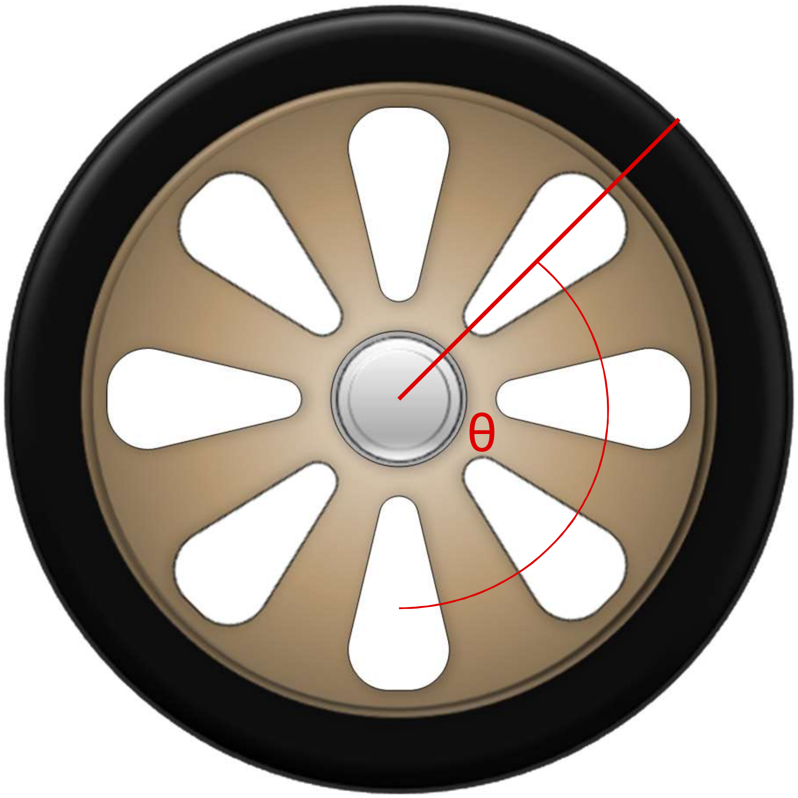
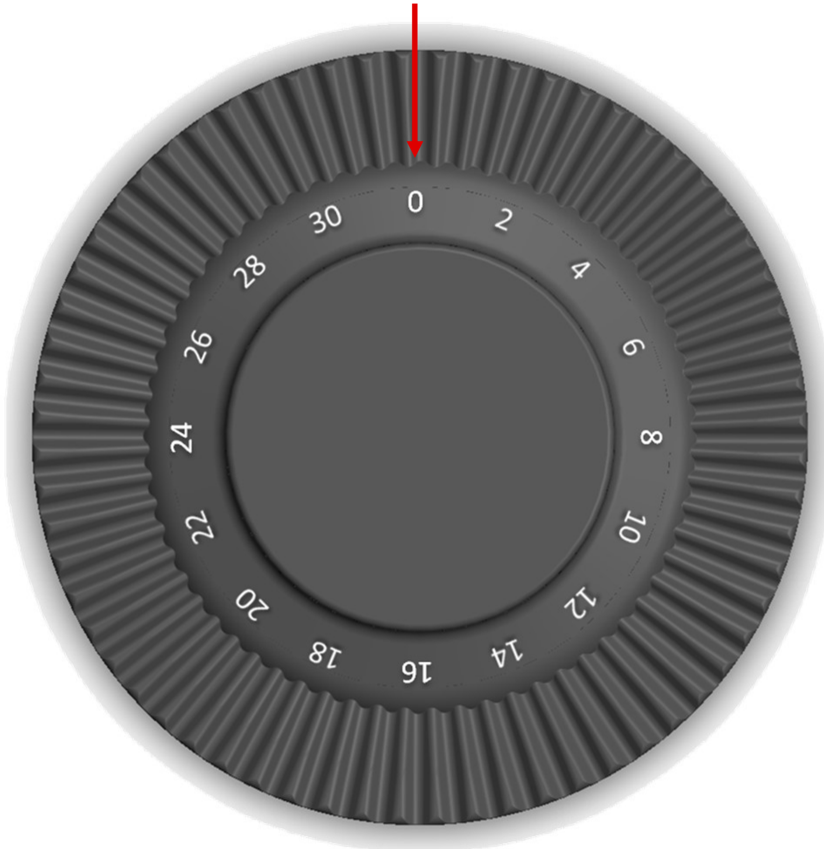
Inductive Sensors: Angle Detection and Rotary Encoding

TI Precision Labs – Inductive Sensing

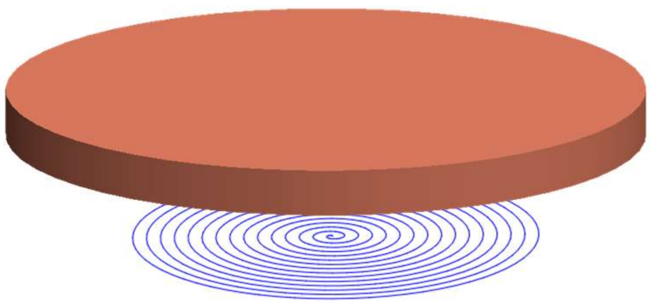
Presented and prepared by Scott Bryson

Rotary Encoding

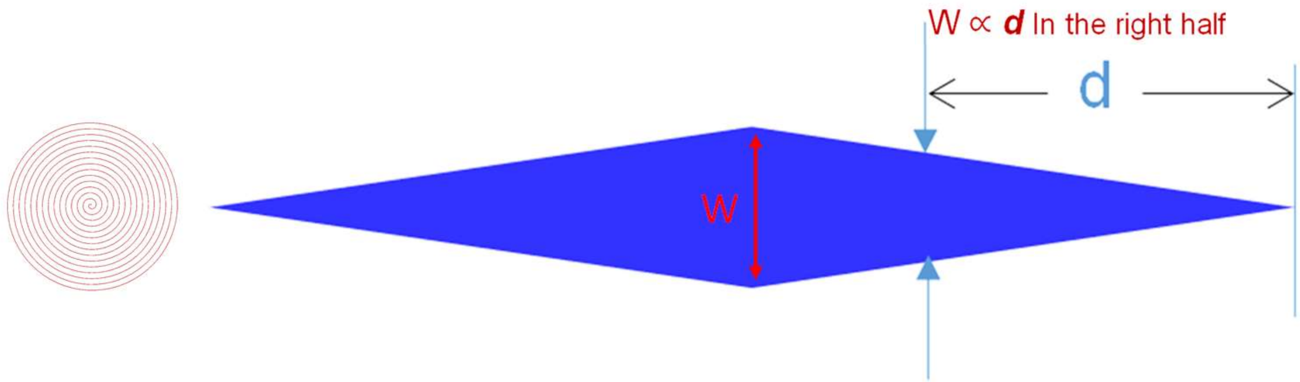


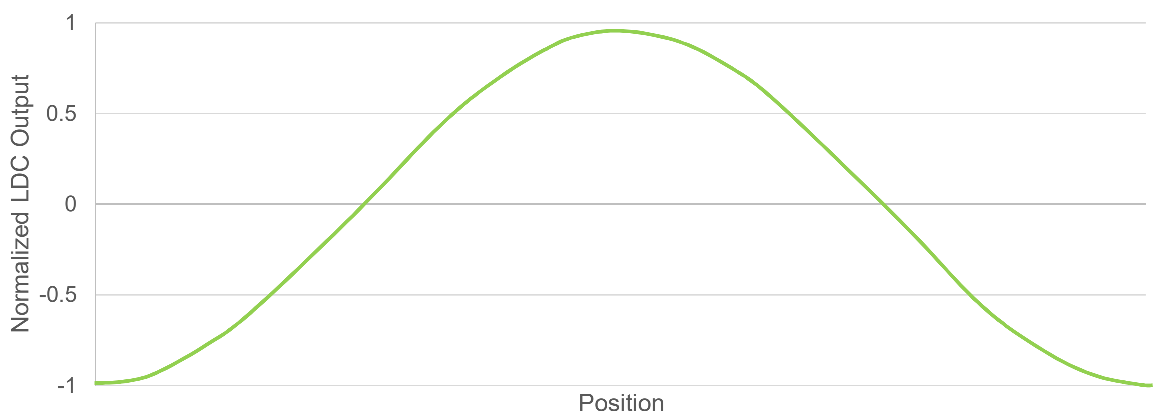


Inductive Sensor Review



Absolute Angle with an Inductive Sensor





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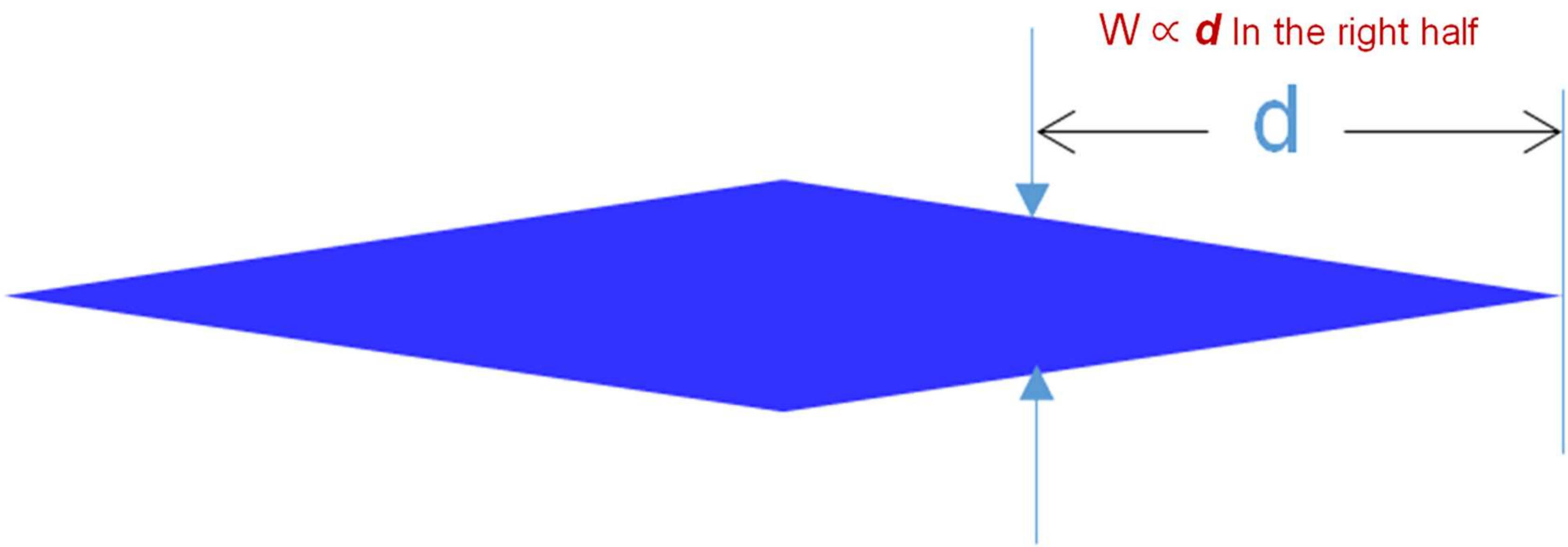

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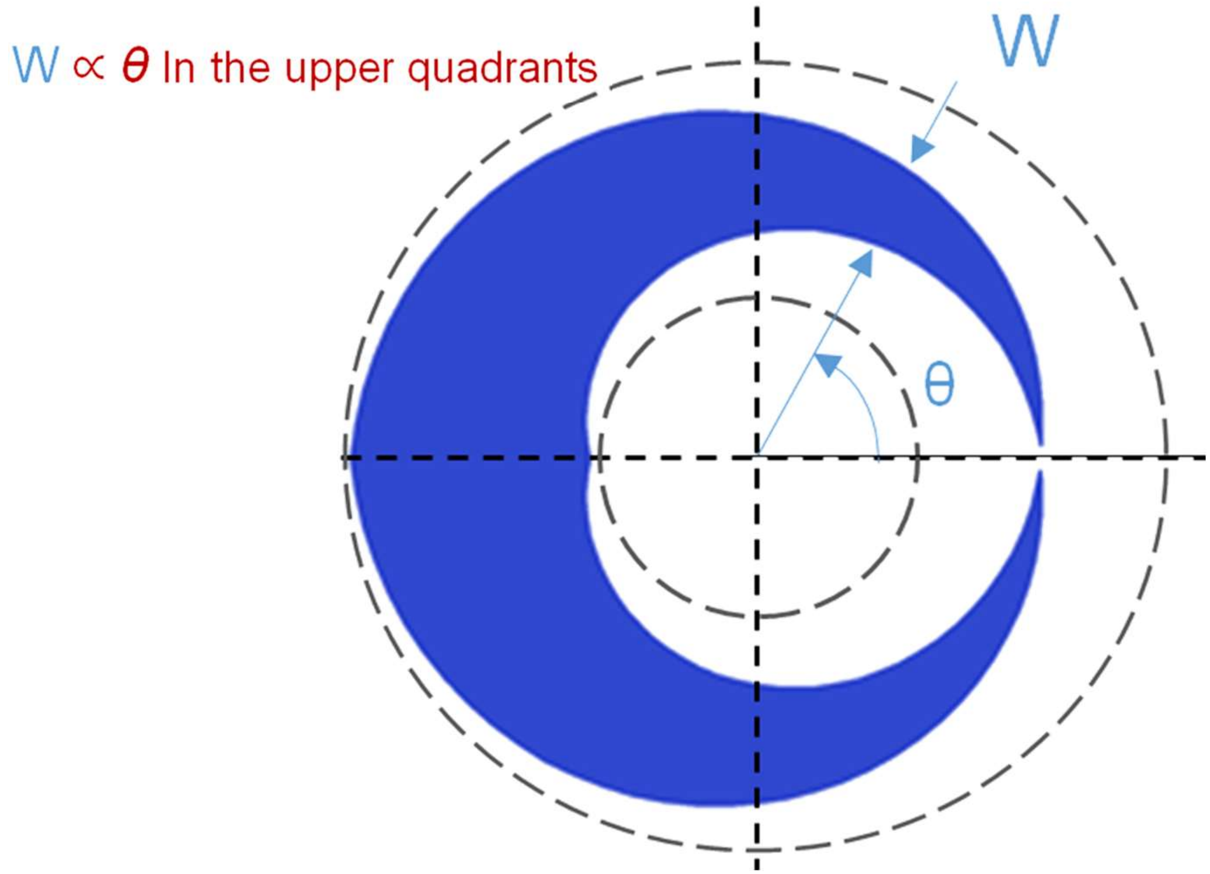

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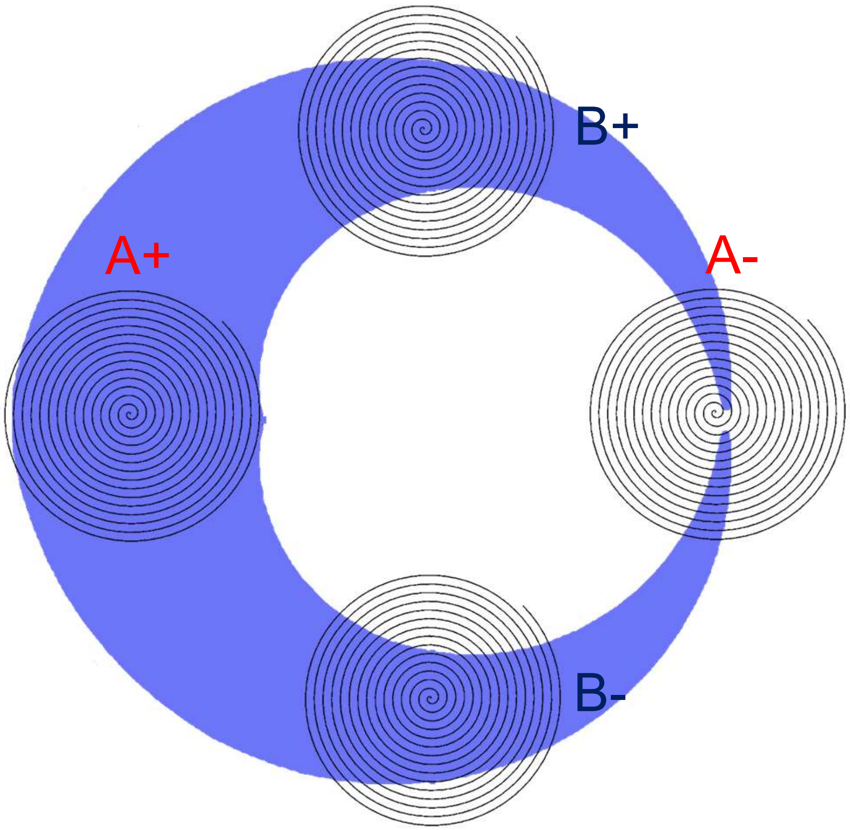

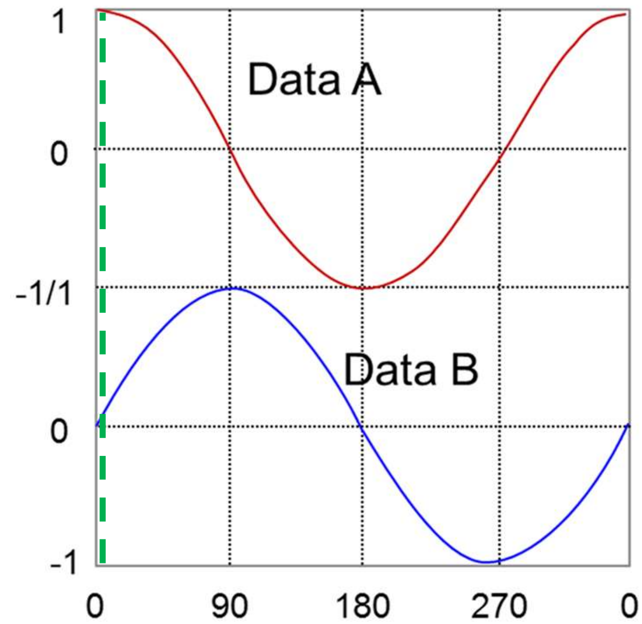

θ = arctan (DataB/DataA)

Absolute Angle with an Inductive Sensor

TI Designs

1° Dial Using the LDC1314 Inductance-to-Digital Converter

TEXAS INSTRUMENTS

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TI Designs

TI Designs provide the foundation that you need including methodology, testing and design files to quickly evaluate and customize the system. TI Designs help you accelerate your time to market.

Design Resources

TIDA-00508	Tool Folder Containing Design Files
LDC1314	Product Folder
MSP430F5528	Product Folder
LP2985-N	Product Folder
TPD4E004	Product Folder

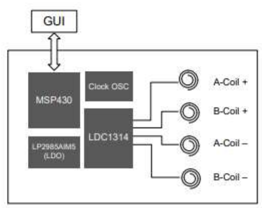
TI E2E™ Community — ASK Our E2E Experts; WEBENCH® Calculator Tools

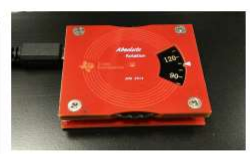
Design Features

- Simple, Low-Cost Solution for Rotational or Lateral Position Sensing
- Robust Against Dirt, Dust, Moisture, and Oil
- Angular Position Sensing with 1° Absolute Accuracy and 0.1° Resolution
- Lateral Position Sensing With 0.3% Absolute Accuracy and 0.03% Resolution
- Differential Design Minimizes Z-Axis Sensitivity
- Algorithm Uses Minimal MCU Resources
- Features Three Calibration Methods
- Completely FR4 PCB-Based Design

Featured Applications

- Control Dials and Knobs
  - Home Appliances
  - Audio Equipment
  - Automotive Infotainment Systems
- Absolute and Incremental Encoders
- Industrial HMI



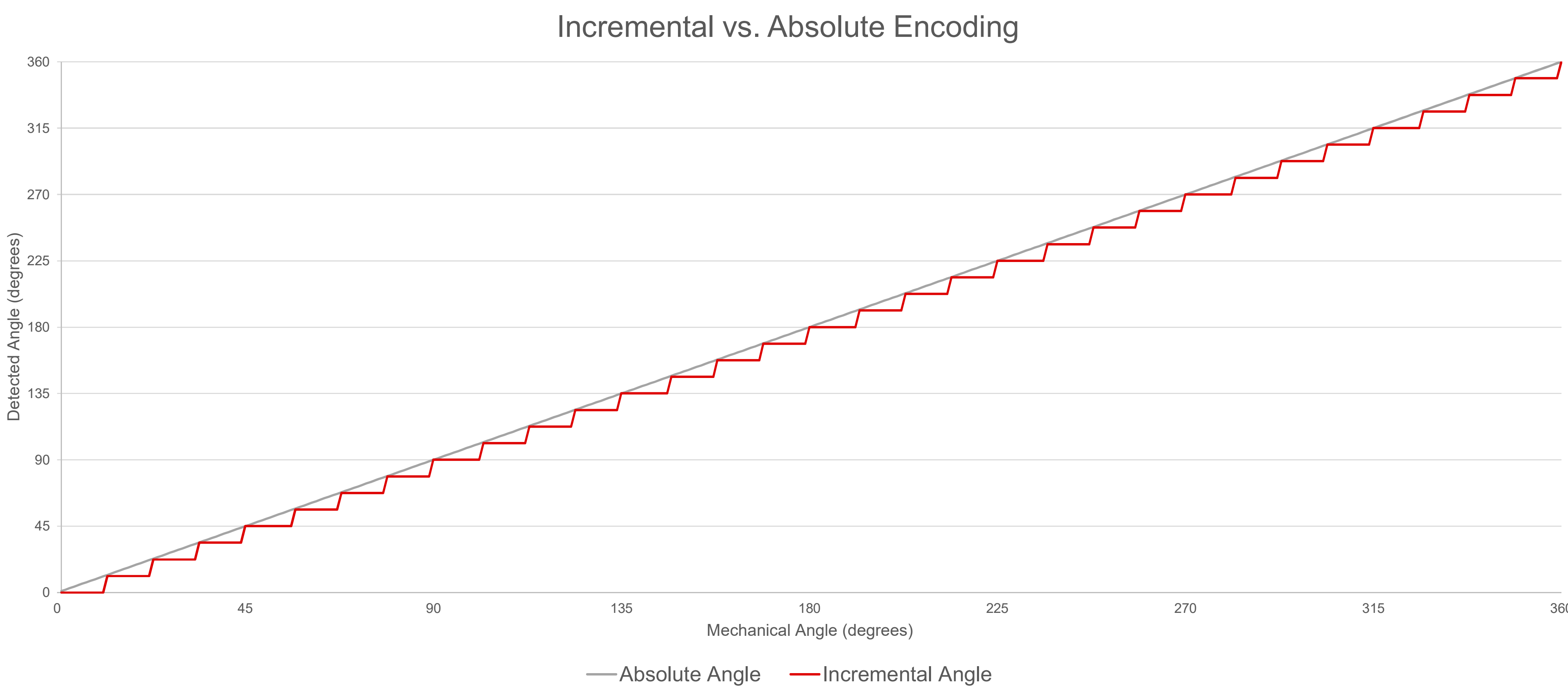


An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.

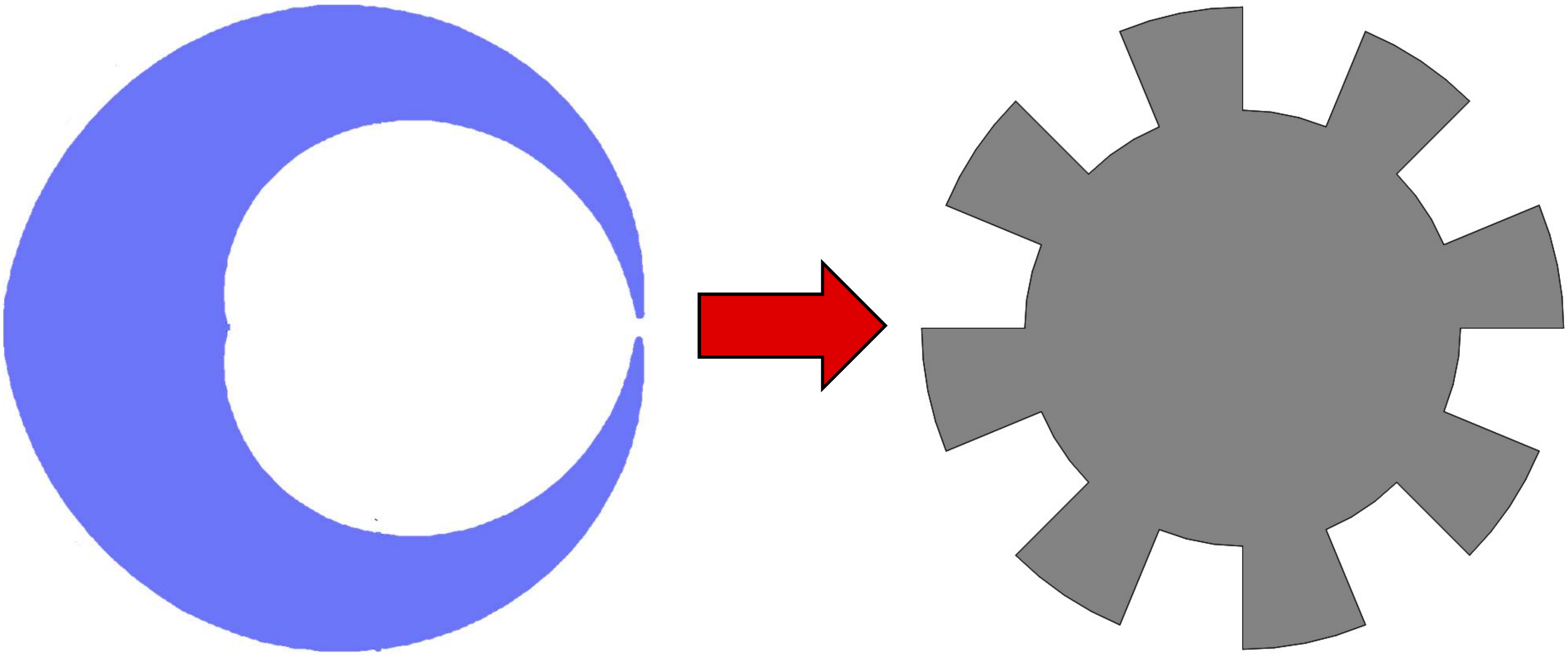
TIDU953–July 2015 — 1° Dial Using the LDC1314 Inductance-to-Digital Converter — 1

Submit Documentation Feedback

Incremental Angle with an Inductive Sensor



Incremental Angle with an Inductive Sensor



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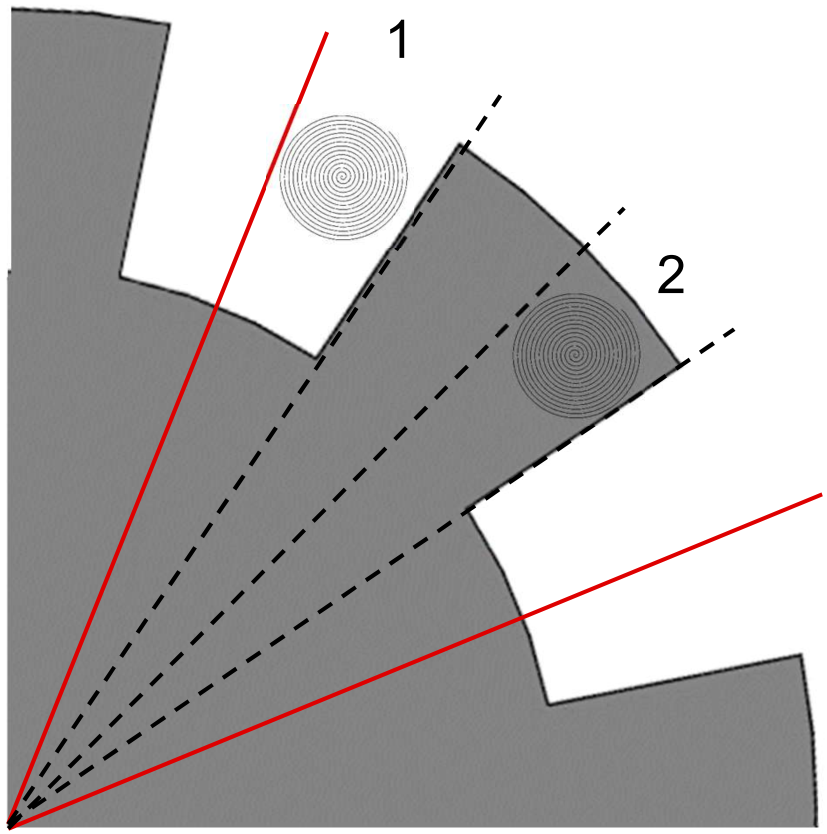
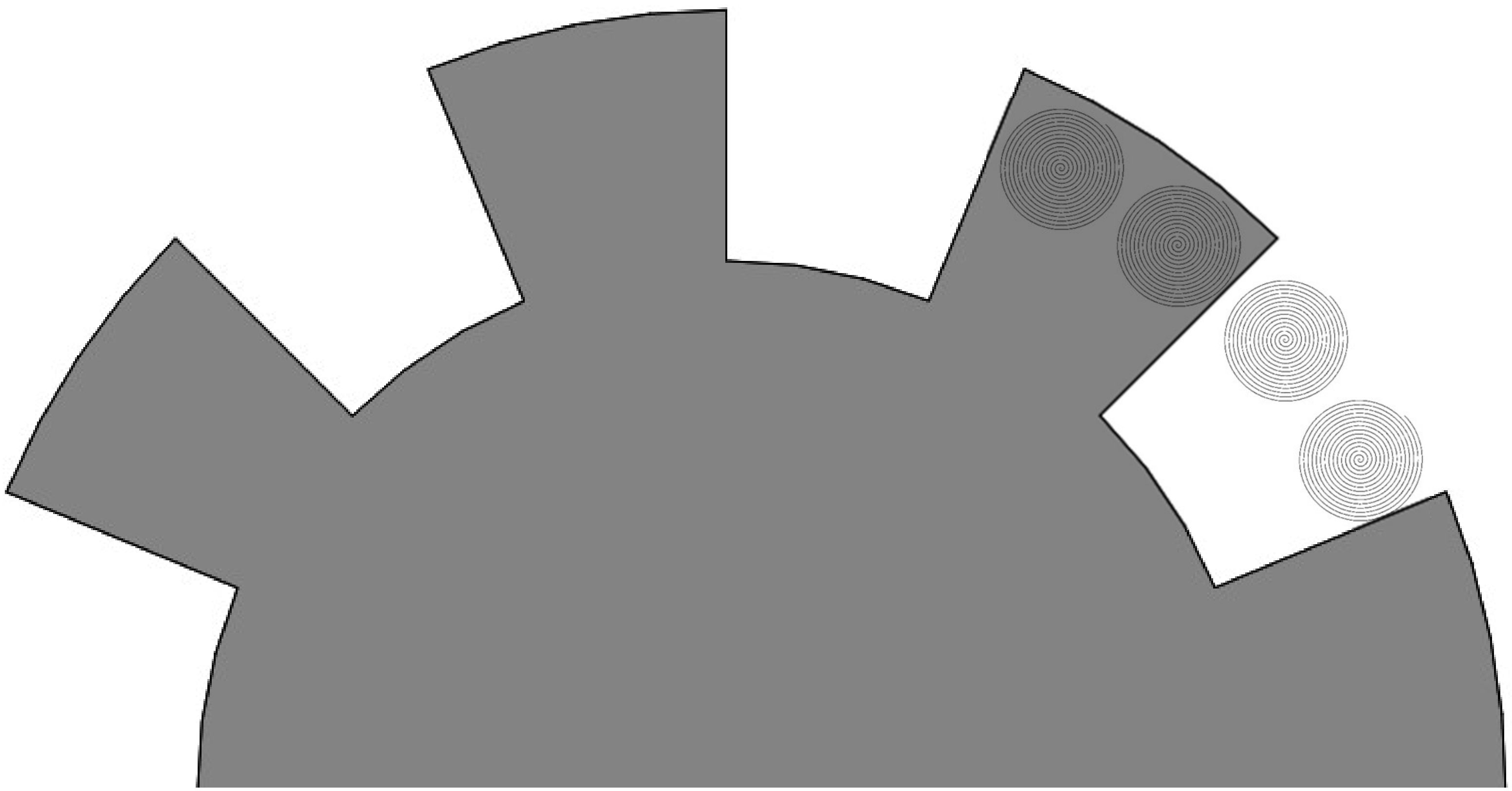


Position	Sensor Coil 1	Sensor Coil 2
1	0	1
2	0	1
3	1	0
4	1	0

Incremental Angle with an Inductive Sensor



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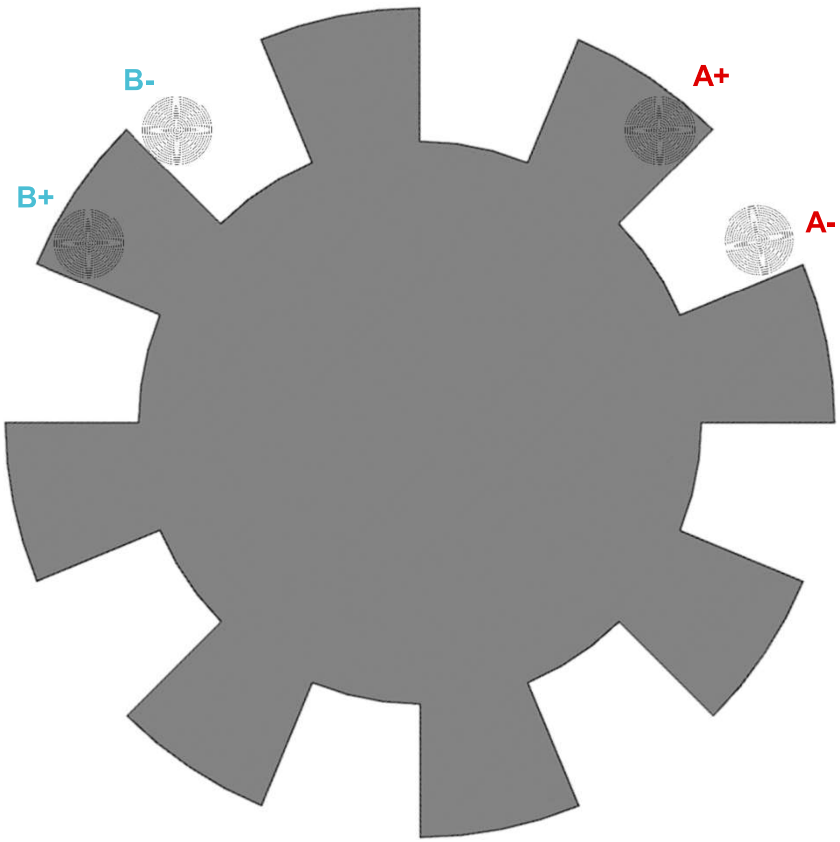

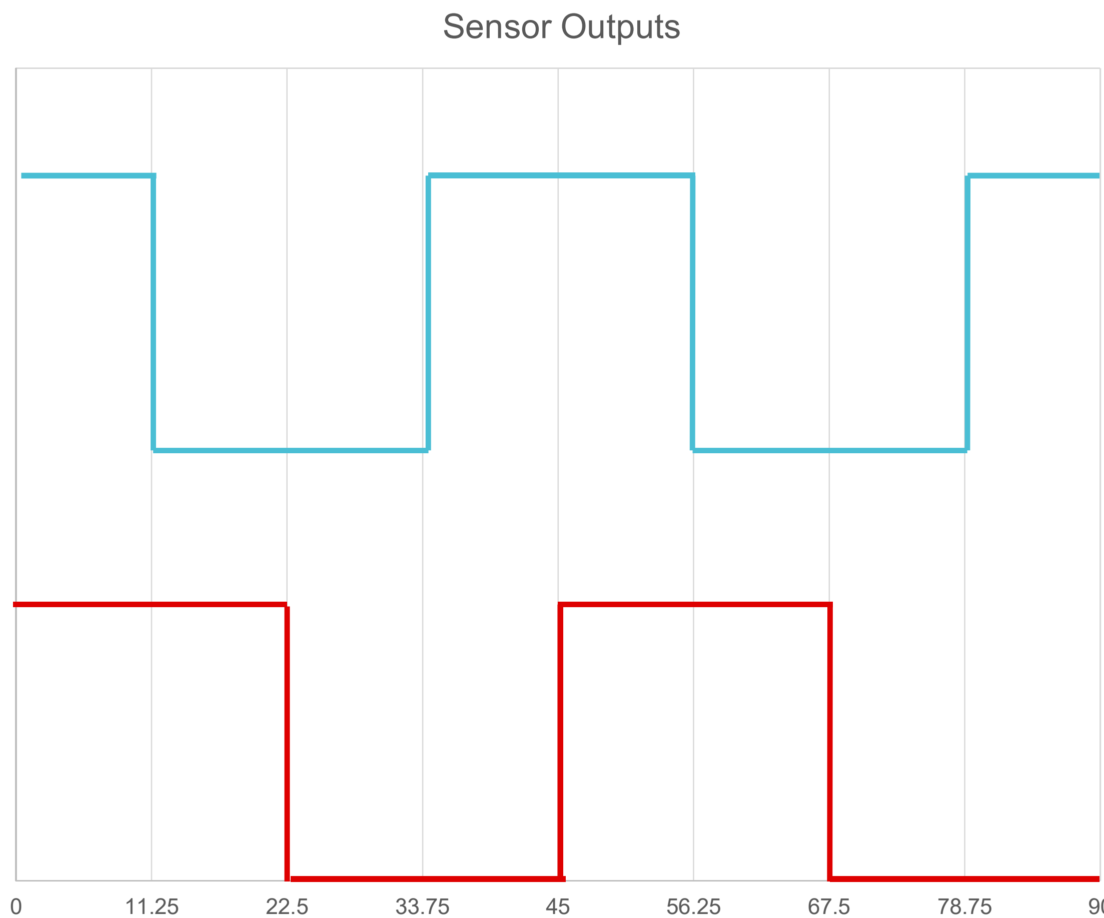

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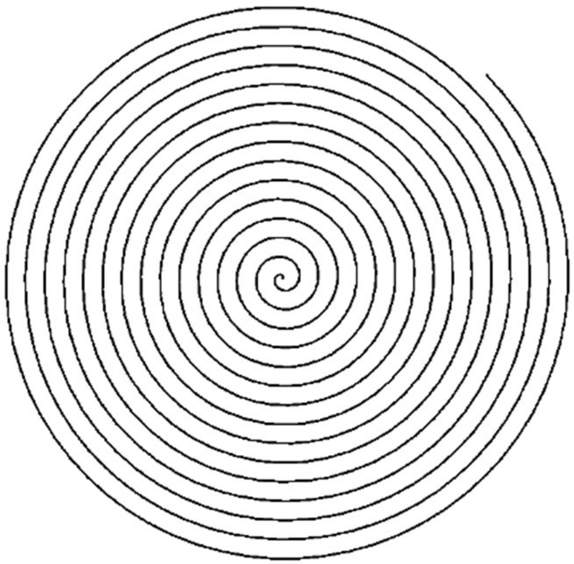
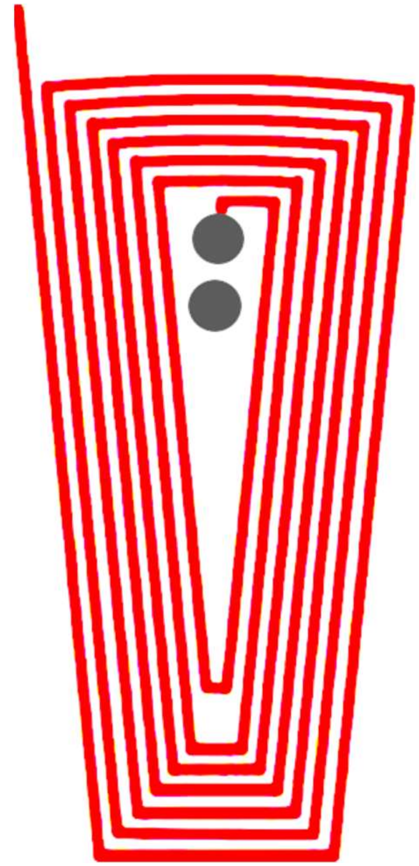




Incremental Angle with an Inductive Sensor

TI Designs
LDC0851 Incremental Rotary Encoder

TEXAS INSTRUMENTS

Design Overview

An inductive sensing based incremental encoder knob design can provide a robust and low-cost interface for control inputs. It can reliably operate in environments which have dirt, moisture, oil or varying temperatures which would pose issues for alternate sensing technologies. This solution requires no magnets.

Design Resources

TIDA-00828	Design Folder
LDC0851	Product Folder
MSP430F5500	Product Folder
LP5951	Product Folder
TPD2E001	Product Folder

TI E2E™ Community — Ask The Analog Experts — WEBENCH® Design Center

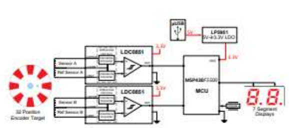
Design Features

- Contactless, high reliability incremental position knob using LDC technology
- No calibration required
- Power consumption of <6mA (excluding MCU & LED indicators)
- Sensor and knob can be placed remotely with respect to LDC0851 device
- 32 steps/rotation
  - design can scale to support multiples of 4 positions
- Rotation Speed Measurement of >2000 RPM
- External magnets will not affect functionality
- Minimal MCU memory and instructions:
  - 1 byte of RAM
  - 208 bytes of ROM/Flash

Featured Applications

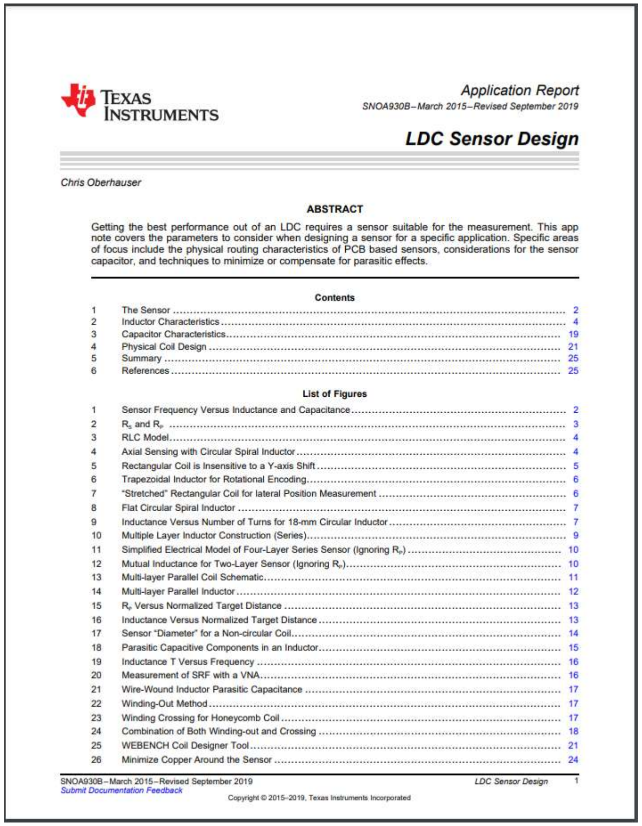
- Automotive Center Control Panels
- Rolling jog wheels
- Appliance interfaces, including cooktops and cleaning appliances
- Home audio and consumer electronics
- Industrial System control

Block Diagram



TIDUBG5 – January 2016 — *LDC0851 Incremental Rotary Encoder* — 1

Design Tools



Texas Instruments

Application Report

SNOA930B–March 2015–Revised September 2019

LDC Sensor Design

Chris Oberhauser

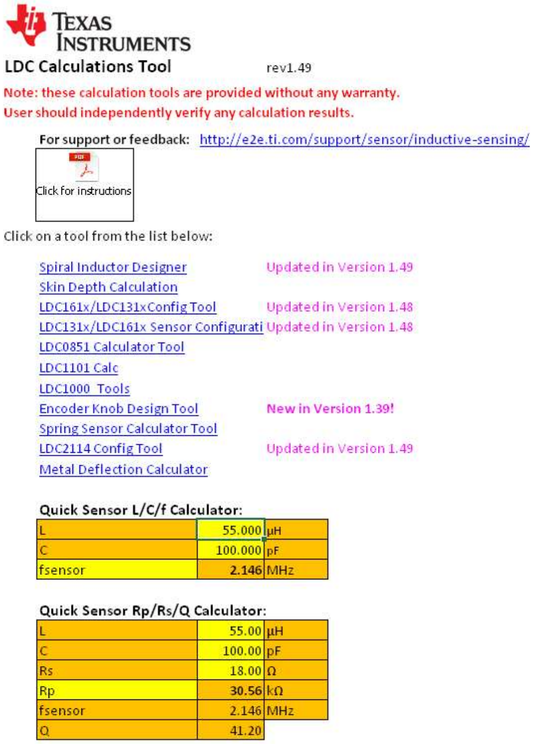
ABSTRACT

Getting the best performance out of an LDC requires a sensor suitable for the measurement. This app note covers the parameters to consider when designing a sensor for a specific application. Specific areas of focus include the physical routing characteristics of PCB based sensors, considerations for the sensor capacitor, and techniques to minimize or compensate for parasitic effects.

Contents

List of Figures

https://www.ti.com/lit/an/snoa930b/snoa930b.pdf



Texas Instruments

LDC Calculations Tool rev1.49

Note: these calculation tools are provided without any warranty.
User should independently verify any calculation results.

For support or feedback: http://e2e.ti.com/support/sensor/inductive-sensing/

Click for instructions

Click on a tool from the list below:

Spiral Inductor Designer	Updated in Version 1.49
Skin Depth Calculation	
LDC161x/LDC131xConfig Tool	Updated in Version 1.48
LDC131x/LDC161x Sensor Configurati	Updated in Version 1.48
LDC0851 Calculator Tool	
LDC1101 Calc	
LDC1000_Tools	
Encoder Knob Design Tool	New in Version 1.39!
Spring Sensor Calculator Tool	
LDC2114 Config Tool	Updated in Version 1.49
Metal Deflection Calculator	

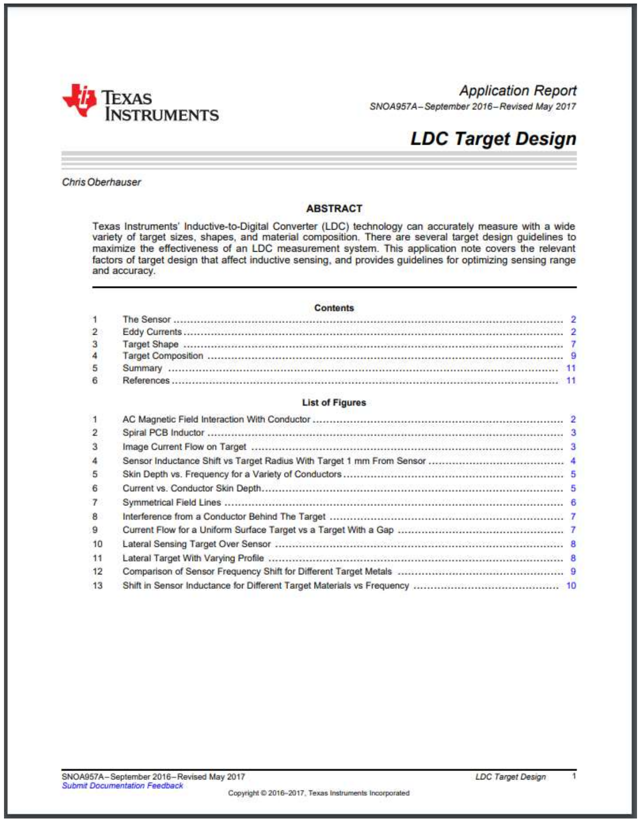
Quick Sensor L/C/f Calculator:

L	55.000	µH
C	100.000	pF
fsensor	2.146	MHz

Quick Sensor Rp/Rs/Q Calculator:

L	55.00	µH
C	100.00	pF
Rs	18.00	Ω
Rp	30.56	kΩ
fsensor	2.146	MHz
Q	41.20	

https://www.ti.com/lit/zip/slyc137



Texas Instruments

Application Report

SNOA957A–September 2016–Revised May 2017

LDC Target Design

Chris Oberhauser

ABSTRACT

Texas Instruments' Inductive-to-Digital Converter (LDC) technology can accurately measure with a wide variety of target sizes, shapes, and material composition. There are several target design guidelines to maximize the effectiveness of an LDC measurement system. This application note covers the relevant factors of target design that affect inductive sensing, and provides guidelines for optimizing sensing range and accuracy.

Contents

List of Figures

https://www.ti.com/lit/an/snoa957a/snoa957a.pdf

Other Resources

To find materials for rotary applications using Hall Effect Sensors, visit https://training.ti.com/ti-precision-labs-magnetic-sensors

To find more inductive sensor resources and products, visit ti.com/sensors/specialty-sensors/inductive/products.html

Inductive Sensors: Angle Detection and Rotary Encoding

TI Precision Labs – Inductive Sensing

Presented and prepared by Scott Bryson

LDC Angle Detection

1) T/F Incremental Encoding measures angle for a linear output response
   a) True
   b) False

2) LDC sensors are (select all that apply)
   a) Robust against dirt and grime
   b) Sensitive to non conductive targets
   c) Tolerant of nearby fixed permanent magnets
   d) Great for long distance measurements

LDC Angle Detection

3) What coil shape is best suited for the gear shaped target for incremental encoding
   a) Trapezoidal
   b) Circular
   c) Racetrack
   d) Rectangular

4) In absolute encoding, Differential coils help:
   a) Add a fail safe to the design
   b) Create discrete output increments
   c) Normalize the output signal
   d) Increase design complexity

LDC Angle Detection

5) Select all that apply to incremental angle encoding
   a) Power on state is easily determined
   b) Resolution is defined by gap spacing on the target
   c) Angle is defined by width of the target
   d) Angle tracking is calculated using simple counter logic

6) Select all that apply to absolute angle encoding
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To find more inductive sensor resources and products, visit ti.com/sensors/specialty-sensors/inductive/products.html