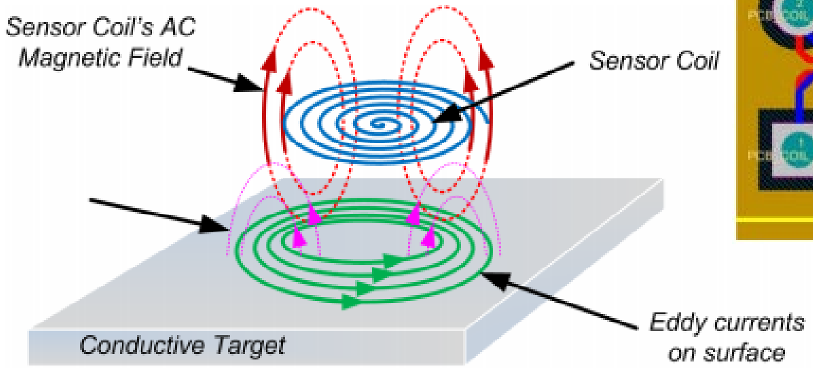
Introduction to the LDC calculator tool

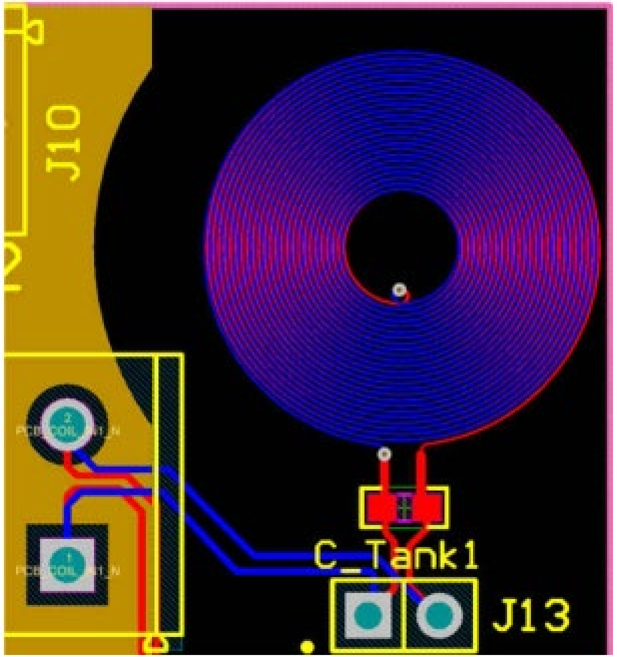
TI Precision Labs – LDC calculator tool

Presented by Justin Beigel

Why does the tool exist?

- Key sensor design components
  - Sensor size
    - Outer diameter
    - Inner diameter
    - Layers
    - Trace width
    - Trace spacing
  - Inductance
  - Capacitance
  - Frequency
  - Q factor
  - Device chosen
  - Target interaction





LDC calculator overview

Two places to download the link:

- Inductive sensing home page | Technical resources
- Device product page link

Inductive sensing calculator

Use our inductive sensor calculator to find the optimal device configuration based on your system requirements.

Download calculator ›

CALCULATION TOOL

Inductive Sensing Design Calculator Tool (Rev. F)

SLYC137F.ZIP (984 KB)

Download

Zip file includes:

- Excel_FEMM spreadsheet
- LDC_Tools spreadsheet
- Read-Me text file

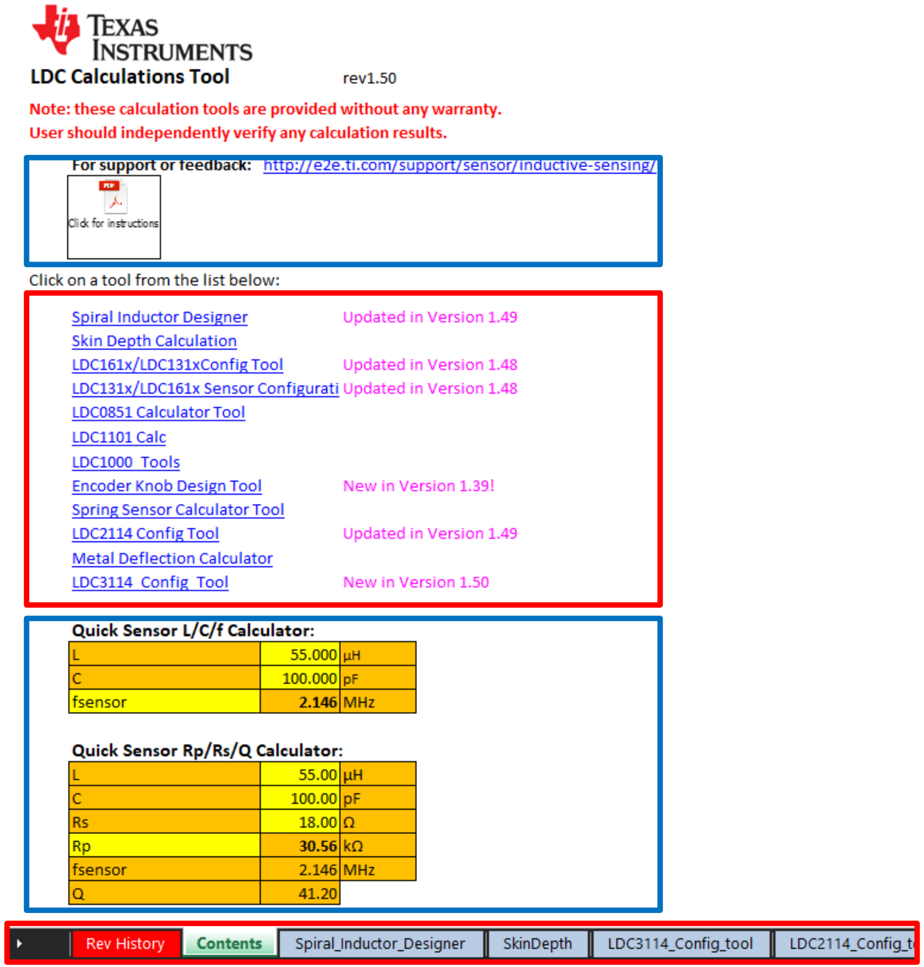
Contents

Instructions

Links to different tabs

Quick Calculations

Different tabs

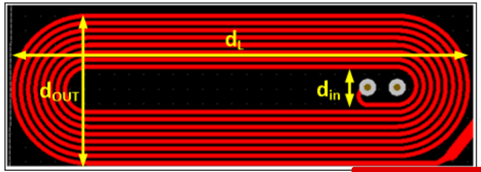


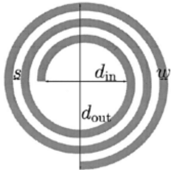
Spiral inductor designer

TI LDC InductanceCalculator Return to Main page Ver O

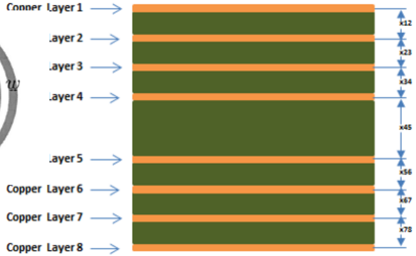
Estimator tool for racetrack spiral coils. This tool is provided without warranty or support. User assumes all liability.

Take a look at this blog post for additional information





Layer Stackup



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		**LDC3114**		
Operating temperature	T	25	°C	Enter operating temperature
Sensor capacitance	C	**220.0**	pF	Select LC tank capacitance
Layers	M	**2**	Layers	Number of layers on PCB board (1≤M≤8)
Turns (per layer)	N	**8**	Turns	Number of turns per layer
Outer diameter of the inductor	d_{OUT}	**8.00**	mm	Outer Diameter of the spiral inductor
Sensor Shape		**Circular**		
Long side of inductor	d_L	**20.00**	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 lay	h12	8.000	mil	Space between layer 1 and 2 (mm or mil)
PCB thickness between 2nd layer and 3rd lay	h23	30.000	mil	Space between layer 2 and 3 (mm or mil)
PCB thickness between 3rd layer and 4th lay	h34	8.000	mil	Space between layer 3 and 4 (mm or mil)
PCB thickness between 4th layer and 5th lay	h45	8.000	mil	Space between layer 4 and 5 (mm or mil)
PCB thickness between 5th layer and 6th lay	h56	8.000	mil	Space between layer 5 and 6 (mm or mil)
PCB thickness between 6th layer and 7th lay	h67	1.575	mil	Space between layer 6 and 7 (mm or mil)
PCB thickness between 7th layer and 8th lay	h78	1.575	mil	Space between layer 7 and 8 (mm or mil)
Copper thickness	t	1.000	oz-Cu	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

Contents | Spiral_Inductor_Designer | SkinDepth | LDC3114_Config_tool | LDC2114_Config_tool | LDC131x-LDC161x_Config | LDC0851_calc | Encoder_Calc_Tool | LDC11

Skin depth

Skin Depth Calculator

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AC currents remain on the surface of conductor, decaying in an exponential manner. The depth of ~63% of the current is called the skin depth. A higher frequency will have a shallower skin depth. It is recommended to use a target thickness of at least 3 skin depths for a good LDC measurement. If you want to minimize the effect of a conductor, use a target thickness of less than 0.5 skin depths
Reminder: 1oz copper is ~35μm thick.

Target Material	Aluminum	
Resitivity	26.5E-9	Ωm
Relative Permeability	1.00	
Sensor Frequency	7.000	MHz
Skin Depth	31.0	μm
Material Thickness	0.20	mm
Number of Skin Depths	**6.46**	skin depths
Percentage of Current:	**99.843**	%

$$Skin\ Depth = \delta_s = \sqrt{\frac{2\rho}{2\pi f \mu_0 \mu_R}}$$

where :

ρ = bulk resitivity (ohm − meters)

f = frequency (Hertz)

μ_0 = permeability constant (Henries / meter) = $4\pi \times 10^{-7}$

μ_r = relative permeability (usually ~ 1)

Courtesy of Microwaves101.com

Quick Sensor L/C/f Calculator

L	20.000	μH
C	100.000	pF
fsensor	**3.559**	MHz

Device specific

- Device tabs

LDC3114_Config_tool | LDC2114_Config_tool | LDC131x-LDC161x_Config | LDC0851_calc

- LDC3114 tab for reference

LDC3114 Configuration Tool

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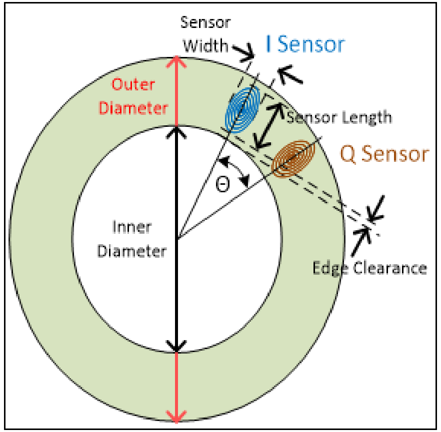
Device : LDC3114

Raw Data Mode — ☑ Enable Raw

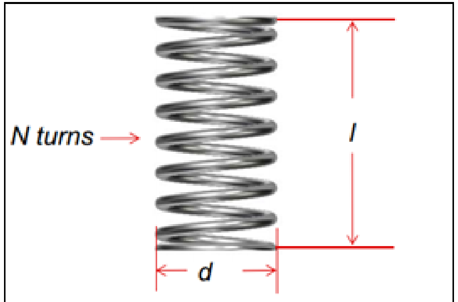
	Sensor 0		Sensor 1	
Enabled Buttons:	☑ Enable Ch0		☑ Enable Ch1	
Enabled in LP mode:	☐ Ch0 Low Power		☐ Ch1 Low Power	
Sensor R_P	4.00	kΩ	2.00	kΩ
Sensor R_P Range	800Ω ≤ RP ≤ 10kΩ		350Ω ≤ RP ≤ 4kΩ	
f_{SENSOR} (with target)	4.00	MHz	20.00	MH:
Target Sample Time interval	1.00	ms	1.00	ms
LCDIV	0		3	
Sensor Cycle Count	30		19	
Actual Sample Time Interval	**1.142**	ms	**1.054**	ms
CNTSC	0		0	

Specific application tabs

- Encoder
- Dial
- Metal deflection (Button)
- Spring

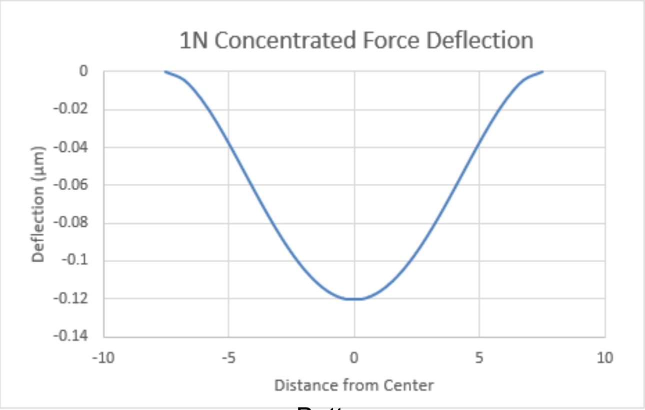


Encoder



$$L = \frac{d^2 N^2}{l + 0.45d} \mu H$$

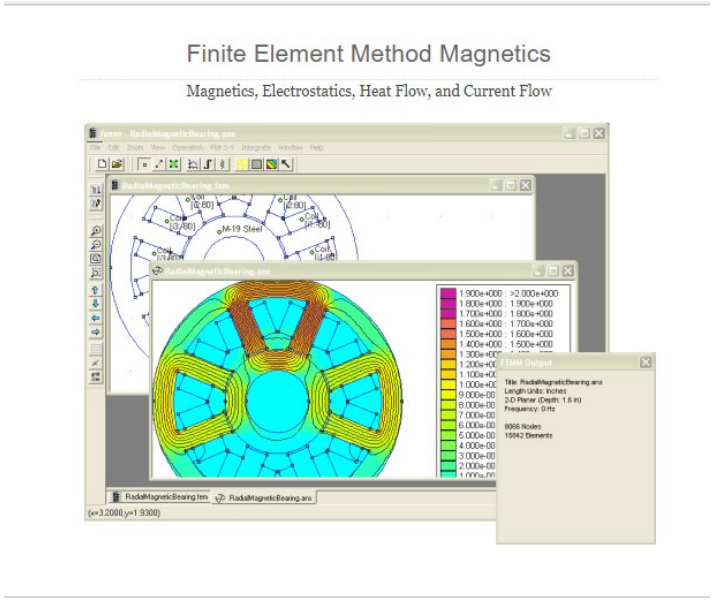
Spring



Button

Excel FEMM tool

- <u>F</u>inite <u>E</u>lement <u>M</u>ethod <u>M</u>agnetics
  - www.femm.info



FEMM Simulation Results (only updated after pressing Run FEMM button			221800
Pass Parameters for FEMM SIM			
L		11.1960	µH
Rp		7.477	kΩ
Q		33.44	
Sensor Frequency with Target		3.1781	MHz
Target Movement shift		0.0100	mm
Sensor Frequency at shifted target			MHz
Sensitivity (frequency shift)			ppm/µm

Run FEMM

☐ Run Sensitivity Analysis

☐ Save FEMM simulation

To find more Inductive Sensor technical resources and search products, visit the inductive sensing home page

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