LDC Button Application

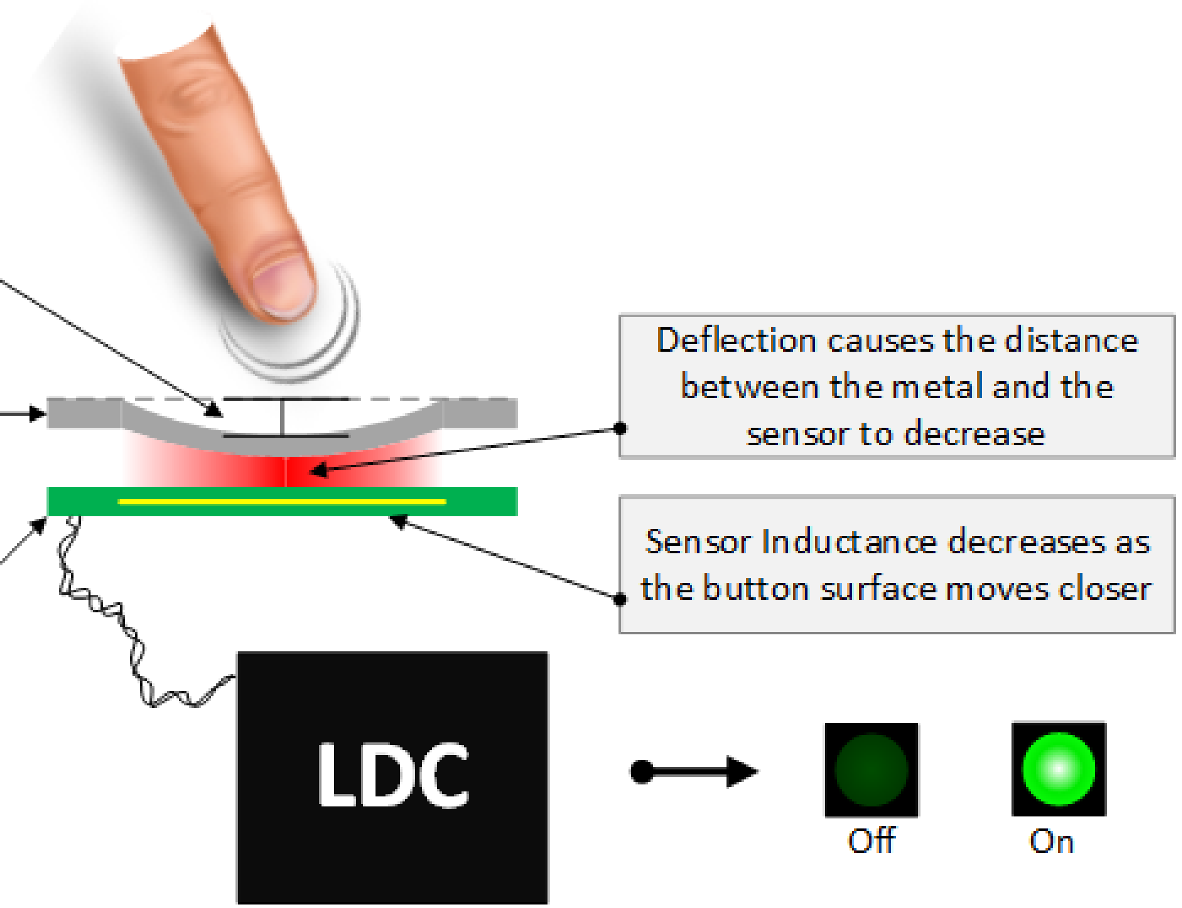
TI Precision Labs – Inductive Sensing

Presented Justin Beigel

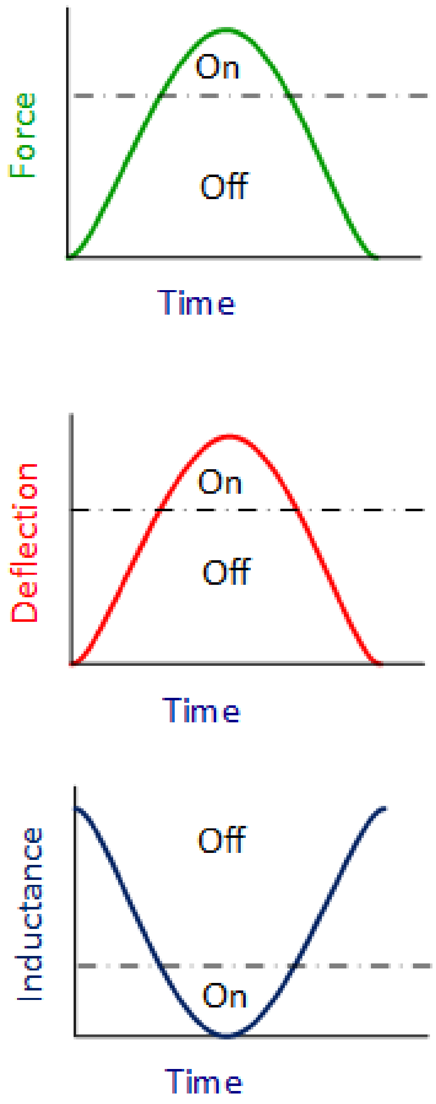
Inductive Touch

Basic Concept

16 Button HMI



Smartwatch

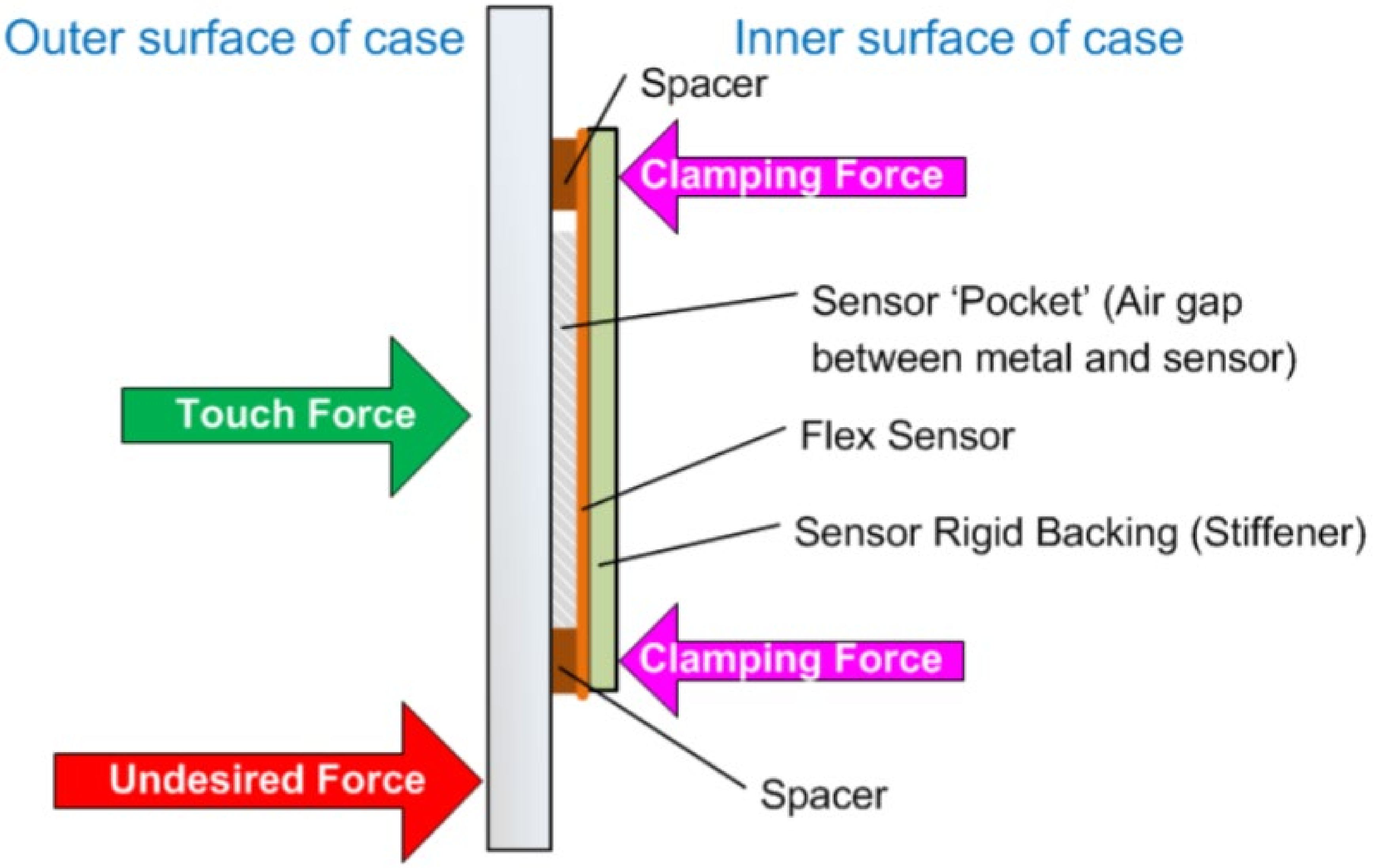


Deflection observed in the button surface is in the order of few hundred nanometers and has been exaggerated in the above drawing.

Inductive Touch
Key Advantages

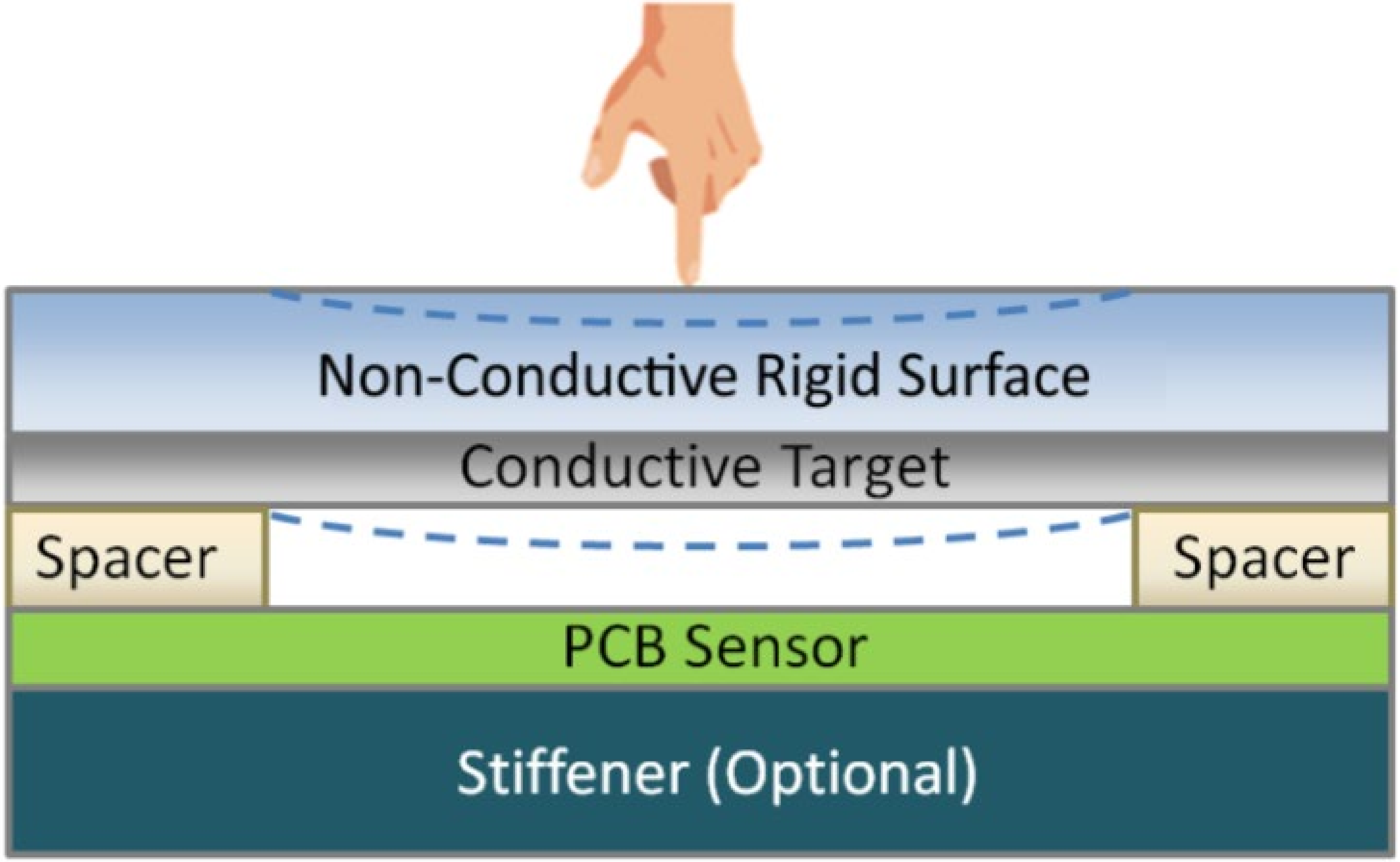
- **Simplified design approach** :
    - **Doesn't require cutouts or holes** in the button surface
    - Button surface **doesn't need to be grounded**
    - **Customizable** sensor design and shape.
    - More button placement options
    - Sensor fabrication **uses existing manufacturing processes** and materials
- **Senses** actual **mechanical deflection** of the button surface :
    - Provides a **force response**
    - **Works with gloves**
    - **Immune to false button response**
- **Rugged functionality** – Highly resistant to environmental factors like dust, dirt, oil, and water.
- **High reliability and extended life span -** does not include any moving components or contacts

Inductive Touch Mechanical Structure

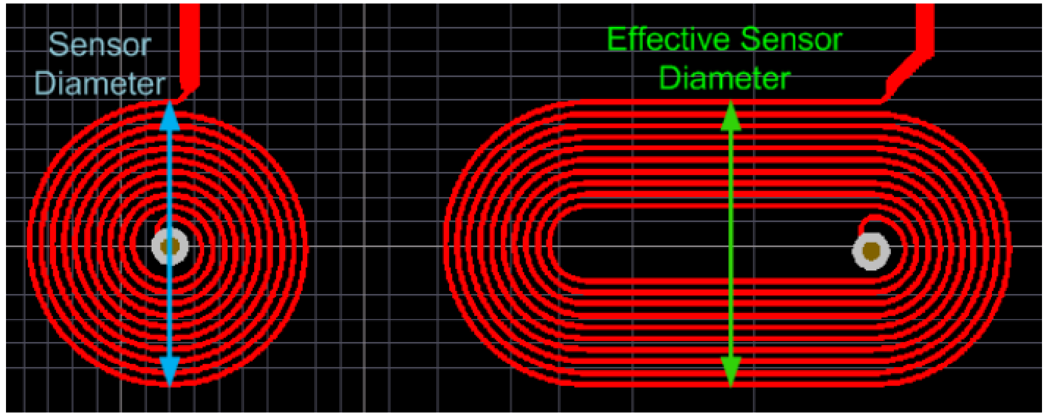


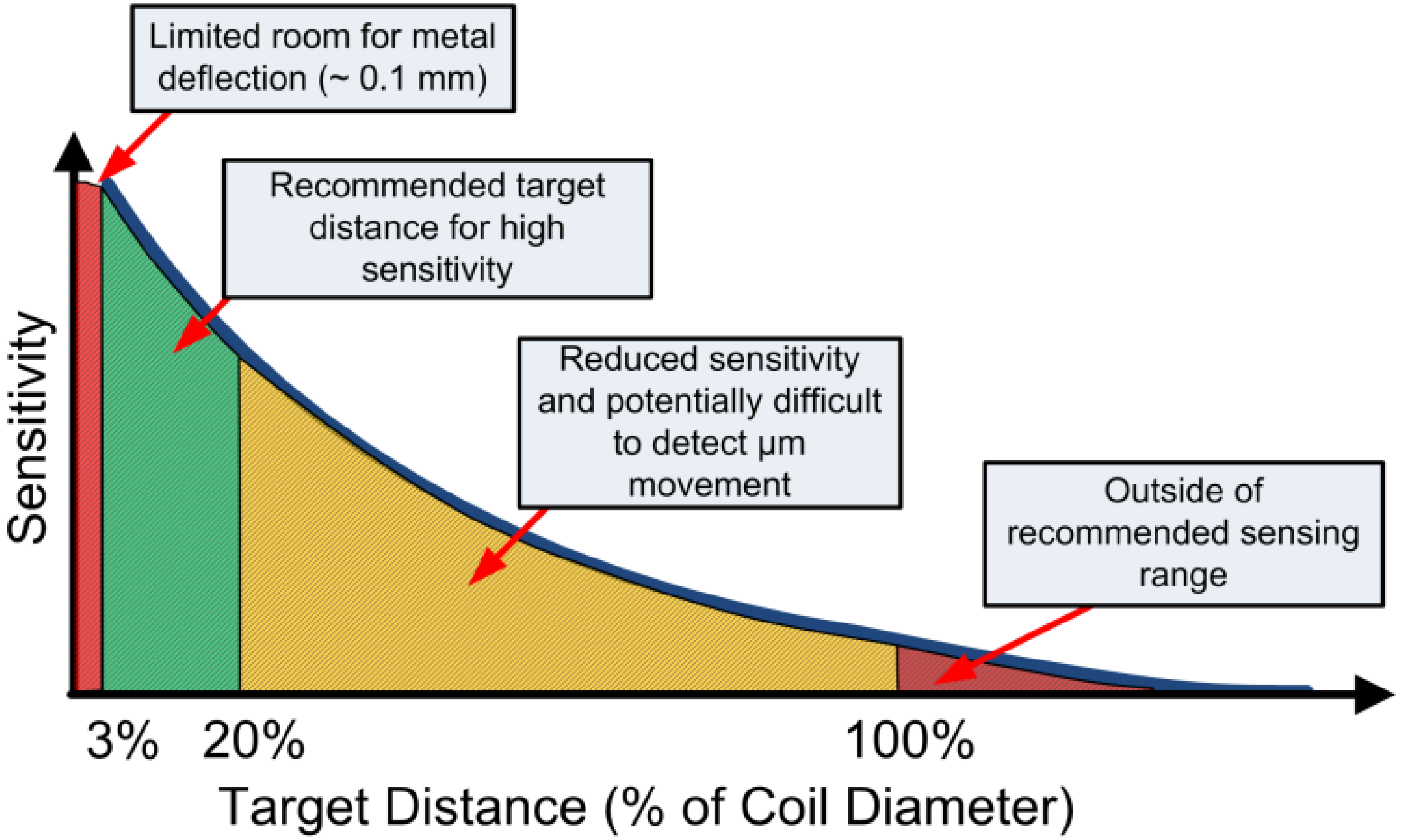
Mechanical Structure for Non-Conductive Cases

For non-conductive case materials such as plastic, a metal insert can be added to create a conductive target.



Button Design Considerations





- Target
  - Height, Width, Skin Depth
- Coil
  - Circular vs Racetrack
  - Diameter
  - Inductance
  - Resistance
    - Parallel vs Series
- Target Distance vs. Coil Diameter

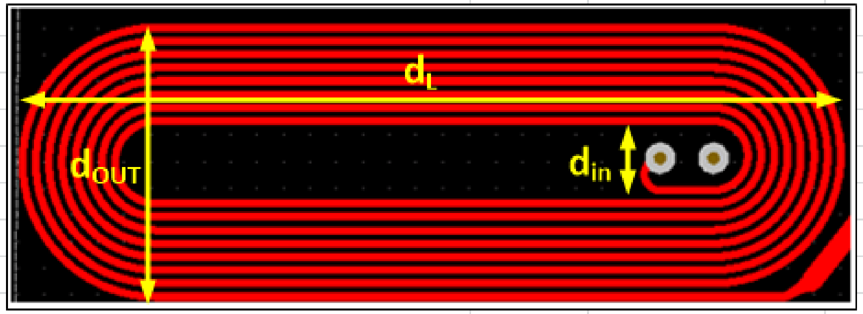
Design Tools and Resources

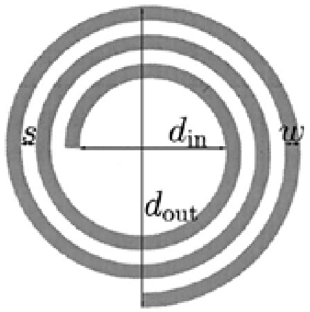
Research	Evaluate/Demo	Design	Debug
LDC Training Videos	LDC Device EVMs	LDC Sensor Design (Rev. B) App Note	E2E – Inductive Sensing FAQ
Common Inductive and Capacitive Sensing Applications (Rev. A)	LDC Coil EVMs	LDC1xxx LDC Target Design (Rev. A) App Note	E2E Forum
LDC Device Selection Guide (Rev. C)	Inductive Touch Buttons for wearables	LDC Calculator Spreadsheet	
	LDC Demos and Reference Designs (TIDAs)	FEMM Tool	
		Device Datasheets	
		EMI App Note	

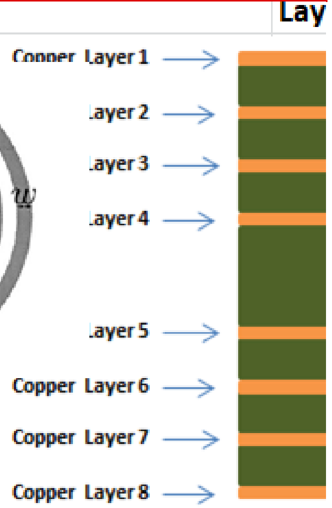
Design Tool Example

- Excel calculation spreadsheet
  - Support for different LDC devices
    - Sensor design and individual tabs
  - Helps design for target and sensor interaction

Take a look at this blog post for additional information







Enter only in Yellow Fields (pull-down for mm or mil)
Results in Orange Fields

Click for Instructions

←Double-Click For Instructions

LC Sensor calculations				
LDC Device		LDC2112/4		
Operating temperature	T	22	°C	Enter operating temperature
Sensor capacitance	C	350.0	pF	Select LC tank capacitance
Layers	M	2	Layers	Number of layers on PCB board (1≤M≤8)
Turns (per layer)	N	9	Turns	Number of turns per layer
Outer diameter of the inductor	d_{OUT}	6.00	mm	Outer Diameter of the spiral inductor
Sensor Shape		Circular		
Long side of inductor	d_L	4.00	mm	
spacing between traces	S	5.000	mil	Space between traces (mm or mil)
width of trace	w	5.000	mil	Width of the trace (mm or mil)
PCB thickness between 1st layer and 2nd layer	h12	0.040	mm	Space between layer 1 and 2 (mm or mil)
PCB thickness between 2nd layer and 3rd layer	h23	30.000	mm	Space between layer 2 and 3 (mm or mil)
PCB thickness between 3rd layer and 4th layer	h34	8.000	mm	Space between layer 3 and 4 (mm or mil)
PCB thickness between 4th layer and 5th layer	h45	8.000	mm	Space between layer 4 and 5 (mm or mil)
PCB thickness between 5th layer and 6th layer	h56	8.000	mm	Space between layer 5 and 6 (mm or mil)
PCB thickness between 6th layer and 7th layer	h67	1.575	mm	Space between layer 6 and 7 (mm or mil)
PCB thickness between 7th layer and 8th layer	h78	1.575	mm	Space between layer 7 and 8 (mm or mil)
Copper thickness	t	0.028	mm	Copper layer thickness (mm,Oz-Cu, or mil)

Design Tool Example – Cont.

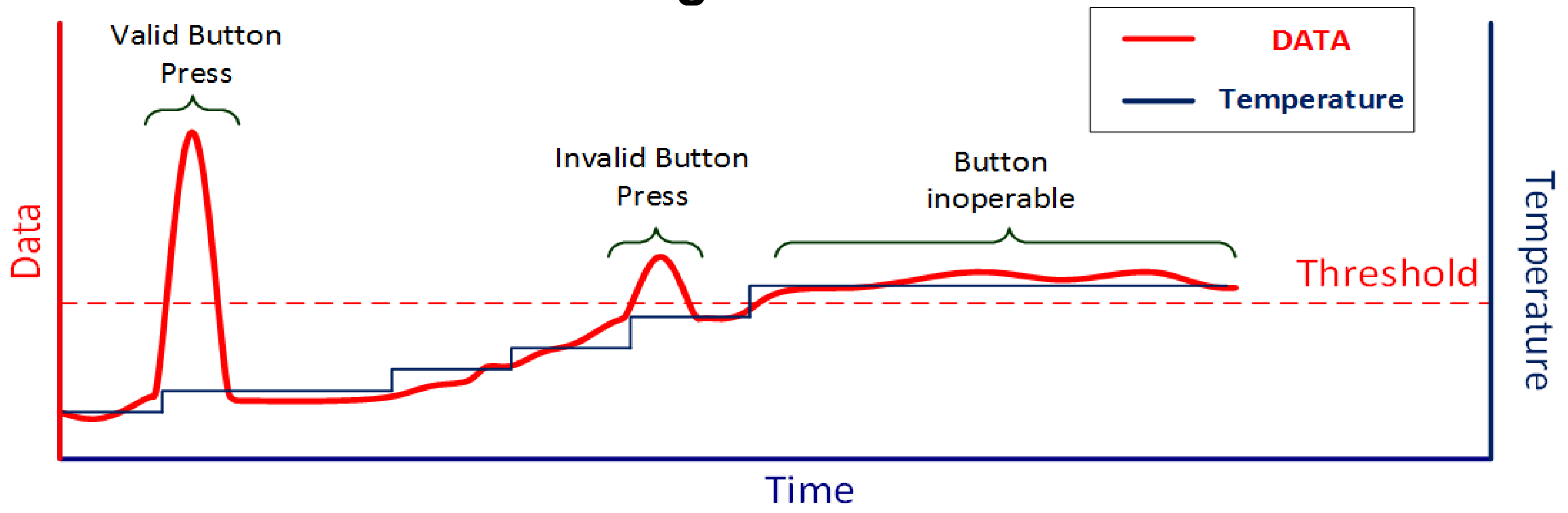
PCB thickness between 7th layer and 8th layer	h78	1.575	mm	Space between layer 7 and 8 (mm or mil)
Copper thickness	t	0.028	mm	Copper layer thickness (mm,Oz-Cu, or mil)
Conductor Resistivity (at 20°C)	pr	1.68E-08	Ωm	Use 1.68e-08 for Copper
Conductor Resistivity temperature coef	pr_tc	0.393	%/°C	Use 0.393 for Copper
Conductor relative permeability	μ_r	1.00		Use 1.0 for Copper
Parasitic capacitance	Cpar	4.0	pF	Estimate - generally in the rage of 1 to 5 pf
Copper resistivity at operating temperature	pr_t	1.693E-08	Ωm	
Coil Fill Ratio	din/dout	**0.24**		0.2> din/dout >0.8 is recommended for highest Q
Inductor inner diameter	din	**1.428**	mm	Inner diameter of the spiral inductor (mm or mil)
Self inductance per layer	L	0.276	µH	
Total Inductance with no target	L_{TOTAL}	**1.007**	µH	
Sensor Operating Frequency no target	f_{RES}	**8.430**	**MHz**	
Rp with no Target	R_P	**1.64**	**kΩ**	
Q factor	Q	**30.48**		
Self resonant frequency (estimated)	SRF	79.309	MHz	SRF should be >1.25*Fsensor
Target Distance	D	**0.300**	mm	For aluminum target of at least 5 skin depths
Sensor Inductance from Target Interaction	L'	**0.375**	µH	
Sensor Frequency with Target Interaction	f_{RES}'	**13.815**	**MHz**	
Rp with Target Interaction	R_P'	**0.54**	**kΩ**	
Q Factor with target	Q'	**16.4**		
Ccom Value (with Target)	Ccom	**2.1< C <26.8**	nF	

Spiral_Inductor_Designer / LDC2114_Config_tool / LDC0851_calc / LDC131x-LDC161x_Config / Encoder_Calc_Tool

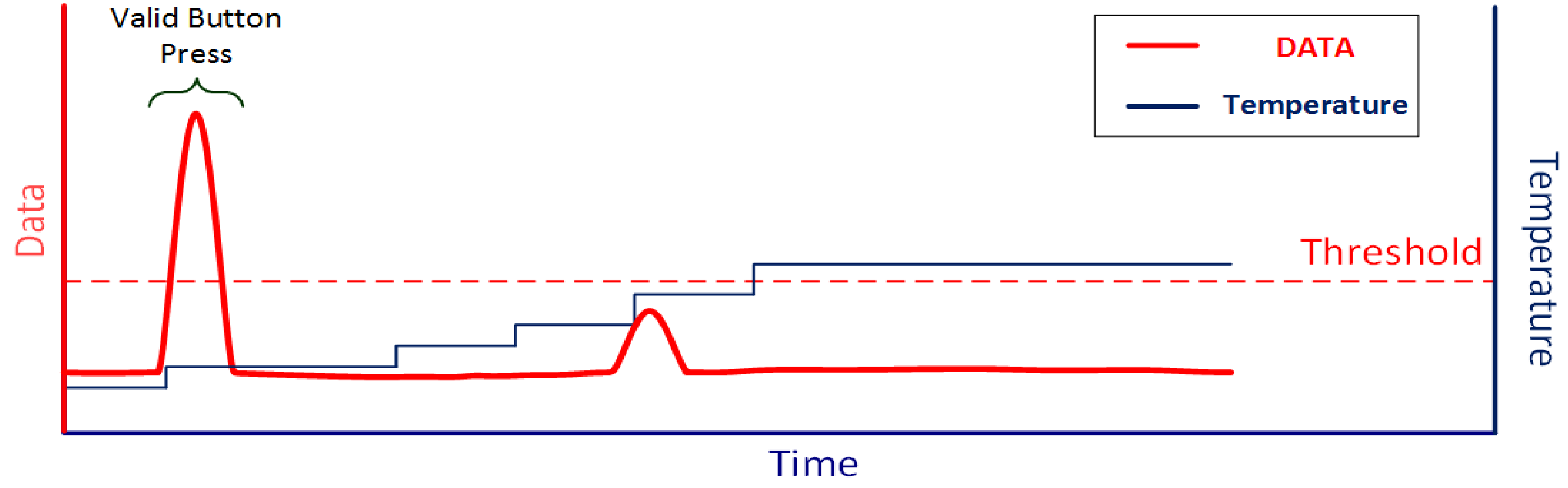
Baseline Tracking

Baseline Tracking for Environmental Factors

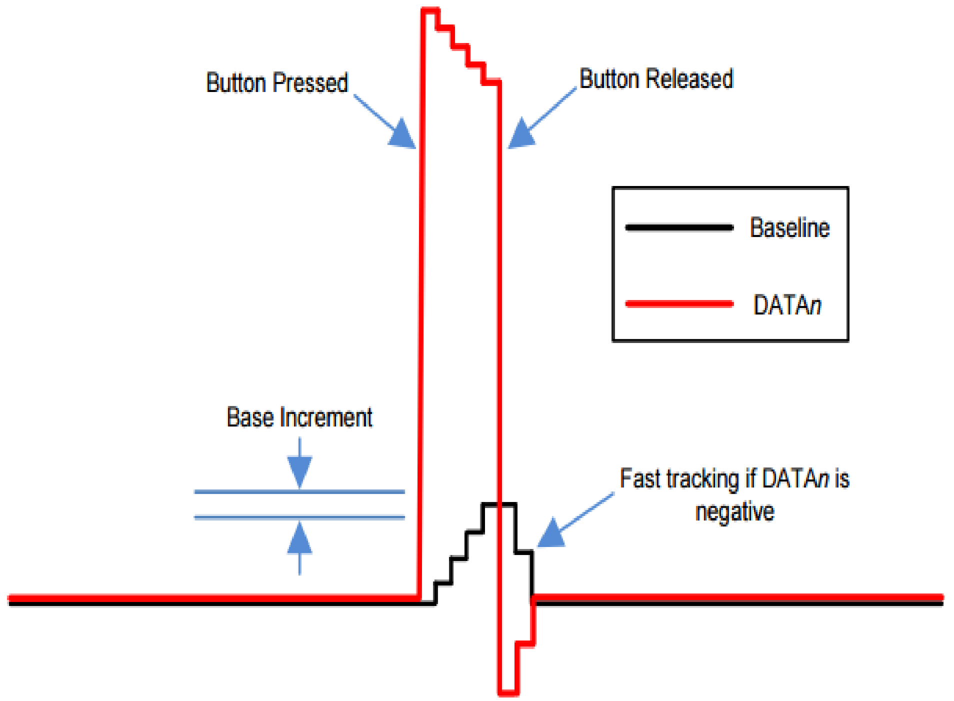
Environmental shifts degrade measurements



LDC Baseline Tracking compensation



Implementation



Compensates for:

- For environmental factors
- Permanent deformation of button surface (drops, dents etc.)

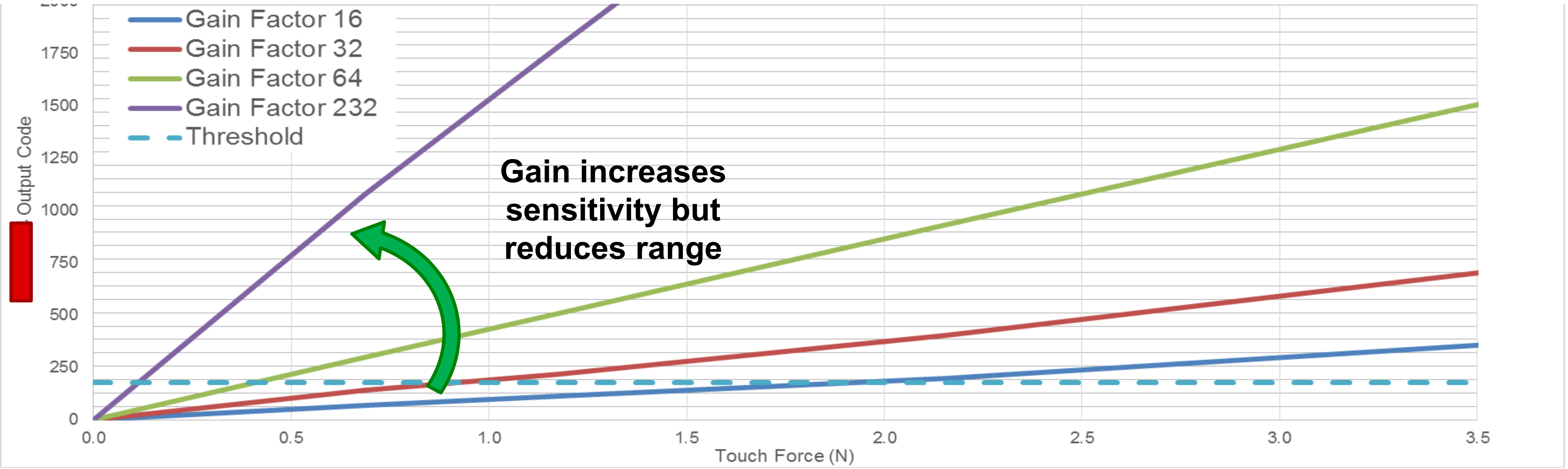
Button Gain/Sensitivity

GAIN Configuration

A button press event is create when the data crosses the threshold.

- Gain Factor sets desired button trigger force. (help compensate for stronger or weaker metal deflection)
    - Across temperature

Force vs LDC Net Data Response



Button sensitivity can be easily adjusted by GAIN:

- A higher GAIN value results in a higher sensitivity.

To find more inductive sensor resources and products, visit:

https://www.ti.com/sensors/specialty-sensors/inductive/products.html