not shown below) as illustrated in Figure 1.

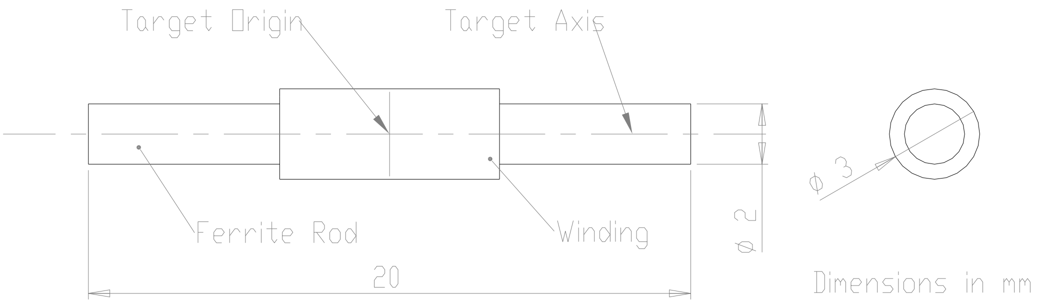


**Figure 5 L20 Rod Target Drawing**

Table 2 lists specifications for the L20 Rod target.

**Table 2 L20 Rod Target Specifications**

| Item | Specification | Comments |
|---|---|---|
| Resonant Frequency | 187.5kHz | Nominal Resonator Centre Frequency of CAM312 IC<br>Frequency measured in situ in the application, with any metal nearby |
| Q-factor | 150 | Lower values possible at the expense of Amplitude and hence lower Noise Free Resolution |
| Winding wire | 0.1mm enamelled self bonding | May be varied providing the Q-factor remains sufficiently high |
| Number of turns | 131 | Adjust to centre resonant frequency on CAM312 nominal |
| Rod material | 3B1 | e.g. Ferroxcube ROD02/20-3B1-DL |
| Resonating capacitor value | 680pF | Adjust value to centre resonant frequency on CAM312 nominal |
| Resonating capacitor peak voltage rating | 200V min | Adjust if wire and/or turns number adjusted |
| Resonating capacitor dielectric | COG/NPO | Or other dielectric delivering high Q-factor |

## 2.2 L25 Rod

This option includes a larger wound ferrite rod. This allows the part to be operated at a greater distance from target axis to sensor. It also means that the target will generate more Amplitude for a given distance, and hence an improvement in Noise Free Resolution.

Figure 8 shows the rod and its winding. The winding is connected to a resonating capacitor (not shown below) as illustrated in Figure 1.

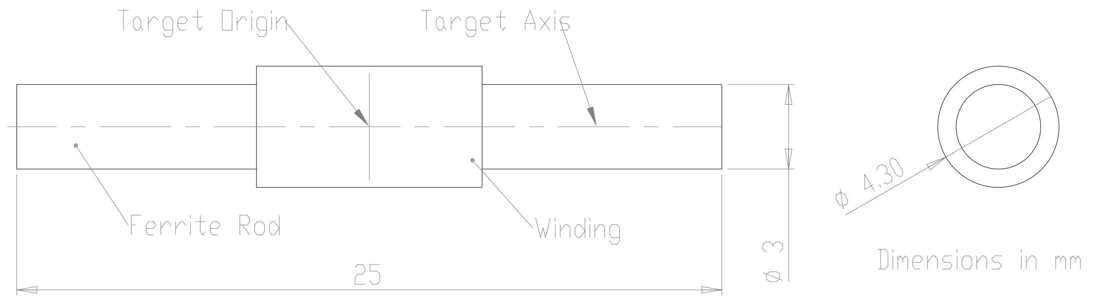


**Figure 6 L25 Rod Target Drawing**

Table 3 lists specifications for the L25 Rod target.

**Table 3 L25 Rod Target Specifications**

| Item | Specification | Comments |
|---|---|---|
| Resonant Frequency | 187.5kHz | Nominal Resonator Centre Frequency of CAM312 IC<br>Frequency measured in situ in the application, with any metal nearby |
| Q-factor | 180 | Lower values possible at the expense of Amplitude and hence lower Noise Free Resolution |
| Winding wire | 0.15mm enamelled self bonding | May be varied providing Q-factor remains sufficiently high |
| Number of turns | 166 | Adjust to centre resonant frequency on CAM312 nominal |
| Rod material | 3B1 | e.g. Fair-Rite 3078990871 |
| Resonating capacitor value | 1nF | Adjust value to centre resonant frequency on CAM312 nominal |
| Resonating capacitor peak voltage rating | 200V min | Adjust if wire and/or turns number adjusted |
| Resonating capacitor dielectric | COG/NPO | Or other dielectric delivering high Q-factor |

## 2.3 D14 Cylinder

This target design option includes a wound cylinder instead of a wound rod, which means that there is space for parts to run through it along the Target Axis. In most applications these parts will be made from steel, for example a steel rod. For this reason, the design also includes an aluminium sleeve which acts as a screen. This prevents the steel from becoming magnetised along with the target. This in turn prevents excessive losses in the steel part.

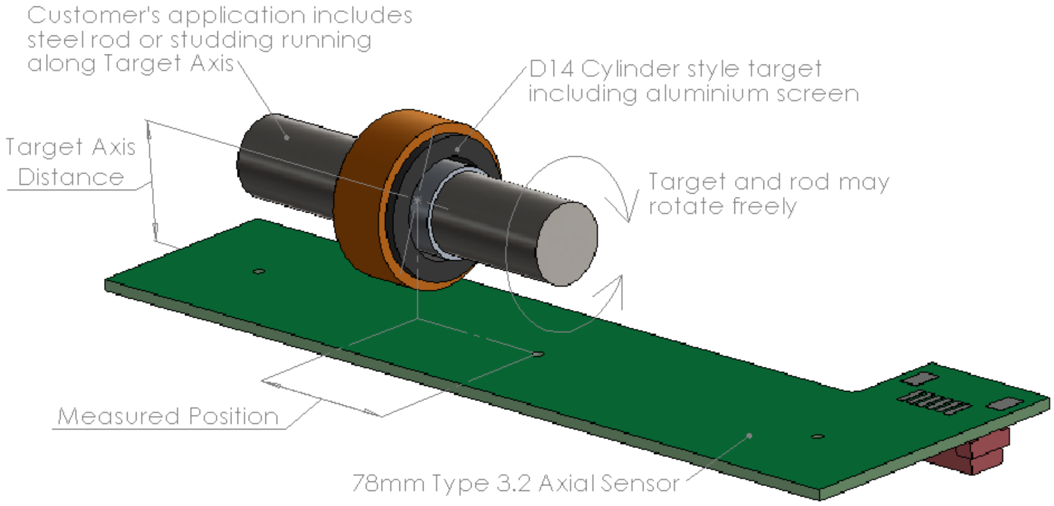


**Figure 7 Sensor Assembly illustrated with D14 Cylinder style target**

Figure 8 shows the D14 Cylinder target parts. The winding is connected to a resonating capacitor (not shown below) as illustrated in Figure 1.

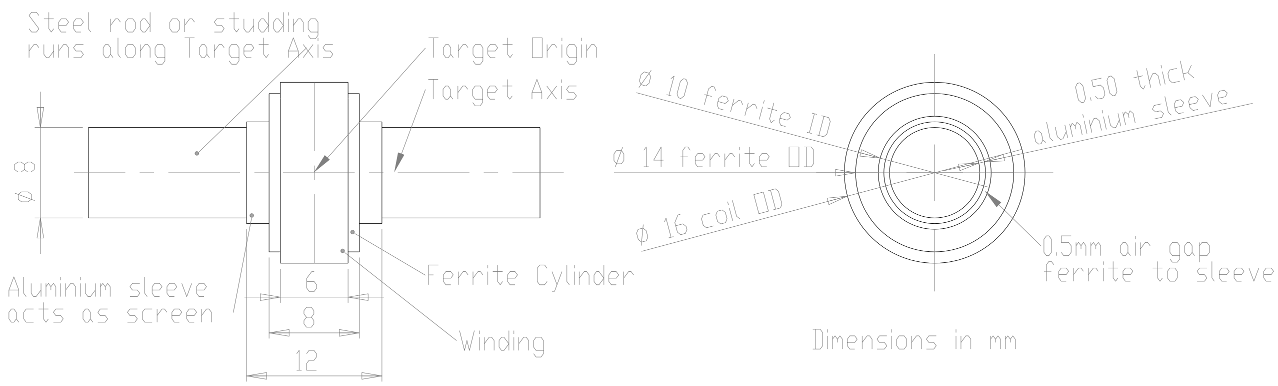


**Figure 8 D14 Cylinder Target Drawing**

Unless otherwise stated, performance measurements using this D14 Cylinder style target presented in section 4 are taken with 8mm stainless steel studding running along the Target Axis. Results with mild steel and stainless steel will be similar. Results with a solid rod or tube with 8mm outside diameter will also be similar.

Table 4 lists specifications for the D14 target.

**Table 4 D14 Cylinder Target Specifications**

| Item | Specification | Comments |
|---|---|---|
| Resonant Frequency | 187.5kHz | Nominal Resonator Centre Frequency of CAM312 IC<br>Frequency measured in situ in the application, with any metal nearby |
| Q-factor | 73 | With 8mm steel studding in place along Target Axis |
| Winding wire | 20 x 0.05mm enamelled self bonding Litz | Litz wire preferred for high Q-factor. Replace with a similar volume of 0.15mm single strand enamelled copper wire for lowest cost construction at the expense of Noise Free Resolution and maximum gap. |
| Number of turns | 69 | Adjust to centre resonant frequency on CAM312 nominal |
| Cylinder part | WURTH 782114096080 | Or equivalent |
| Resonating capacitor value | 3.3nF | Adjust value to centre resonant frequency on CAM312 nominal |
| Resonating capacitor peak voltage rating | 100V min | Adjust if wire and/or turns number adjusted |
| Resonating capacitor dielectric | COG/NPO | Or other dielectric delivering high Q-factor |

## 2.4 D16 Cylinder

This target design option also includes a wound cylinder instead of a wound rod, which means that there is space for parts to run through it along the Target Axis, like for the D14 Cylinder version. However the D16 Cylinder target is physically larger, which means it can accommodate a steel part with larger diameter inside and operates at bigger Target Axis distances.

Figure 9 shows the D16 Cylinder target parts. The winding is connected to a resonating capacitor (not shown below) as illustrated in Figure 1.

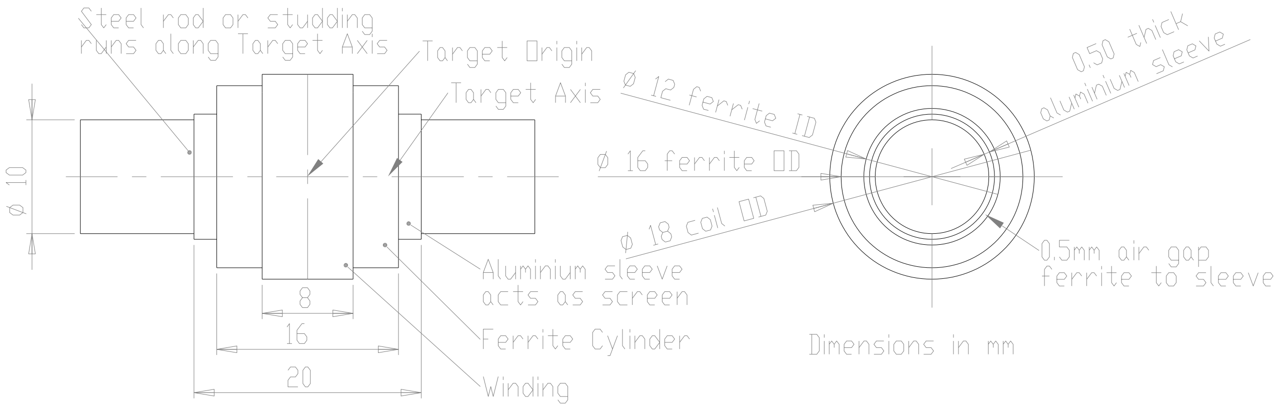


**Figure 9 D16 Cylinder Target Drawing**

Unless otherwise stated, performance measurements using this D16 Cylinder style target presented in section 4 are taken with 10mm stainless steel studding running along the Target Axis. Results with mild steel and stainless steel will be similar. Results with a solid rod or tube with 10mm outside diameter will also be similar.

Table 5 lists specifications for the D16 target.

**Table 5 D16 Cylinder Target Specifications**

| Item | Specification | Comments |
|---|---|---|
| Resonant Frequency | 187.5kHz | Nominal Resonator Centre Frequency of CAM312 IC<br>Frequency measured in situ in the application, with any metal nearby |
| Q-factor | 86 | With 8mm steel studding in place along Target Axis |
| Winding wire | 20 x 0.05mm enamelled self bonding Litz | Litz wire preferred for high Q-factor. Replace with a similar volume of 0.15mm single strand enamelled copper wire for lowest cost construction at the expense of Noise Free Resolution and maximum gap. |
| Number of turns | 70 | Adjust to centre resonant frequency on CAM312 nominal |
| Cylinder part | WURTH 782114096080 | Or equivalent |
| Resonating capacitor value | 1.8nF | Adjust value to centre resonant frequency on CAM312 nominal |
| Resonating capacitor peak voltage rating | 200V min | Adjust if wire and/or turns number adjusted |
| Resonating capacitor dielectric | COG/NPO | Or other dielectric delivering high Q-factor |

## 2.5 D25 Air Coil

This target design option includes a simple coil of wire to form the resonating inductor. This option suits applications where the target axis is located a relatively large distance from the sensor, beyond the operating range of rod style targets. It is also suitable for applications where plastic parts need to run along the axis, or where the axis needs to be kept open. Copper wires may run through the coil, but not steel ones.

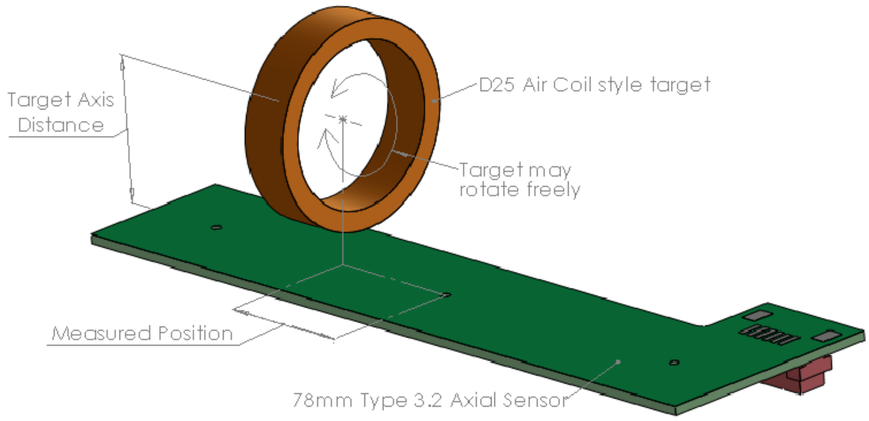


**Figure 10 Sensor Assembly illustrated with D25 Air Coil Target**

Figure 11 shows the coil. The winding is connected to a resonating capacitor (not shown below) as illustrated in Figure 1.

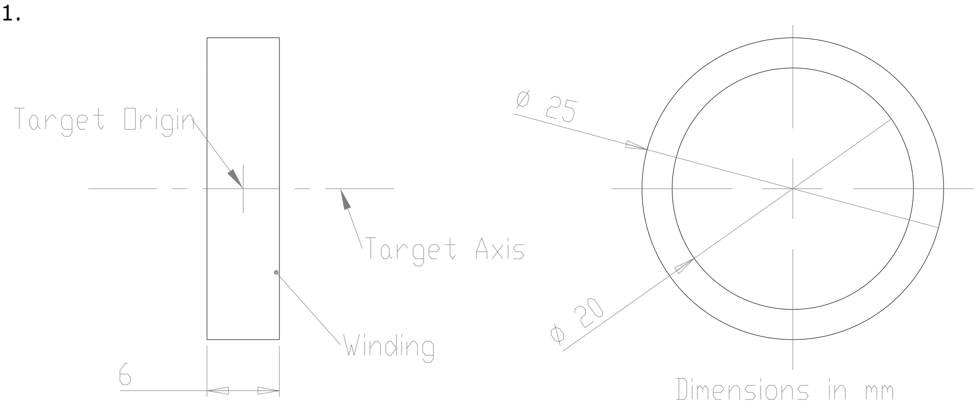


**Figure 11 D25 Air Coil Drawing**

Table 6 lists specifications for the D25 Air Coil target.

**Table 6 D25 Air Coil Target Specifications**

| Item | Specification | Comments |
|---|---|---|
| Resonant Frequency | 187.5kHz | Nominal Resonator Centre Frequency of CAM312 IC<br>Frequency measured in situ in the application, with any metal nearby |
| Q-factor | 120 | Lower values possible at the expense of Amplitude and hence lower Noise Free Resolution |
| Winding wire | 20 x 0.05mm enamelled self bonding Litz | Litz wire preferred for high Q-factor. Replace with a similar volume of 0.15mm single strand enamelled copper wire for lowest cost construction at the expense of Noise Free Resolution and maximum gap. |
| Number of turns | 148 | Adjust to centre resonant frequency on CAM312 nominal |
| Resonating capacitor value | 1.2nF | Adjust value to centre resonant frequency on CAM312 nominal |
| Resonating capacitor peak voltage rating | 200V min | Adjust if wire and/or turns number adjusted |
| Resonating capacitor dielectric | COG/NPO | Or other dielectric delivering high Q-factor |

## 2.6 D40 Air Coil

This air coil design with larger diameter is suited for applications requiring an even larger distance between sensor and target axis. It is suitable for applications where plastic parts need to run along the axis, or where the axis needs to be kept open. Copper wires may run through the coil, but not steel ones. This style of target is particularly suited to integration inside a float for liquid level sensing applications.

Figure 12 shows the coil. The winding is connected to a resonating capacitor (not shown below) as illustrated in Figure 1.

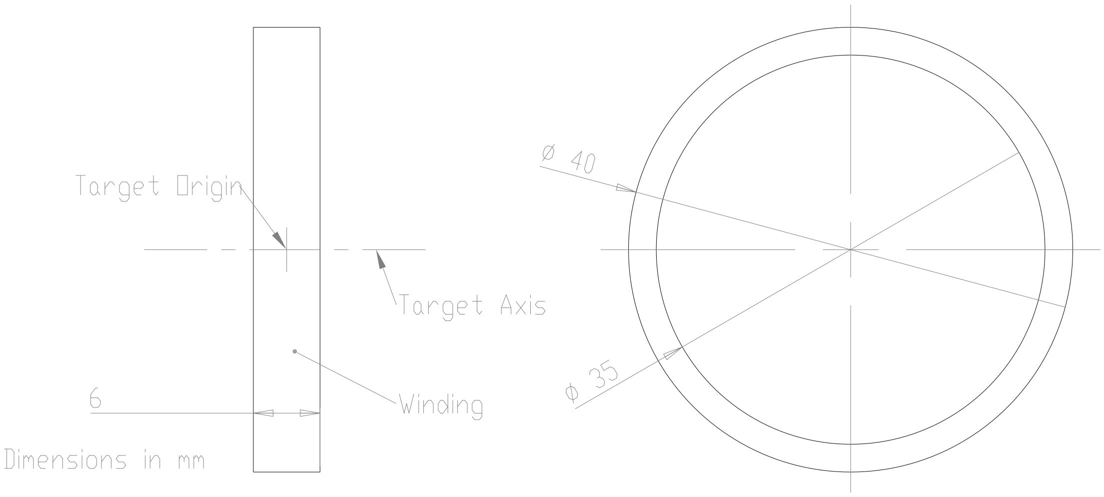


**Figure 12 D40 Air Coil Drawing**

Table 7 lists specifications for the D40 Air Coil target.

**Table 7 D40 Air Coil Target Specifications**

| Item | Specification | Comments |
|---|---|---|
| Resonant Frequency | 187.5kHz | Nominal Resonator Centre Frequency of CAM312 IC<br>Frequency measured in situ in the application, with any metal nearby |
| Q-factor | 135 | Lower values possible at the expense of Amplitude and hence lower Noise Free Resolution |
| Winding wire | 20 x 0.05mm enamelled self bonding Litz | Litz wire preferred for high Q-factor. Replace with a similar volume of 0.15mm single strand enamelled copper wire for lowest cost construction at the expense of Noise Free Resolution and maximum gap. |
| Number of turns | 131 | Adjust to centre resonant frequency on CAM312 nominal |
| Resonating capacitor value | 680pF | Adjust value to centre resonant frequency on CAM312 nominal |
| Resonating capacitor peak voltage rating | 200V min | Adjust if wire and/or turns number adjusted |
| Resonating capacitor dielectric | COG/NPO | Or other dielectric delivering high Q-factor |

# 3 Definitions

## 3.1 Coordinate System

Figure 13 illustrates the coordinate system for the sensor and target. The Sensor Origin is the centre of the copper coil pattern whose nominal location is shown in Figure 2.

The Target Origin is the mechanical centre of the target. The Target Axis is the magnetic axis of the target.

The X-Direction is to the right, and Actual Position is the distance between the Sensor Origin and Target Origin in the X-Direction.

The Y-Direction is upwards as drawn in the upper view, and Y Misalignment is the distance between the Sensor Origin and Target Origin in the Y-Direction.

The Z-Direction is upwards as drawn in the lower view, and the Target Axis Distance is the distance between the sensor PCB face nearest the target and the Target Origin (not to the Target Axis in fact, except in the absence of angular misalignment).

Yaw Angle is defined as the angle between the Target Axis and its projection onto the X-Z plane, as illustrated in the upper view of Figure 13.

Pitch Angle is defined as the angle between the Target Axis and its projection onto the XY plane, as illustrated in the lower view of Figure 13.

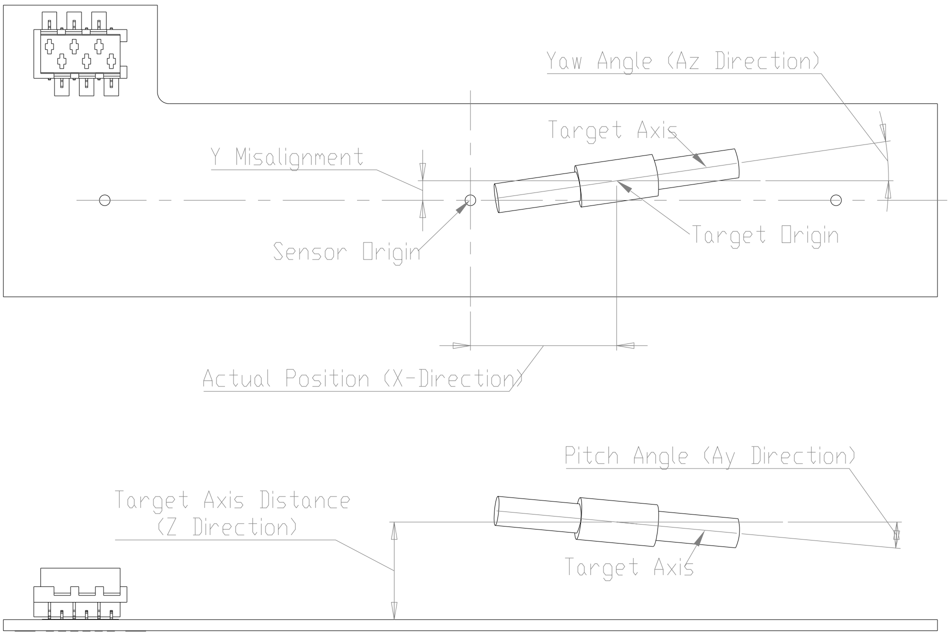


**Figure 13 Coordinate Definitions**

Practical targets including imperfections due to manufacturing and installation tolerances may rotate about a direction that is not parallel to X- and Y-Directions. In this case the Target Axis refers to the actual magnetic axis of the part, and its angular misalignment is described by Pitch and Yaw Angle components. Note that as the imperfect target rotates about its mechanical rotation axis by 360°, Pitch and Yaw Angles vary sinusoidally across one period in phase quadrature. There may be an additional angular offset in each due to the misalignment of the rotation axis relative to the X- and Y- Directions of the sensor. The worst case Pitch angle deviation from zero is the angular misalignment of the rotation axis in the Pitch Angle direction plus the magnetic axis misalignment relative to the mechanical rotation axis.

Gap is the distance between the sensor PCB surface facing the target and the nearest point on the target.

## 3.2 Transfer Function and Performance Metrics

The sensor is connected to a CTU chip which reports position as a 32-bit signed integer, here denoted *CtuReportedPositionI32*. The CTU chip also reports a VALID flag to indicate when the resonator is in range. These vary with Actual Position as illustrated in Figure 14.

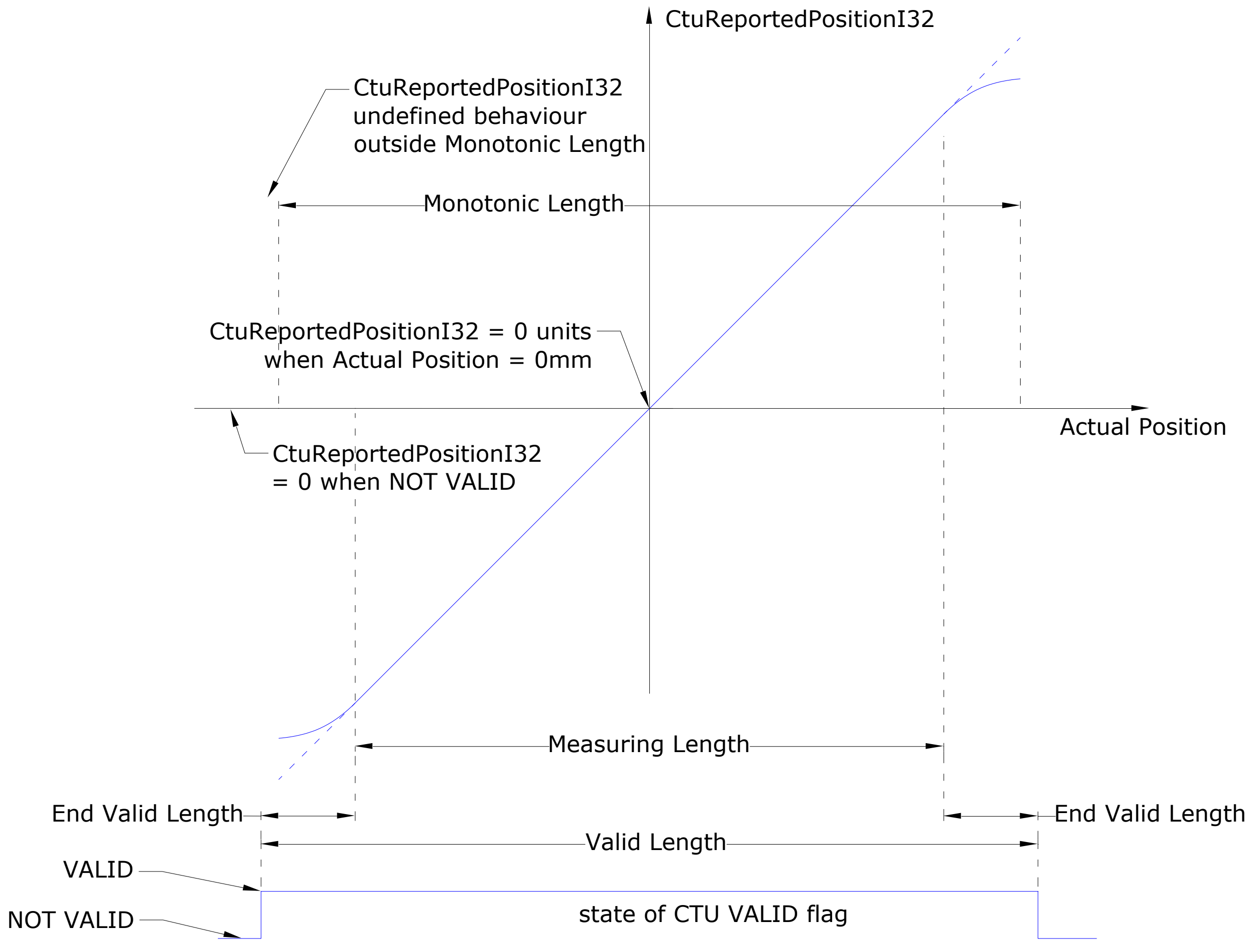


**Figure 14 Transfer function (not to scale)**

The Measuring Length for the sensor is the position range across which performance measurements are defined, including Linearity Error and Minimum Amplitude. It is somewhat arbitrary, because it does not correspond to any particular mechanical feature or performance metric. CtuReportedPositionI32 varies approximately linearly with Actual Position across the Measuring Length, with deviations from linear measured with Linearity Error (section 3.4). The slope of the transfer function is defined by the SinLength parameter.

The Monotonic Length is the position range across which CtuReportedPositionI32 varies monotonically with Actual Position. Outside of this range CtuReportedPositionI32 is undefined, and its value may change abruptly with Actual Position including polarity reversals. CtuReportedPositionI32 data should not therefore be used outside of the Monotonic Length.

The VALID Range is the distance over which the CTU reports VALID. The Valid Range exceeds the Measuring Range by an amount End Valid Range each side, so that the sensor’s output can be VALID throughout the Measuring Range.

The CTU chip's position output may be converted to reported position in physical units using:

$$Reported\ Position = \frac{CtuReportedPositionI32}{65536} \times SinLength$$

**Equation 1**

This figure is nominally equal to the Actual Position defined in section 3.1. The figures differ due to random noise, Linearity Error and Offset Error:

$$Reported\ Position - Actual\ Position = Random\ Noise + Linearity\ Error + Offset\ Error$$

**Equation 2**

## 3.3 Random Noise and Resolution

Random noise is inherent in any analog measurement. The random noise present in the CTU's reported measurements can be considered Gaussian (*well behaved noise*). There are two general measures of Random Noise, Peak to Peak Noise and Standard Deviation. Defining Peak to Peak Noise such that it encompasses 99.9% of samples (100% is physically impossible due to the statistical nature of noise) yields the following relationship:

$$Peak\ to\ Peak\ Noise = 6.6\ \times Standard\ Deviation$$

**Equation 3**

Another common measure of noise used in encoders is Noise Free Resolution, which is related to Peak to Peak Noise as follows:

$$Noise\ Free\ Resolution = \log_2 \frac{Measuring\ Range}{Peak\ to\ Peak\ Noise}$$

**Equation 4**

Noise Free Resolution can be improved by averaging raw samples from a CTU, or applying some other digital filter to the samples. Averaging $2^N$ samples increases Noise Free Resolution by N/2 bits. So averaging 4 samples (N=2) improves Noise Free Resolution by 1 bit, and averaging 16 (N=4) samples improves Noise Free Resolution by 2 bits. Measurements of Linearity Error and Offset Error are separated from Random Noise by averaging in this way.

## 3.4 Linearity Error and Offset Error

Linearity Error is the deviation of the transfer function from a best fit straight line. Strictly, the figures quoted in this datasheet are based on a best fit straight line whose slope and offset are adjusted to minimise the maximum magnitude of Linearity Error, across the Measuring Length, so that the maximum positive and negative linearity departures have equal magnitude.

The slope of the best fit straight line is the SinLength parameter quoted below. Its value can also change due to a small stretch error inherent in the PCB manufacturing process.

There are two main contributions to Offset Error: one from the sensor and one from the target.

The target's contribution to Offset Error is the mechanical tolerance with which the Target Origin can be located relative to appropriate alignment features, and therefore depends on how these features are designed.

The sensor's contribution to Offset Error is mainly due to the PCB manufacturing process, in particular linear misregistration of copper layers relative to chosen registration features, and sensor PCB stretch error between the reference feature and Sensor Origin.

# 4 Performance

Figures below are representative of assembled sensor PCBs 013-0057 and sensor PCBs built to Sensor Blueprint 010-0145. Measurements are taken with sample targets built to the designs presented in section 2, with Type 3 CAM312 CTU Circuitry (see CAM312 datasheet, grade A components), at room temperature. Sensors are mounted flush against a flat surface for test purposes, and are taken in free space with no metal nearby unless otherwise stated.

Measurements are presented as a function of Target Axis Distance, which is defined in section 3.1, with zero Y Misalignment. The effect of Y Misalignment is small for this sensor, up to at least about 2mm.

## 4.1 Monotonic Length

Monotonic Length is the distance over which the system reports position without reversals or discontinuities, and is at least 86mm for all target designs presented in section 2.

## 4.2 Linearity Error

Linearity Error is defined in section 3.4. Figure 15 shows how Linearity Error changes with Target Axis Distance for different target styles.

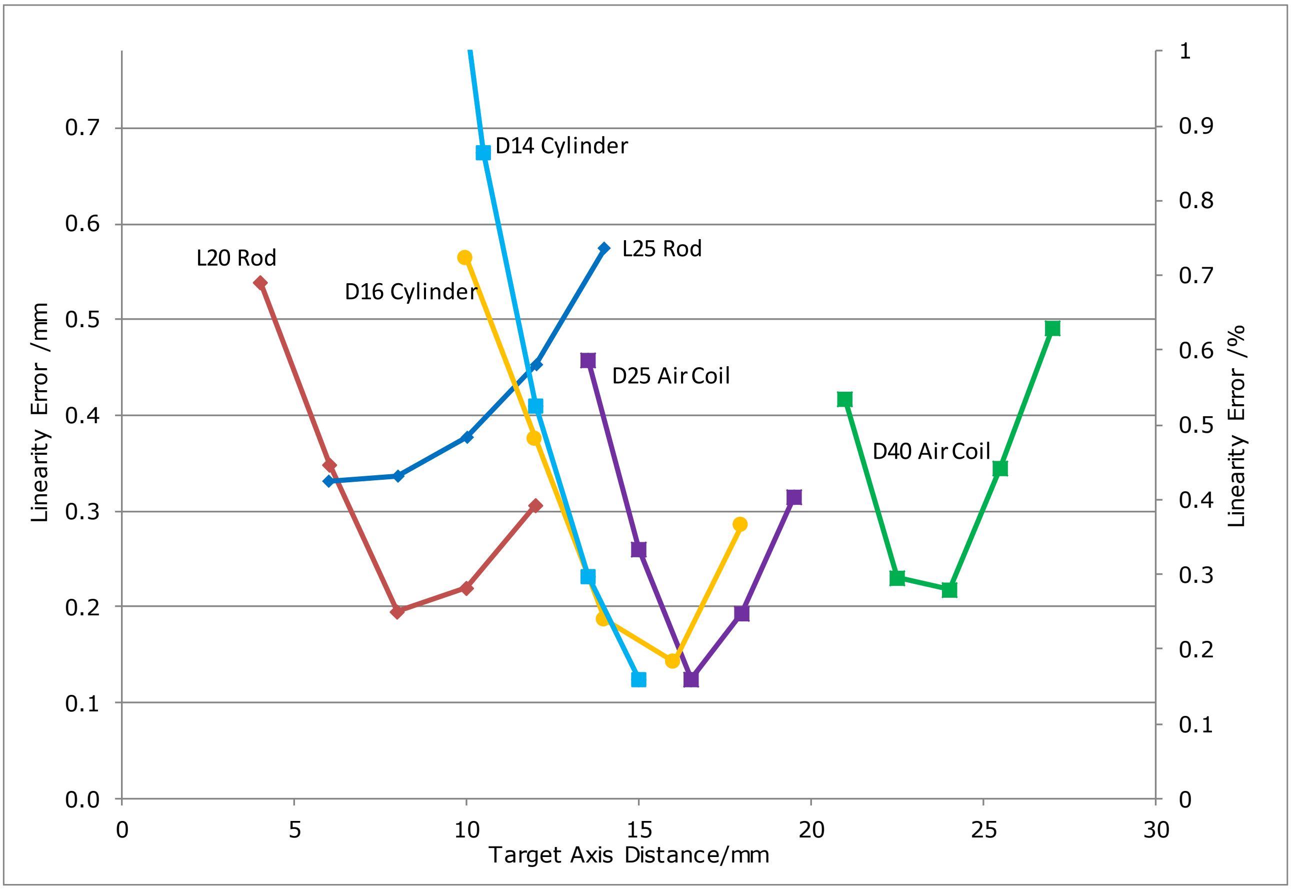


**Figure 15 Linearity Error as a function of Target Axis Distance for different target styles**

## 4.3 SinLength Value

The SinLength parameter is defined in 3.2, and roughly corresponds to the sinusoidal pitch of the fine sensor coils. For most practical purposes a value of 55.5mm is adequate. However the exact best fit value for use in Equation 1 is also a weak function of Target Axis Distance and target style, as illustrated in Figure 16.

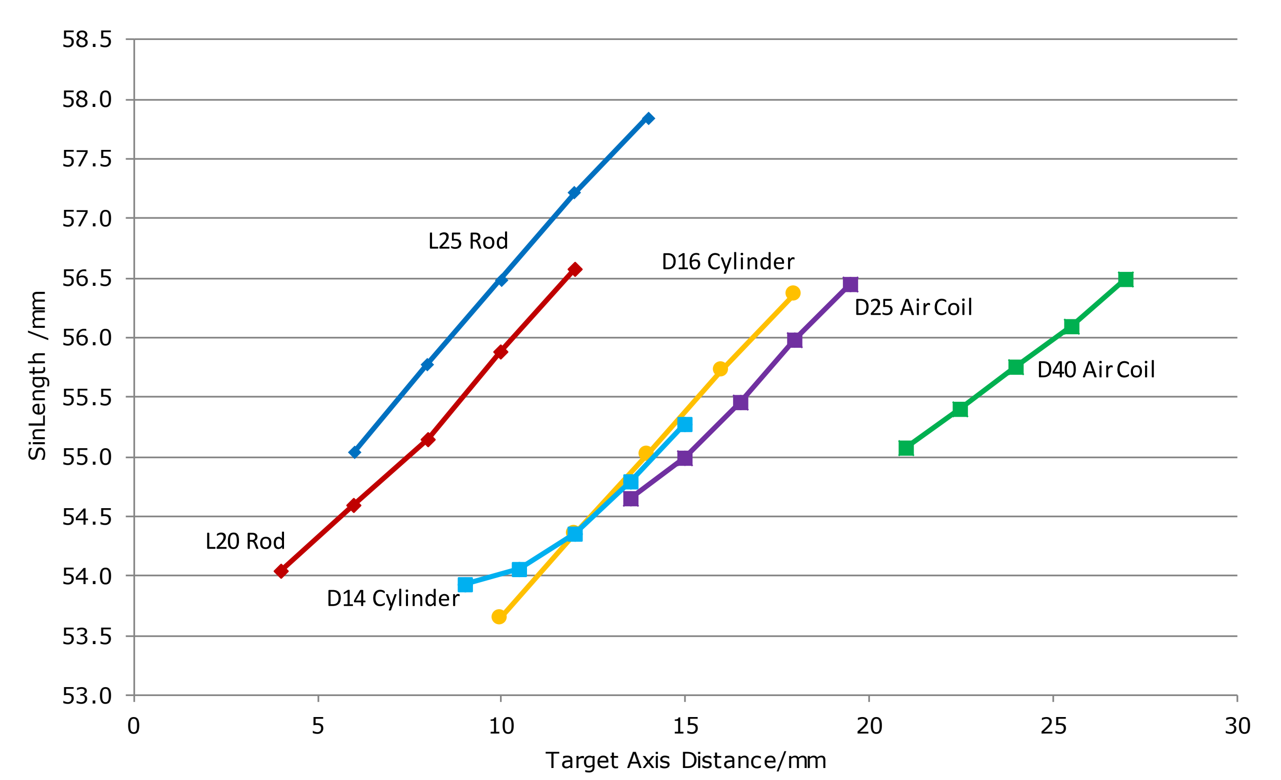


**Figure 16 SinLength value as a function of Target Axis Distance for different target styles**

The exact SinLength value is also subject to ~±0.1% error due to stretch error in the PCB fabrication process. Thermal expansion also affects the length of the PCB and hence the SinLength value. Its magnitude is ~13ppm/°C, assuming FR4 PCB material that is allowed to expand.

## 4.4 Amplitude

In addition to reporting position, the CTU chip also reports Amplitude. Amplitude is a useful measure of system health, and reduces with Gap as shown in Figure 17. Amplitude also reduces with the presence of nearby metal, and sensor installations should be checked to ensure any reduction is not excessive.

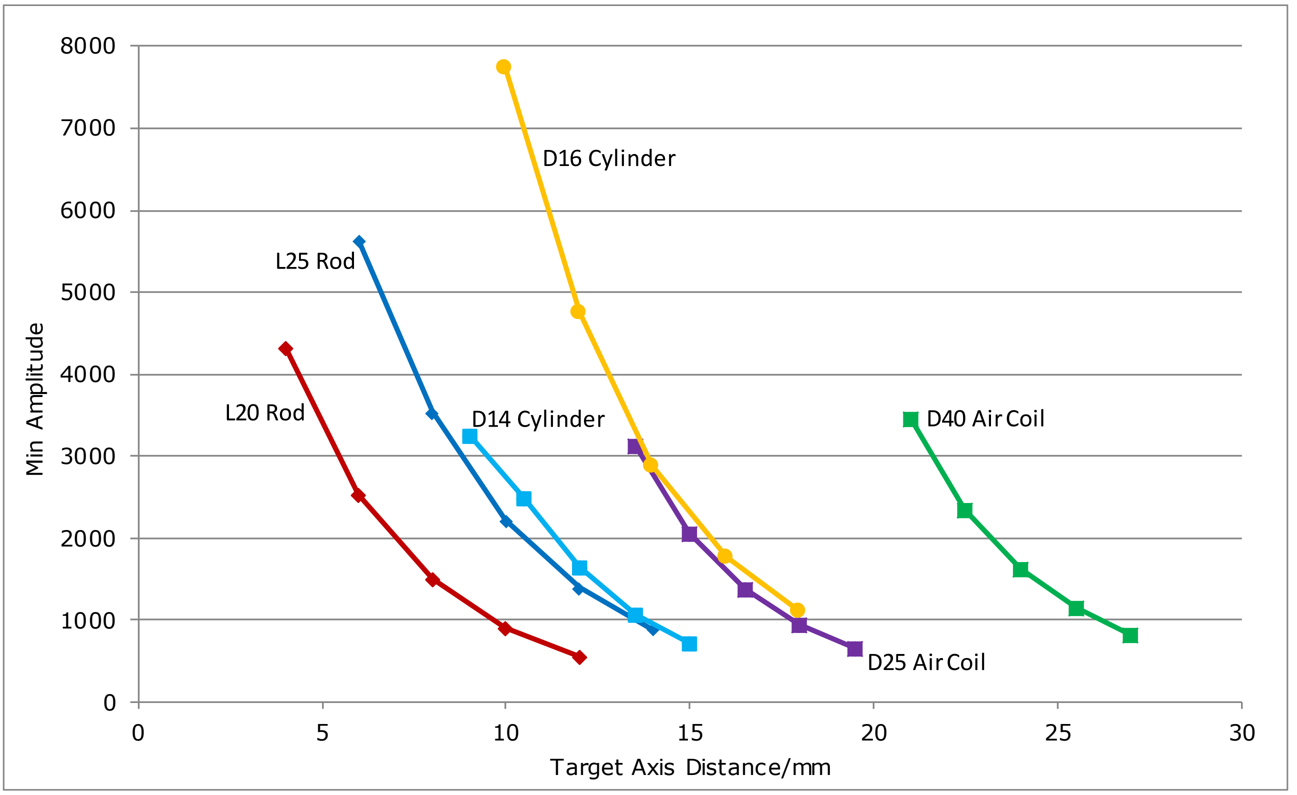


**Figure 17 Minimum Reported Amplitude as a function of Target Axis Distance for different target styles**

## 4.5 Noise Free Resolution

Noise Free Resolution is defined in section 3.3. It is a function of the signal level detected by the CTU chip. It therefore reduces with Gap and metal proximity in a similar way to Reported Amplitude as illustrated in Figure 18.

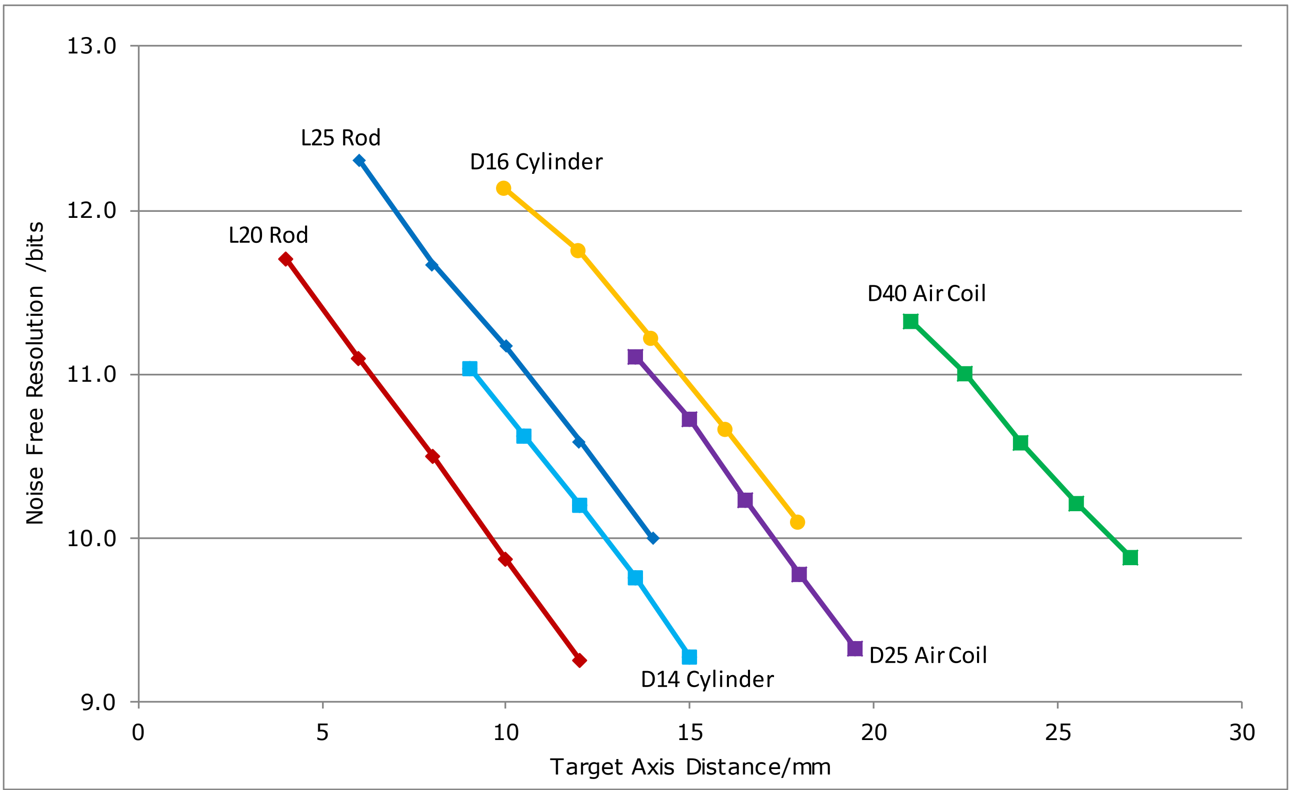


**Figure 18 Noise Free Resolution as a function of Target Axis Distance for different target styles**

Quoted Noise Free Resolution is based on single measurements from a CTU chip. The host may average (or otherwise digitally filter) measurements to yield a higher resolution than shown above, at the expense of greater latency.

## 4.6 Sensitivity to Angular Misalignment

Section 3.1 defines Pitch and Yaw angles, which describe how the actual magnetic axis of the target deviates from the sensor's measuring direction.

The 78mm Type 3.2 Axial Sensor's reported position changes slightly with Pitch Angle. Sensitivity tends to increase with Target Axis Distance, and is sensitivity is also a weak function of position with worst case at the extremes of the Measuring Length. The largest magnitude of rate of change of reported position with Pitch Angle across the Measuring Length is illustrated in Figure 19.

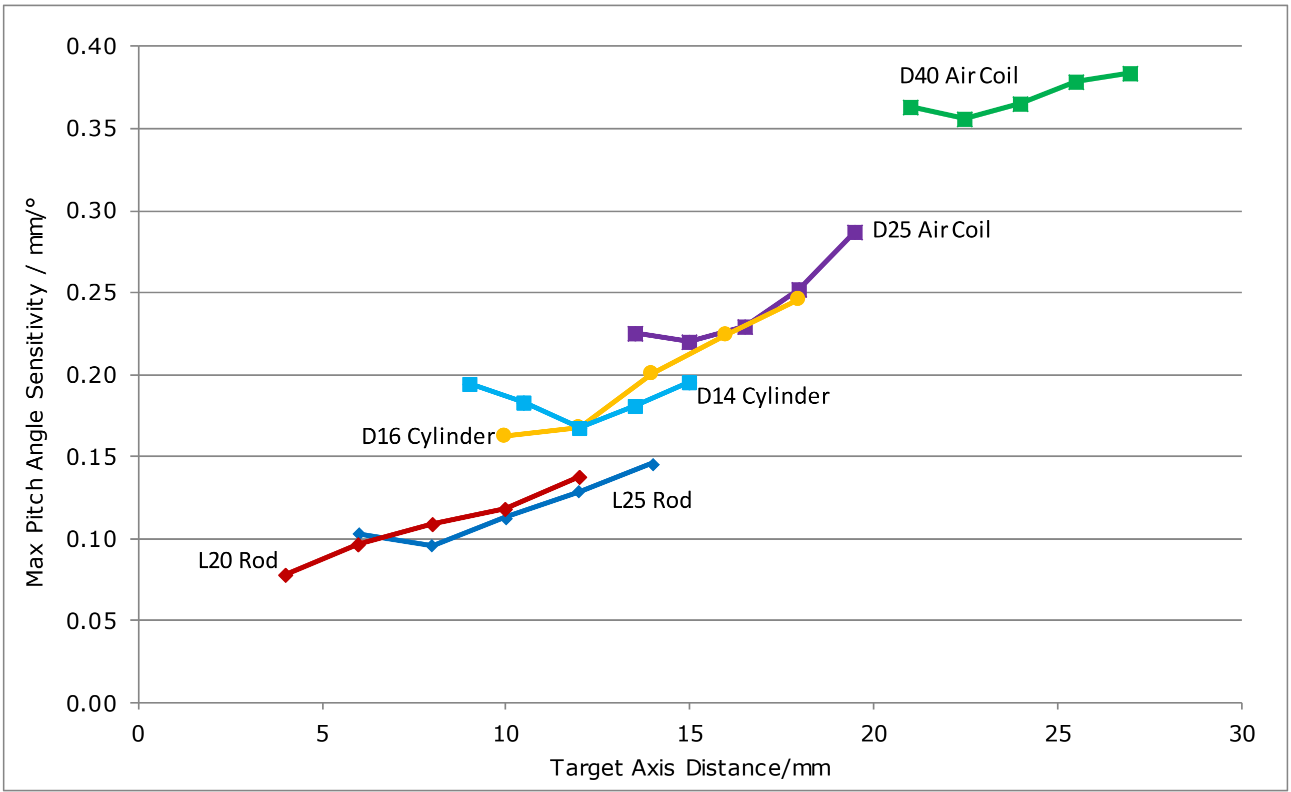


**Figure 19 Pitch Angle Sensitivity as a function of Target Axis Distance for different target styles**

Sensitivity to Yaw Angle is much less than sensitivity to Yaw Angle.

# 5 Sensor Blueprint 010-0145

## 5.1 Purpose

A Sensor Blueprint is data defining the pattern of conductors for building the sensor onto a PCB. A customer may build their own sensors for use with CambridgeIC's CTU chips, either as stand-alone sensors or combined with their own circuitry.

## 5.2 Fabrication Technology

Sensor Blueprint 010-0145 is fabricated on a 8-layer PCB. Recommended copper thickness is shown in Table 8.

**Table 8**

| Copper thickness | oz | µm |
|---|---|---|
| Minimum | 0.8 | 28 |
| Recommended | 1 | 35 |

## 5.3 PCB Design Parameters

PCB feature sizes used in the Sensor Blueprint are shown in Table 9. This design features large feature sizes for ease of manufacturing and high yield.

**Table 9**

| PCB Design Rules | Minimum values used | |
|---|---|---|
| | mm | inches |
| Track width | 0.25 | 0.0094 |
| Gap between tracks | 0.25 | 0.0094 |
| Via land outer diameter | 0.96 | 0.038 |
| Drill hole diameter | 0.5 | 0.020 |

## 5.4 PCB Integration

Figure 20 illustrates the extent of the copper pattern required to build the sensor on a PCB. The shaded area is the sensor itself. The coil pattern may be rotated or flipped to fit a customer's assembly, in which case the position reported by the CTU will be transformed accordingly.

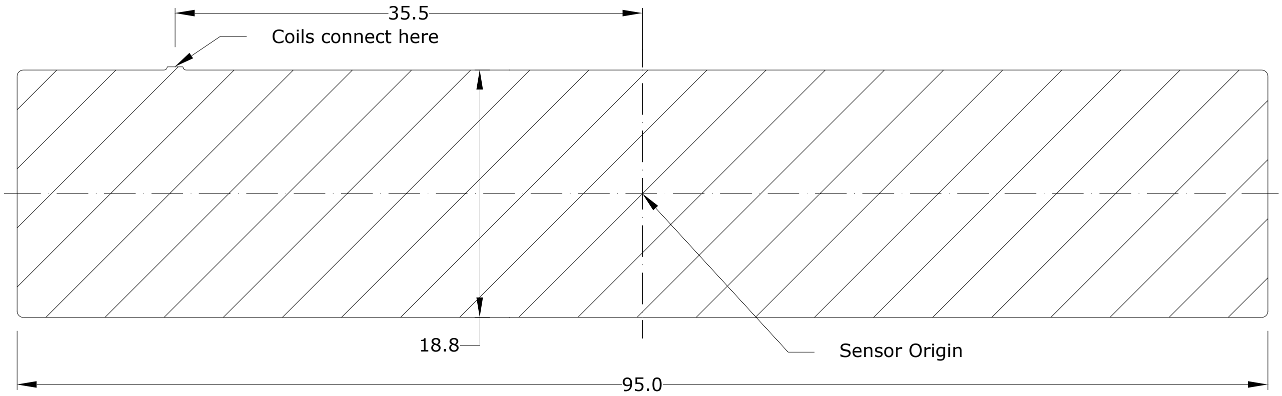


**Figure 20 Copper extent, Sensor Blueprint 010-0145**

When integrating with other electronic circuitry, a keep-out of 3mm is recommended all around the sensor's conductors. Copper traces surrounding the sensor must not include a complete loop, otherwise these may appear as a "shorted turn" to the sensor's excitation coil and Amplitude may be reduced significantly.

## 5.5 Data Format

The Sensor Blueprint is supplied as Gerber data in RS-274-X format with the following settings: imperial, 2.4 precision and leading zero suppression. Coordinates are relative to the Sensor Axis.

## 5.6 Trace Connections

There are 4 pairs of tracks (EXA, EXB, COS and SIN with their respective common returns _REF), which should be connected to the respective CTU circuit connections with the minimum practical trace lengths.

Please refer to the CTU datasheet for recommendations on track design for connecting sensors to CTU circuitry.

# 6 Environmental

Assembled sensor assembly part number 013-0057 conforms to the following environmental specifications:

| Item | | Comments |
|---|---|---|
| Minimum operating temperature | -40°C | Sensor assembly limited by the connector |
| Maximum operating temperature | 85°C | |
| Maximum operating humidity | 95% | Non-condensing |

# 7 RoHS Compliance

CambridgeIC certifies, to the best of its knowledge and understanding that part number 013-0057 is in compliance with EU RoHS directive 2011/65/EU, China RoHS and Korea RoHS.

# 8 Document History

| Revision | Date | Comments |
|---|---|---|
| 0001 | 28 April 2020 | First draft |
| 0002 | 10 June 2020 | Corrected title in metadata<br>Added syringe applicaiton |

# 9 Contact Information

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# 10 Legal