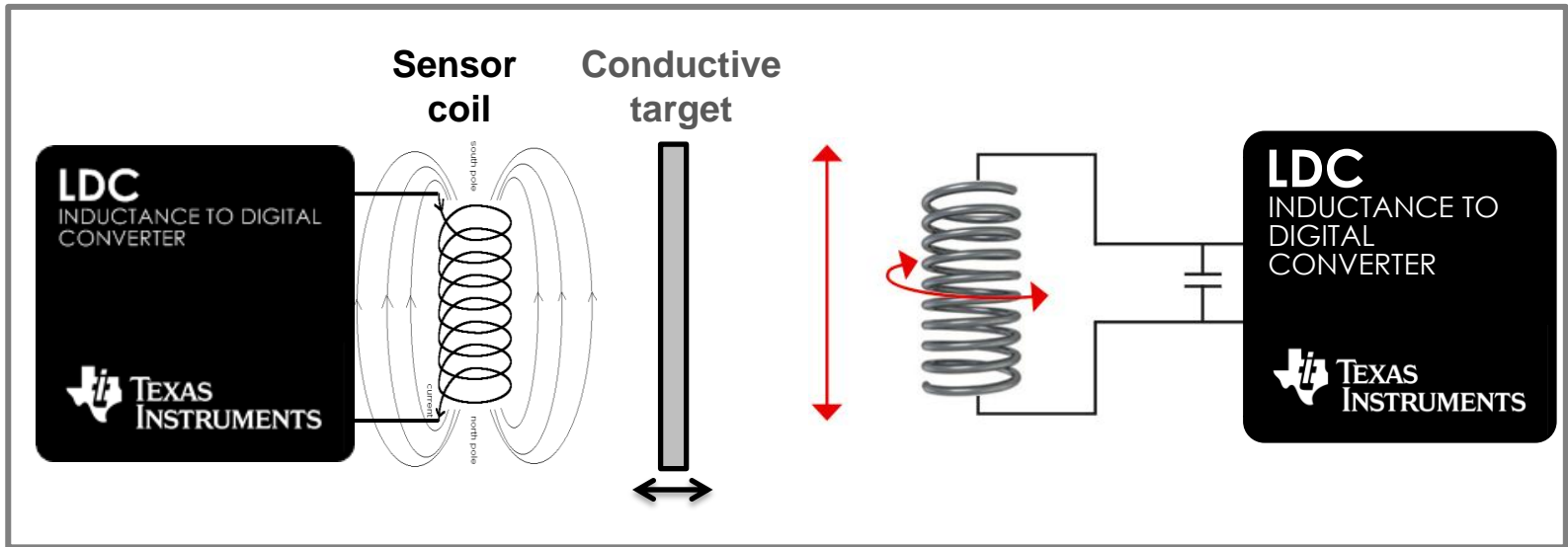


Inductance-to-Digital Converters (LDCs) for Inductive Sensing



LDC Enables Inductive Sensing

Inductive sensing



Benefits

Advantages of Inductive Sensing:

- ⦿ Does not require magnets
- ⦿ Reliable by virtue of being contactless
- ⦿ Insensitive to environmental contaminants (dust, dirt, etc.)
- ⦿ Sub-micron resolution
- ⦿ Sensor is low-cost
- ⦿ Electronics can be located remotely from the sensor

Target markets and applications

Industrial



Automotive



Consumer



Medical



Computing & Mobile Devices

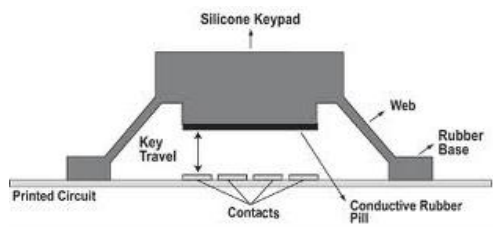


Communications



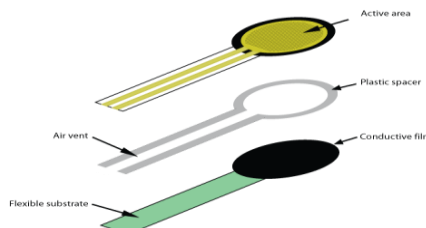
Existing sensing technologies

OHMIC (ON/OFF)



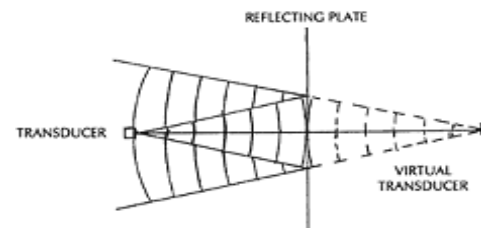
Unreliable in dirty environments

FSR (PRESSURE)



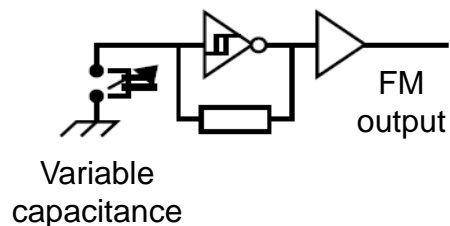
Limited resolution, not for distance sensing

ULTRASONIC



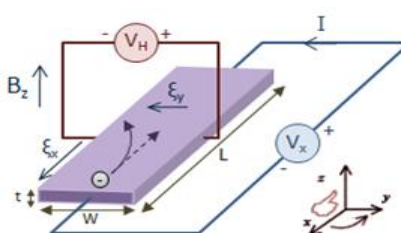
Not suited for short-range sensing

CAPACITIVE



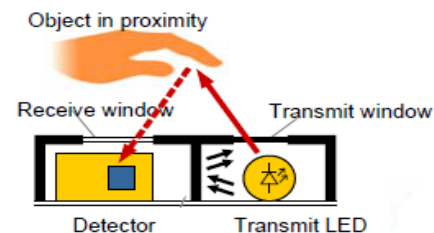
High sensitivity, poor selectivity

HALL



Requires magnets and calibration

OPTICAL

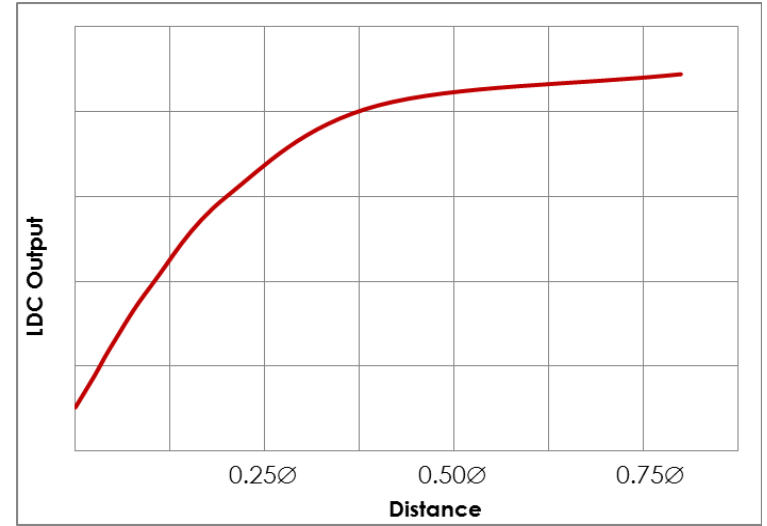
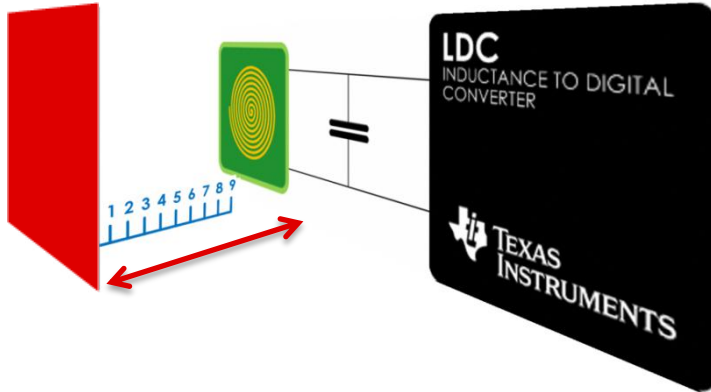


Unreliable in dirty environments

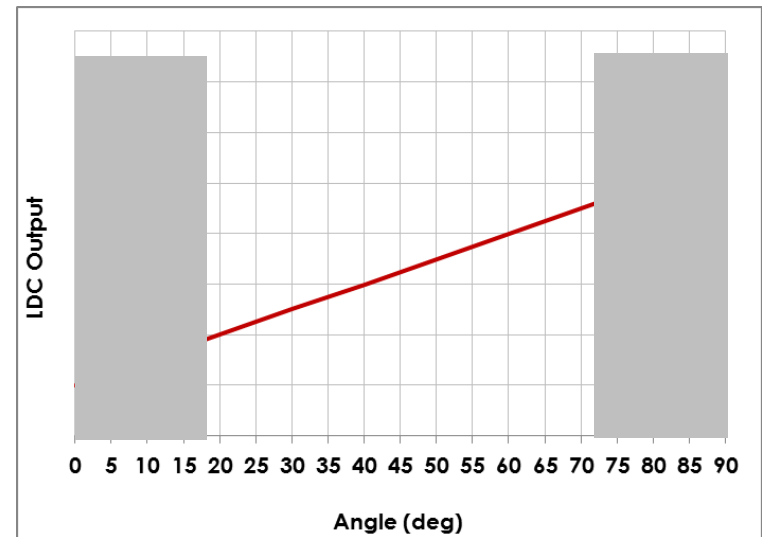
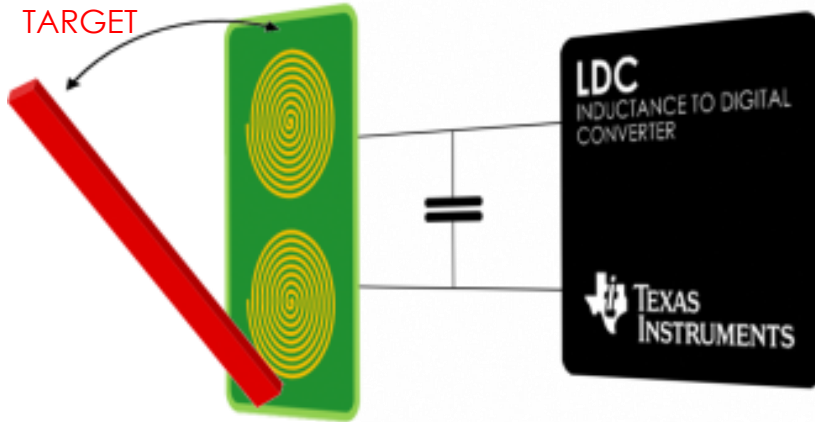
Basic Modes of Operation

Axial Sensing

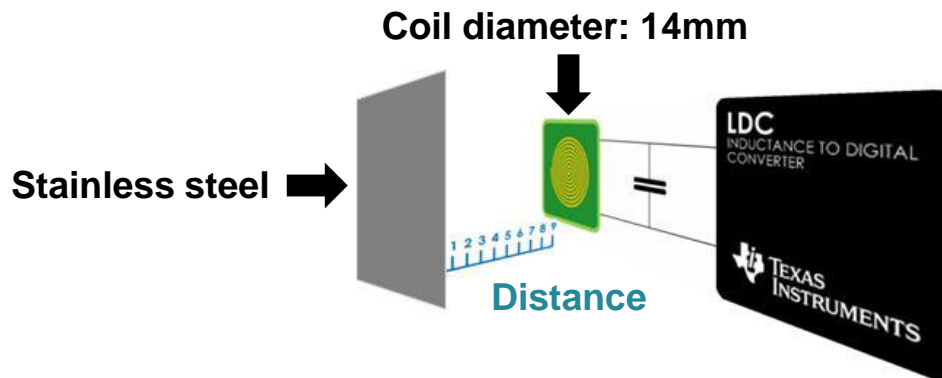
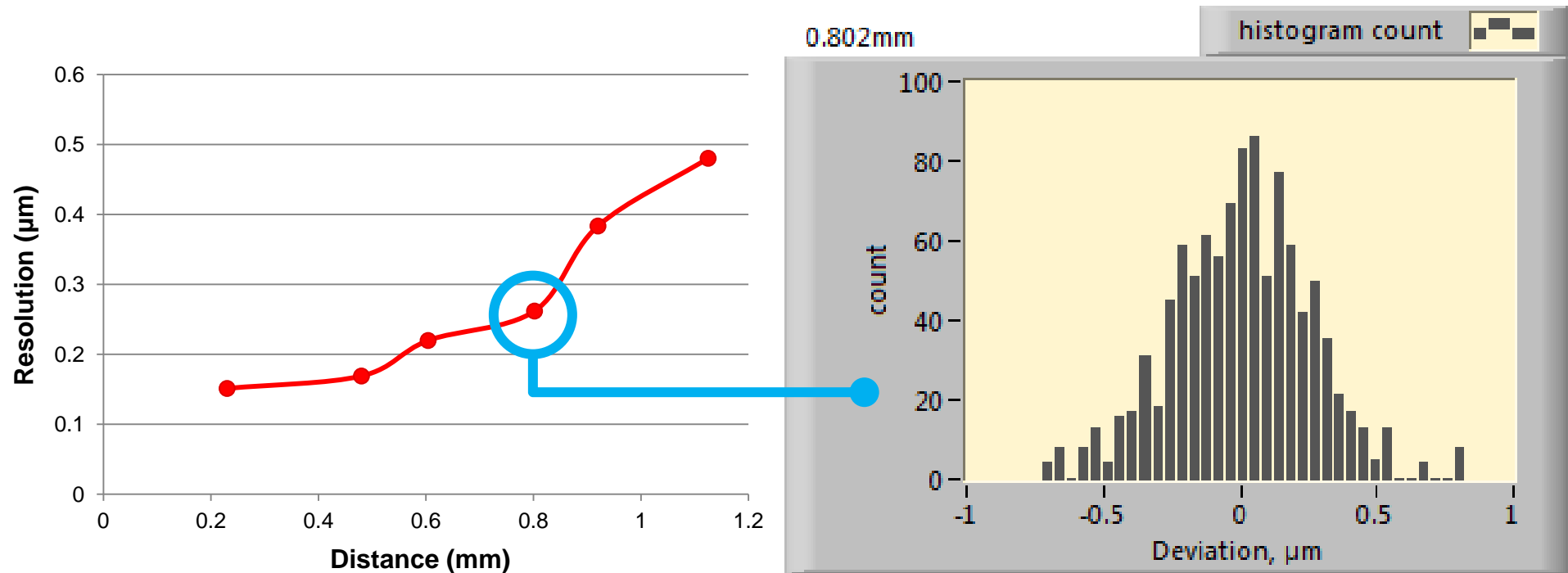
CONDUCTIVE TARGET



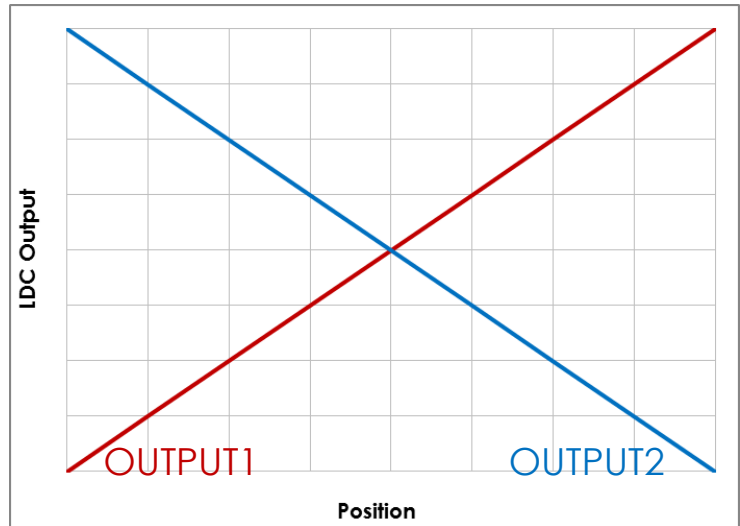
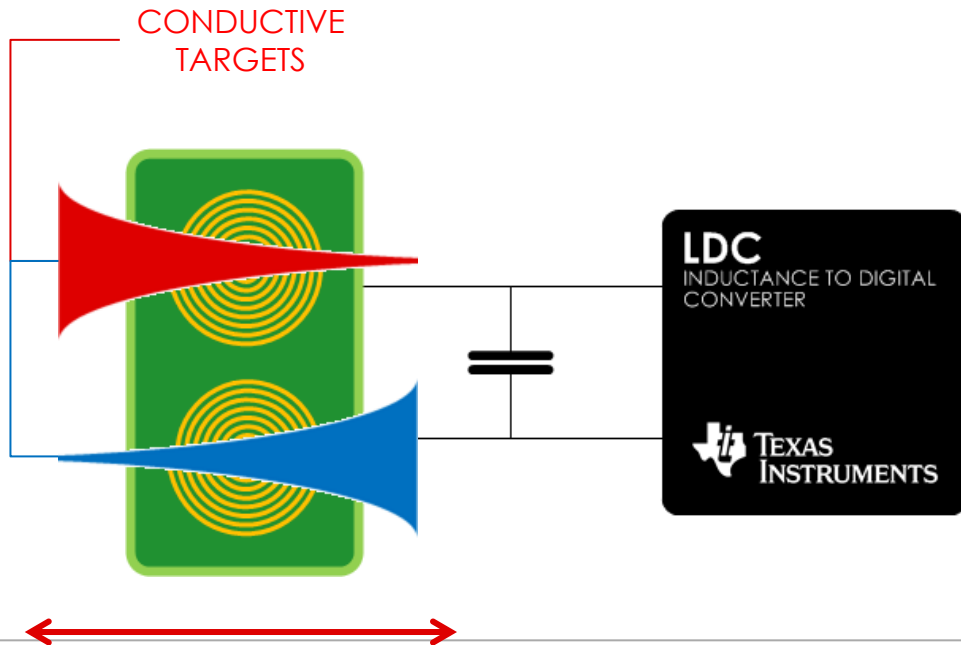
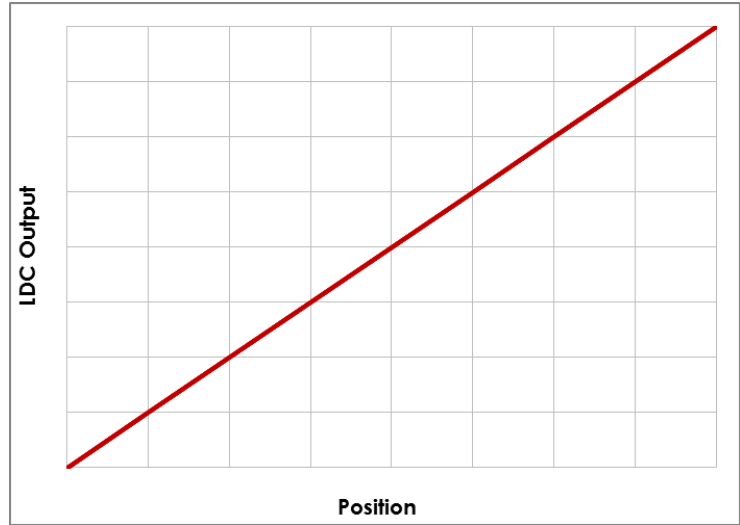
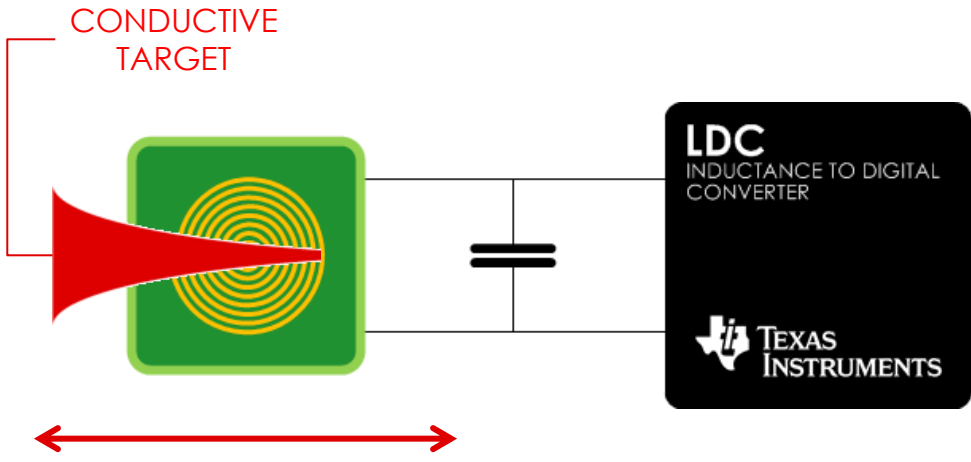
CONDUCTIVE TARGET



LDC1000 achieves sub-micron resolution

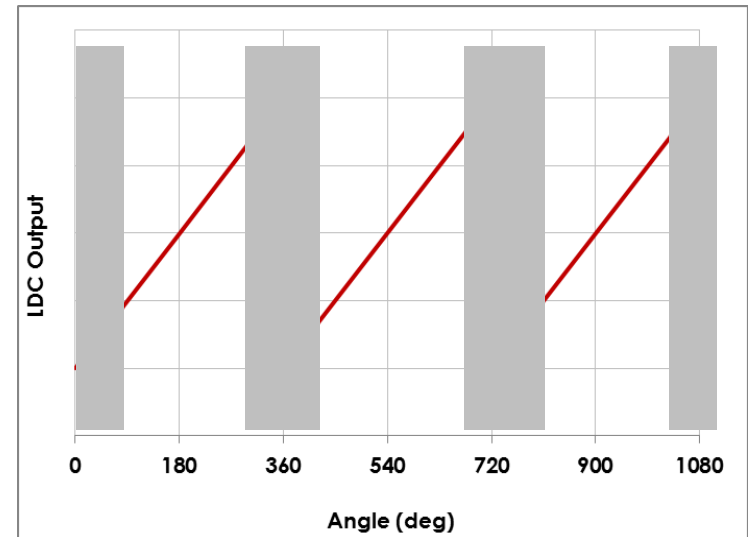
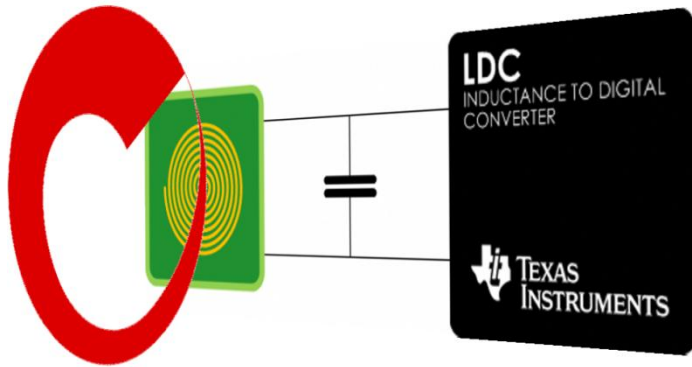


Lateral Sensing

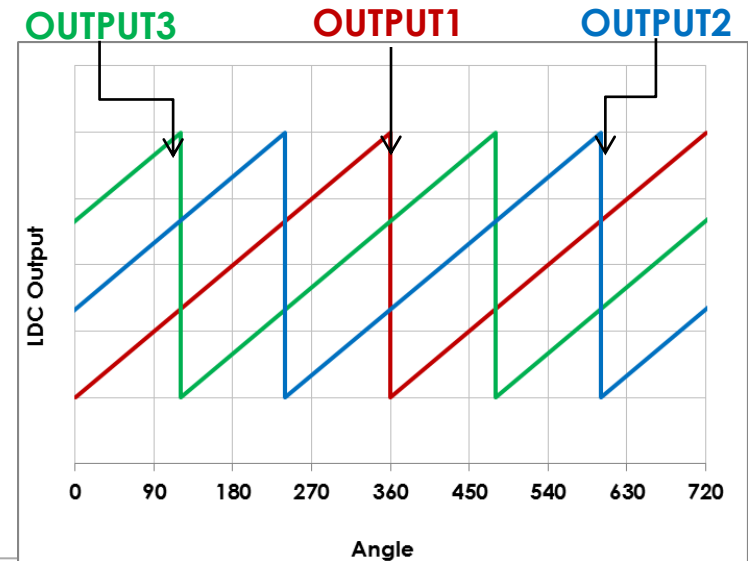
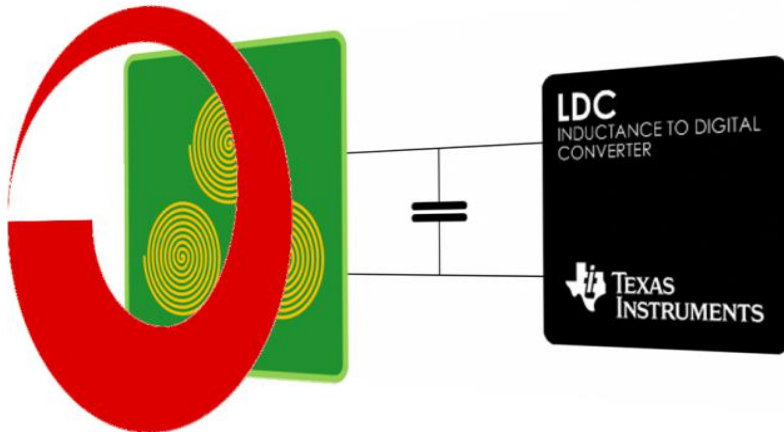


Rotational Sensing

CONDUCTIVE TARGET

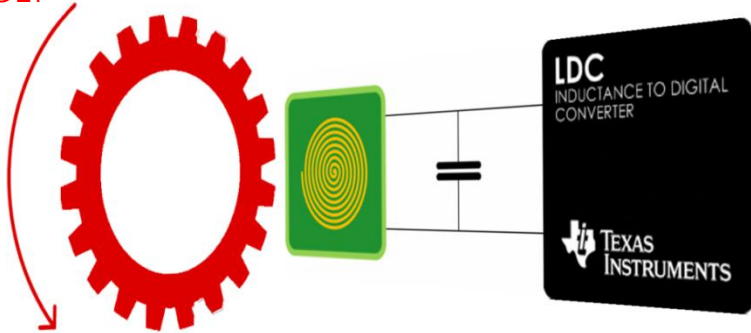


CONDUCTIVE TARGET

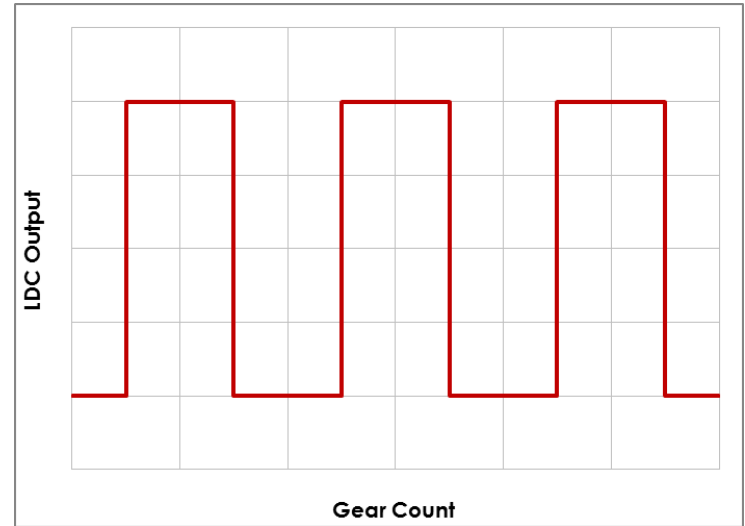


Event Counting

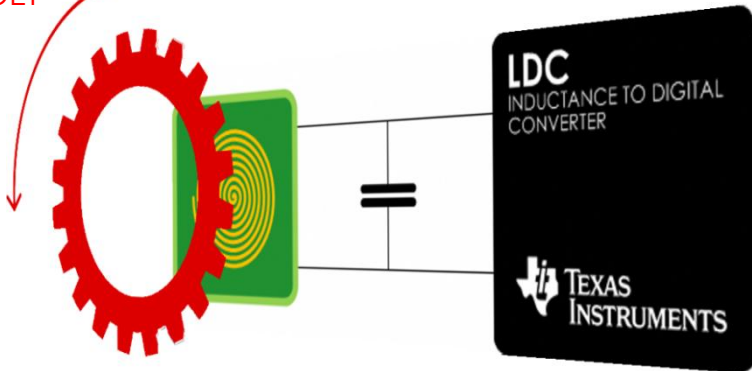
CONDUCTIVE TARGET



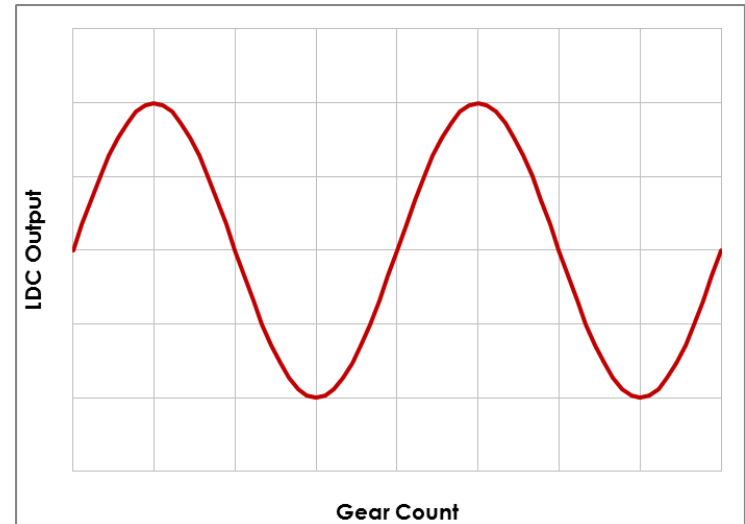
Axial: Target perpendicular to coil



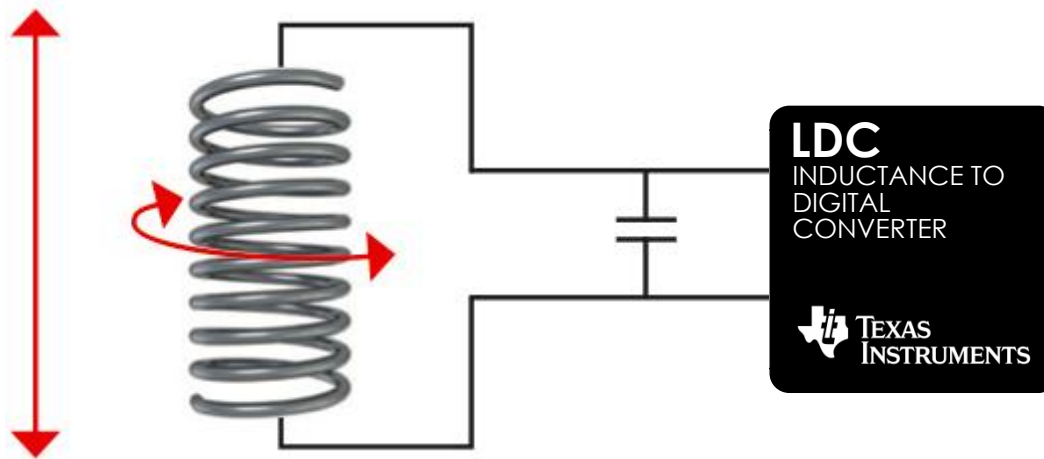
CONDUCTIVE TARGET



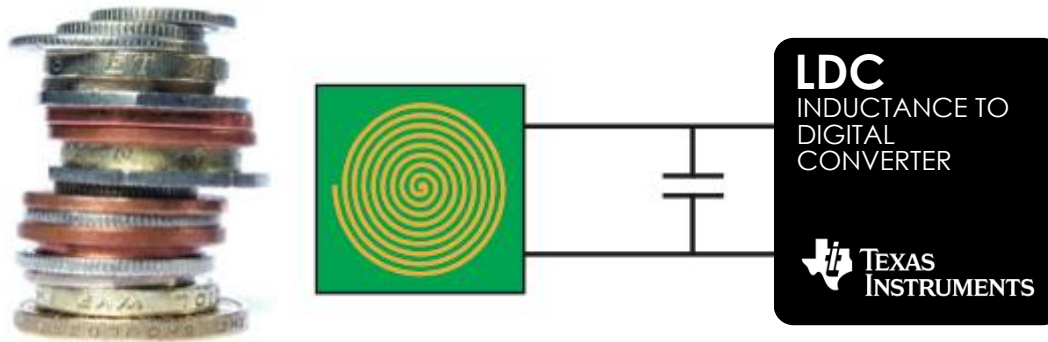
Lateral: Target parallel to coil



Spring and metal sensing



Compression, extension and twist using a spring as a sensor



Metal composition identification

LDC1000

5.0V LDC, High-Res, 1-Channel

Specs

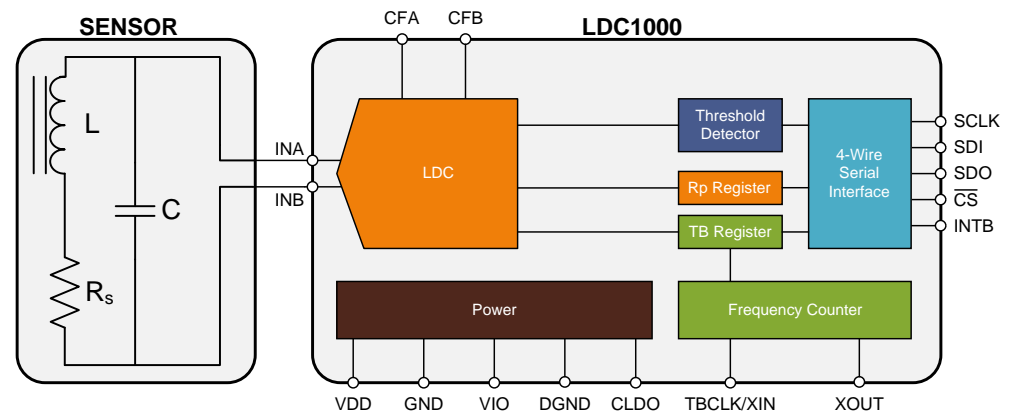
- Supply Voltage = 5.0V
- Current Consumption (Active) = 1.7mA
- Current Consumption (Sleep) = 250uA
- Channels = 1
- Oscillation Frequency = 5kHz-5MHz
- Resolution = 16-bit (Rp) / 24-bit (L)
- Output = 4-Wire SPI
- Temperature Range = -40C/+150C
- Package = SON16

Benefits

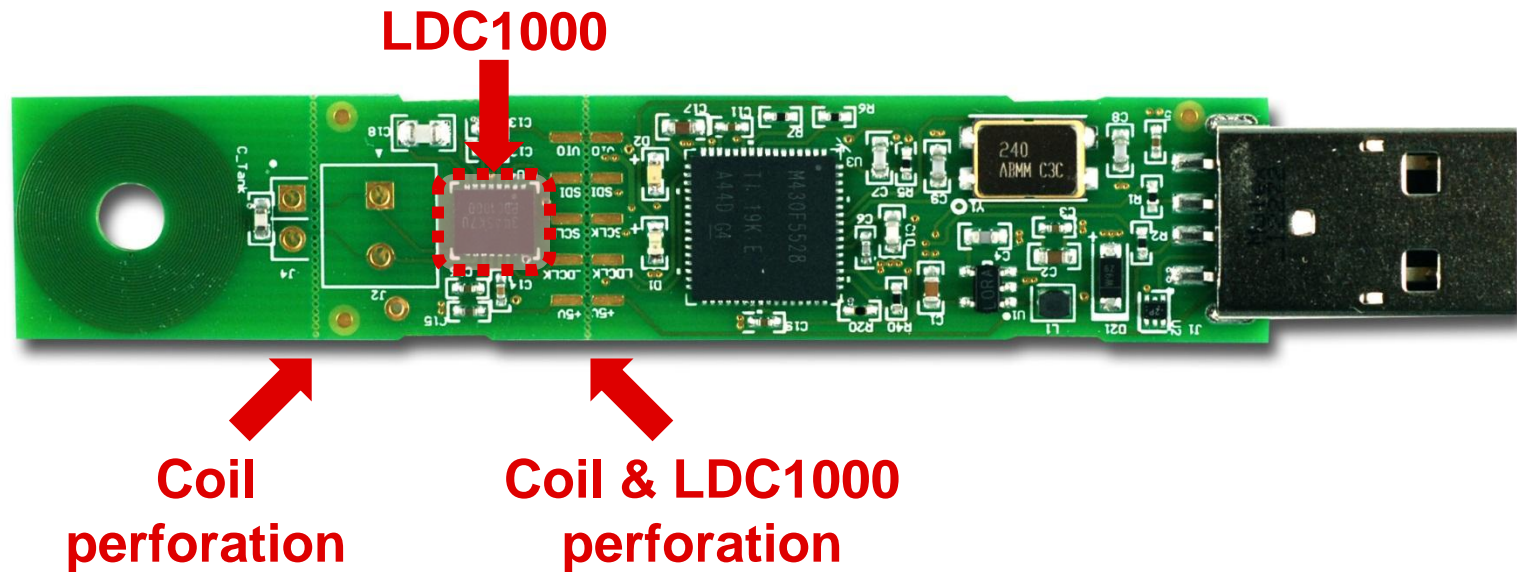
- Magnet-free operation
- Adjustable sensing range via coil design
- Lower system cost using PCB sense elements
- Remote sensor placement
- High durability/contactless technology
- Insensitivity to environmental interference (dirt, dust, water)
- High Resolution

Applications

- Paper Stack Height measurement
- High-Precision Position measurement
- High-Precision Angle measurement



Explore with LDC1000EVM



- EVM and GUI provide complete prototyping and evaluation platform
- USB interface allows control and evaluation of LDC1000 with GUI
- Includes 14-mm, 2-layer PCB coil sensor
 - Coil can be removed to allow prototyping with other coils, springs or inductors
- Coil and LDC1000 board section can be removed
 - Interface with other MCUs
 - Implement multi-channel prototyping

Inductive Sensing Demo Kit



Inductive Sensing Demo



WEBENCH[®]

Inductive Sensing Coil Designer

Webench[®] Inductive Sensing Designer

Key functionalities:

- Online tool to design sensor coils
- Provides analysis of the coil and related system characteristics
- Generates PCB layout of the selected coil
- Exports PCB layout to user's preferred CAD software

Webench[®] Tool – Requirements gathering

- User fills in basic requirements
 - Maximum distance to be measured.
 - Precision.
 - Metal target type (radius and material).
 - Size limitations, if any (example – max area/diameter of coil).

Requirements and Conceptual Diagram

Distance	<input type="text" value="1.5"/>	(cm)
Resolution	<input type="text" value="20"/>	(μm)
Target Diameter	<input type="text" value="10"/>	(cm)
Target material	<input type="text" value="Stainless(SS410)"/>	

Conductive Target

Sensor Coil

Click on this button to go to coil design solution page after entering required inputs

Webench[®] Tool – Coil Design Solution look

WEBENCH Designer for Inductive Sensing Applications : Axial position sensing (BETA)

My Designs/Projects

Assistant

Enter user requirements to see coil design solutions change

Filter solution list using sliders based on calculated outputs like Number of layers, C, Number of turns, Diameter, inductance, minimum distance etc

Coil Design solution list with specific inductance, number of turns, diameter, capacitance associated with inductor, series resistance, number of layers

Requirements and Conceptual Diagram

Distance: (cm)

Resolution: (μm)

Target Diameter: (cm)

Target material:

Inductive Sensing

Filter Results

Coil 1: 5, Layers 2: 4

Diameter (cm): 1 to 20, L (μH): 34 to 1383

Footprint (cm²): 1 to 20, Turns (#): 28 to 125

Resolution (μm): 1 to 19, Rp (kΩ): 57 to 409

Cap (pF): 18 to 148

Advanced Charting

X Axis: Resolution (μm) | Y Axis: Footprint (mm²) | Bubble Size: Number of Layers

Resolution (μm) vs. Footprint (mm²) vs. Number of Layer

Click and drag to zoom

Solutions

Solutions: (20 found)

Part	Create	Coil Footprint (cm ²)	Coil Turns (#)	Coil Diameter (cm)	Layers (#)	Resolution (μm)	Free Field Inductance (μH)	Rp @ Distance (kΩ)	External Capacitance (pF)	Free Field Frequency (Hz)
PCB inductor coil 1	<input type="button" value="Open Design"/>	12.06	98	3.92	2	1.53	486.36	95.46455	52.08	1000000
PCB inductor coil 2	<input type="button" value="Open Design"/>	13.85	112	4.48	2	1.26	722.95	137.78734	42.11	1000000
PCB inductor coil 3	<input type="button" value="Open Design"/>	15.76	112	4.48	2	1.26	722.95	137.78734	35.03	1000000

Webench tool – Design Summary

PCB Coil Designer Tool for Inductive Sensing Applications : Axial position sensing

My Designs/Projects

Click on individual windows for detailed view

Charts

Distance I... 1.5 (cm)

Plot

Rp vs Distance

Plots:

- Rp vs distance
- Resolution vs. distance
- Inductance vs. distance

Schematic

Coil Image

Operating Values

Name	Value
capacitance (pF)	52.1
Inductance (uH)	486
Number of turns	98
Number of layers	2
Coil diameter (cm)	3.92
Coil trace width (mil)	4
Coil trace spacing (mil)	4
Coil trace thickness (mil)	1.5
Coil trace conductivity (MS/m)	58
Target radius(cm)	5
Target conductivity(MS/m)	1.5

Bill of Materials

Part	Manufacturer	Part Number	Quan	Price	Att
Clank	Yageo America	CC0805JRNPO9BN1	1	\$0.01	Ca 0.0
Ltank		PCB coil	1	NA	
IC	Texas Instruments	LDC1000	1	NA	

Your Complete Design

Product Folder

WEBENCH Downloads:

CAD File Export

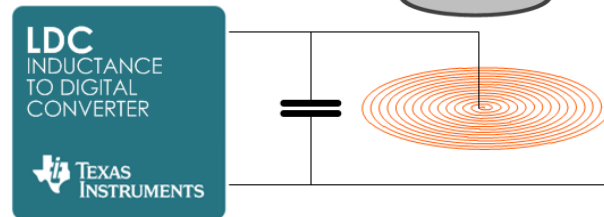
Export design report and PCB layout

Applications

Buttons



Buttons on game controllers can be made more reliable with contactless implementation. When a button crosses set threshold, it is detected by the coil

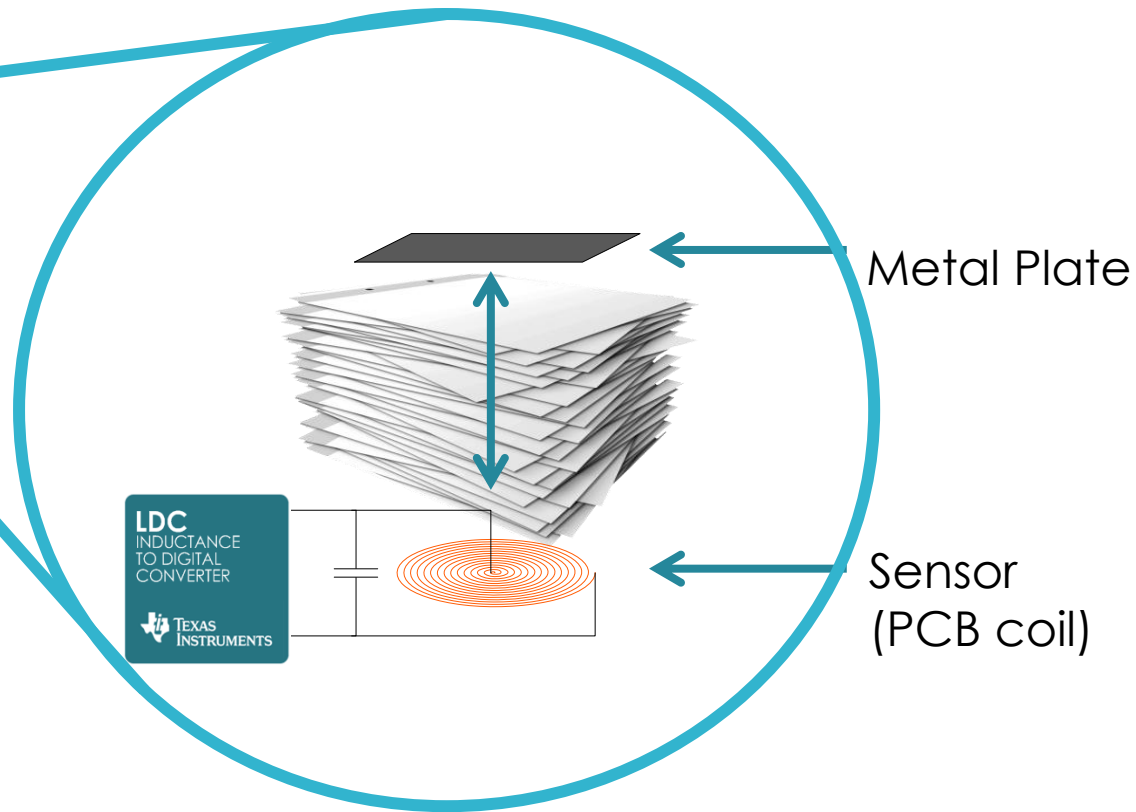


Paper Stack Height

Paper stack height measurement can be done by placing a coil under the stack, and a metal target on top.

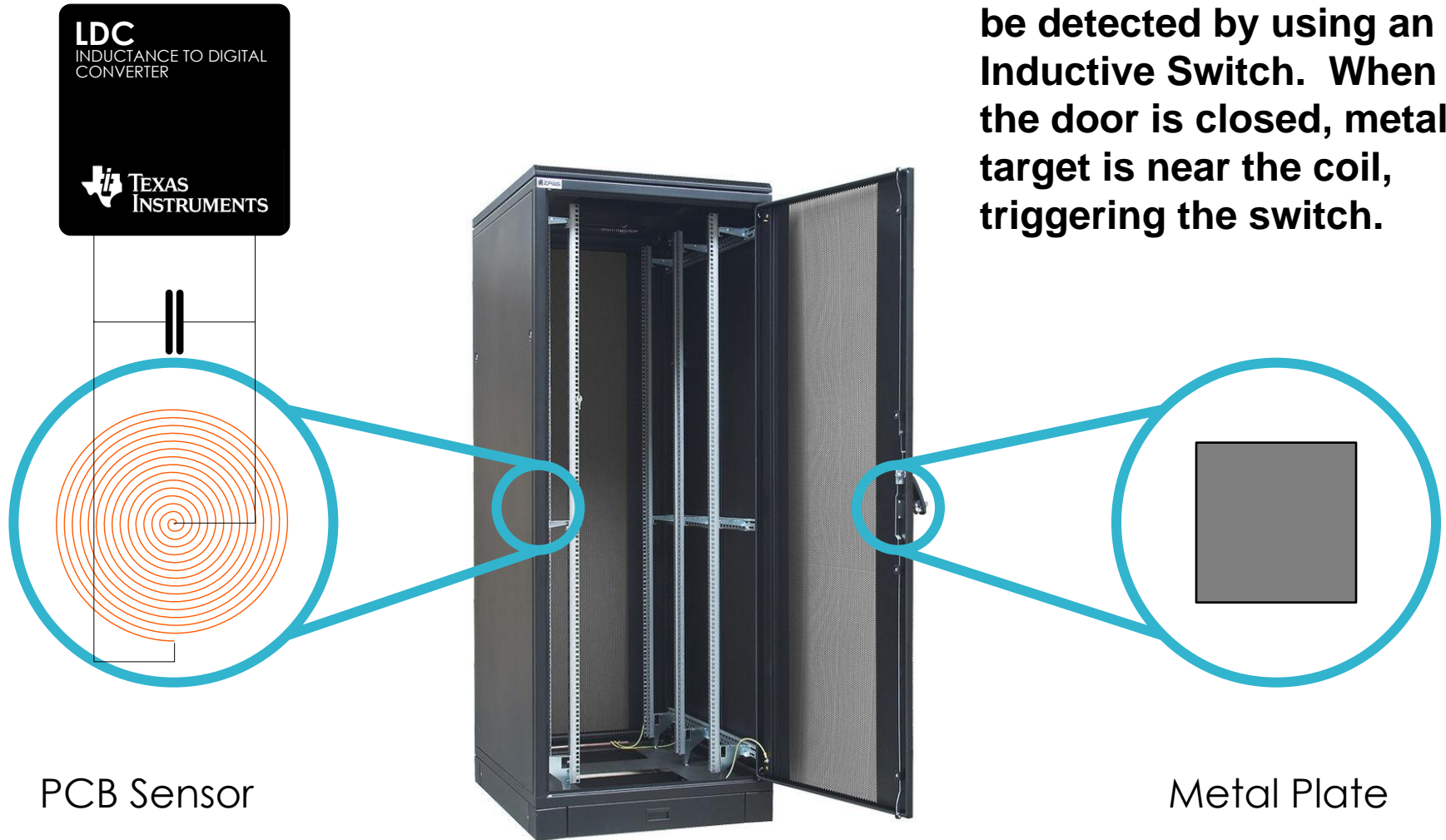


Number of sheets can be calculated by dividing the measured distance by sheet thickness.



Door Open/Closed

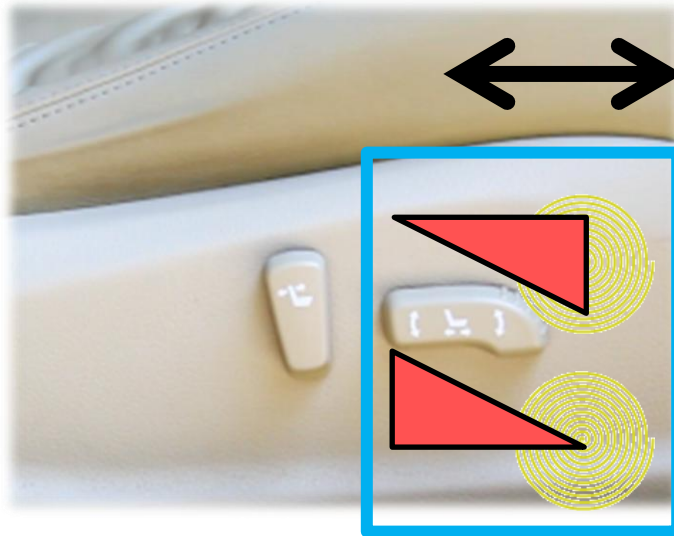
Open/Closed doors can be detected by using an Inductive Switch. When the door is closed, metal target is near the coil, triggering the switch.



PCB Sensor

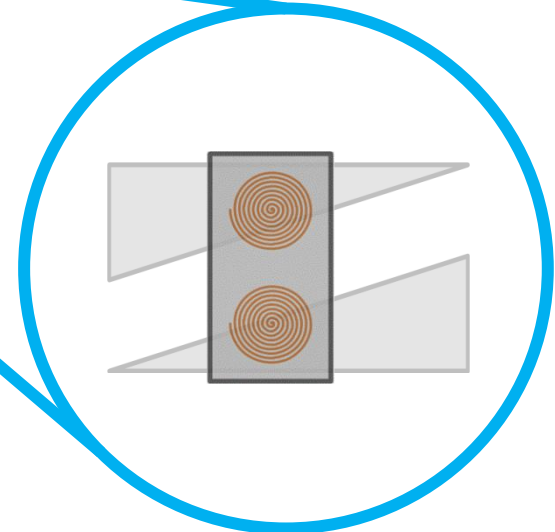
Metal Plate

Car Seat Travel

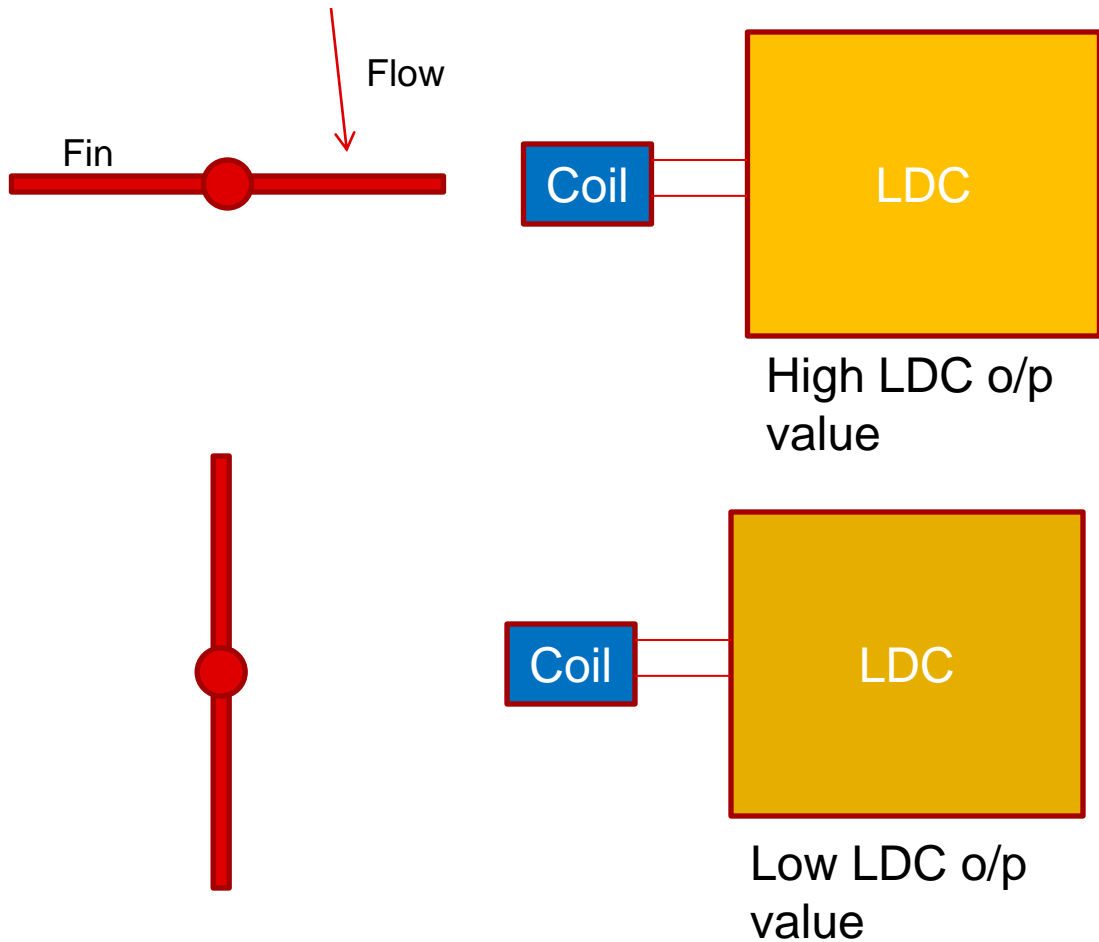


Car seat travel can be detected with high resolution using the LDC and a 2-coil sense system. An 8-coil system can be implemented to also compensate for up/down and side-to-side movement.

As the car seat travels, the coverage of metal (red) above the coil (yellow) changes. These changes are tracked by the LDC.



Turbine Flow Meter

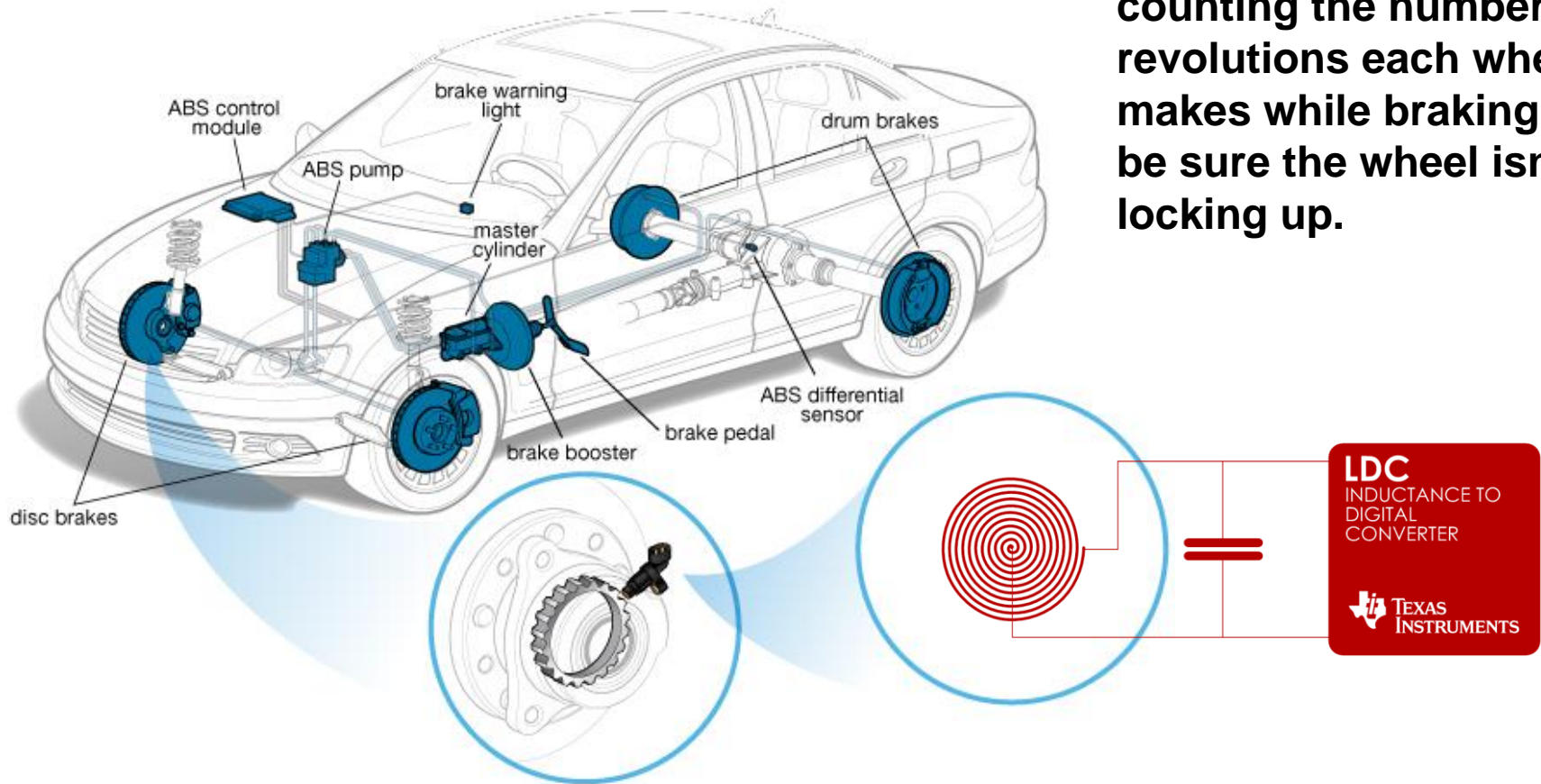


Metal Fin of the flow meter inside the sensing range.

Metal Fin of the flow meter outside the sensing range.

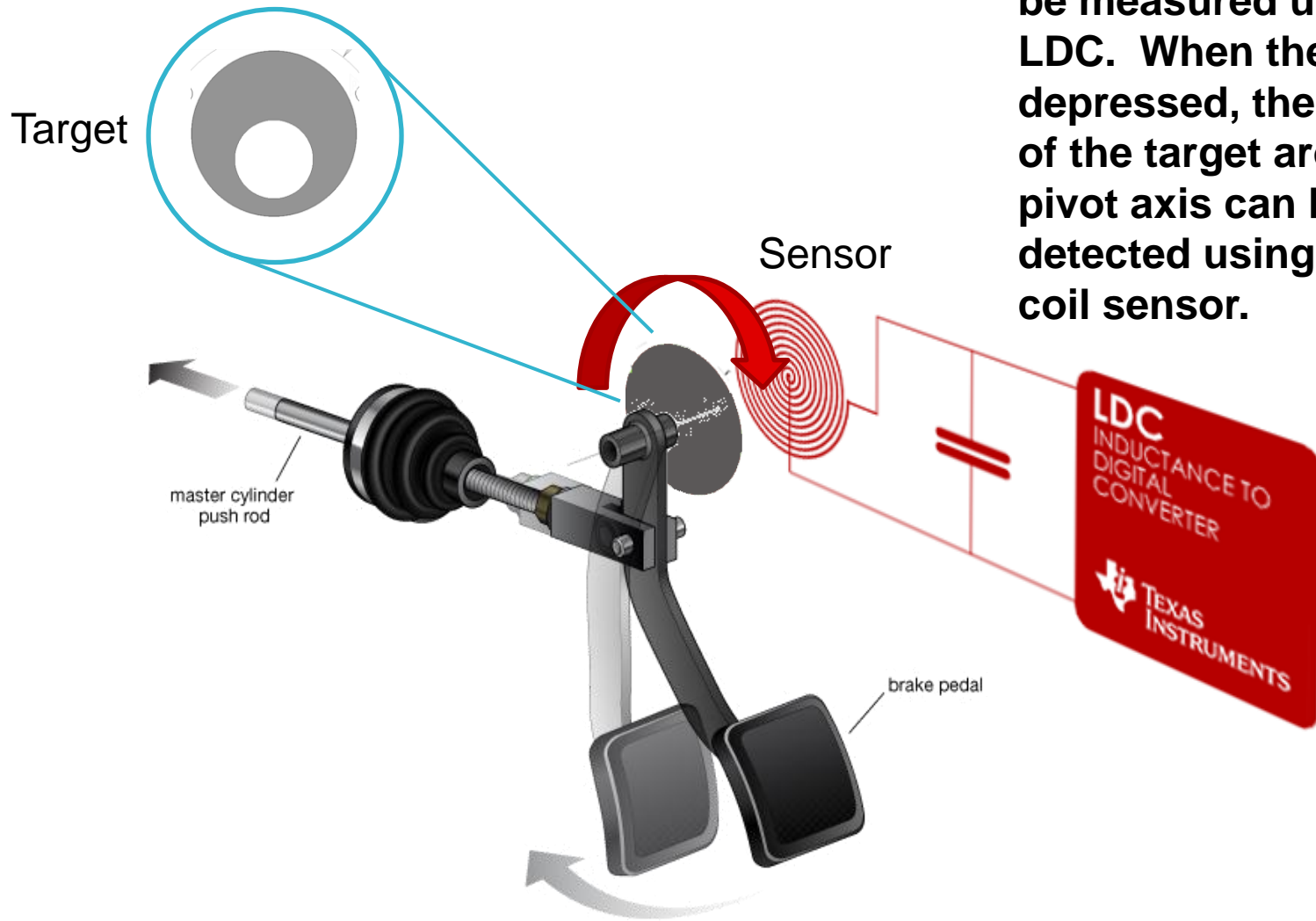
ABS Wheel Speed Sensor

LDC with an LC tank can be used as an ABS wheel speed sensor. Such sensor measures the speed of each wheel by counting the number of revolutions each wheel makes while braking to be sure the wheel isn't locking up.



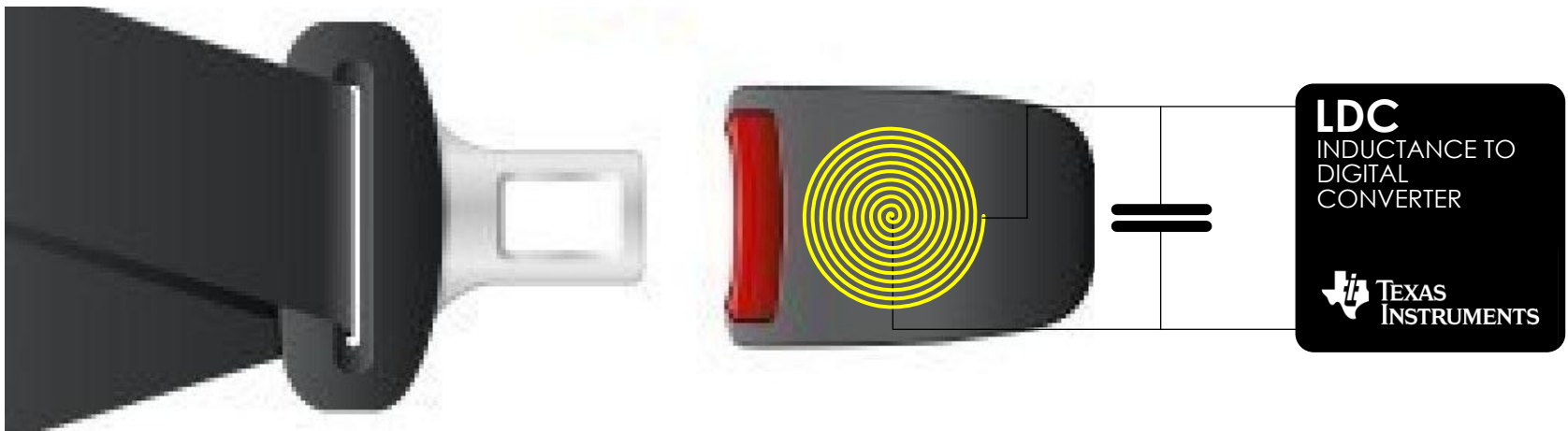
Brake Pedal Position Sensor

Brake pedal travel can be measured using the LDC. When the pedal is depressed, the rotation of the target around the pivot axis can be detected using a PCB coil sensor.



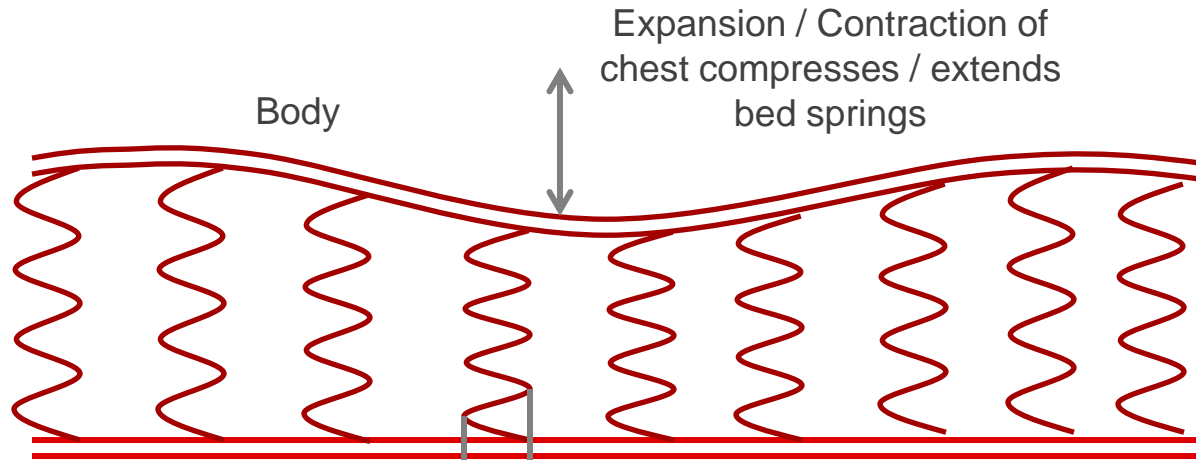
Seatbelt Buckle Detection

PCB coil inside the buckle can be used as a sensor (LC tank). The insertion of the seatbelt buckle generates losses in the LC tank which can be detected by the LDC.



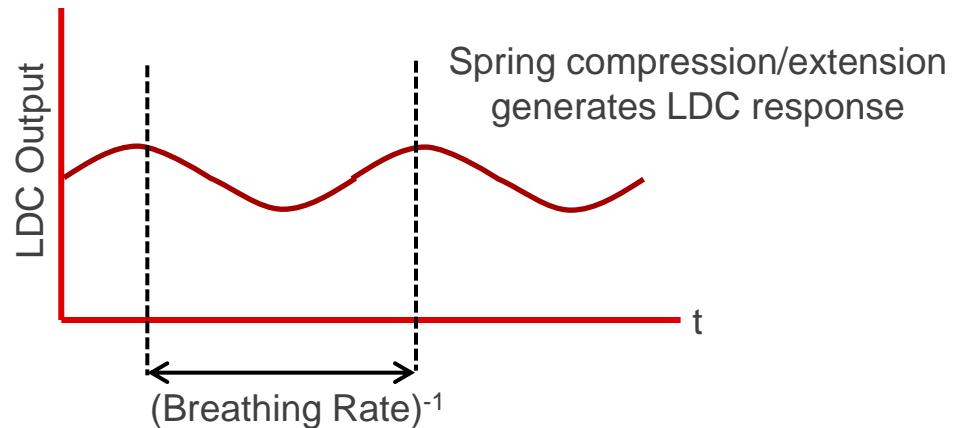
Spring Motion Monitoring

Non-Contact Breathing Monitor



Example use cases:

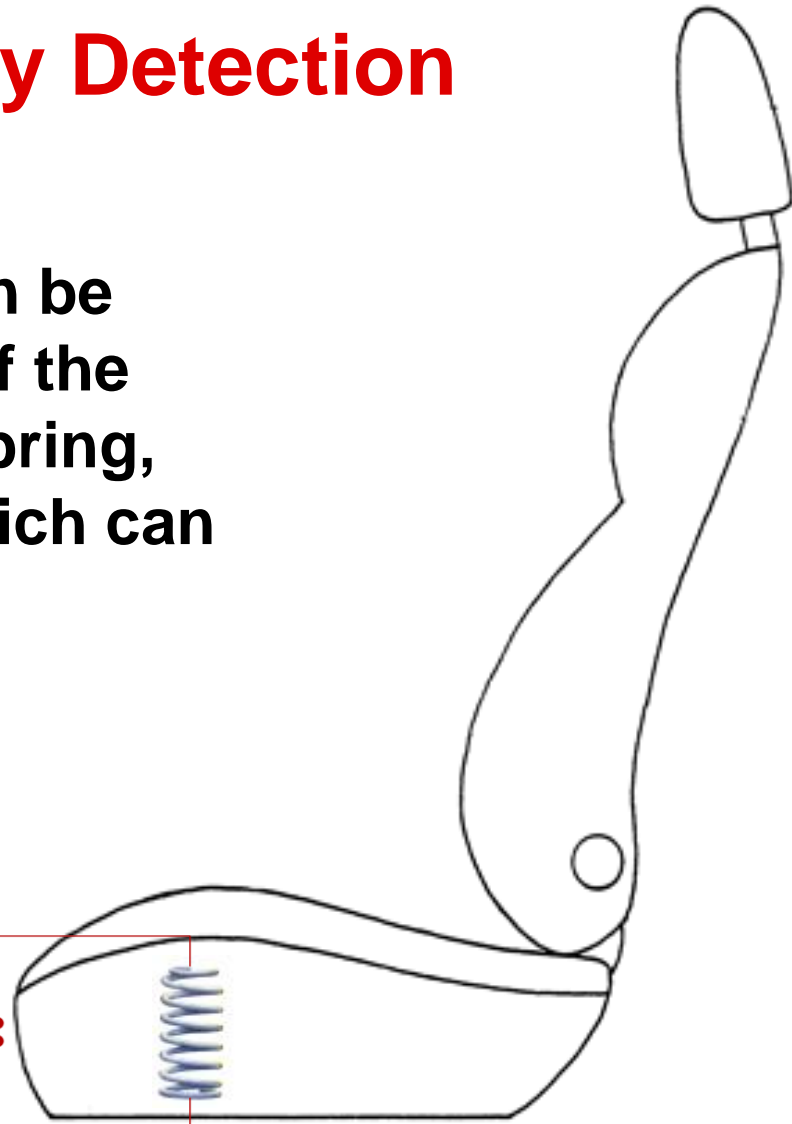
- Baby crib monitoring
- Infant bed monitoring
- Elderly care
- Hospital care
- Patient transport monitoring



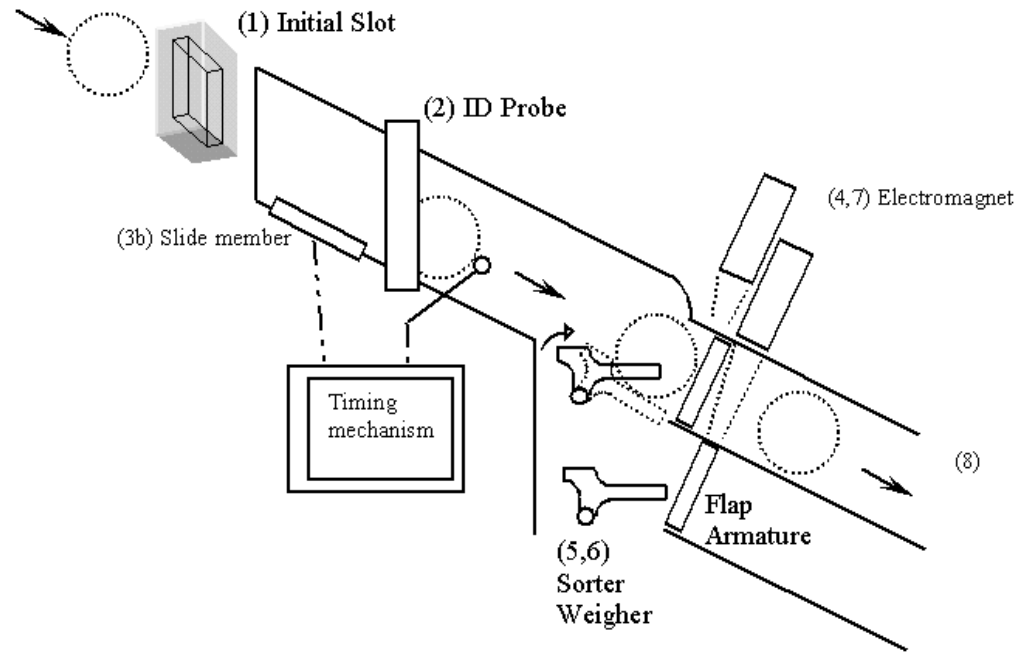
Periodicity of LDC response is reciprocal of breathing rate

Passenger Occupancy Detection

Coil spring inside a seat can be used as a sensor. Weight of the person will compress the spring, changing its inductance which can be measured with the LDC.



Metal Identification



can detect metal composition/type by eddy current loss signatures