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REFERENCE DESIGN
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NCS32100 Linear Sensor Reference Design

TND6527/D

Introduction

This note describes the NCS32100 linear sensor reference design. The sensor supports UART output. The key dimension of the sensor is below:

The scope of this report includes sensor design and simulation using the web design tool, reference schematic and PCB layout, and sensor calibration procedure.

Table 1. REFERENCE DESIGN KEY DIMENSION

REFE	64/63
Fine Coil Pitch	4 mm
Fine Coil Width	10.9 mm
Coarse Coil Pitch	4.063 mm
Coarse Coil Width	3.9 mm
Air Gap	0.5 ± 0.2 mm

Coil Design

Figure 1 shows the sensor and track coil design.

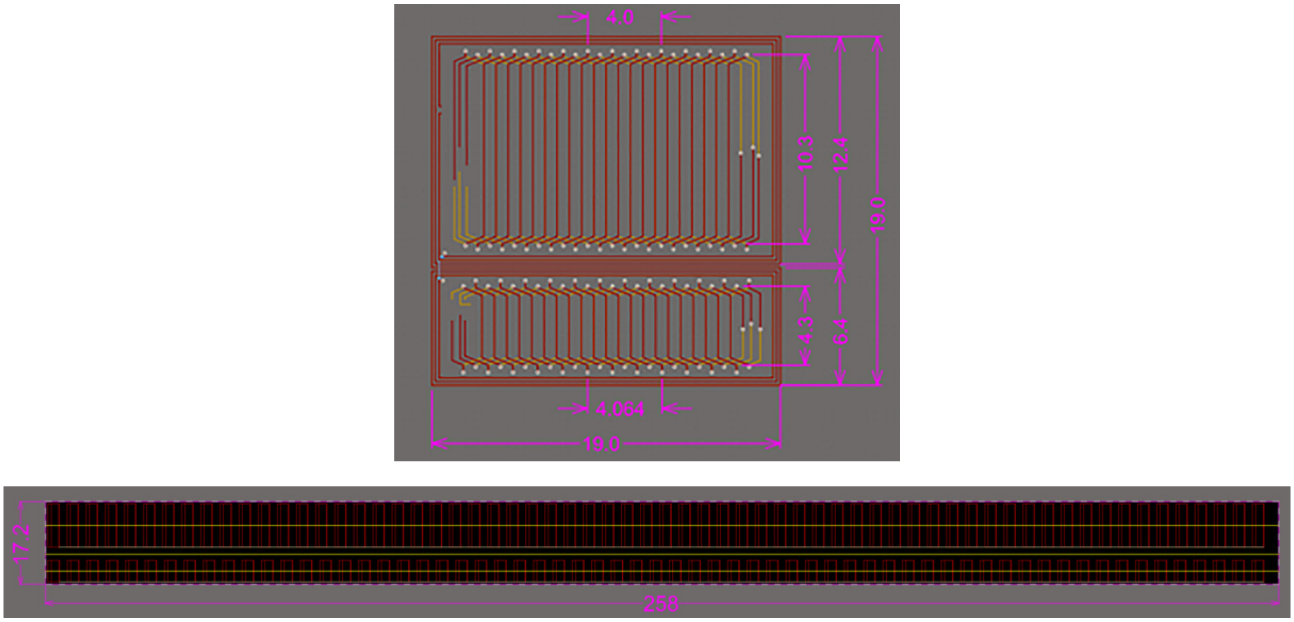

Figure 1. Sensor and Track Coil

Excitation Coil Simulation

To ensure the sensor oscillator starts up normally, the loaded self-inductance of the excitation coil shall be greater than 500 nH, the loaded Q factor of the excitation coil shall be high enough that the oscillation can start up normally. Higher loaded Q factor by adding more turns is preferred when the layout and signal strength is allowed.

Figure 2 shows that within the air gap range the loaded self-inductance is greater than 500 nH, the loaded Q factor is about 12. Based on self-inductance, the tank cap should be 3.3 nF, 17 mA driving current is needed to achieve 4.7 V oscillation voltage. Figure 3 shows that within the air gap range the excitation voltage can settle within 4 μs; the fundamental frequency is 4.38 MHz; the 3rd harmonics is about −40 dB lower than the fundamental frequency.

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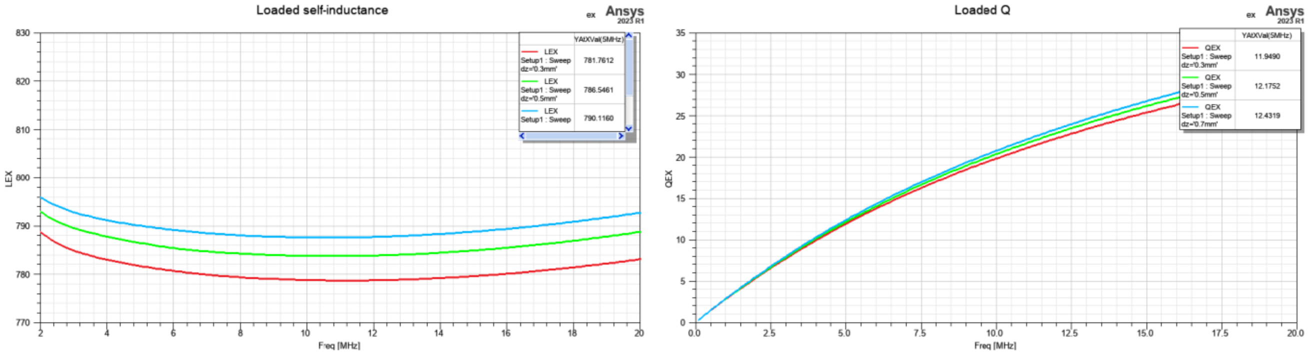

Figure 2. Excitation Coil Loaded Self-inductance and Q Factor

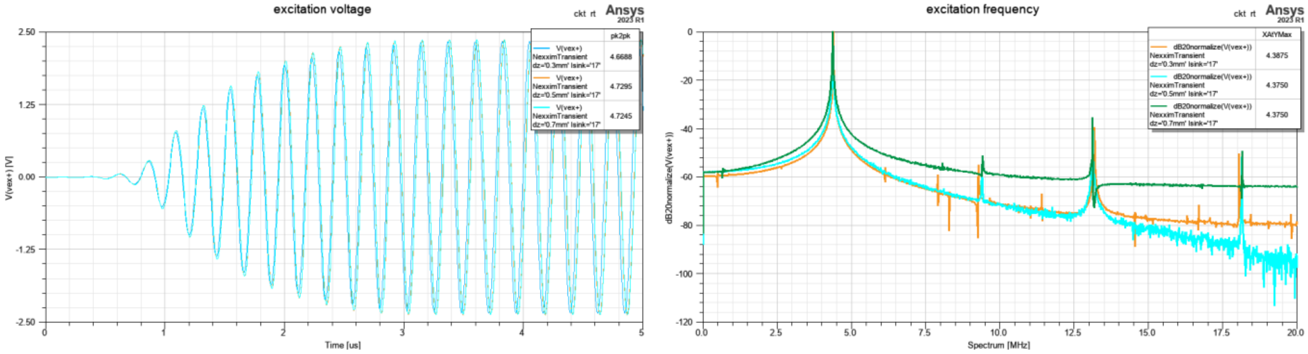

Figure 3. Excitation Voltage with 3.3 nF Tank Cap and 17 mA Driving Current

Signal Strength and Accuracy Simulation

Since the ENOB of the sensor is determined by the signal strength of the fine signal, to minimize the sensor size, coil is designed so that the fine signal is about 50% higher than the coarse signal. Figure 4 shows the simulation result of the sensor signal and accuracy. At 4.7 V excitation voltage, receiver signal is about 80 mV at nominal 0.5 mm air gap, 120 mV at minimal 0.3 mm air gap and 45 mV at maximal 0.7 mm air gap. Signal strength drops at both ends since the track does not fully cover the sensor, both ENOB and accuracy degrades at those regions.

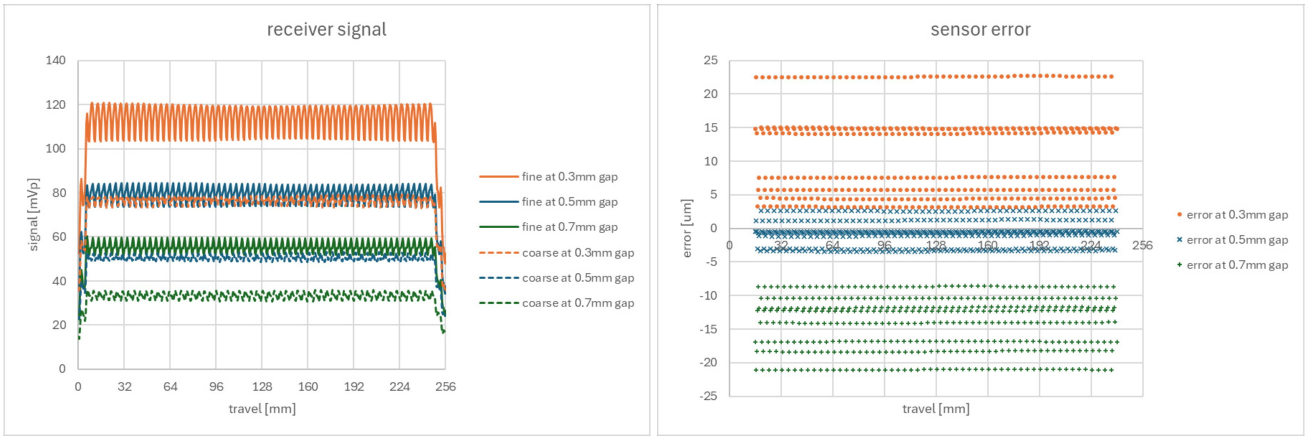

Figure 4. Signal Strength and Accuracy

PCB Design

Figure 5 shows the sensor shows the sensor core reference circuit and its corresponding PCB layout. The best practice of the layout for optimum sensor accuracy include:

1. The path from the excitation coil to the tank cap should be as short as possible to avoid the high current on the path inducing direct coupling.
2. AC ground of the receiver coil should be close to the chip ground.

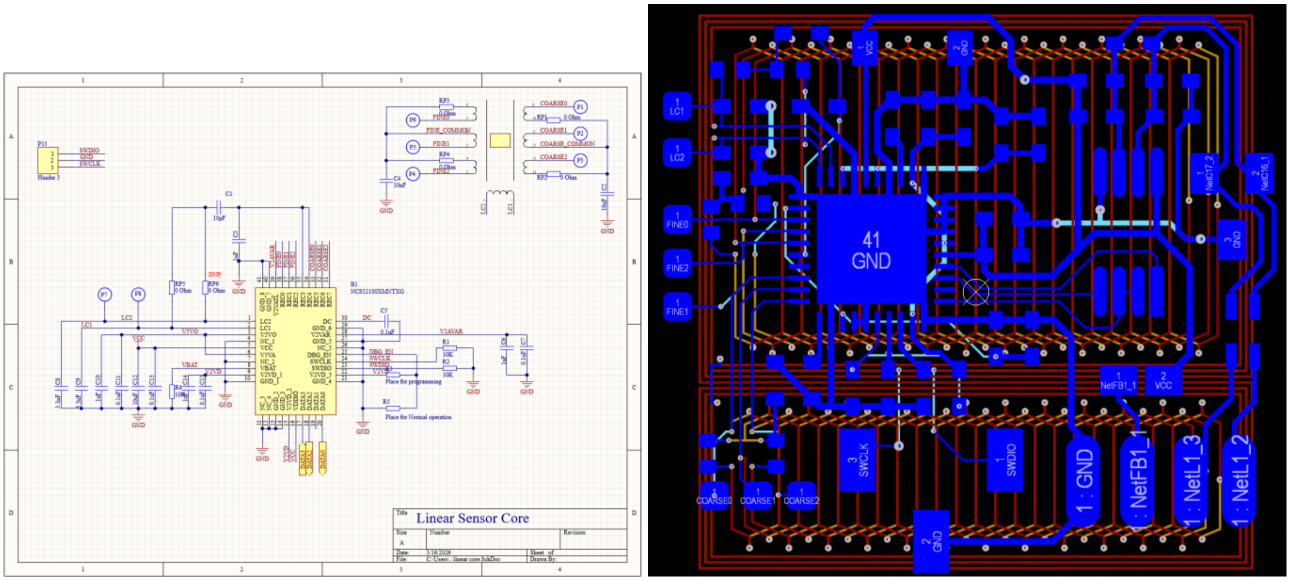

Figure 5. Schematic and PCB Layout

PCB Simulation

After PCB layout is completed, a few simulations are necessary to ensure the layout is correct. One simulation is the receiver signal when there is no track, this direct coupling should be sufficiently low so that sensor will not have output jump when the air gap changes. Table 2 shows the direct coupling of this PCB layout.

Table 2. DIRECT COUPLING

	C1 [mV]	C2 [mV]	C3 [mV]	F1 [mV]	F2 [mV]	F3 [mV]
Single Ended	12.07	2.78	8.64	–4.56	–17.12	0.26
	C12 [mV]	**C23 [mV]**	**C31 [mV]**	**F12 [mV]**	**F23 [mV]**	**F31 [mV]**
Differential	9.29	–5.86	–3.43	12.56	–17.38	4.81

The second simulation is the polarity check to ensure all signals are in correct 3-phase relation. Figure 6 shows that the polarity is correct.

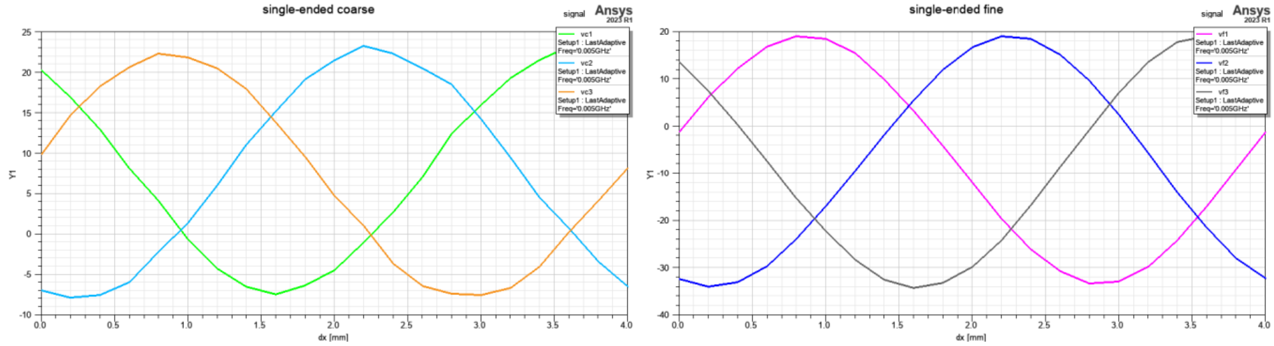

Figure 6. Single-ended Coarse Signal and Fine Signal

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Prototype

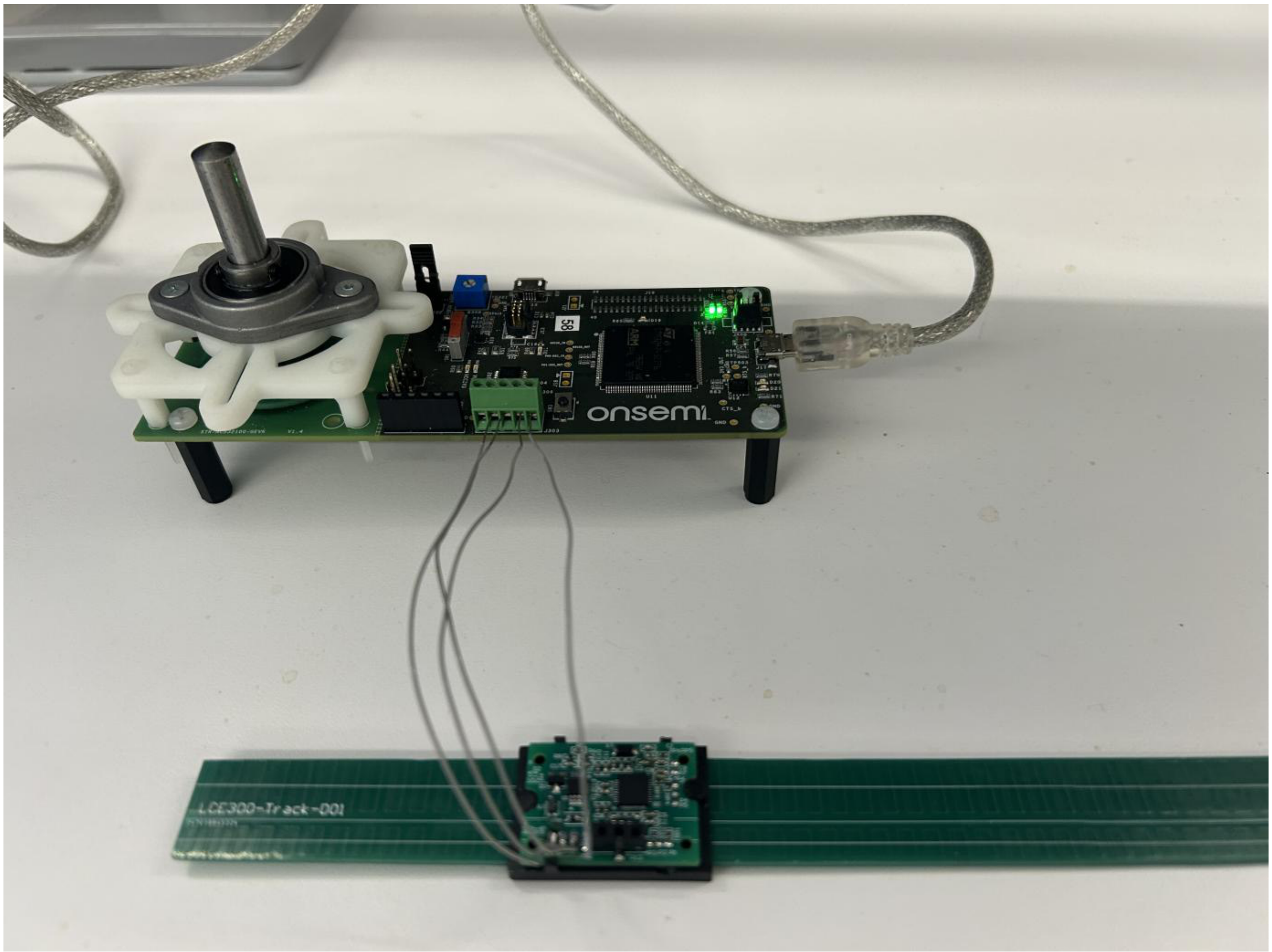

Figure 7. Prototype Set Up

Figure 7 shows the prototype set up. It uses a 3D printed fixture to assemble the sensor on the track with controlled air gap and alignment, use EVK as the master controller via RS485 communication.

Test

The sensor needs to be updated with firmware V1.25, register in Table 3 and NVM in Table 4 need to be initially programmed before self-calibration.

Table 3. REGISTER CONTENT

Description	Address	Value	Comment
CHANNEL SELECT	0x2F	0x1	Swap fine and coarse receiver signal
SELECTION MATRIX FOR COARSE BLOCK	0x10	0x0B6D	REC5, 6, 7 as coarse signal, REC4 as coarse reference
SELECTION MATRIX FOR FINE BLOCK	0x11	0xF249	REC0, 1, 2 as fine signal, REC3 as fine reference
SENSOR SELECTION	0x5F	0x3	Fine count is 64

Table 4. NVM CONTENT

Description	Address	Value
Coarse Period Configuration	Page 7, Address 12	63
Constant Multiplier	Page 7, Address 13	63
Averaging Points	Page 7, Address 14	4

After initial programming, slowly move the sensor on the track, continuously record ADC for a few back-and-forth travels. Figure 8 shows the recorded ADC. Those ADC readings can be used to optimize the Clark coefficient so that the mismatch between the coarse angle and the fine angle is minimized.

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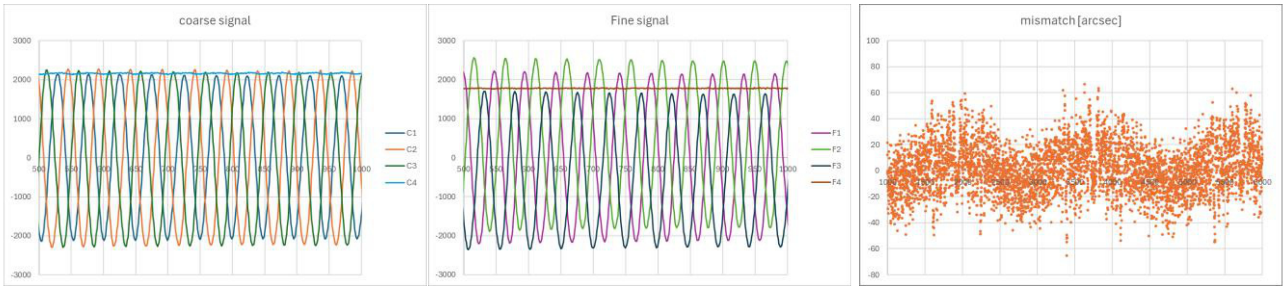

Figure 8. ADC Read and Mismatch of and Mismatch between Coarse and Find Angle

After the sensor is programmed with the optimized Clark coefficient, a sawtooth output in Figure 9 will be observed.

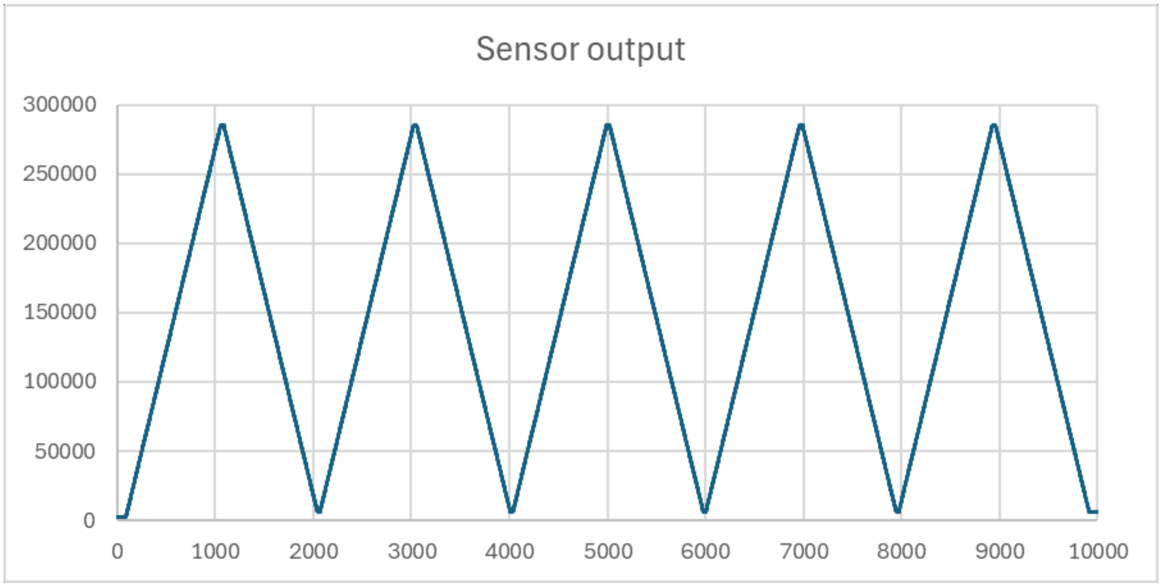

Figure 9. Sensor Output

Figure 10 is the sensor output error measured by a customer at 0.5 mm air gap. Including the PCB manufacturing error, the sensor accuracy is ±25 μm after self-calibration. The accuracy can be improved to ±5 μm.

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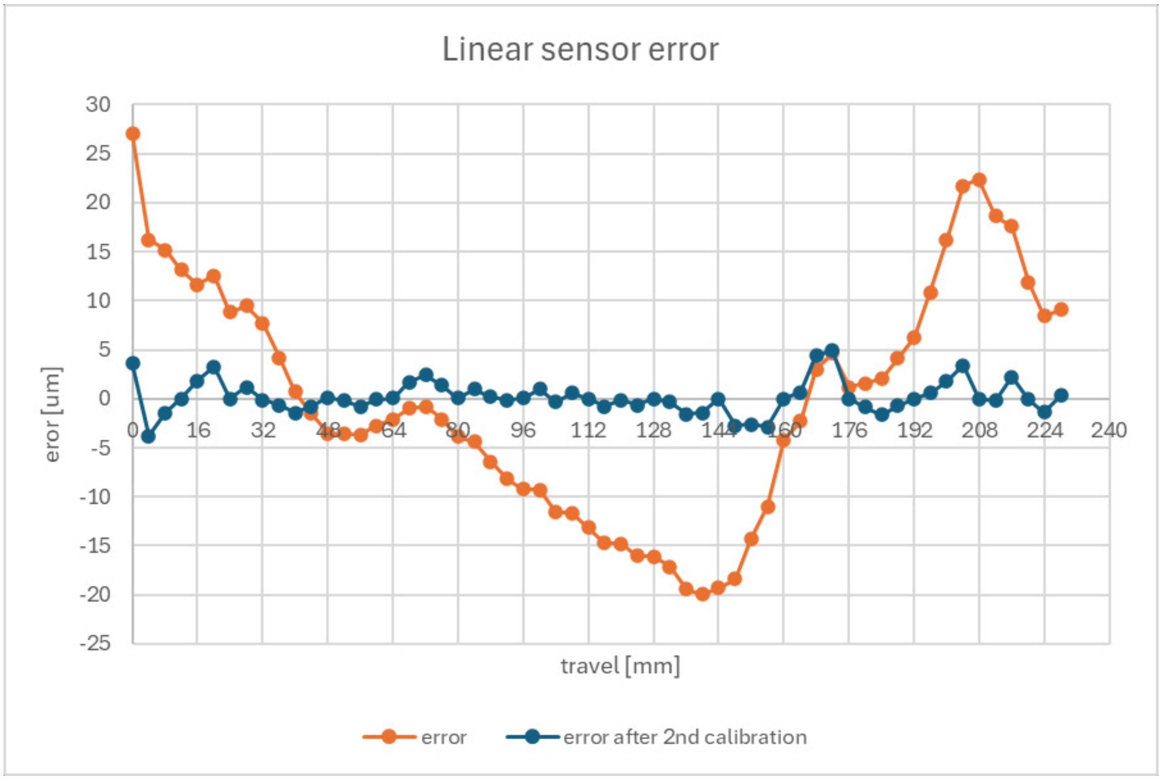

Figure 10. Sensor Error Measurement at 0.5 mm Air Gab

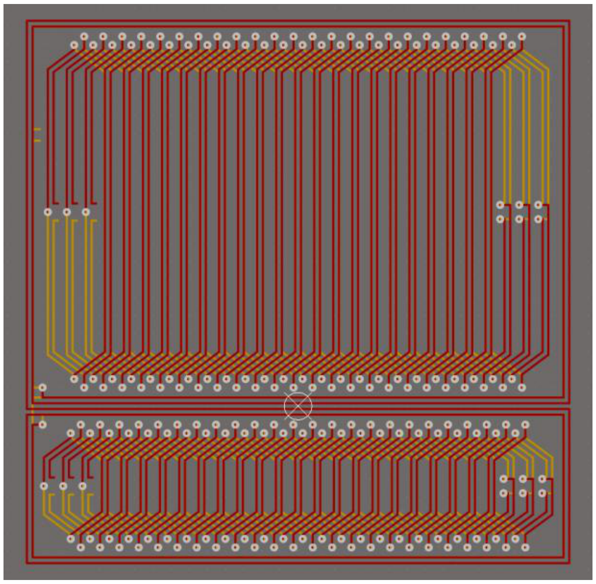

Figure 11. Coil for New Design

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REVISION HISTORY

Revision	Description of Changes	Date
0	Initial document release.	6/18/2026

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