

Description

CambridgeIC's B6 precision linear resonant inductive position sensors have measuring lengths from 40mm to 100mm. These sensors include specially patterned coils built using a conventional PCB process.

Sensors detect the position of a moving, contactless target. This also comprises specially patterned coils built using a conventional PCB process, and assembled with two SMD capacitors to form a resonant circuit.

The sensors have two sets of sensor coils: one for taking fine incremental measurements at high accuracy and resolution, and another for coarse, absolute measurements.

Sensors are connected to a CAM622 processor IC from CambridgeIC. The CAM622 combines the information from both sets of coils to deliver an absolute, high accuracy and high resolution output to a host system.

Features

- Full absolute linear sensing
- 40mm to 100mm Measuring Lengths
- Sensors built from 4-layer PCB process
- Target built from 6-layer PCB process

Performance, Free Space

- Linearity Error $< \pm 0.05\text{mm}$ at 0mm...1.5mm Gap
- Noise Free Resolution > 15 bits up to 1.5mm Gap
- Up to 0.5mm Y Misalignment

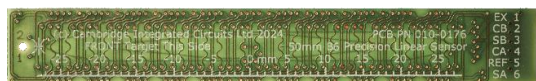


Figure 1 Sensor PCB Assembly 013-0070, FRONT

Applications

- Actuator position feedback
- Linear motor feedback
- Optical and magnetic scale replacement
- Lab automation

Product identification	
Part no.	Description
013-0072	40mm B6 linear sensor assembly
013-0070	50mm B6 linear sensor assembly
013-0073	100mm B6 linear sensor assembly
013-1042	Matching target, 833kHz
010-0178	Sensor PCB design
010-2007	Target PCB design
013-6021	6-way PicoBlade EZmate Sensor Cable

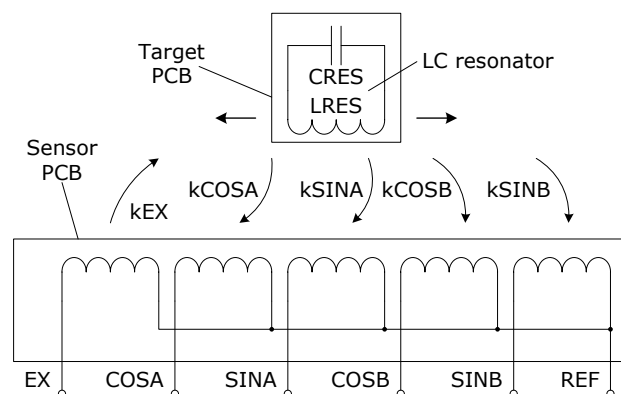


Figure 2 Equivalent circuit

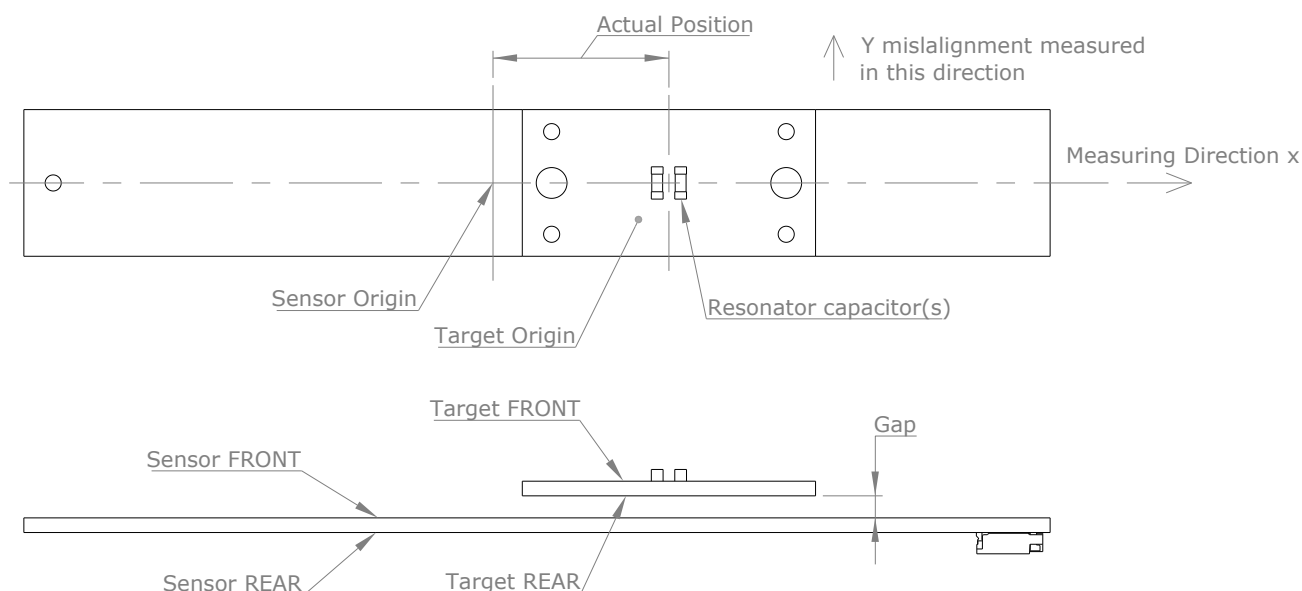


Figure 3 Alignment of sensor PCB assemblies with target 013-1042

1 Sensor Design

Sensors are built using a conventional PCB process on 4 copper layers. They each comprise 5 specially patterned printed coils, whose equivalent circuit is illustrated in Figure 2. Section 1.1 details the PCB space required for these coils, and details relevant to their manufacture.

Sensor PCBs assembled with a connector are available from CambridgeIC for evaluation and initial prototyping. Their design is detailed in section 1.2.

Customers manufacture and assemble sensor PCBs themselves. This delivers the lowest possible cost solution, and allows the PCB design to be customised. Customisation can include a different connector, adding processing electronics to the same PCB, changing the board outline, how the board is mounted and screening.

1.1 Sensor PCB Coil Designs

The extent of the sensor PCB's copper patterning is illustrated in Figure 4, viewed from the FRONT.

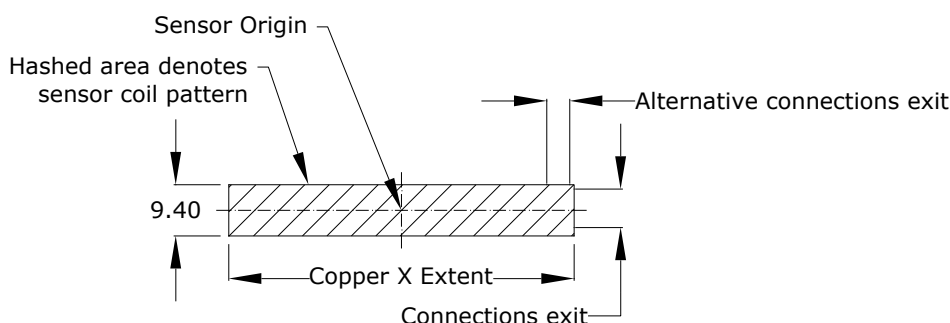


Figure 4 Sensor Coil PCB Extents and Connection Locations

The Copper X Extent value for each design is specified in Table 1. Required copper thickness on all layers is specified in Table 2. Minimum geometry sizes are specified in Table 3.

Table 1 Copper X Extent

PCB design part number	Measuring Length	Copper X Extent
010-0180	40mm	53.4mm
010-0176	50mm	63.4mm
010-0182	100mm	113.4mm

Table 2 Sensor PCB copper thickness

Copper thickness	oz	µm
Minimum	0.8	28
Recommended	1	35

Table 3 Sensor PCB design rules

PCB Design Rules	Minimum values used	
	mm	inches
Track width	0.16	0.0063
Gap between tracks	0.16	0.0063
Via land outer diameter	0.64	0.0025
Drill hole diameter	0.3	0.012

The sensor PCB design is available to customers as Gerber files or as an Altium file.

The assembly layer includes a table that specifies the endpoints of the sensor coils, in case a customer wishes to route them differently. Please refer to the Type B Sensor Reference Manual for advice on routing connections to the sensor coils.

1.2 Assembled Sensors

The B6 Precision Linear Sensors are available as assembled PCB including connector. An image of the FRONT side of the 50mm version part 013-0070 is shown in Figure 1. Figure 5 is a mechanical drawing.

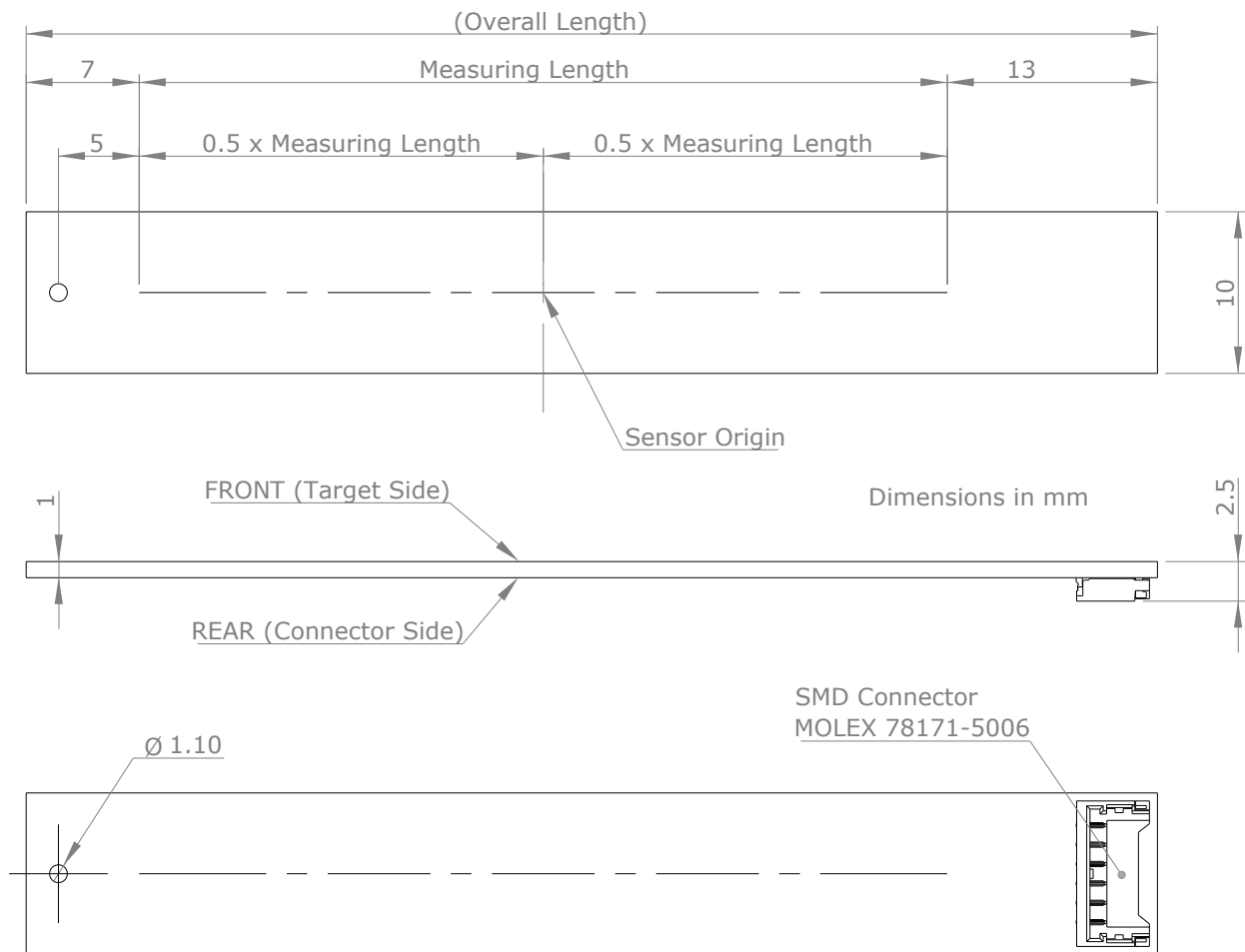


Figure 5 B6 Linear Sensors Mechanical drawing

The Overall Length of each sensor assembly is shown in Table 4.

Table 4 Overall Length

Sensor Assembly Part Number	Measuring Length	Overall Length
013-0072	40mm	60mm
013-0070	50mm	70mm
013-0073	100mm	120mm

The sensor measures Actual Position relative to the Sensor Origin. The nominal location of the Sensor Origin is [5mm plus $0.5 \times \text{Measuring Length}$] to the right of the Ref Hole marked in Figure 5.

The REAR of each sensor PCB is fitted with a surface mounted connector MOLEX 78171-5006. Its pinout is shown in Table 5.

Table 5 Sensor PCB electrical connections

Pin no	Marking	Signal name
1	EX	EX
2	CB	COSB
3	SB	SINB
4	CA	COSA
5	REF	REF
6	SA	SINA

Figure 6 shows how to connect a mating connector.

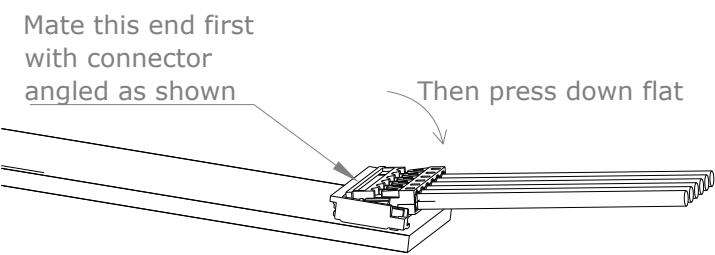


Figure 6 Mating EZmate connectors

The B6 Precision Linear Sensors work with the Single Lobe Linear Target described in section 2, including part number 013-1042. Their relative alignment is illustrated in Figure 3. The target must be positioned adjacent the FRONT of the sensor PCB, which is the opposite side to the sensor’s connector.

2 Target Design

The target is built using a conventional PCB process on 6 copper layers. It comprises a specially patterned printed coil with a single lobe, whose equivalent circuit is illustrated in Figure 2. Section 2.1 details the PCB space required for these coils, and details relevant to their manufacture.

Target PCBs assembled with a connector are available from CambridgeIC for evaluation and initial prototyping. Their design is detailed in section 2.2.

Customers manufacture and assemble target PCBs themselves. This delivers the lowest possible cost solution, and allows the PCB design to be customised. Customisation can include modified capacitor footprints, changing the board outline, how the board is mounted and screening.

2.1 Target PCB Coil Design PN 010-2008

The extent of the target PCB's copper patterning is illustrated in Figure 7, viewed from the FRONT.

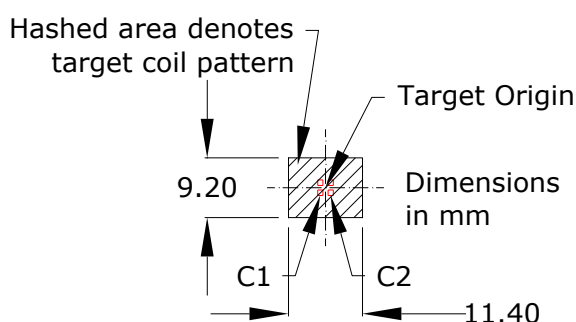


Figure 7 Target Coil PCB Extents and Connection Locations

Required copper thickness on all layers is specified in Table 6. Minimum geometry sizes are specified in Table 7.

Table 6 Target PCB copper thickness

Copper thickness	oz	µm
Minimum	1.6	55.7
Recommended	2.0	70

Table 7 Target PCB design rules

PCB Design Rules	Minimum values used	
	mm	inches
Track width	0.2	0.0079
Gap between tracks	0.2	0.0079
Via land outer diameter	1.0	0.0039
Drill hole diameter	0.5	0.02

Table 8 shows the expected nominal value of the resonator coil's self inductance LRES, for PCBs manufactured to design 010-2007. Nearby metal or screening affects performance and resonator frequency. Please refer to the Type B Sensor Reference Manual for details of how to select resonator capacitors, especially if the target is mounted near metals.

Table 8 Resonator coil inductance

Parameter	Value	Comments
LRES, nominal	15.5µH	Free space, based on 1.0mm finished thickness and 0.2mm cores
LRES tolerance	±2%	Simulated, based on finished thickness tolerance of ±10%

The target PCB design is available to customers as Gerber files or as an Altium file.

2.2 Assembled Target PN 013-1042

The Single Lobe Target for the B6 Precision Linear Sensors is available as an assembled PCB including resonating capacitor. An image of its FRONT side is shown in Figure 2. Figure 9 is a mechanical drawing.

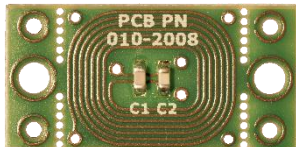


Figure 8 Target PCB Assembly 013-1042, FRONT (capacitor side)

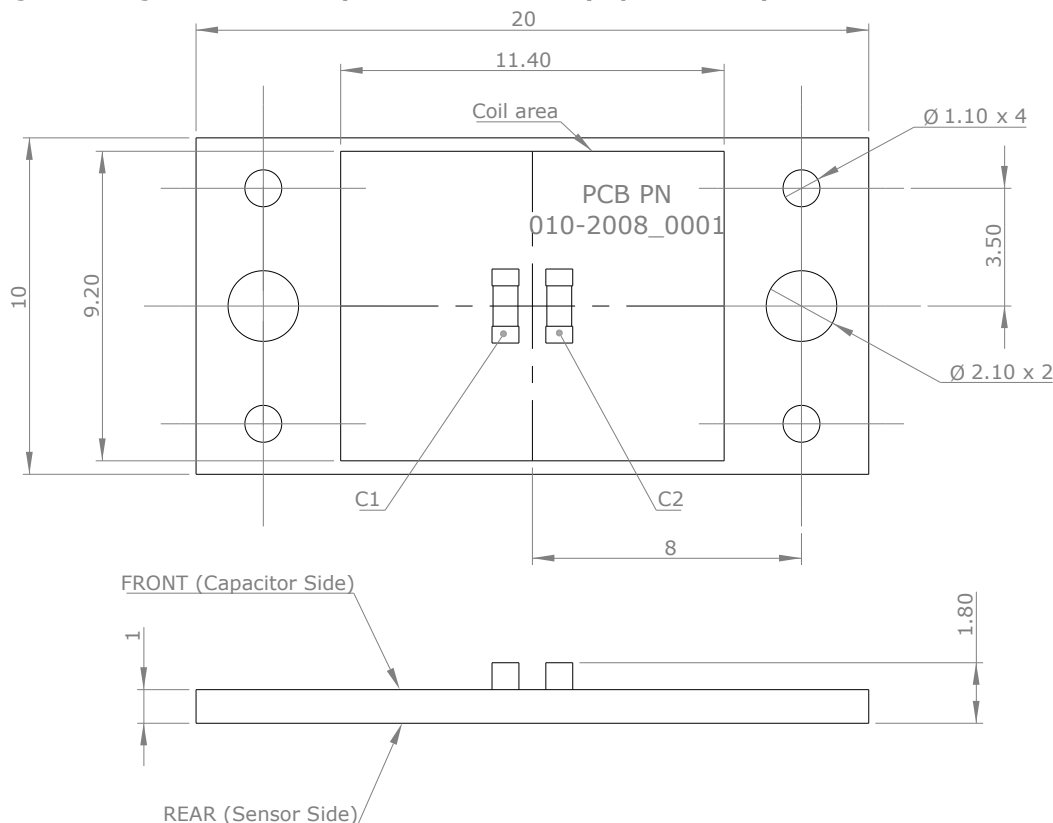


Figure 9 Mechanical drawing, target PCB assembly 013-1043

The target comprises target PCB PN 010-2008 with resonator capacitor shown in Table 9, to yield the frequency specifications of Table 10.

Table 9 Fitted components

Location	Value	Description
C1	2.2nF	50V COG (NPO) $\pm 2\%$ 0603
C2	150pF	50V COG (NPO) $\pm 5\%$ 0603

Table 10 Frequency specifications

Parameter	Value	Comments
Resonant frequency	833kHz	Free space, no metal nearby, no screening, matches CAM622 centre frequency
Resonant frequency tolerance	$\pm 4\%$	

3 Performance

Figures below are representative of CambridgeIC's assembled sensors and sensor PCBs built to sensor PCB designs, working with target assembly 013-1042 and targets built to target PCB design 010-2008.

Measurements are taken with typical CAM622 CTU Circuitry (see CAM622 datasheet, grade A components), at room temperature. Sensors are mounted flush against a flat surface for test purposes.

Measurements are presented as a function of Gap, which is defined in Figure 3. Unless otherwise stated, values presented below are worst case across Y misalignment of up to 0.5mm.

Measurements in this section are taken in free space with no metal nearby unless otherwise stated.

3.1 Linearity Error

Figure 10 shows how Linearity Error changes with Gap. Each plot corresponds to one sensor measuring length, and is worst case across Y misalignment up to 0.5mm.

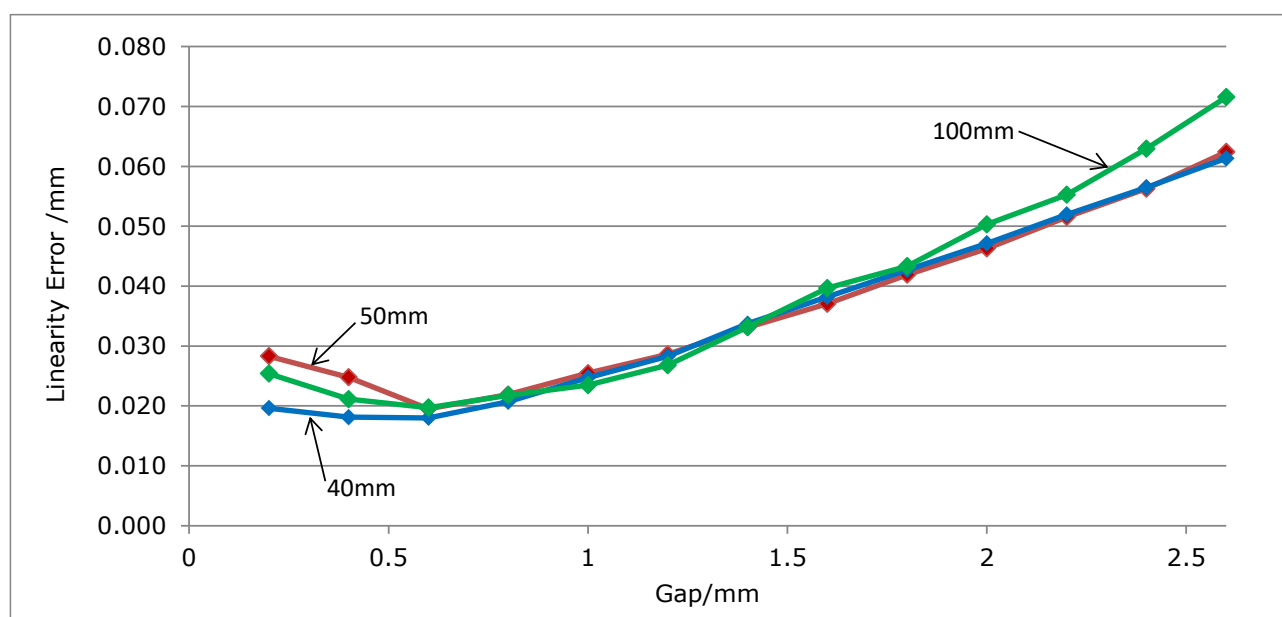


Figure 10 Linearity Error as a function of Gap

The worst case figure given on page 1 is the worst case of Figure 10 at up to 1.5mm gap, with an additional allowance of 0.012mm for variability across PCBs and grade A components.

3.2 End Valid Range

Figure 11 shows how the minimum End Valid Range varies with gap. End Valid Range is the distance beyond the measuring length where the CAM622 still reports VALID.

Performance degrades when the target is outside the Measuring Length, up to the point the system reports NOT VALID. However in this case the 40mm – 100mm B6 sensors are designed to report position approximately correctly and free from gross errors.

The presence of metal or screening material may disrupt measurements beyond the measuring range. Please contact CambridgeIC if such an application requires the system to report position correctly when the target is beyond the Measuring Length.

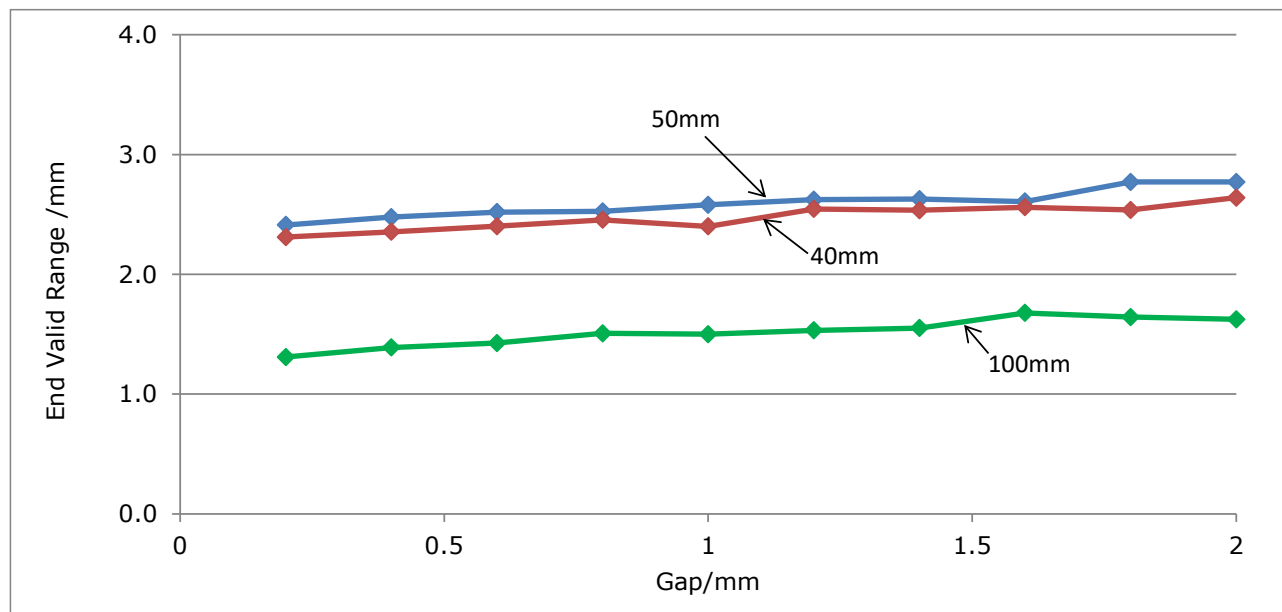


Figure 11 End Valid Range as a function of gap

3.3 SinLength Value

The SinLength parameter is close to the repeat distance of the fine sensor coil design, 20mm. However to optimise linearity across the entire measuring length the value is adjusted slightly as illustrated in Figure 12. The value for any given sensor PCB may be expected to vary due to PCB stretch error, typically up to approximately 0.05%. Customers should contact their own manufacturer to establish what tolerance is possible, should stretch error be critical in their application.

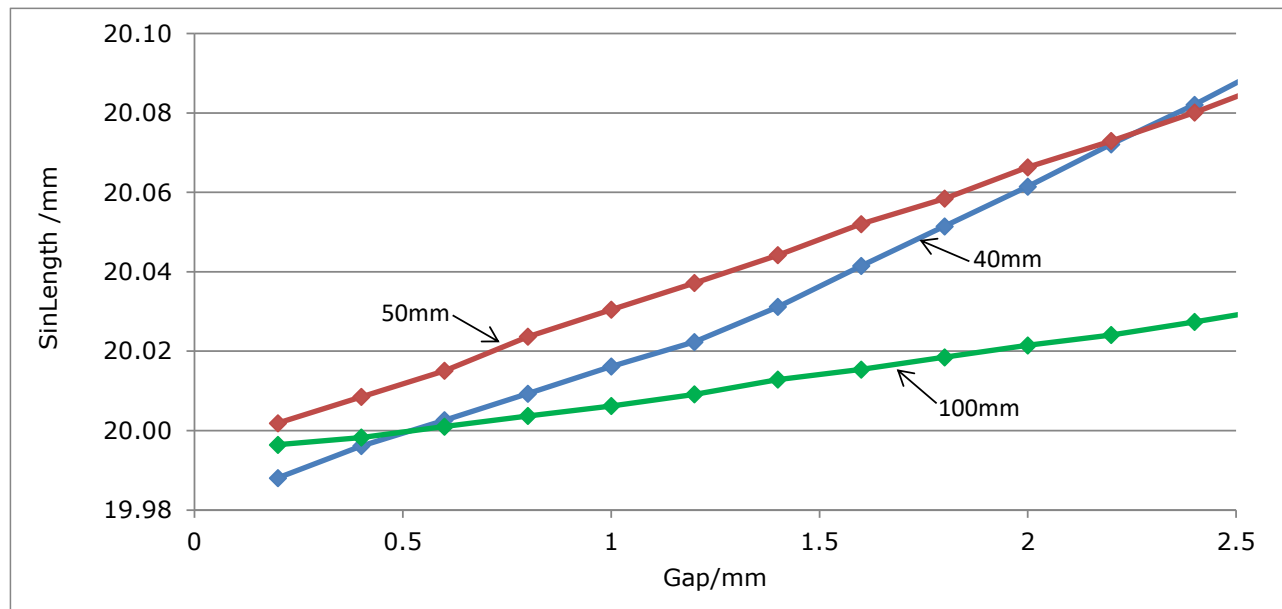


Figure 12 Optimum SinLength value as a function of Gap

3.4 Amplitude

Amplitude measured from the fine coils (strictly AmplitudeA) is a useful measure of system health, and reduces with Gap as shown in Figure 13. Amplitude also reduces with the presence of nearby metal, and sensor installations should be checked to ensure any reduction is not excessive.

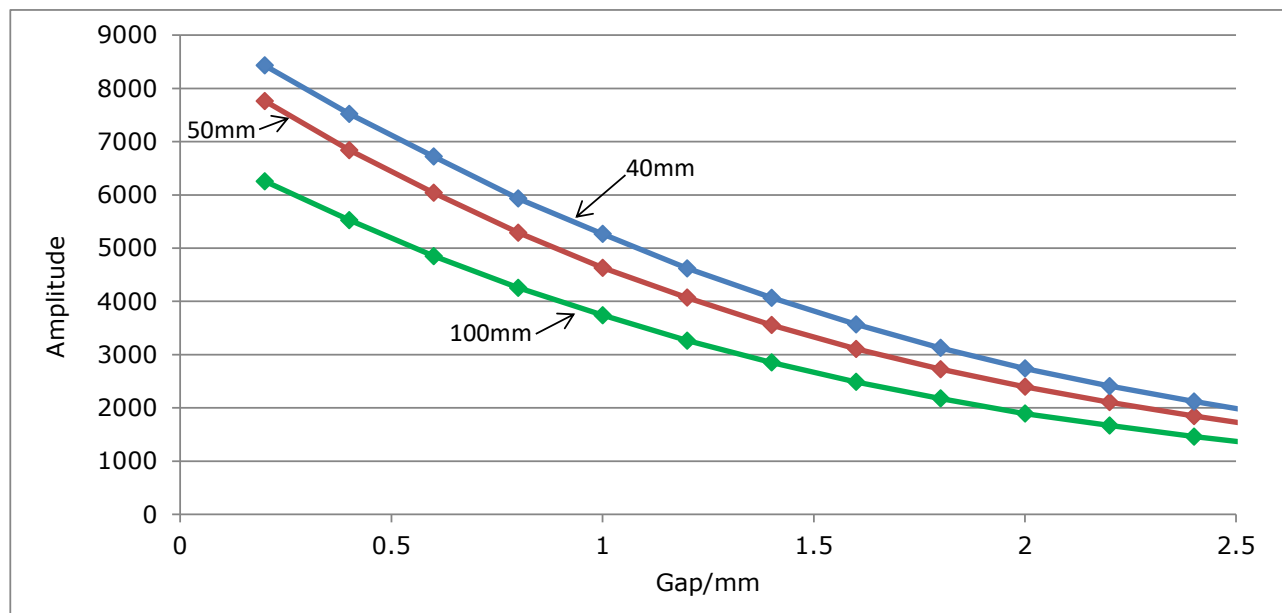


Figure 13 Minimum Reported AmplitudeA as a function of Gap, free space

3.5 Noise Free Resolution

Noise Free Resolution is a function of the signal level detected by the CAM622 chip. It therefore reduces with Gap and metal proximity in a similar way to Reported Amplitude, as illustrated in Figure 14.

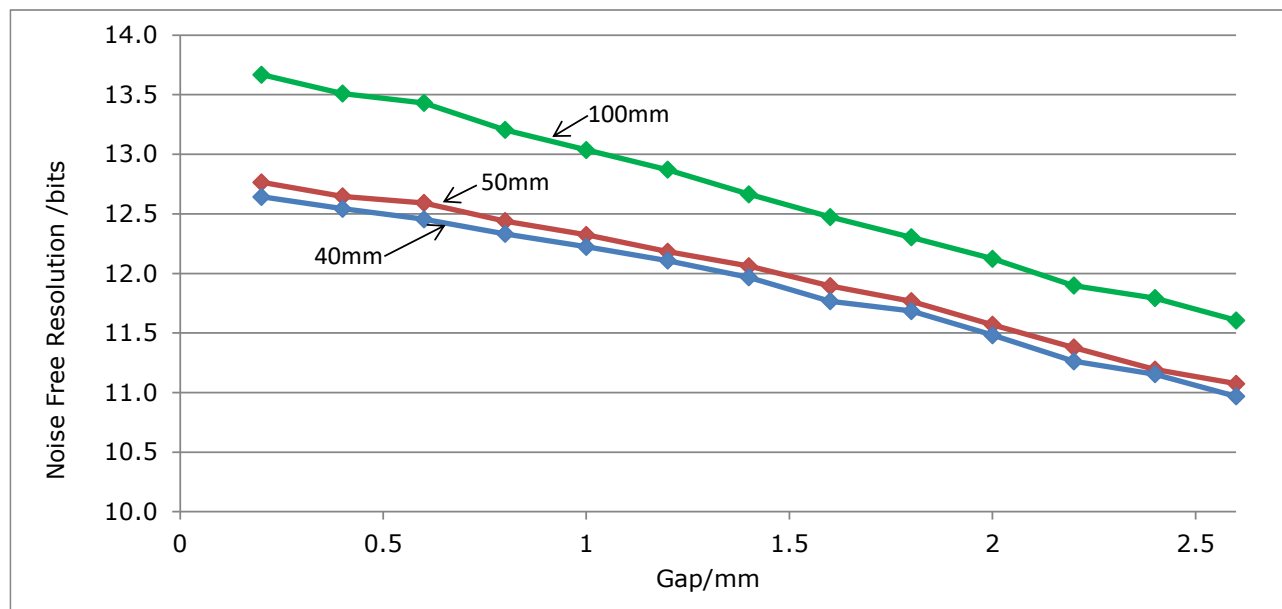


Figure 14 Noise Free Resolution as a function of Gap, CAM622 IC Motion Filter disabled, free space

Noise Free Resolution figures given in Figure 14 are "raw", with the Motion Filter disabled. For most practical applications the CAM622's Motion Filter will be used, adding up to 3 bits of Noise Free Resolution. "Noise Free Resolution > 15 bits up to 1.5mm Gap" quoted on page 1 is based on using default Motion Filter settings, adding 3 bits to Figure 14.

4 Performance with Metal Nearby

This section presents examples of how nearby metal affects the sensor system, and are based on measurements taken with the 50mm B6 sensor. Please refer to the Type B Sensor Reference Manual for definitions of the terms used in this section, and for more details of the effect of nearby metals. Unless otherwise noted, measurements in this section are made with a Gap between sensor and target of 1mm.

4.1 Metal Plate Behind Sensor

Aluminium behind the sensor tends to reduce Amplitude less than steel...

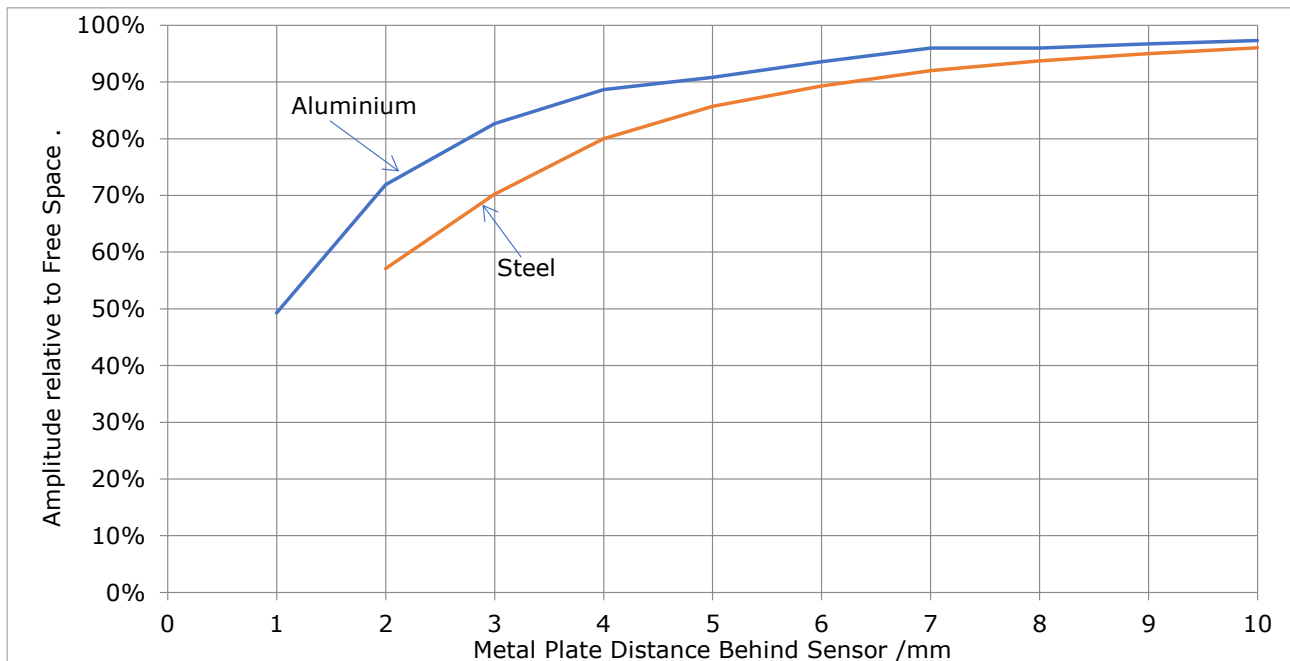


Figure 15 Effect of metal plates behind the sensor on Amplitude

On the other hand, aluminium tends to increase the target's resonant frequency more than steel does...

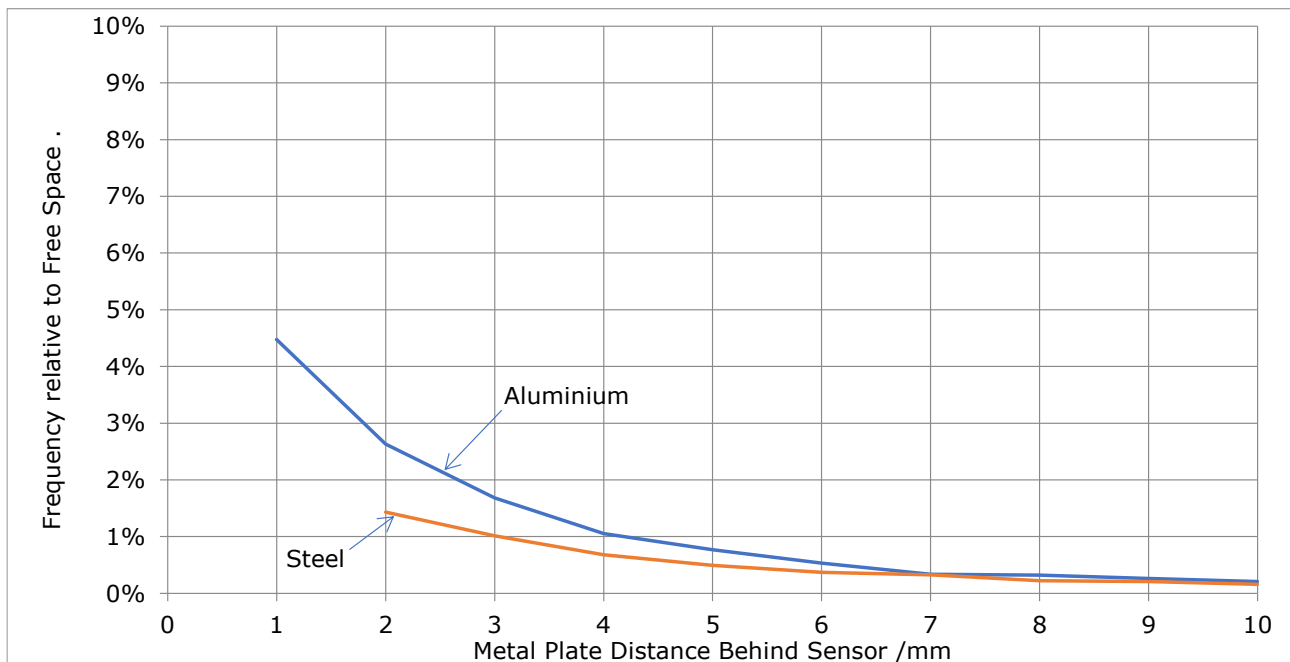


Figure 16 Effect of metal plates behind the sensor on resonator frequency

4.2 Metal Plate Behind Target

Steel near the target has a somewhat greater effect than when it is the same distance behind the sensor, because steel reduces the Q-factor of the target's resonator substantially.

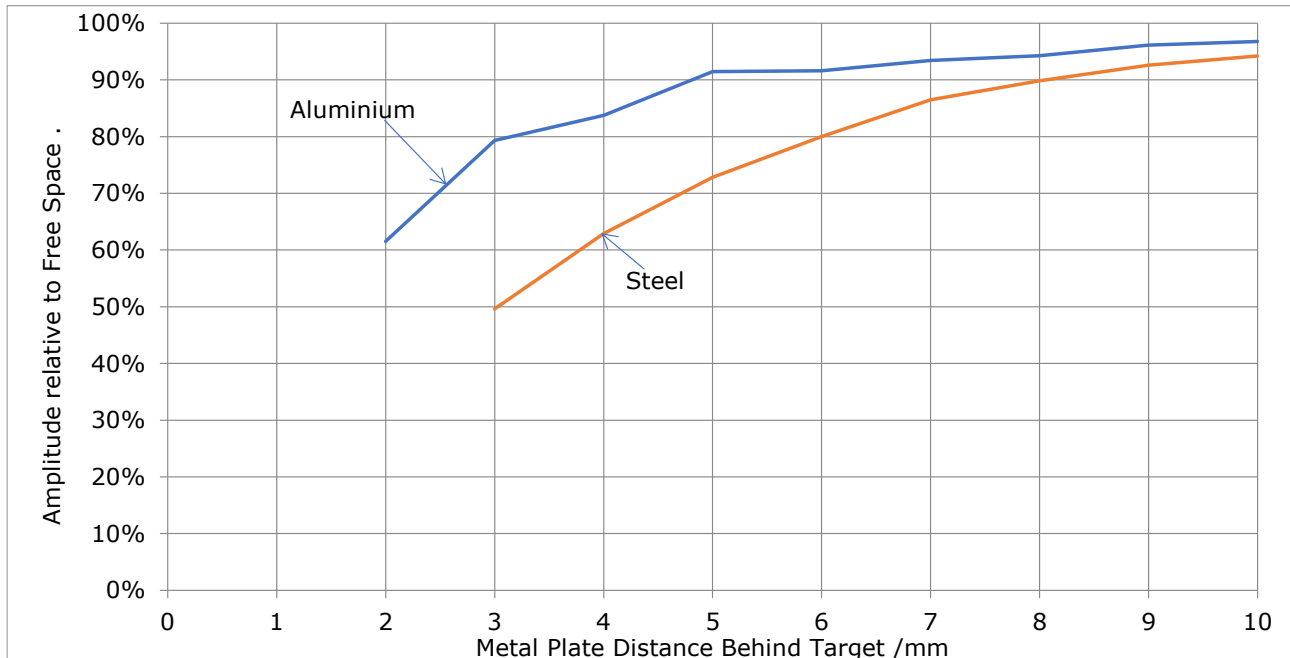


Figure 17 Effect of metal plates behind the target on Amplitude

Metals behind the target have a greater effect than when they are the same distance behind the sensor, because it is mainly the metal's proximity to the target that matters. The graph of Figure 18 is similar to that of Figure 16 with its x-axis shifted 2mm to the left, because the metal is 2mm further from the target in Figure 16 (1mm sensor thickness plus 1mm gap).

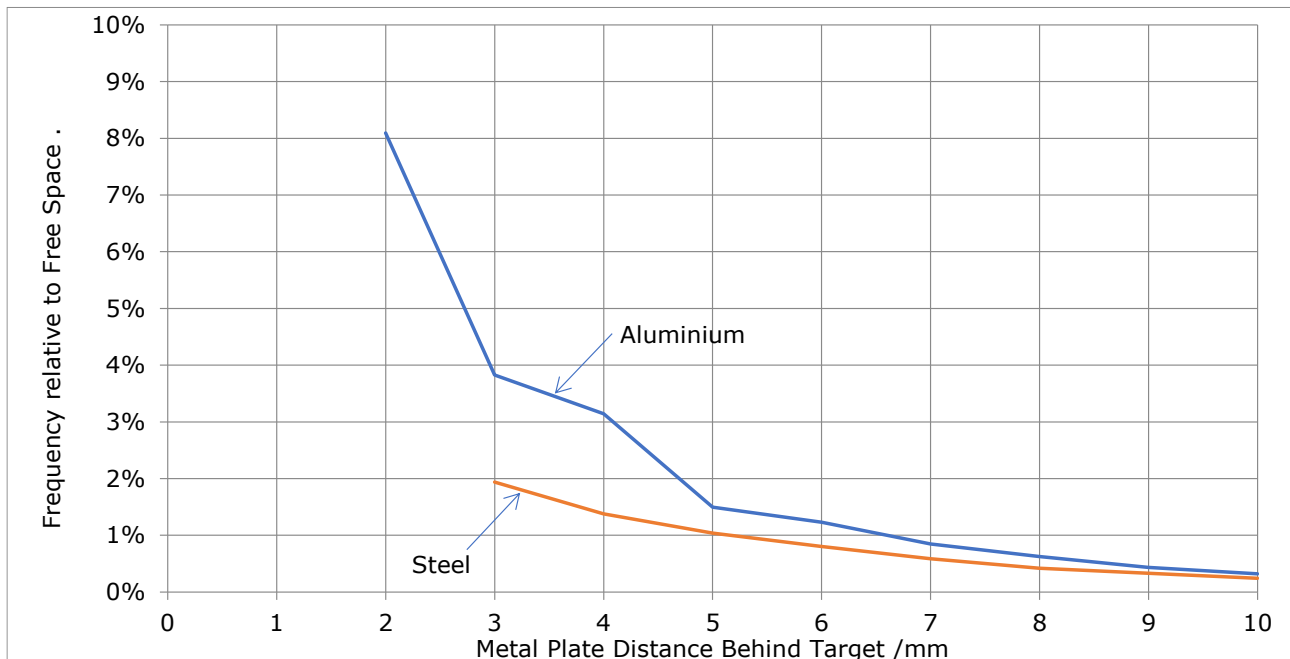


Figure 18 Effect of metal plates behind the target on resonator frequency

4.3 Metal Plate to the Side of Sensor and Target

Steel and aluminium close to the side of the sensor and target have a relatively small effect, as illustrated below.

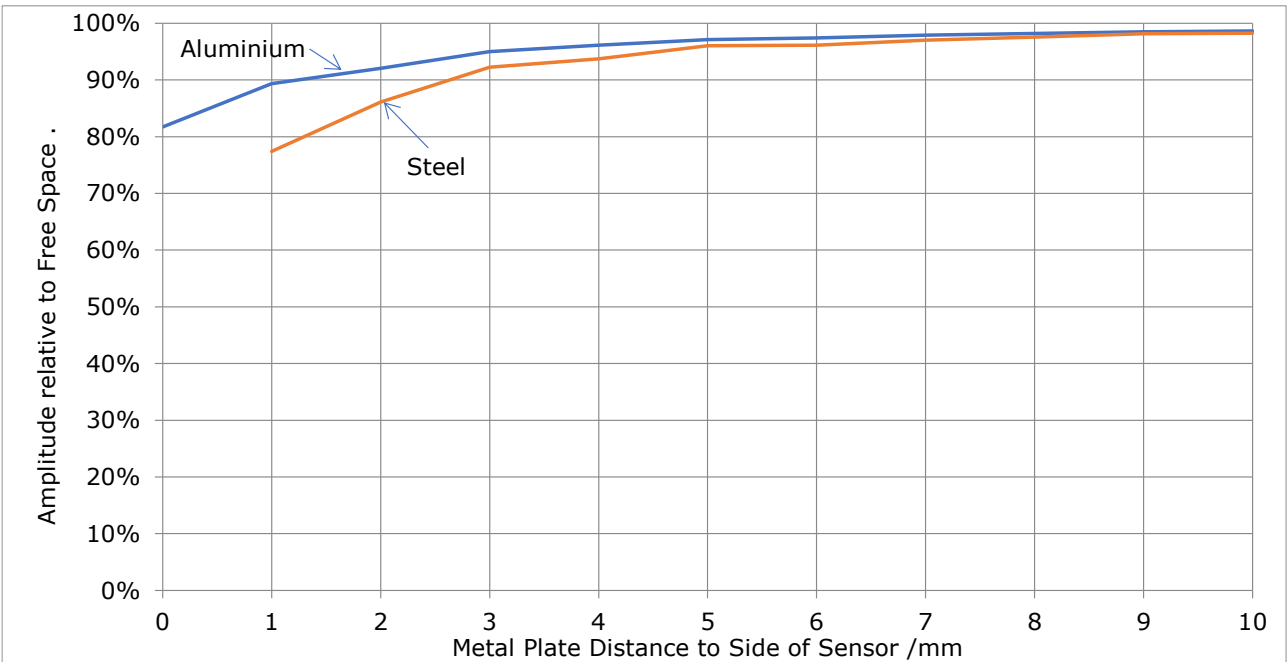


Figure 19 Effect of metal plates to the side of the sensor and target on Amplitude

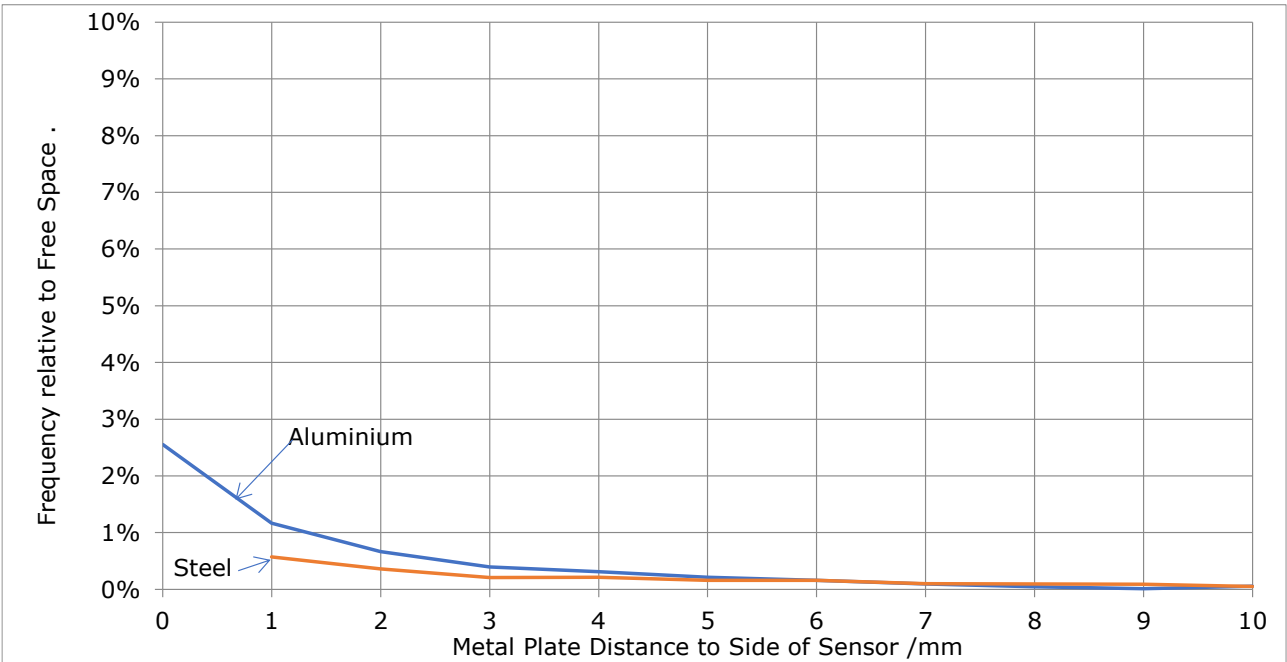


Figure 20 Effect of metal plates to the side of the sensor and target on resonator frequency

5 Environmental

Assembled sensors and target 013-1042 conform to the following environmental specifications:

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

The maximum operating temperature of the sensor PCB may be increased if a customer manufactures their own sensor PCB to CambridgeIC's design, and uses an alternative, higher temperature, connecting method.

6 RoHS Compliance

CambridgeIC certifies, to the best of its knowledge and understanding that part number 013-0067 is in compliance with EU RoHS directive 2011/65/EU, China RoHS and Korea RoHS.

7 Document History

Revision	Date	Comments
0001	14 May 2025	First draft
0002	18 Nov 2025	Minor corrections

8 Contact Information

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9 Legal

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The design of the sensor, comprising each of the patterned copper layers, drill locations, silk screens, assembly layers and board outline are protected by copyright.