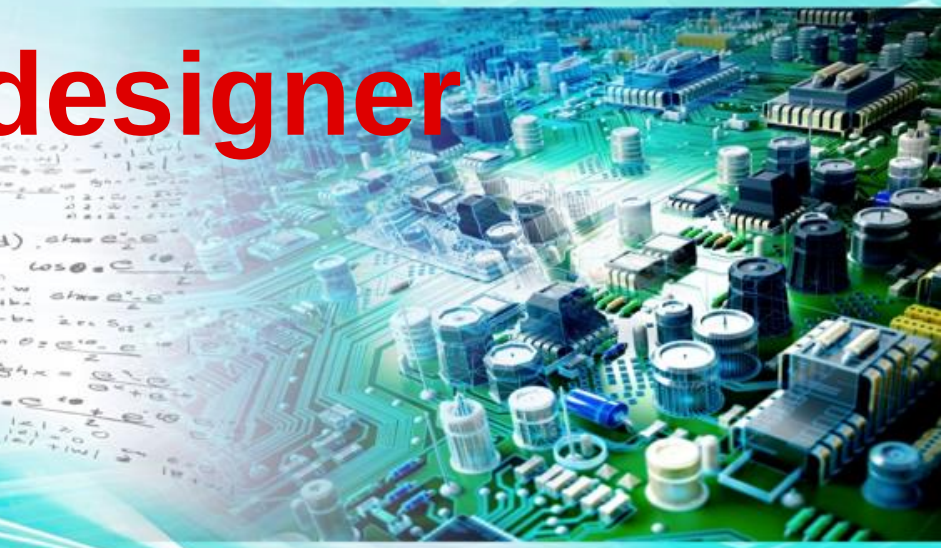
Spiral inductor designer and skin depth

TI Precision Labs – LDC calculator tool



Presented by Justin Beigel

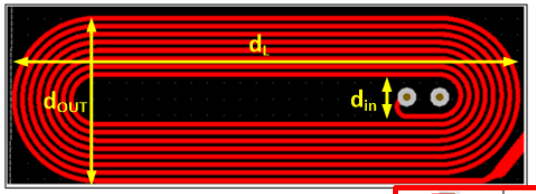
Spiral inductor designer tab

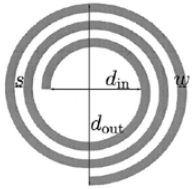
- Graphics at the top
- Instructions
- Parameters

TI LDC InductanceCalculator Return to Main page Ver O

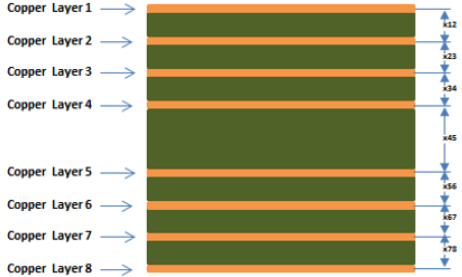
Estimator tool for racetrack spiral coils. This tool is provided without warranty or support. User assumes all liability.

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	**390.0**	pF	Select LC tank capacitance
Layers	M	**2**	Layers	Number of layers on PCB board (1≤M≤8)
Turns (per layer)	N	**10**	Turns	Number of turns per layer
Outer diameter of the inductor	d_{OUT}	**9.00**	mm	Outer Diameter of the spiral inductor
Sensor Shape		**Circular**		
Long side of inductor	d_L	**20.00**	mm	
spacing between traces	S	**4.000**	mil	Space between traces (mm or mil)
width of trace	w	**4.000**	mil	Width of the trace (mm or mil)
PCB thickness between 1st layer and 2nd laye	h12	8.000	mil	Space between layer 1 and 2 (mm or mil)
PCB thickness between 2nd layer and 3rd laye	h23	30.000	mil	Space between layer 2 and 3 (mm or mil)
PCB thickness between 3rd layer and 4th laye	h34	8.000	mil	Space between layer 3 and 4 (mm or mil)
PCB thickness between 4th layer and 5th laye	h45	8.000	mil	Space between layer 4 and 5 (mm or mil)
PCB thickness between 5th layer and 6th laye	h56	8.000	mil	Space between layer 5 and 6 (mm or mil)

Inputs

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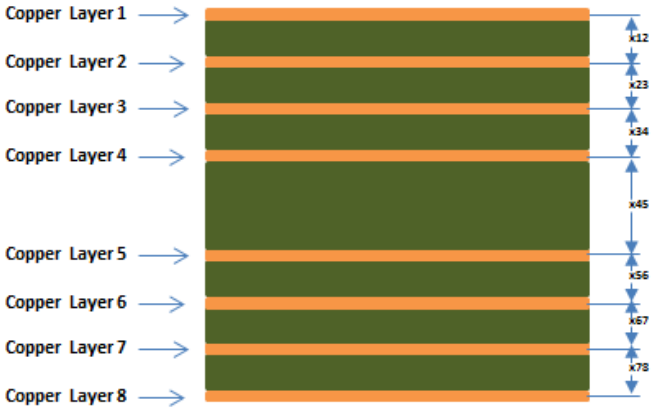
PCB thickness between 6th layer and 7th laye	h67	1.575	mil	Space between layer 6 and 7 (mm or mil)
PCB thickness between 7th layer and 8th laye	h78	1.575	mil	Space between layer 7 and 8 (mm or mil)
Copper thickness	t	1.000	oz-Cu	Copper layer thickness (mm,Oz-Cu, or mil)

Layers



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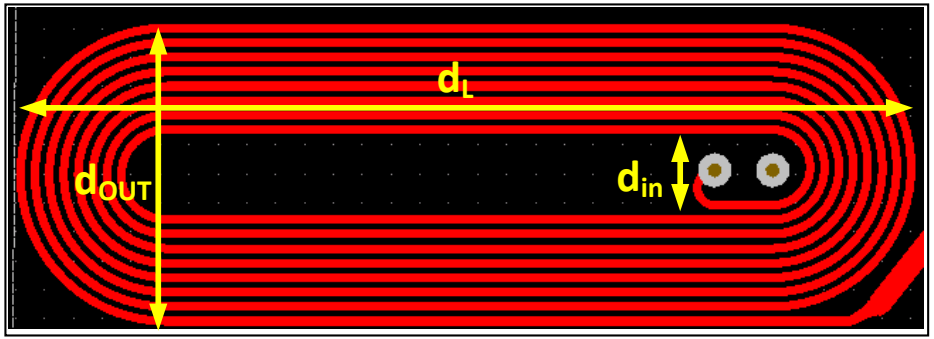
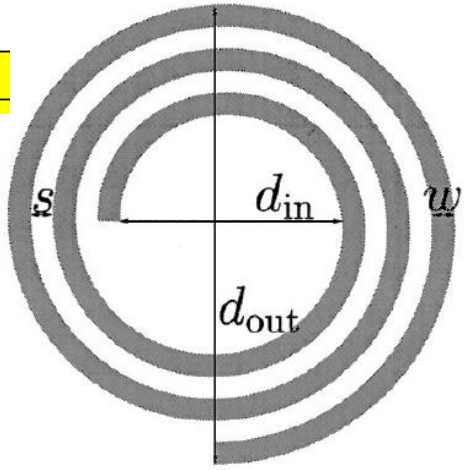
Shape and size

N	10	Turns
d_{OUT}	9.00	mm
	Circular	
d_L	Circular / Racetrack	mm
S	4.000	mil





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Copper properties

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
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	1.713E-08	Ωm	

Outputs

Coil Fill Ratio	din/dout	0.55		0.2> din/dout >0.8 is recommended for highest Q
Inductor inner diameter	din	4.936	mm	Inner diameter of the spiral inductor (mm or mil)
Self inductance per layer	L	0.941	µH	
Total Inductance with no target	L_{TOTAL}	**3.304**	**µH**	
Sensor Operating Frequency no target	f_{RES}	**4.411**	**MHz**	
Rp with no Target	R_P	**2.40**	**kΩ**	
Q factor	Q	**25.92**		
Self resonant frequency (estimated)	SRF	43.782	MHz	SRF should be >1.25*Fsensor

Target distance

Target Distance	D	**5.000**	mm	For aluminum target of at least 5 skin depths
Sensor Inductance from Target Interac	L'	**3.281**	**µH**	
Sensor Frequency with Target Interact	f_{RES}'	**4.426**	**MHz**	Fsensor is too low
Rp with Target Interation	R_P'	**2.38**	**kΩ**	
Q Factor with target	Q'	**25.9**		

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

To find more Inductive Sensor technical resources and search products, visit ti.com/ldc