150 - 200mm B12 Precision Linear Sensors

Description

CambridgeIC's B12 precision linear resonant inductive position sensors have measuring lengths of 150mm and 200mm. 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
- 150mm and 200mm Measuring Length
- Sensor built from 4-layer PCB process
- Target built from 6-layer PCB process

Performance, Free Space

- Linearity Error <0.06mm at 0mm…2mm Gap
- Noise Free Resolution > 16 bits up to 2mm Gap
- Up to 0.5mm Y Misalignment

Applications

- Actuator position feedback
- Linear motor feedback
- Optical and magnetic scale replacement
- Steering rack position sensing

Product identification	
Part no.	**Description**
013-0075	150mm B12 Linear Sensor Assembly
013-0071	200mm B12 Linear Sensor Assembly
013-1043	Matching Double Lobe Target, 833kHz
010-0186	150mm B12 Linear Sensor PCB design
010-0178	200mm B12 Linear Sensor PCB design
010-2007	Double Lobe Target PCB design
013-6021	6-way PicoBlade EZmate Sensor Cable

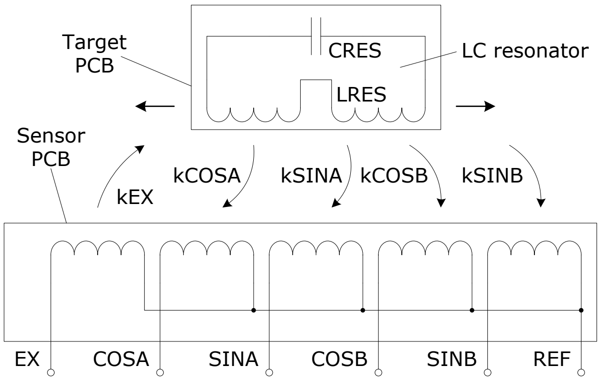

Figure 1 Equivalent circuit

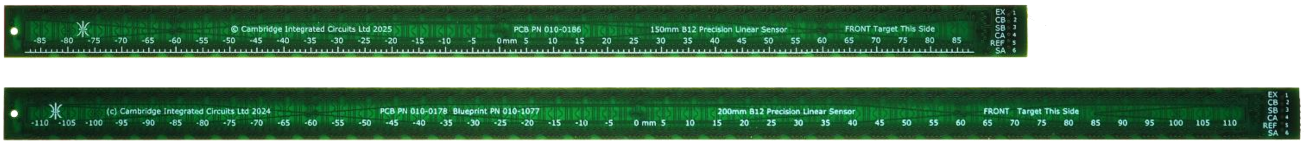

Figure 2 Sensor PCB Assemblies, Front

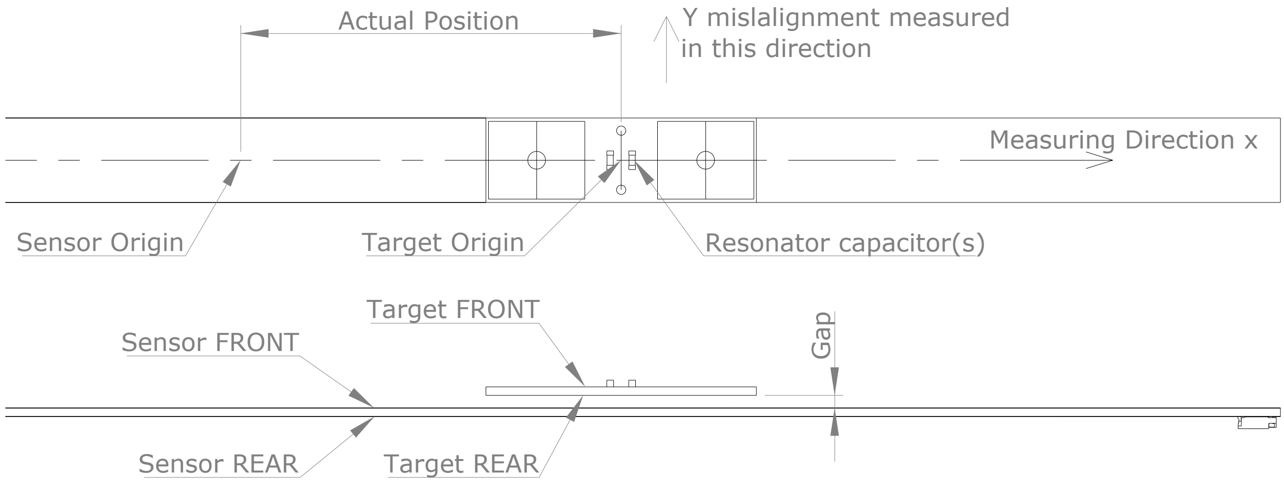

Figure 3 Alignment of sensor PCB assemblies with target 013-1043

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 1. 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.

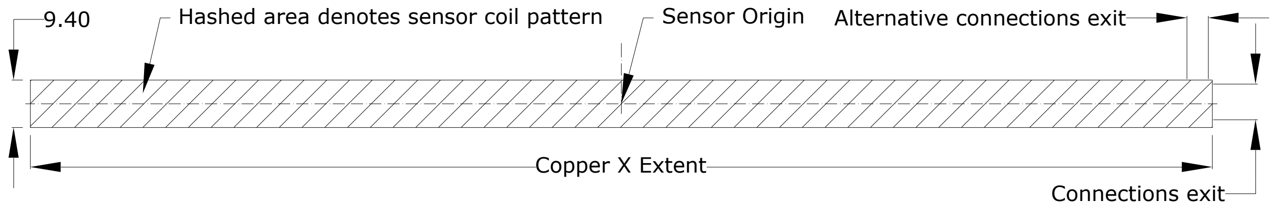

Figure 4 Sensor Coil PCB Extents and Connection Locations

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
010-0186	150mm	183.4mm
010-0178	200mm	233.4mm

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 B12 Precision Linear Sensors are available as assembled PCBs including connector. An image of their FRONT sides is shown in Figure 2. Figure 5 is a mechanical drawing.

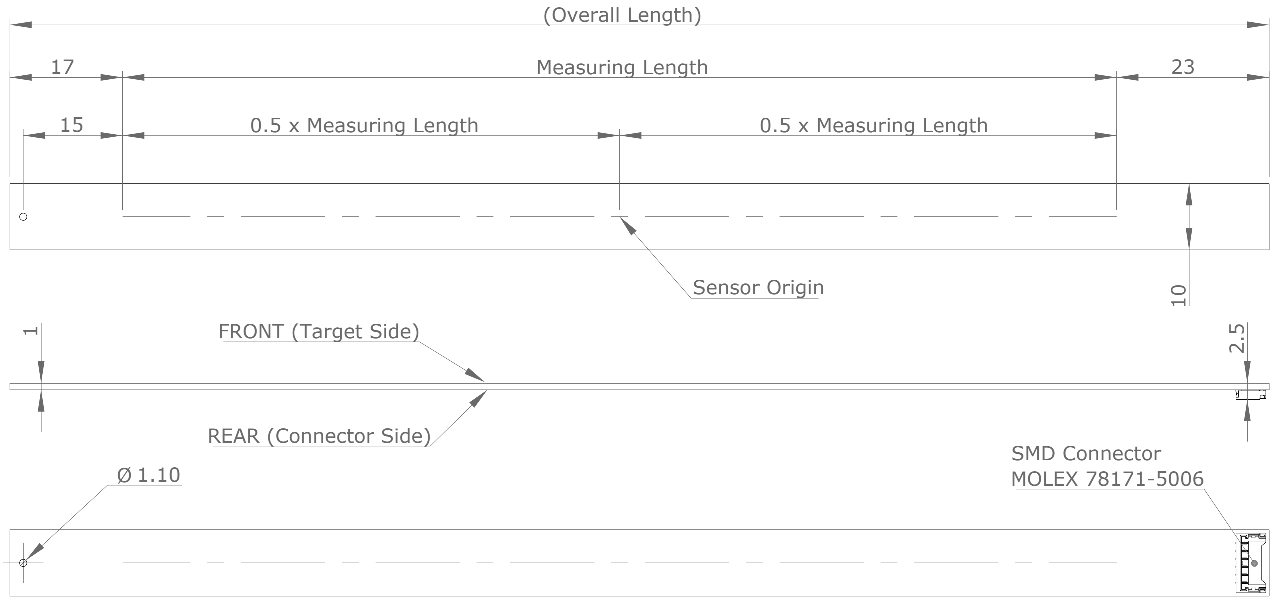

Figure 5 B12 Linear Sensors Mechanical drawing

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

Table 4 Overall Length

Sensor Assembly Part Number	Measuring Length	Overall Length
013-0075	150mm	190mm
013-0071	200mm	240mm

The sensor measures Actual Position relative to the Sensor Origin. The nominal location of the Sensor Origin is [15mm plus 0.5 x Measuring Length] to the right of the Ref Hole marked in Figure 5.

The REAR of the sensor PCB is fitted with an SM connector MOLEX 78171-5006. Its pinout is shown in Table 5. Figure 6 shows how to connect a mating connector.

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

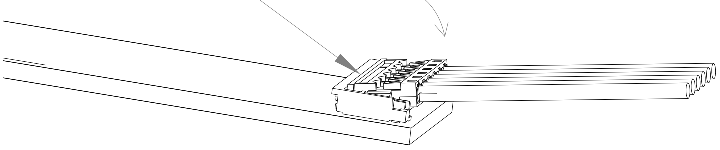

Figure 6 Mating EZmate connectors

The B12 Precision Linear Sensors work with the Dual Lobe Linear Target described in section 2, including part number 013-1043. 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 two lobes, whose equivalent circuit is illustrated in Figure 1. 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 010-2007

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

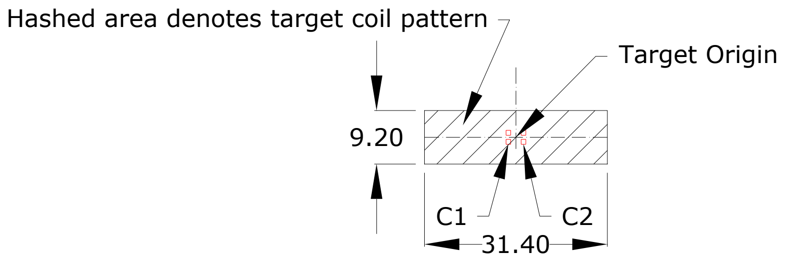

Figure 7 Target Coil PCB Extents and Connection Locations

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	30.5µH	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 013-1043

The Dual Lobe Target for the B12 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.

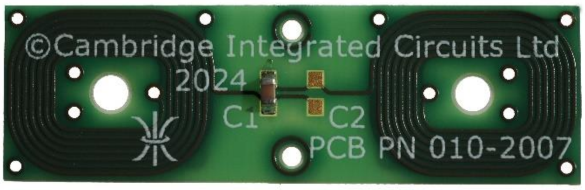

Figure 8 Target PCB Assembly 013-1043, FRONT (capacitor side)

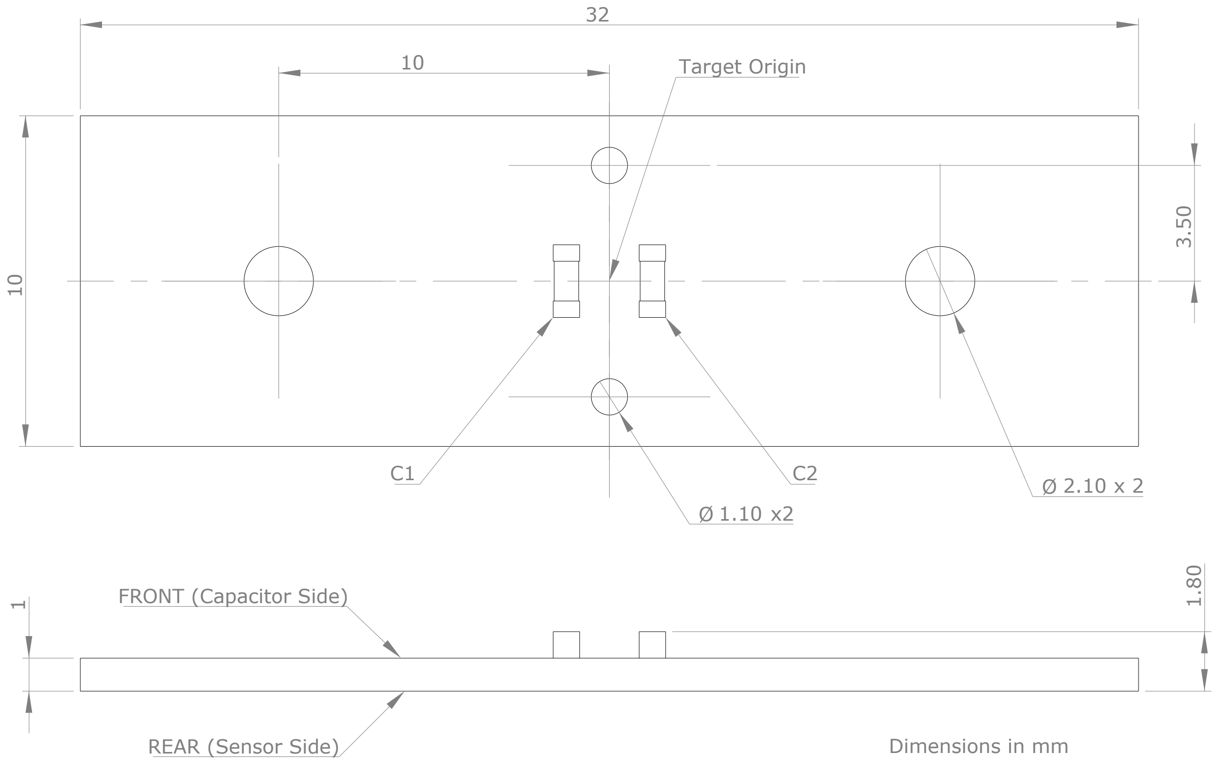

Figure 9 Mechanical drawing, target PCB assembly 013-1043

The target comprises target PCB PN 010-2007 with resonator capacitor(s) shown in Table 9, to yield the frequency specifications of Table 10.

Table 9 Fitted components

Location	Value	Description
C1	1nF	100V COG (NPO) ±2% 0603
C2	180pF	50V COG (NPO) ±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	±4%	

3 Performance

Figures below are representative of CambridgeIC's assembled sensors and sensor PCBs built to sensor PCB designs, working with target assembly 013-1043 and targets built to target PCB design 010-2007.

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.

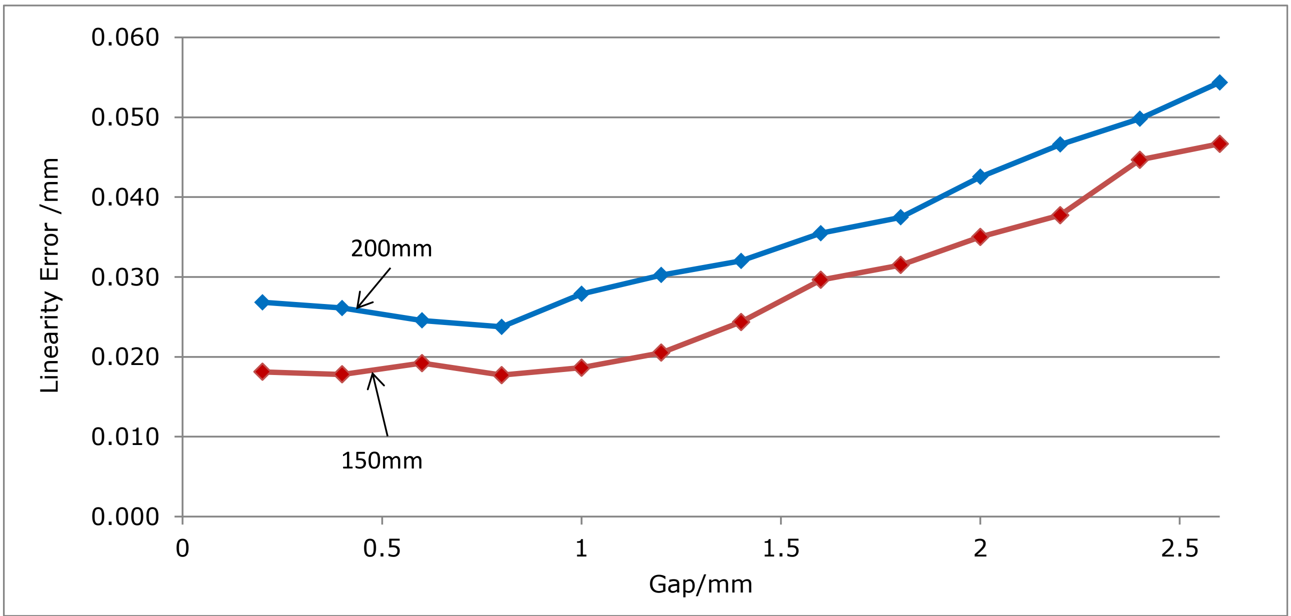

Figure 10 Linearity Error as a function of Gap

The worst case figure given on page 1 is the worst case of Figure 10 at up to 2mm gap, with an additional allowance of 0.015mm for variability across PCBs and grade A components.

3.2 End Valid Range

The performance of the 150mm and 200mm B12 sensors degrades when the target is beyond the Measuring Length. However the system will report VALID up to 3mm beyond each end of the Measuring Length, and the reported position value will change monotonically with position. Beyond that distance the system's reported position may become corrupted, including reporting a position erroneously inside the Measuring Length.

3.3 SinLength Value

The SinLength parameter is the repeat distance of the fine sensor coil design. Its value is defined by the layout of the fine sensor coils, and is 20.0mm by design. This may be expected to vary from board to board 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.

3.4 Amplitude

Amplitude measured form the fine coils (strictly AmplitudeA) is a useful measure of system health, and reduces with Gap as shown in Figure 11. Amplitude also reduces with the presence of nearby metal, and sensor installations should be checked to ensure any reduction is not excessive.

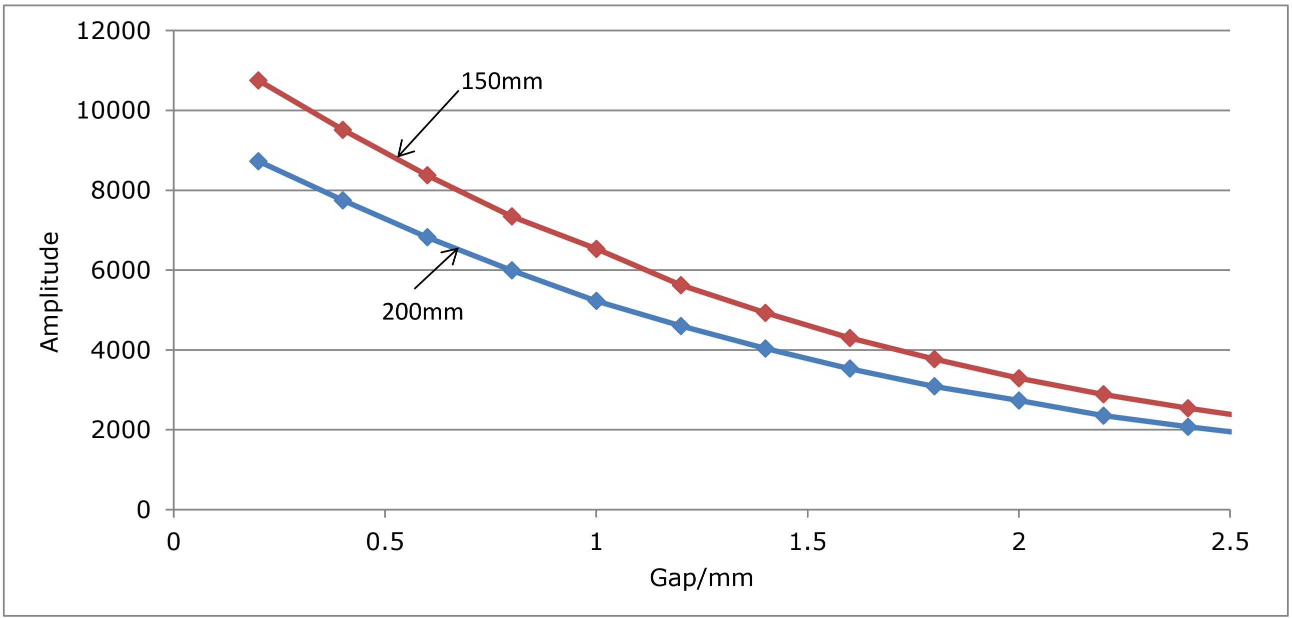

Figure 11 Minimum Reported AmplitudeA as a function of Gap, free space

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 12.

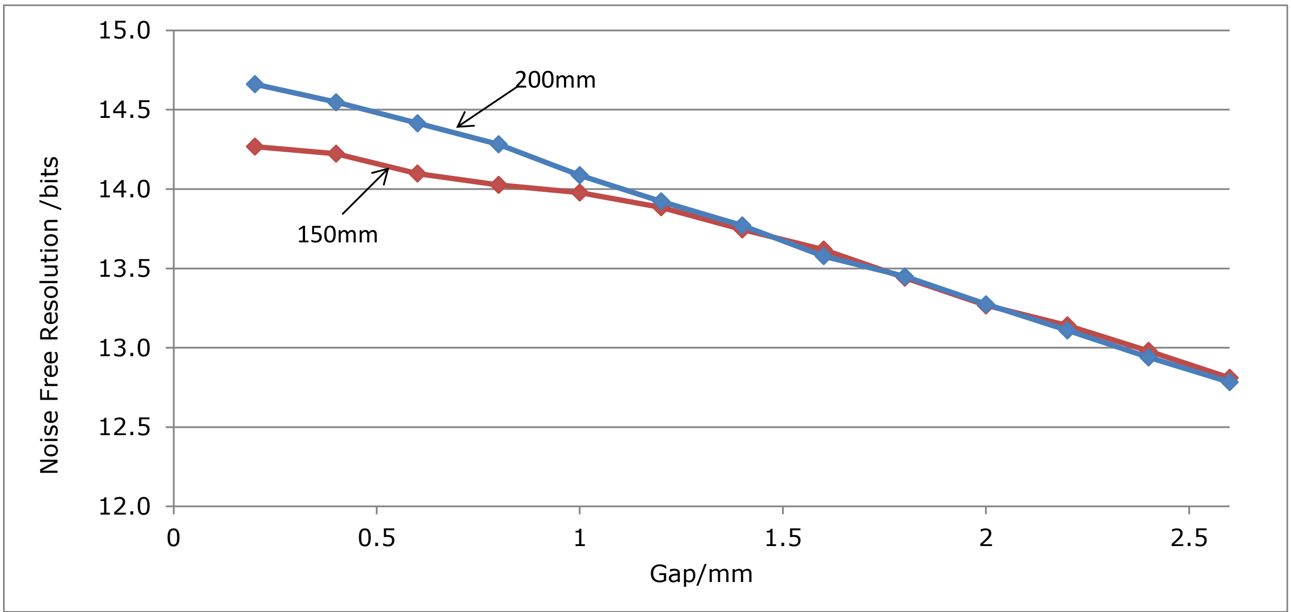

Figure 12 Noise Free Resolution as a function of Gap, CAM622 IC Motion Filter disabled, free space

Noise Free Resolution figures given in Figure 12 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 > 16 bits up to 2mm Gap" quoted on page 1 is based on using default Motion Filter settings, adding 3 bits to Figure 12.

4 Performance with Metal Nearby

This section presents examples of how nearby metal affects the 200mm B12 sensor system. Figures are also representative of the 150mm B12 Linear 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…

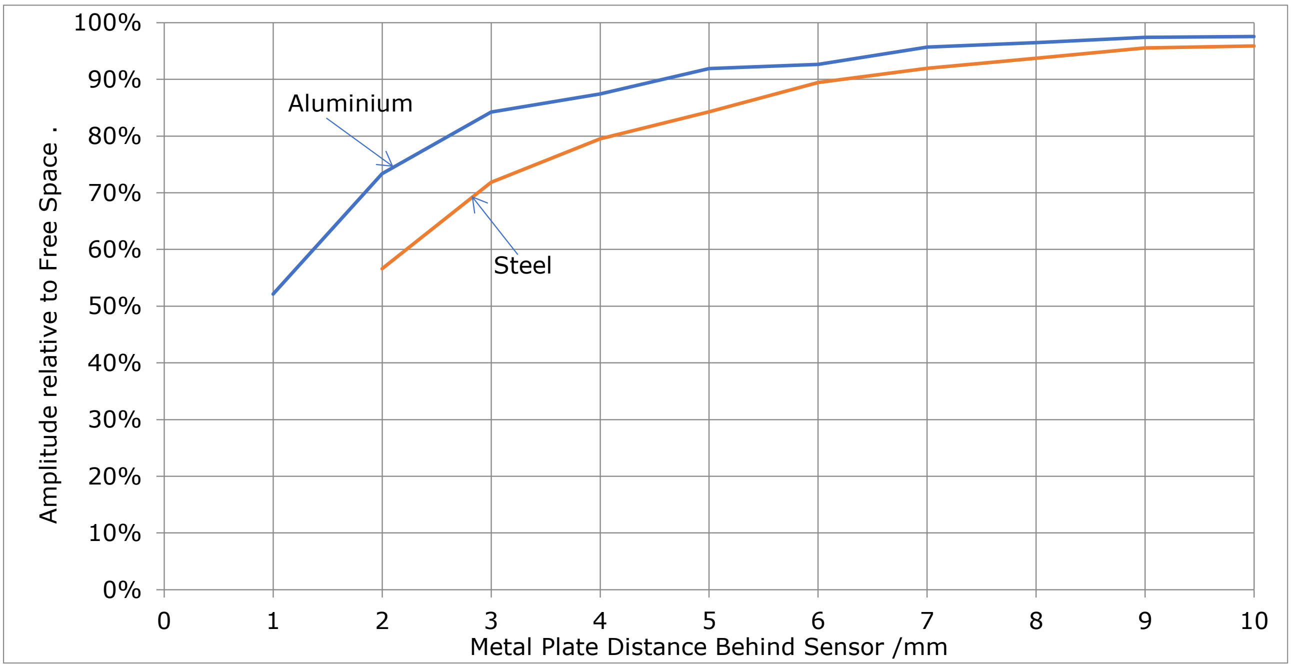

Figure 13 Effect of metal plates behind the sensor on Amplitude

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

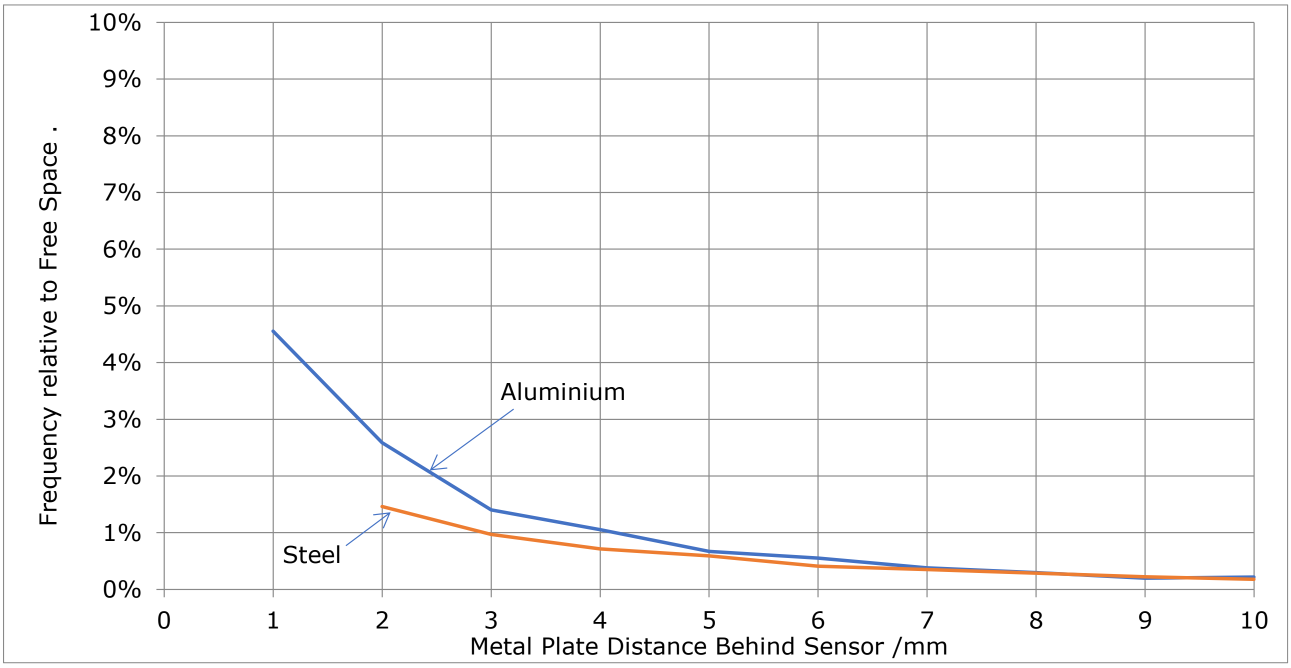

Figure 14 Effect of metal plates behind the sensor on resonator frequency

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.

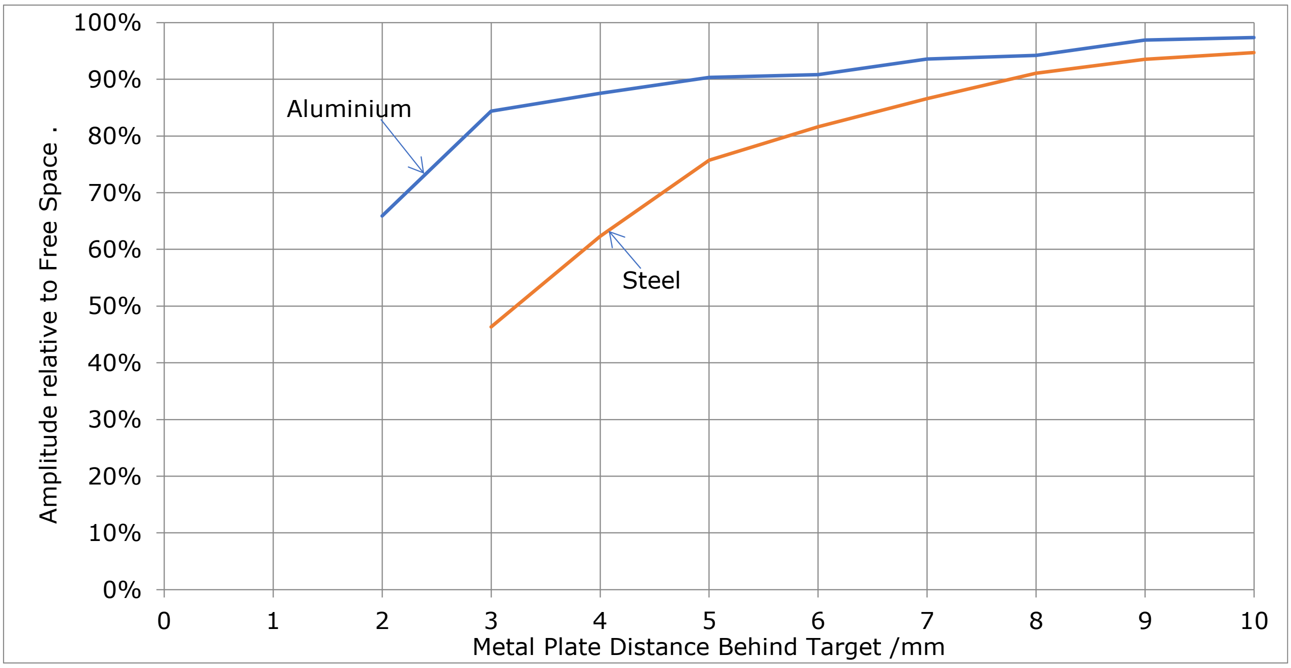

Figure 15 Effect of metal plates behind the target on Amplitude

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 16 is similar to that of Figure 14 with its x-axis shifted 2mm to the left, because the metal is 2mm further from the target in Figure 14 (1mm sensor thickness plus 1mm gap).

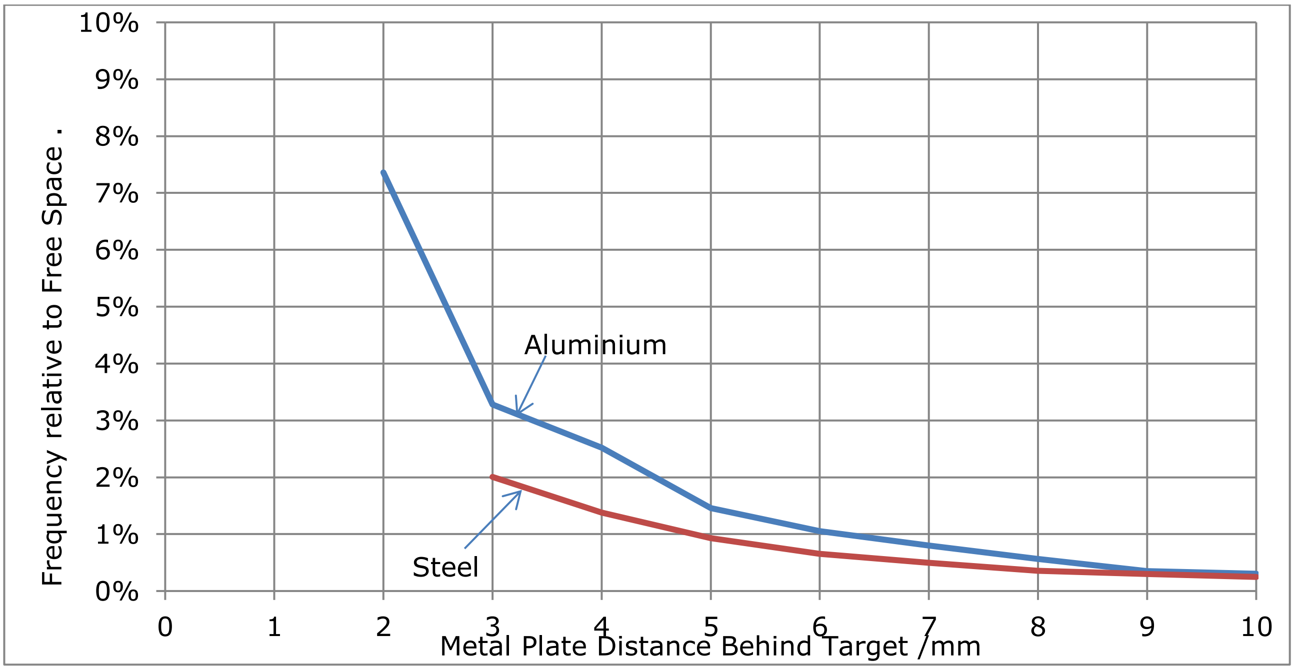

Figure 16 Effect of metal plates behind the target on resonator frequency

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.

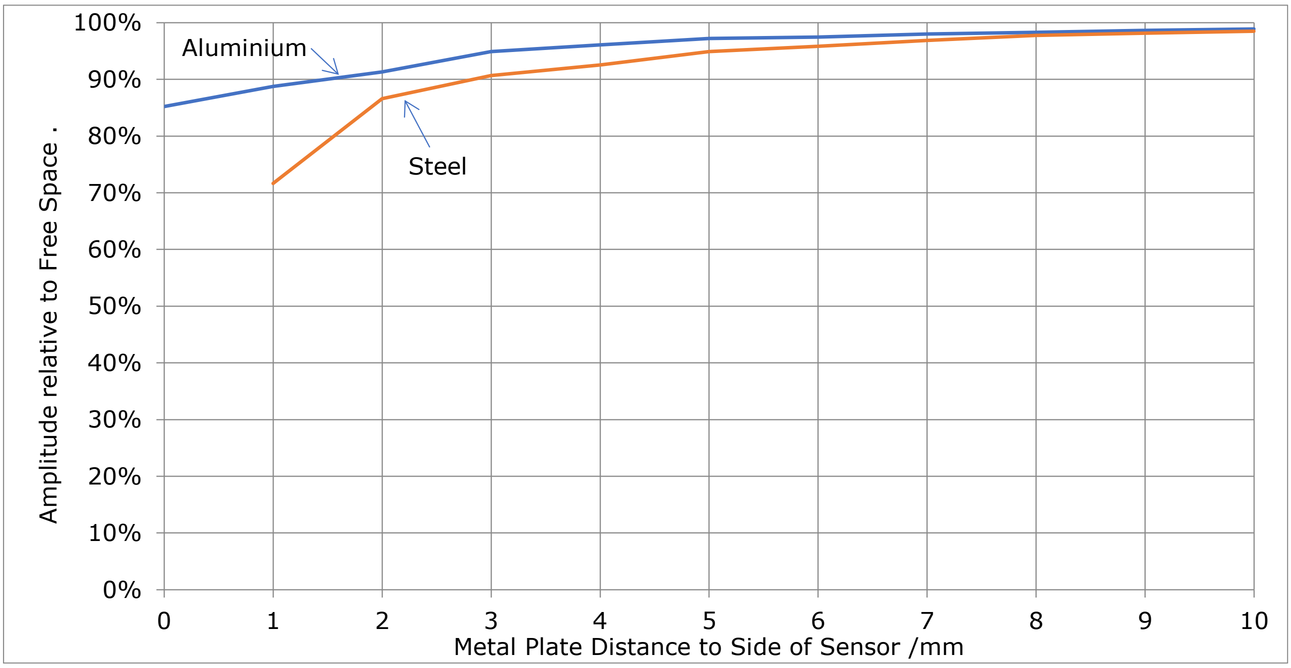

Figure 17 Effect of metal plates to the side of the sensor and target on Amplitude

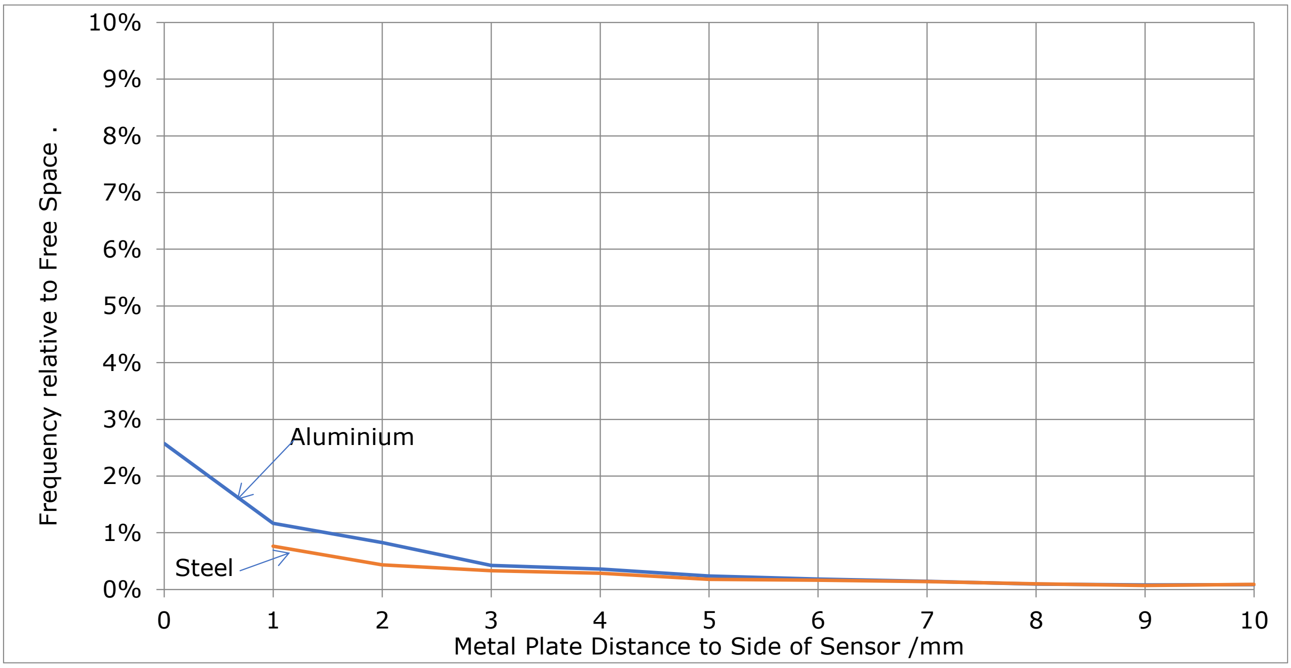

Figure 18 Effect of metal plates to the side of the sensor and target on resonator frequency

5 Environmental

Assembled sensor part number 013-0071 and target 013-1043 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	17 Jan 2025	First draft
0002	14 May 2025	Updated capacitor values for target part 013-1042 Added section: Performance with Metal Nearby
0003	18 November 2025	Updated to include 150mm B12 Linear Sensor

8 Contact Information

Cambridge Integrated Circuits Ltd
21 Sedley Taylor Road
Cambridge
CB2 8PW
UK

Tel: +44 (0) 1223 413500

info@cambridgeic.com

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