FEMM spreadsheet and tool

TI Precision Labs – LDC calculator tool

Presented by Justin Beigel
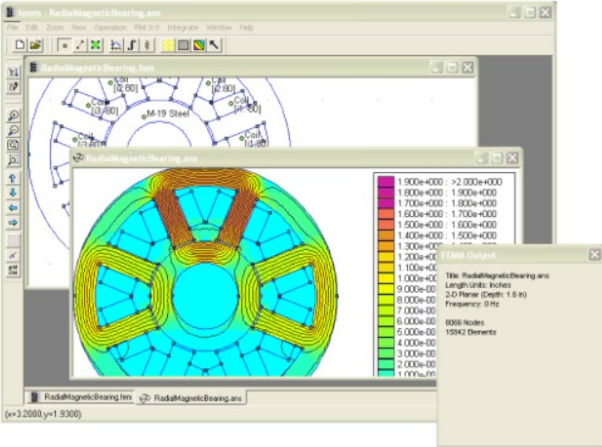
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What is FEMM?

- Finite Element Method Magnetics
- www.femm.info

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FEMM spreadsheet coil design inputs

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	10	Turns	Number of turns per layer
Outer diameter of the inductor	d_{OUT}	10.00	mm	Outer Diameter of the spiral inductor
Sensor Shape		**Circular**		
Long side of inductor	d_L	17.40	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 lay	h23	8.000	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)
PCB thickness between 6th layer and 7th laye	h67	8.000	mil	Space between layer 6 and 7 (mm or mil)
PCB thickness between 7th layer and 8th laye	h78	88.000	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
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	
Coil Fill Ratio	din/dout	0.59		0.2> >0.8 is recommended
Inductor inner diameter	din	5.936	mm	Inner diameter of the spiral inductor (mm or mil)

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FEMM spreadsheet coil design outputs

Copper resistivity at operating temperature	pr_t	1.713E-08	Ωm	
Coil Fill Ratio	din/dout	0.59		0.2> >0.8 is recommended
Inductor inner diameter	din	5.936	mm	Inner diameter of the spiral inductor (mm or mil)
Self inductance per layer	L	1.141	µH	
Total Inductance with no target	L_{TOTAL}	**4.006**	µH	
Sensor Operating Frequency no target	f_{RES}	**5.313**	MHz	
Rp with no Target	R_P	**4.31**	kΩ	
Q factor	Q	31.68		
Self resonant frequency (estimated)	SRF	39.757	MHz	SRF must be >1.25*Fsensor
Target Material		**Aluminum, 1100**		Select Air for No Target
Other target material - enter here & select above		enter here		Enter exactly as named in FEMM materials library
Target Thickness		**0.200**	mm	
Target Distance	D	**3.000**	mm	
Sensor Inductance from Target Interac	L'	**3.874**	µH	
Sensor Frequency with Target Interact	f_{RES}'	**5.403**	MHz	
Rp with Target Interation	R_P'	**4.15**	kΩ	
Q Factor with target	Q'	31.3		Sensor Q too high

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FEMM spreadsheet fixed design

Copper resistivity at operating temperature	pr_t	1.713E-08	Ωm	
Coil Fill Ratio	din/dout	0.72		0.2> >0.8 is recommended
Inductor inner diameter	din	7.155	mm	Inner diameter of the spiral inductor (mm or mil)
Self inductance per layer	L	0.714	µH	
Total Inductance with no target	L_{TOTAL}	2.293	µH	
Sensor Operating Frequency no target	f_{RES}	7.023	MHz	
Rp with no Target	R_P	3.05	kΩ	
Q factor	Q	29.59		
Self resonant frequency (estimated)	SRF	52.554	MHz	SRF must be >1.25*Fsensor
Target Material		Aluminum, 1100		Select Air for No Target
Other target material - enter here & select above		enter here		Enter exactly as named in FEMM materials library
Target Thickness		0.200	mm	
Target Distance	D	3.000	mm	
Sensor Inductance from Target Interac	L'	2.226	µH	
Sensor Frequency with Target Interact	f_{RES}'	7.127	MHz	
Rp with Target Interation	R_P'	2.95	kΩ	
Q Factor with target	Q'	29.3		

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Spreadsheet results

FEMM Simulation Results (only updated after pressing Run FEM			87673
Pass Parameters for FEMM SIM			
L		2.4673	µH
Rp		3.337	kΩ
Q		31.79	
Sensor Frequency with Target		6.7699	MHz
Target Movement shift		0.1000	mm
Sensor Frequency at shifted target		6.7532	MHz
Sensitivity (frequency shift)		24.6	ppm/µm

Run FEMM

☑ Run Sensitivity Analysis

☐ Save FEMM simulation

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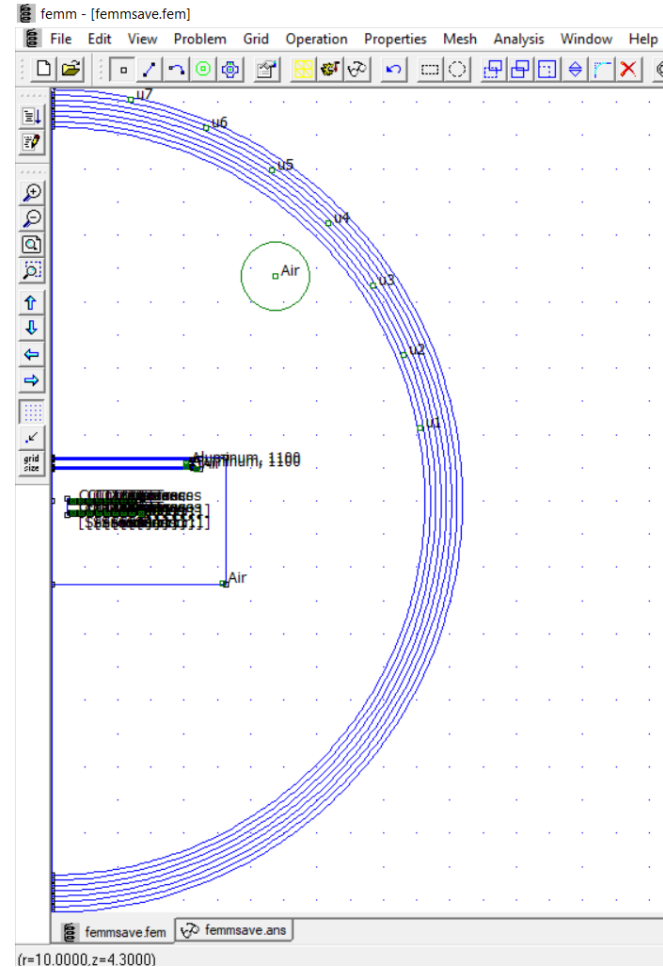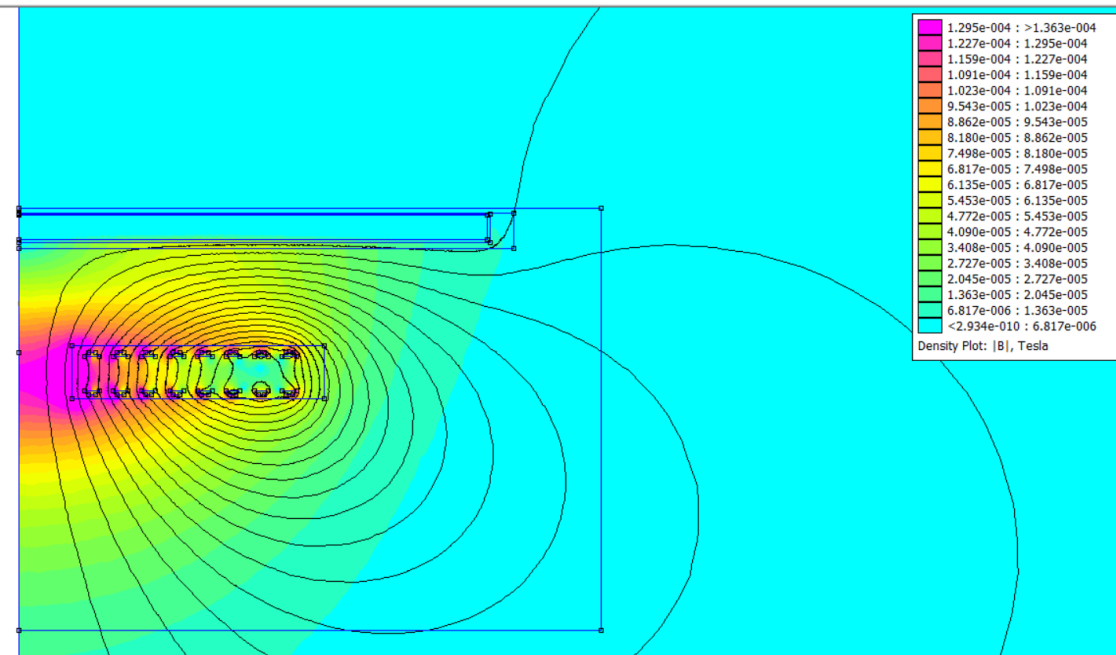
To find more Inductive Sensor technical resources and search products, visit
ti.com/ldc

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